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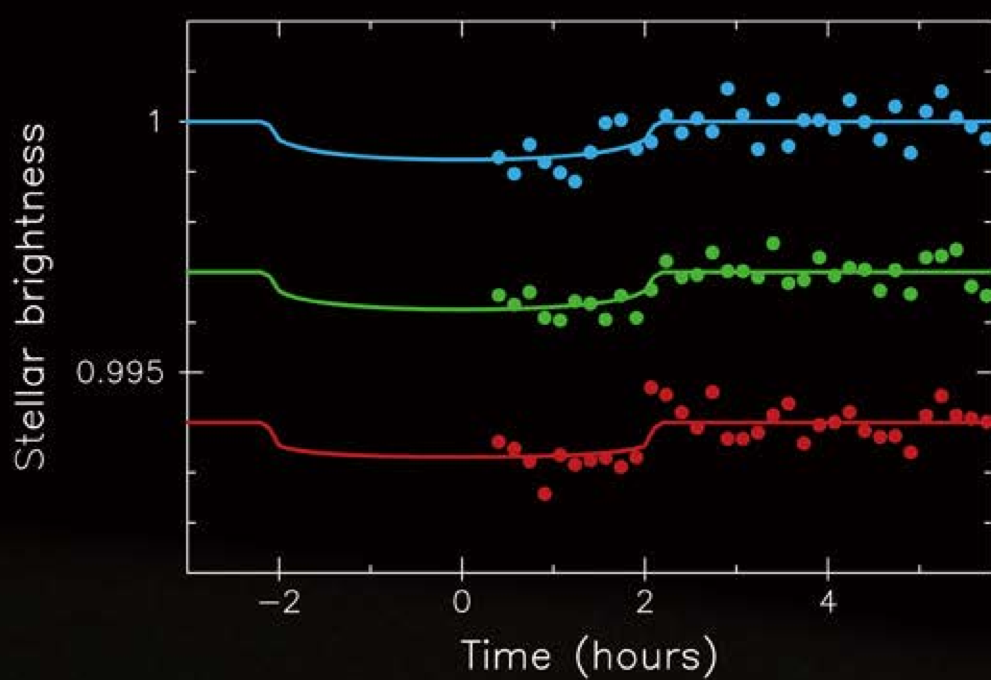
Volume 19 Fiscal 2016



Cover Caption

Using the Okayama 188 cm telescope and multi-band camera MuSCAT (bottom of the back cover), researchers succeeded in observing the extrasolar planet K2-3d (top of the back cover, artistic visualization), which is about the same size and temperature as the Earth, pass in front of its host star (top of the cover, artistic visualization) blocking some of the stellar light (bottom of the cover).
Credit: NAOJ

Postscript

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Annual Report of the National Astronomical Observatory of Japan

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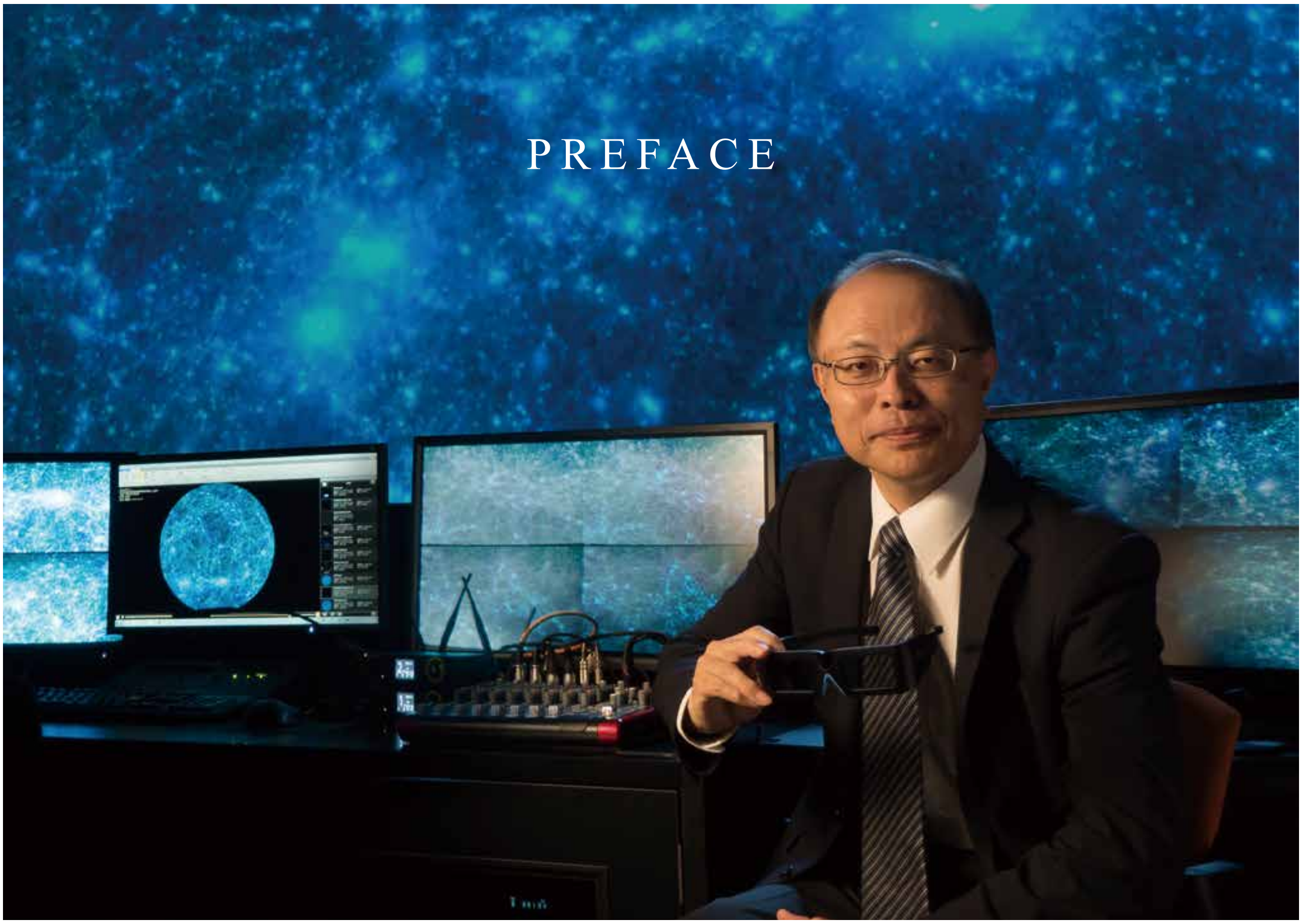
PREFACE



Masahiko HAYASHI
Director General of NAOJ

It is my pleasure to present the Annual Report of the National Astronomical Observatory of Japan.

In February of 2016, it was announced that LIGO had directly detected gravitational waves. Currently in Japan, the Large-scale Cryogenic Gravitational Wave Telescope KAGRA is being constructed in Kamioka, led by the University of Tokyo Institute for Cosmic Ray Research (ICRR) together with the National Astronomical Observatory of Japan (NAOJ) and the High Energy Accelerator Research Organization (KEK). Attempts in Japan to directly detect gravitational waves began in the 1970’s with the creation of a resonant-mass detector by Dr. Hiromasa Hirakawa at the University of Tokyo. Laser interferometer type detectors started at NAOJ from the 1980’s; and in the 1990’s TAMA300 with 300 m arm-lengths was completed and succeeded in continuous operation. At NAOJ, making the best use of experiences like these, the Advanced Technology Center has been developing key components for KAGRA such as the end mirror vibration isolation systems, utilizing 14 m high multistage pendulums, and the main interferometer, which creates laser light interference patters with orthogonal 3 km arms. With KAGRA added to the LIGO and VIRGO gravitational wave detector network, the locations of gravitational wave sources will be able to be determined with a precision of a couple of degrees. Follow-up observations by electromagnetic telescopes will further advance this research, giving us detailed insight into the nature of black holes and neutron stars. Multi-messenger astronomy has already begun.

ALMA started Cycle 4 observations from October 2016. The number of observational proposals submitted from around the world reached 1600, surpassing the Hubble Space Telescope. In June of every year, 150 leading astronomers from the various countries assemble and spend days cooped up in a hotel, holding meetings to examine these proposals and adopt about 400 of them. In Japan, more than half of the proposals were written by young researchers such as graduate students and post-docs.

Almost 1/4 of ALMA’s observations are occupied with planetary system formation observations. When I was an undergraduate student, more than 35 years ago, I read a review paper of the "Kyoto Model." I remember thinking, "It is a beautiful model. But to actually observe planets forming in the Universe, high resolution better than 1 arcsecond would be needed. I don't think I'll see planetary system formation observations within my lifetime." Now, multiple ring structures, like those seen in the HL Tauri protoplanetary disk, are being discovered around one young star after another. I expect that by observing the disks of many young stars, we will be able to see the structural evolution of the protoplanetary disks generated as a result of planetary system formation.

Thanks to ALMA's extremely high sensitivity, it detected the redshifted 88 μm wavelength emission line of ionized oxygen coming from a galaxy more than 13.1 billion light-years away discovered by the Subaru Telescope. This emission line is a good indicator of star formation activity. But because it is in the far infrared, it can't be observed from the ground, so previously it had only been observed by using flying instruments. But when the redshift exceeds 3 (i.e. the distance exceeds 12 billion light-years) the observed wavelength of this emission line shifts to submillimeter waves, making it visible to ALMA. This is an excellent observational method to understand the details of star formation in the early Universe and the history of element production.

At the Subaru Telescope, the strategic program using the ultra-wide-field prime-focus camera (Hyper Suprime-Cam) is proceeding smoothly. This camera's survey speed (= limiting magnitude x field of view area) is more than 10 times that of previous surveys. Equipped with this camera, the Subaru Telescope will without a doubt be on the world's leading edge of observations until the U.S.A.'s Large Synoptic Survey Telescope starts operation in the mid-2020's.

In February 2017, roughly 60 nights of data taken as part of this strategic program were made available in Public Data Release 1. The largest data set covers 108 square degrees on the sky. The data was taken in 9 colors. The limiting magnitude is 26.4 mag with the red filter. The stellar image size is 0.6 to 0.8 arcsecond. There is no comparable data set in the world. By the way the volume of the data set is equivalent to 10 million pictures taken with a normal digital camera. Ultimately, the survey will be 10 times this size, acquiring data across 1400 square degrees on the sky. Observations with Hyper Suprime-Cam will elucidate the distribution of dark matter across wide regions (and in terms of distance, about 90 % of the way out to the edge of the Universe). Hopefully we will be able to pursue the evolution of the large-scale structure of the Universe and get closer to understanding the true nature of dark matter and dark energy.

Regarding the open question of TMT, in FY 2016 the Hawai`i State Board of Land and Natural Resources held public hearings with area residents about reissuing the Maunakea Science Reserve Use Permit, resulting in a new permit being issued in September 2017. Thanks to continuing dialog between TMT International Observatory and the local residents, in Hilo Hawai`i the number of people supporting the construction of TMT is now higher than ever.

From the experience with the Subaru Telescope, the resistance in the Japanese astronomy community to building telescopes overseas disappeared. For ALMA it was a natural assumption that the telescopes would be arrayed overseas; the construction and operation also proceeded as an international project. For NAOJ, that was a new challenge. Fortunately, with the incorporation of NAOJ in 2004 the personnel system for academic faculty was reconsidered and the project system was established, changing the organizational structure to give it the flexibility needed for large international projects. It also became possible to have people with exceptional, specialized skills participate in large international projects as contract employees. Moreover by representing Japan in this kind of large international project, NAOJ's duty as an inter-university research institute became better defined; this role has become making great contributions to strengthening research throughout all of Japan in the field of astronomy. Based on considerations like these, from here forward we would like to continue efforts towards realizing large-scale international collaboration projects.

Masahiko HAYASHI
Director General of NAOJ

I Scientific Highlights

(April 2016 – March 2017)

Oxygen Abundance Determination of B-type Stars with O I 7771–5 Å Lines

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HONDA, Satoshi
(University of Hyogo)

It is known that anomalous abundances are observed in specific light elements (e.g., C or N) in B-type main-sequence stars, which are interpreted as due to mixing caused by rotation-induced meridional circulation. However, the appreciable He enrichment in B-type stars once reported by [1] can not be explained within the framework of the canonical theory of stellar evolution. If this is real, it would require a special non-canonical deep mixing extending to the core where transformation of H→He takes place. Yet, given that He abundance determination from strong He lines is difficult (which critically depends on a choice of microturbulent velocity) and the conclusion of [1] may not necessarily be reliable. In this context, oxygen abundances play a key role, since an appreciable He-enrichment should accompany a significant O-deficit due to dredge-up of ON-cycle product from the deep core region. So, the necessity/existence of non-canonical mixing may be judged by examining the surface oxygen abundances of B stars, where the standard calculation predicts negligibly small O-anomaly ([2]).

Motivated by this consideration, we decided to conduct an O-abundance analysis for a well-defined sample of B-type stars, while employing the O I 7771–5 Å triplet lines. The observations for selected 34 targets (where Be stars and B supergiants are not included) in a wide range of $v_e \sin i$ (~ 0–250 km s^{-1}) as well as $T_{\rm eff}$ (~ 10000–28000 K) were carried out mostly in 2015 September by using the MALLS spectrograph attached to the 2 m NAYUTA telescope at Nishi-Harima Astronomical Observatory of Hyogo University. The resolving power and typical signal-to-noise ratio of the spectra are R ~ 12000 and S/N ~ 200–300, respectively. By using the atmospheric parameters determined from *uvbyβ* colors, we derived the oxygen abundances by applying the spectrum-fitting technique to the O I triplet lines while taking into account the non-LTE effect. The following conclusions were obtained:

— The strength of O I 7771–5 Å lines decreases with an increase in $T_{\rm eff}$, while the non-LTE effect is considerably large for both late-B as well as early-B stars (non-LTE abundance correcton is on the order of ~ −1 dex) and thus has to be taken into account by all means.

— The resulting oxygen abundances of our sample stars distribute around the solar abundance and do not show any systematic dependence upon $v_e \sin i$ as well as $T_{\rm eff}$, which means that any meaningful oxygen abundance anomaly is not observed.

— Since this doe not contradict the prediction from the standard stellar evolution calculations (e.g., [2]), the appreciable enrichment of surface He abundance suggested by [1] may be questionable and worth reinvestigation.

See [3] for more details of this study.

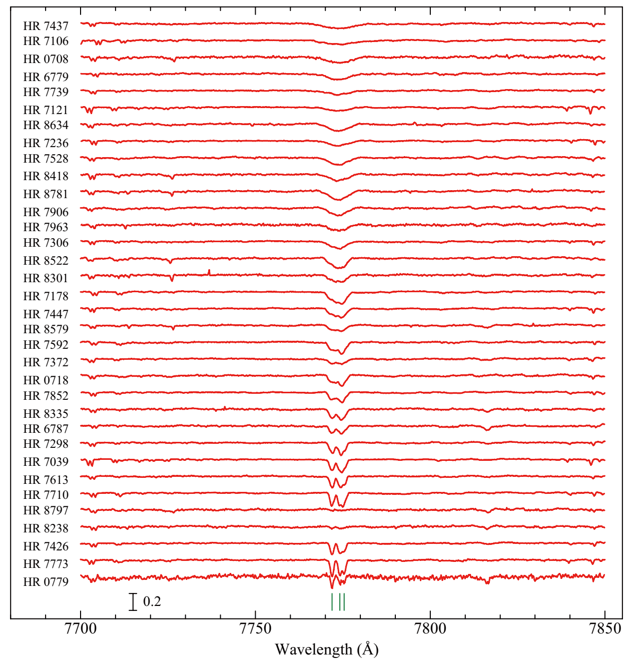

Figure 1: Spectra of our 34 target stars in the 7700–7850 Å region, which are arranged in the descending order of $v_e \sin i$.

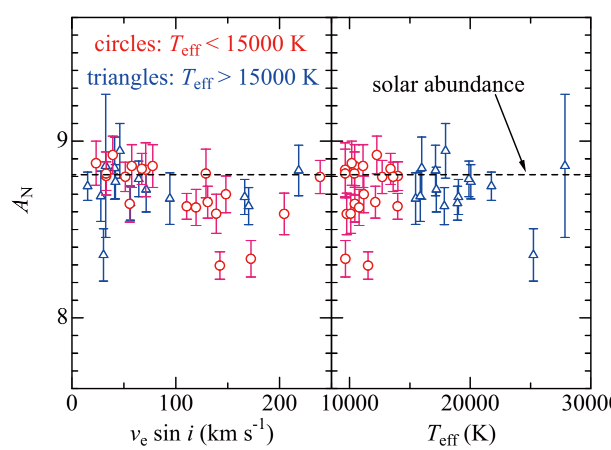

Figure 2: The resulting A_N (non-LTE oxygen abundance) plotted against $v_e \sin i$ as well as $T_{\rm eff}$.

References

[1] Lyubimkov, J. S., et al.: 2004, *MNRAS*, **351**, 745.
[2] Georgy, C., et al.: 2013, *A&A*, **553**, 24.
[3] Takeda, Y., Honda, S.: 2016, *PASJ*, **68**, 32.

IRIS, *Hinode*, *SDO*, and *RHESSI* Observations of a White Light are Produced Directly by Non-thermal Electrons

LEE, Kyoung-Sun[1], IMADA, Shisuke[2], WATANABE, Kyoko[3], BAMBA, Yumi[4], BROOKS, David H.[5]

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Sometimes strong solar flares produce continuum enhancements as a photospheric response, which is termed a white light flare (WLF). Previous observations showed that the continuum enhancement in WLFs is well correlated with hard X-ray emission both spatially and temporally [1,2]. From the correlation, it has been thought that WLFs are produced by the transported energy from accelerated particles such as non-thermal electrons [3]. With recent high spatial resolution observations, WL emission has been reported even in weak flares [4]. The electron flux from these low energy events is not enough to penetrate and heat the photosphere directly. Therefore, other heating mechanisms have also been considered. For example, WL emission is produced by electrons that heat the chromosphere directly and the photosphere indirectly [5]. However, the true heating mechanism in the lower atmosphere remains unclear.

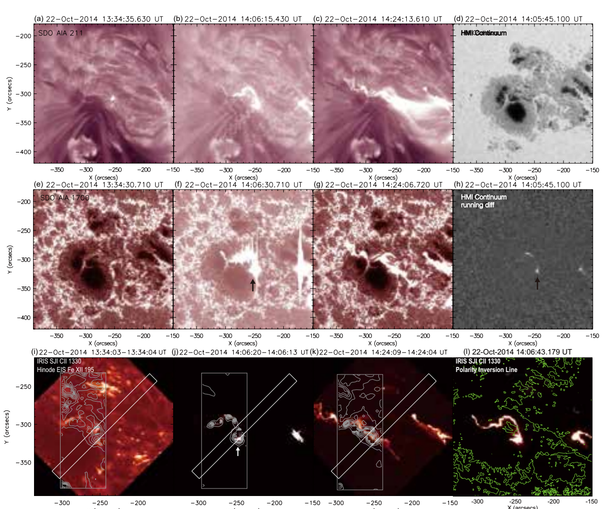

Figure 1: Context images for the X1.6 class flare. (a-c): AIA 211 Å, (e-g): AIA 1700 Å, (i-k): *IRIS* C II 1330 Å slit jaw images with EIS 195 Å intensity contours (gray line) before the flare, at the first HXR peak, and at the flare peak. (d, h): *SDO*/HMI continuum and a running difference image at HXR peak, respectively. (l): the polarity inversion line from the HMI magnetogram. The bright kernel we analyzed is marked with an arrow.

We have investigated An X1.6 flare occurred in AR 12192 on 2014 October 22 at 14:02 UT which was observed by several spectrometer in multi-wavelengths, *Hinode*, *IRIS*, *SDO*, and *RHESSI* (Figure 1). We analyze a bright kernel which produces a WLF with continuum enhancement and a HXR peak. Taking advantage of the spectroscopic observations of *IRIS* and *Hinode*/EIS, we measure the temporal variation of the plasma properties and dynamics in the bright kernel through chromosphere and corona. We found that explosive evaporation was observed when the WL emission occurred, even though the intensity enhancement in hotter lines is quite weak. The temporal correlation of the WL emission, HXR peak, and evaporation flows indicate that the WL emission was produced by accelerated electrons.

To understand the WL emission process, we calculated the energy flux deposited by non-thermal electrons observed by *RHESSI* and compared it to the dissipated energy estimated from a chromospheric line (Mg II triplet) observed by *IRIS*. The deposited energy flux from the non-thermal electrons is about $3 \sim 7.7 \times 10^{10}$ erg cm^{-2} s^{-1} for a given low energy cut-off of $30 \sim 40$ keV, assuming the thick target model. The energy flux estimated from the temperature changes in the chromosphere measured using the Mg II subordinate line is about $4.6–6.7 \times 10^9$ erg cm^{-2} s^{-1}: $\sim$ 6–22 % of the deposited energy. This comparison of estimated energy fluxes implies that the continuum enhancement was directly produced by the non-thermal electrons.

This research has been published to the Astrophysical Journal in 2017 [6].

References

[1] Neidig, D. F.: 1989, *Sol. Phys.*, **121**, 261.
[2] Watanabe, K., et al.: 2010, *ApJ*, **715**, 651.
[3] Brown, J. C.: 1971, *Sol. Phys.*, **18**, 489.
[4] Hudson, H. S.,Wolfson, C. J., Metcalf, T. R.: 2006, *Sol. Phys.*, **234**, 79.
[5] Machado, M. E., Emslie, A. G., Avrett, E. H.: 1989, *Sol. Phys.*, **124**, 303.
[6] Lee, K.-S., et al.: 2017, *ApJ*, **836**, 150.

Impact of New Gamow-Teller Strengths on Explosive Type Ia Supernova Nucleosynthesis

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Type Ia supernovae (SNe Ia) are thought to be a thermonuclear explosion on accreting white dwarfs. SNe Ia produce a large amount of iron group elements and play an important role on galactic chemical evolution. However, it is known that some of neutron-excess nuclei are overproduced compared with solar abundance in conventional network calculations [1].

Electron capture heavily affects nucleosynthesis because density at the center of SNe Ia reaches higher than 10^9 g/cm^3. Recently the Gamow-Teller (GT) transition strength of an unstable nucleus ^{56}Ni was measured [2] and it was shown that a conventional theory did not reproduce the experimental data qualitatively. In this study, we used a new shell model GXPF1J [3], which reproduces the experimental value better, in order to calculate electron capture rates of unstable nuclei and calculated nucleosynthesis. Then we calculated nucleosynthesis using the conventional shell model KBF [4] and compared the results. In addition to that, we compared a deflagration model W7 and a delayed-detonation model WDD2 bacause the explosion dynamics of SNe Ia is not understood well.

As a result, it is shown that the difference in abundances of each nucleus is a few percent between the two shell models. This is because the density and the chemical potential of electrons decrease so rapidly that the difference between GT strengths becomes small. The upper figure in Figure 1 shows the result of nucleosynthesis with W7 and GXPF1J. It can be seen that ^{54}Fe and ^{58}Ni are still overproduced. On the other hand, the lower figure shows the result with WDD2 and GXPF1J. This figure shows that the overproduction of the neutron-excess nuclei is improved. Moreover, we point out that the production of ^{54}Cr depends on the burning regime and observations of that nuclei can distinguish the explosion dynamics [5].

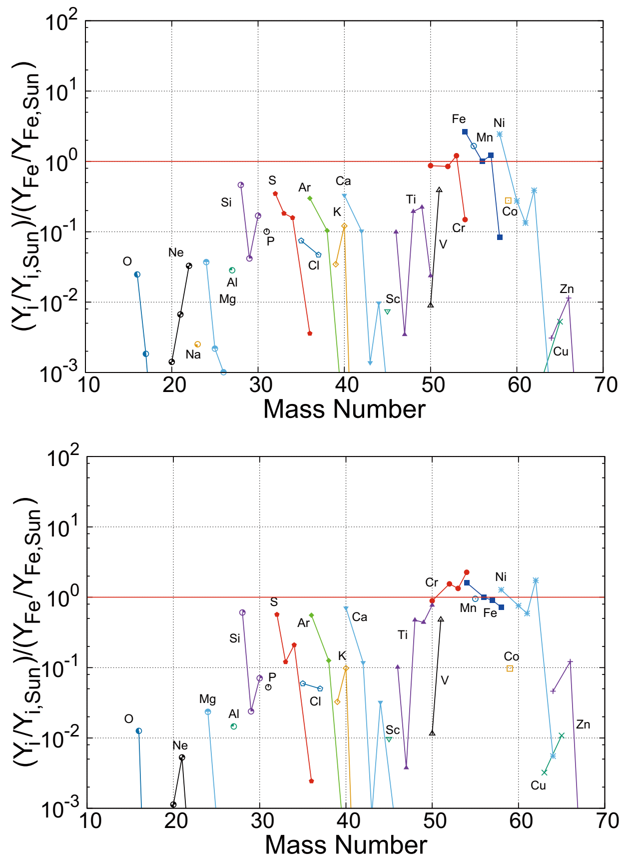

Figure 1: (Upper) Comparison to solar for the deflagration model W7. The abundance is normalized by the solar abundance and the ^{56}Fe abundance. (Lower) Comparison to solar for the delayed-detonation model WDD2.

References

[1] Iwamoto, K., et al.: 1999, *ApJS*, **125**, 439.
[2] Sasano, M., et al.: 2011, *Phys. Rev. Lett.*, **107**, 202501.
[3] Suzuki, T., et al.: 2011, *Phys. Rev. C*, **83**, 044619.
[4] Caurier, E., et al.: 1999, *Nucl. Phys. A*, **653**, 439.
[5] Mori, K., et al.: 2016, *ApJ*, **833**, 179.

Compact Dense Molecular Gas Emission at the Putative AGN Location in NGC 1068

IMANISHI, Masatoshi, NAKANISHI, Kouichiro (NAOJ)

IZUMI, Takuma (University of Tokyo)

According to the widely accepted unified model of active galactic nucleus (AGN), a mass accreting supermassive blackhole is surrounded by a toroidally-distributed dust and gas, the so-called torus. Various observational properties of AGNs can naturally be explained by different viewing angle toward the torus. However, since the torus is very compact in size (< 10 pc or < 0.15″ at distance ~15 Mpc), its observational understanding is still highly incomplete. ALMA is expected to play an important role for its observational understanding, thanks to its very high angular resolution.

We have observed the nearby well-studied AGN, NGC 1068 (z=0.0037, distance is ~14 Mpc) using ALMA at the HCN J=3–2 (265.89 GHz) and HCO^+ J=3–2 (267.56 GHz) lines. The achieved angular resolution is 0.1″ × 0.2″. Molecular gas observations of NGC 1068 have previously been conducted with > 0.5″ angular resolution, but molecular gas emission at the location of the putative AGN torus has not been clearly revealed, because it is overwhelmed by the nearby, very bright molecular gas emission at the eastern side of the host galaxy. Thanks to our new very high angular resolution ALMA data, we successfully detected molecular gas emission at the putative AGN torus location (C-peak in Figure 1), by clearly separating from the nearby bright molecular gas emission in the host galaxy [1]. The estimated dense molecular gas mass and size are several × $10^5\,M_\odot$ and ~10 pc, respectively, both of which are roughly comparable to theoretically predicted values.

We have also detected the possible sign of molecular gas emission which bridges between the eastern bright molecular gas emission knot and the AGN position (Figure 1). We may be witnessing the theoretically argued molecular gas supply from the host galaxy to the torus. Additionally, we found that the HCN-to-HCO^+ flux ratios at J=3–2 in the central several arcsec regions of NGC 1068 are high, as seen in AGN-important regions (Figure 2). This supports the previously argued scenario that physical conditions at the NGC 1068 nuclear regions are dominated by AGN activity. However, thanks to the very high sensitivity of ALMA, we have also detected continuum emission at several off-nuclear regions, suggesting the presence of weak (~10 % of AGN luminosity), but a detactable amount of star-formation activity in the central several arcsec of NGC 1068.

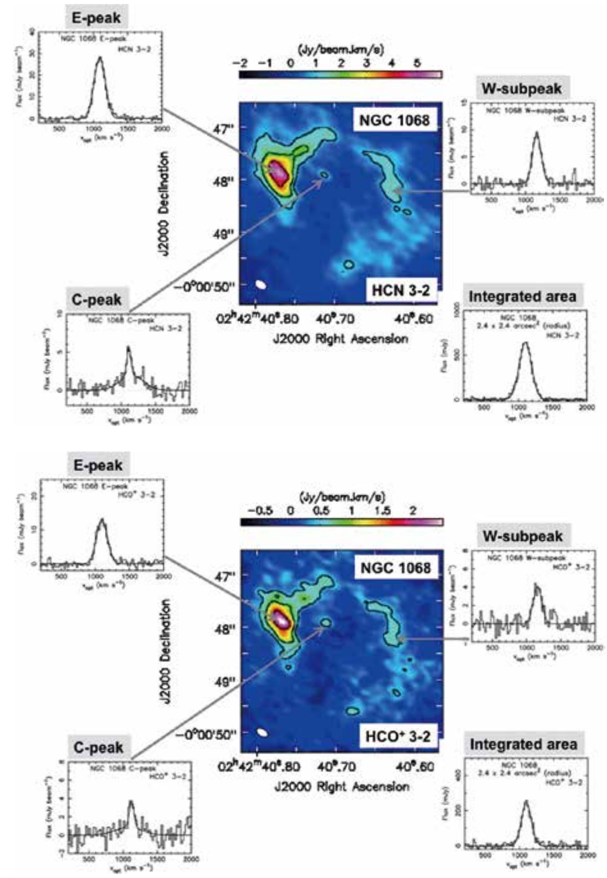

Figure 1: Integrated intensity maps and velocity profiles, at selected positions, of HCN J=3–2 (Upper) and HCO^+ J=3–2 (Lower) in the NGC 1068 nucleus.

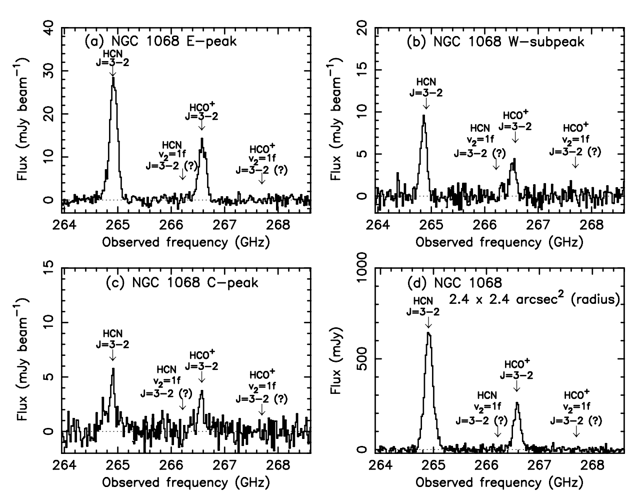

Figure 2: Spectra at the representative positions (shown in Figure 1) in NGC 1068.

Reference

[1] Imanishi, M., et al.: 2016, *ApJL*, **822**, L10.

ALMA Molecular Line Observations of Luminous Infrared Galaxies as a Tool to Detect Extremely Deeply Buried AGNs

IMANISHI, Masatoshi, NAKANISHI, Kouichiro (NAOJ)
IZUMI, Takuma (University of Tokyo)

When gas-rich galaxies collide and merge, star-formation and AGN (= mass accretion onto a supermassive blackhole) are activated and generate energy at dust-obscured regions, and become luminous infrared galaxies (LIRGs). Since these energy sources are obscured by dust, observations at the wavelengths of low dust extinction effects are necessary. An AGN has two distinguished properties, when compared to a starburst (= active star-formation). First, an AGN can produce a larger amount of hot (> 100 K) dust, originating in the high radiative energy generation efficiency (6–42 % of Mc^2) by a mass-accreting supermassive blackhole, than a starburst. Second, the X-ray to UV luminosity ratio is much higher in an AGN than a starburst. Due to these different properties, an AGN and a starburst can input different physical/chemical effects to the surrounding molecular gas, and so can produce different molecular line flux ratios. Since there are rotational J-transition lines of many molecules at the almost dust-extinction-free (sub) millimeter wavelength, these molecular line flux ratios can be a powerful tool to scrutinize dust-obscured energy sources in LIRGs. High dipole moment molecules, such as HCN and HCO^+, can be particularly effective to probe how dense molecular gas at LIRG's nuclei are affected by dust-obscured energy sources.

Using ALMA, we have conducted HCN and HCO^+ J=3–2 observations, at the submillimeter 250 GHz range, of starbursts, optically-identified AGNs, and LIRGs whose energy sources were diagnosed based on previous infrared spectroscopy. We have confirmed that AGN-important galaxies identified through previous optical/infrared/X-ray spectroscopy tend to display higher HCN-to-HCO^+ flux ratios at J=3–2 than starburst-dominated regions (Figure 1) [1]. More importantly, our ALMA observations have discovered extremely deeply buried AGN candidates which do not show AGN signatures in the optical/infrared/X-rays, but do show in the (sub) millimeter. These LIRGs display elevated HCN-to-HCO^+ J=3–2 flux ratios and signatures of vibrationally excited (v_2=1f) HCN emission lines. Detection of the vibrationally excited (v_2=1f) HCN emission lines (T > 1000 K) requires the presence of strong infrared 14 μm continuum emission, most likely originating in AGN-heated hot dust. We argue that (sub)millimeter molecular line observations can be the most powerful way to elucidate deeply buried AGNs in LIRGs, thanks to much lower dust extinction effects than other methods (infrared or hard X-rays). Further systematic ALMA molecular line observations are important to better understand the energetic role of elusive deeply buried AGNs in LIRGs.

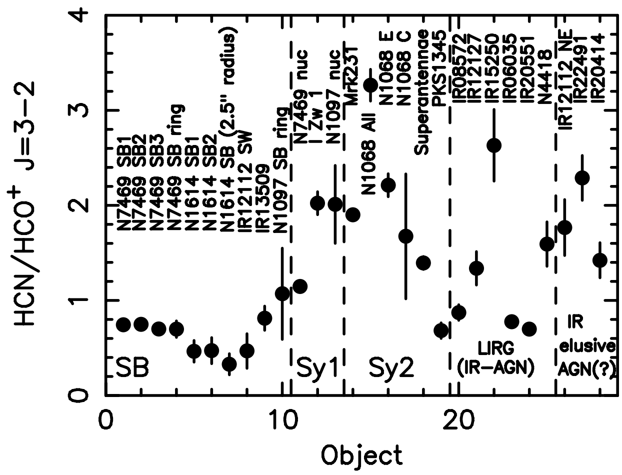

Figure 1: The observed HCN-to-HCO^+ flux ratios at J=3–2 (modified from [1]). "SB", "Sy1", "Sy2", "LIRG (IR-AGN)", and "IR elusive AGN(?)" mean starburst-dominated regions, optically identified Seyfert 1 type AGNs, optically identified Seyfert 2 type AGNs, luminous infrared galaxies with optically-elusive, but infrared-detectable buried AGN signatures, and candidates of infrared-elusive, but (sub)millimeter-detectable extremely deeply buried AGNs, respectively. Sources with AGN signatures tend to show elevated HCN-to-HCO^+ J=3–2 flux ratios, compared to starbursts [1].

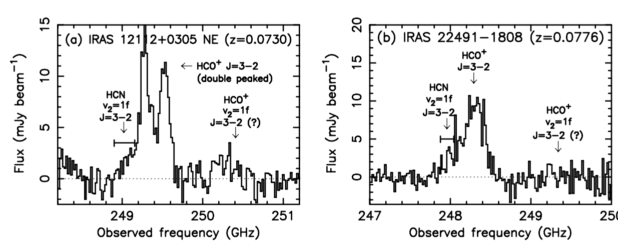

Figure 2: Zoom-in spectra of two LIRGs which show the signatures of vibrationally excited (v_2=1f) HCN emission lines. The extended tails at the lower frequency side of the bright HCO^+ J=3–2 emission lines at the vibrational ground level (v=0) are usually interpreted as the contribution from the HCN v_2=1f J=3–2 emission lines. Both of these sources show high HCN-to-HCO^+ J=3–2 flux ratios (second and third objects from the right in Figure 1).

Reference

[1] Imanishi, M., et al.: 2016, *AJ*, **152**, 218.

Dense Molecular Gas Emission and Infrared Radiative Pumping in the Ultraluminous Infrared Galaxy IRAS 20551−4250

IMANISHI, Masatoshi, NAKANISHI, Kouichiro (NAOJ)
IZUMI, Takuma (University of Tokyo)

Ultraluminous infrared galaxies (ULIRGs) which emit huge infrared luminosity with $L_{IR} > 10^{12} L_\odot$ are usually produced by gas-rich galaxy mergers and are shining brightly due to dust thermal radiation heated by starburst and/or AGN activity hidden behind dust. Distinguishing the hidden energy sources of the ULIRG population is closely related to understand how stars are formed and supermassive blackholes grow in mass during gas-rich galaxy mergers in the universe. Since the compact AGN can easily be embedded in dust, we need to observe at the wavelengths where dust extinction effects are small. (Sub) millimeter is one such wavelength and molecular line flux ratios in this wavelength can be a good tool to probe the highly embedded energy sources in ULIRGs, because the ratios are expected to be different between AGNs and starbursts, due to different physical/chemical effects to the surrounding molecular gas, coming from different amount of hot dust and X-ray radiation. Molecular gas observations, such as HCN, HCO^+, and HNC have been conducted for nearby ULIRGs, and it has been argued that elevated HCN emission can be a good AGN indicator.

Possible explanations for the enhanced HCN emission in AGNs include (1) higher HCN abundance in molecular gas largely influenced by AGN radiation, and (2) higher HCN excitation in AGNs. Additionally, it was proposed that an infrared radiative pumping can contribute. Namely, HCN is vibrationally excited by absorbing infrared 14 μm photons, and through the decay back to the vibrational ground level, HCN rotational J-transition line fluxes can be higher. Since an AGN can emit the infrared 14 μm photons more strongly than a starburst, due to AGN-heated hot dust emission, this mechanism is expected to work more efficiently in an AGN. However, HCO^+ and HNC can also be vibrationally excited by absorbing infrared 12 μm and 22 μm photons, respectively. We need to investigate the strengths of vibrationally excited emission lines for all of HCN, HCO^+, and HNC, if we are to confirm if this mechanism is indeed responsible for elevated HCN emission in AGNs.

We have observed the ULIRG, IRAS 20551–4250, using ALMA (Figure 1), and detected vibrationally excited (v_2=1f) J=3–2 emission lines for HCN and HNC, but did not for HCO^+ (Figure 2). We calculated an infrared radiative pumping rate for HCN, HCO^+, and HNC, by using the available Spitzer IRS 5–35 μm infrared spectrum, and found that observational results can be explained if HCN abundance is higher than HCO^+ and HNC by a factor of at least a few. Based on the vibrational excitation temperature and Einstein A coefficients for vibrational and rotational transitions, we estimated that the infrared radiative pumping plays a role for rotational level population at least for HCN and HNC [1]. It is demonstrated that including the infrared radiative pumping, in addition to the widely assumed collisional excitation, is needed to understand molecular gas emission in AGNs.

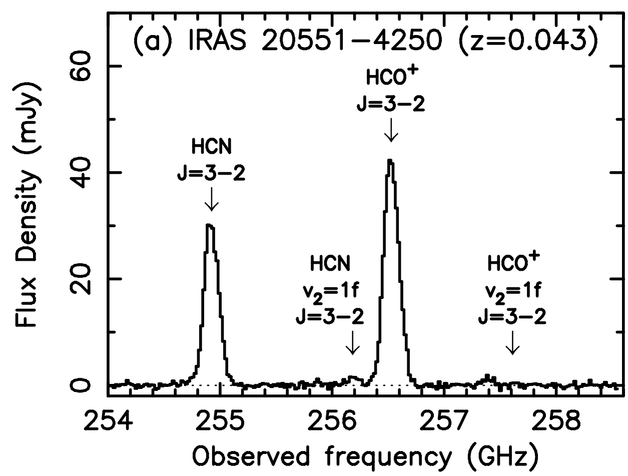

Figure 1: Spectrum of IRAS 20551–4250 obtained with ALMA [1]. Although the HCN-to-HCO^+ J=3–2 flux ratio is slightly less than unity, it is still higher than starburst galaxies.

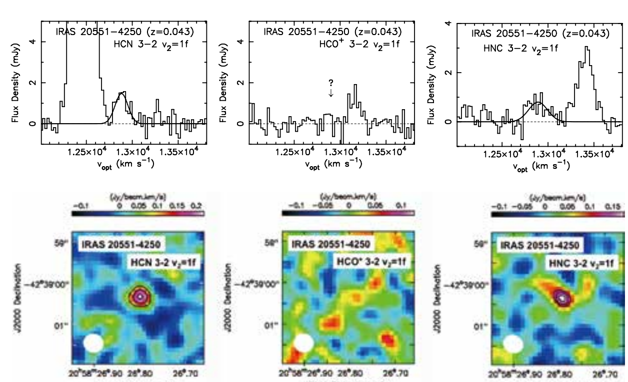

Figure 2: Spectra and integrated intensity maps of vibrationally excited (v_2=1f) J=3–2 emission lines of HCN (Left), HCO^+ (Middle), and HNC (Right) [1].

Reference

[1] Imanishi, M., et al.: 2016, *ApJ*, **825**, 44.

New Electron Orbits in Collisionless Magnetic Reconnection

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Magnetic reconnection, an explosive energy-release process in space plasmas, is mediated by complex particle motion of plasmas. The electron motion is one of the smallest elements in reconnection systems, and has long been studied by using particle-in-cell (PIC) simulations. However, as PIC data have become larger and larger in size, it has become more and more difficult to diagnose particle orbits in simulations. The theories on particle orbits in the reconnection system were established in 1980's.

In this work, we extensively analyzed electron dynamics in magnetic reconnection by using a 2D PIC simulation. We surveyed twenty million trajectories, so as not to overlook any interesting trajectories. As a result, we discovered various electron orbits that have never been discussed before. Figure 1 show example electron orbits. One can see that the red and blue orbits do not cross the midplane (the horizontal dotted line), while the traditional theories assume that all orbits cross the midplane. We examined and classified various electron orbits, as schematically illustrated in Figure 2. The new orbits are indicated by the double frames. Surprisingly, it was found that a majority of electrons follow the new orbits. These results raise a serious question to previous discussions for the kinetic physics of magnetic reconnection. Since the particle orbits are fundamental elements, our findings could lead to the revision of theoretical models.

Our results were published in the *Physics of Plasmas* journal [1]. Owning to fundamental results in this research field, our paper was highlighted by American Institute of Physics (AIP) [2] and by Physics of Plasmas.

We note that NASA's Magnetospheric Multiscale (MMS) spacecraft will start detail observation in the nightside reconnection regions in the Earth magnetosphere in May, 2017. Our findings will provide a clue to interpret MMS data and to understand the fundamental physics of magnetic reconnection.

References

[1] Zenitani, S., Nagai, T.: 2016, *Phys. Plasmas*, **23**, 102102.
[2] https://publishing.aip.org/publishing/journal-highlights/japanese-researchers-find-new-classes-electron-orbits

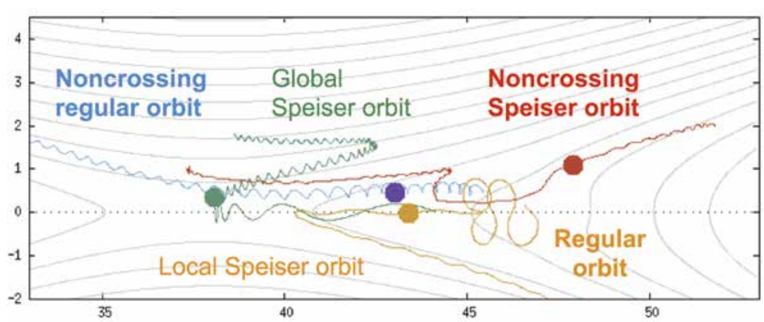

Figure 1: Typical electron orbits in our PIC simulation. Magnetic field lines are overplotted.

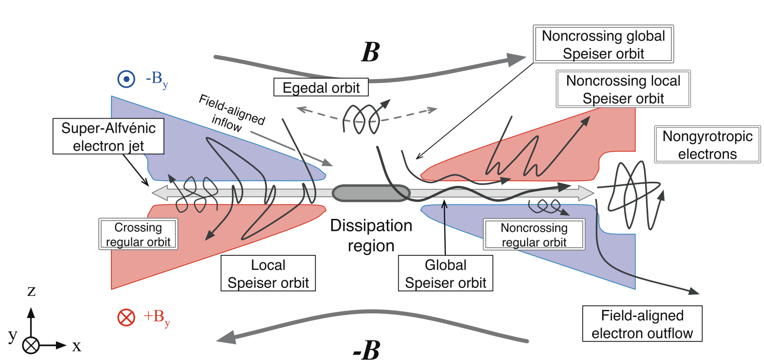

Figure 2: Summary of electron orbits in magnetic reconnection (Ref. [1]). The new orbits are indicated by the double frames.

Kilonova Emission from Compact Binary Mergers

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Mergers of compact stars, i.e., neutron star (NS) and black hole (BH), are promising candidates for direct detection of gravitational waves (GWs). On 2015 September 14, Advanced LIGO has detected the first ever direct GW signals from a BH-BH merger (GW150914) [1]. This discovery marked the dawn of GW astronomy. NS-NS mergers and BH-NS mergers are also important and leading candidates for the GW detection. When the designed sensitivity is realized, Advanced LIGO, Advanced Virgo, and KAGRA can detect the GWs from these events up to ~200 Mpc (for NS-NS mergers) and ~800 Mpc (for BH-NS mergers). Although the event rates are still uncertain, more than one GW events per year are expected.

Since localization only by the GW detectors is not accurate, e.g., more than a few 10 deg^2, identification of electromagnetic counterparts is essentially important to study the astrophysical nature of the GW sources. NS-NS mergers and BH-NS mergers are expected to emit EM emission in various forms. Among variety of emission mechanisms, optical and infrared emission powered by radioactive decay of *r*-process nuclei is of great interest. This emission is called "kilonova". Observations of kilonova will also have important implications for the origin of *r*-process elements in the Universe.

In this paper, we reviewed the current understanding of kilonova emission by performing radiative transfer simulations of the dynamical ejecta from NS-NS mergers and BH-NS mergers [2]. Kilonova emission from the dynamical ejecta of 0.01 $M_\odot$ has a typical luminosity is an order of 10^{40}–10^{41} erg s^{-1} with the characteristic timescale of about 1 week (Figure 1). Because of the high opacity and the low temperature, the spectral peak is located at red optical or near-IR wavelengths (Figure 2). In addition to the emission from the dynamical ejecta, a subsequent disk wind can cause an additional emission which may peak earlier with a bluer color if the emission is not absorbed by the precedent ejecta.

At 200 Mpc distance, a typical peak brightness of kilonova emission is about 22 mag in the red optical wavelengths (*i* or *z* bands, Figure 1). The emission quickly fades to > 24 mag within ~10 days. To distinguish GW sources from SNe, observations with multiple visits in a timescale of < 10 days are important to select the objects with rapid temporal evolution. The use of multiple filters are also helpful to select red objects. Since the extremely high expansion velocities (v ~ 0.1–0.2c) are unique features of dynamical mass ejection from compact binary mergers, detection of extremely smooth spectrum will be the smoking gun to conclusively identify the GW sources.

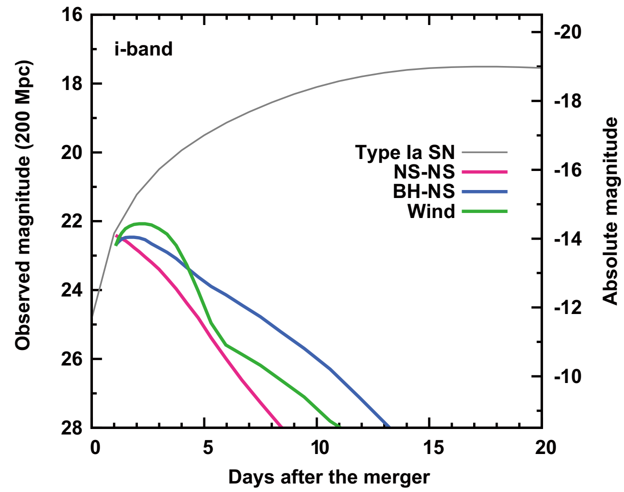

Figure 1: Expected observed magnitudes of kilonova models at 200 Mpc distance. The red, blue, and green lines show the models of NS-NS merger, BH-NS merger, and a wind model, respectively.

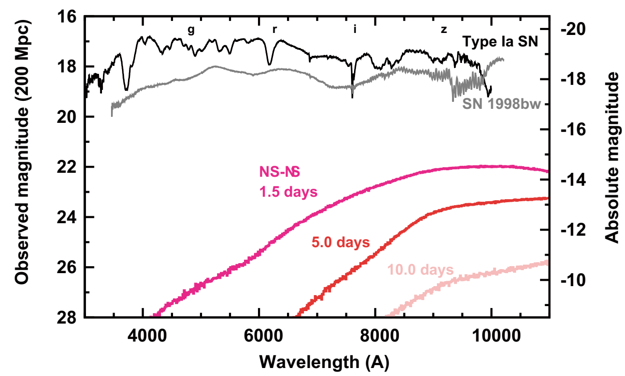

Figure 2: Expected observed spectra of the NS-NS merger model compared with the spectra of normal Type Ia SN 2005cf and broad-line Type Ic SN 1998bw.

References

[1] Abbott, B. P., et al.: 2016, *Phys. Rev. Lett.*, **116**, 061102.
[2] Tanaka, M.: 2016, *Advances in Astronomy*, **2016**, 634197.

Chemodynamical Evolution of Dwarf Galaxies Deduced from *r*-process Elements

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Abundances of *r*-process elements (such as Eu and Ba) could help us clarify early evolutionary histories of galaxies. The *r*-process abundances in the Local Group galaxies tend to be lower than those of the Milky Way halo. The *r*-process abundances would reflect the star formation rates and mixing of metals in the early stages of galaxy formation.

One of the most promising astrophysical sites of *r*-process elements are neutron star mergers. Previous studies show that it is possible to explain the observed abundances of *r*-process elements by neutron star mergers [1]. However, the relation among *r*-process abundances, star formation rates, and efficiency of metal mixing is not yet understood.

In this study, we perform a series of chemodynamical simulations of dwarf galaxies with different star formation rates and efficiencies of metal mixing to clarify how the star formation rates and efficiency of metal mixing affect the *r*-process abundances. We use the *N*-body/hydrodynamic simulation code, ASURA [4]. In this study, we implement the *r*-process element ejection models by neutron star mergers [1] and metal mixing model [5] to ASURA. We adopt the isolated dwarf galaxy models with different central densities and total masses of halos.

Figure 1 shows *r*-process abundance ratios in dwarf galaxy models with different star formation histories [2]. According to Figure 1, stars with *r*-process elements appear at higher metallicity in higher star formation rates due to their faster chemical evolution. This result suggests that early star formation rates should be less than $10^{-3}\,M_{\odot}\,\mathrm{yr}^{-1}$ to explain the abundances of *r*-process elements in extremely metal-poor stars.

Figure 2 shows *r*-process abundance ratios with different efficiencies of metal mixing [3]. Figure 2 (a) and (b) do not have stars with high *r*-process abundance ratios ([Ba/Fe] > 1). On the other hand, Figure 2 (c), (d), and (e) have these stars. We assume an efficiency of metal mixing estimated from turbulence theory in Figure 2 (a) and (b). This result suggests that it is possible to explain observed abundances of *r*-process elements in dwarf galaxies if the metals are mixed with the efficiency consistent with estimation from turbulence theory. We find that the timescale of metal mixing is less than 40 Myr in Figure 2 (a) and (b). This timescale is significantly shorter than the dynamical times (~100 Myr) of dwarf galaxies. Our results demonstrate that future observations will be able to more precisely estimate star formation rates and efficiency of metal mixing through *r*-process abundances.

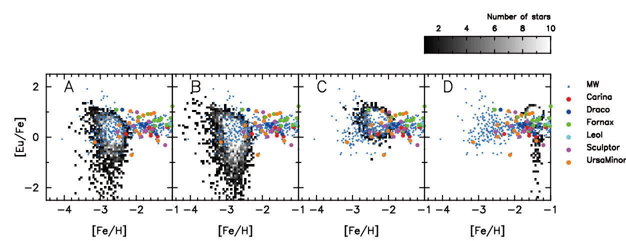

Figure 1: *r*-process abundance ratios in galaxies with different star formation rates. Grey scales show model prediction. Small and large dots represent observational results with the Milky Way and the Local Group dwarfs (SAGA database [6]). Star formation rates increase from (A) to (D).

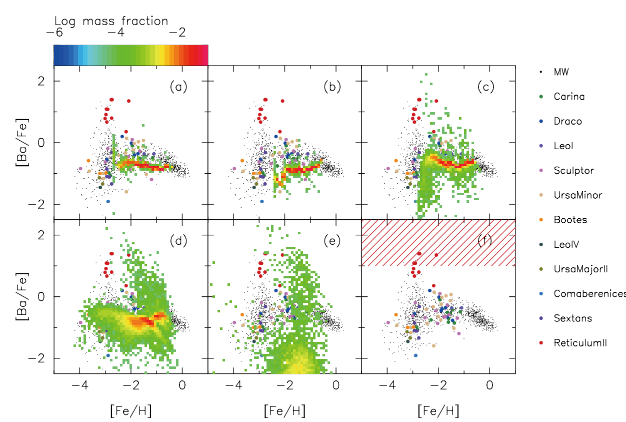

Figure 2: *r*-process abundances in galaxies with different efficiencies of metal mixing. Color contours show the model prediction. Small, large, and red dots represent observational results of the Milky Way, the Local Group dwarfs, and the Reticulum II ultrafaint dwarf (SAGA database [6]). Efficiencies of metal mixing decrease from (a) to (d). (e) represents the model without metal mixing. (f) shows observations. The red shaded region shows that the area with no stars in dwarfs. We correct the Ba abundances to only reflect contributions from *r*-process.

References

[1] Hirai, Y., et al.: 2015, *ApJ*, **814**, 41.
[2] Hirai, Y., et al.: 2017, *MNRAS*, **466**, 2474.
[3] Hirai, Y., Saitoh, T. R.: 2017, *ApJL*, **838**, L23.
[4] Saitoh, T. R., et al.: 2008, *PASJ*, **60**, 667.
[5] Saitoh, T. R.: 2017, *AJ*, **153**, 85.
[6] Suda, T., et al.: 2008, *PASJ*, **60**, 1159.

Magnetic Properties of Solar Active Regions That Govern Large Solar Flares and Eruptions

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It is known that solar flares and coronal mass ejections (CMEs), especially the larger ones, emanate from active regions (ARs) holding sunspots. In order to understand the statistical properties of ARs that produce such strong flare events, we surveyed all flare events with GOES levels ≥M5 within 45° from the Sun's disk center for 6 years from May 2010 [1]. Figure 1 shows a sample flare event that occurred in NOAA AR 12192, which exhibited the largest sunspots in about 24 years. From these observational data, we measured various parameters such as sunspot area, magnetic flux, field strength, area of flare ribbons (elongated intensity enhancements observed in the chromosphere), and flare duration, and conducted statistical analysis.

As a result, we found that more than 80 % of the 29 ARs that produced a total of 51 flare events exhibit "δ-sunspots," the most complex magnetic configuration in the sunspot classification. It is suggested that the δ-spots, in which positive and negative magnetic polarities are closely packed, store a high magnetic energy, which could be released in the form of solar flares. The above trend is consistent with previous observations [2].

We also found that the flare duration is linearly related with the size scales of flare ribbons (ribbon distance, ribbon area, and total flux inside the ribbon). These relations can be explained by the standard flare model based on the magnetic reconnection theory [3].

It has been known that some flares do not accompany any CME eruptions. Our statistical results show that the ratio of the ribbon area to the sunspot area is significantly smaller for the CME-less events compared to the CME-eruptive ones. This result may indicate that in the non-eruptive ARs, large over-lying arcade fields may inhibit the CME eruptions, which is well in line with preceding event studies [4].

Figure 2 displays the observation of perhaps the largest-ever-imaged sunspot-related flare ribbons. This great sunspot appeared in July 1946 and ranks 4th in size since the late 19th century. Comparison with the SDO statistics suggests that this AR might contain a total magnetic flux of 1.5×10^{23} Mx and that the magnetic energy contributing to the flare eruption (not the released energy) could amount to 8×10^{33} erg. If we suppose that the largest sunspot group in history (April 1947: total flux $\sim 2 \times 10^{23}$ Mx) causes a strong flare eruption, the estimated magnetic energy reaches 10^{34} erg, which is already in the category of "superflares."

2014-10-24 X3.1-class flare NOAA AR 12192

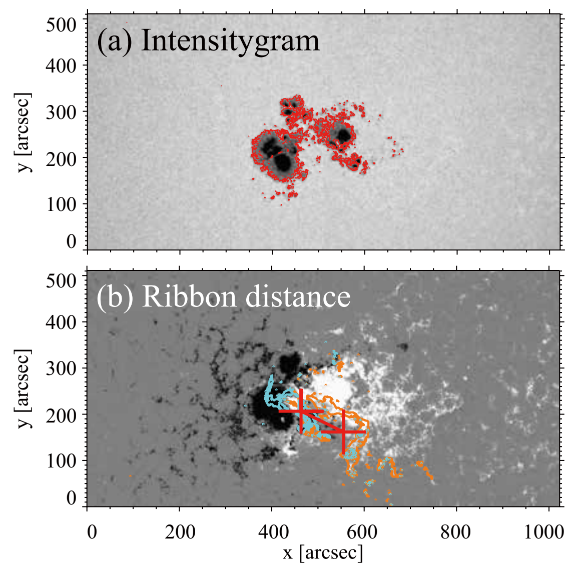

Figure 1: Sample flare data. (a) Continuum image showing the entire AR. (b) Magnetogram showing the magnetic fields (white: positive, black: negative), on which the flare ribbons observed by near UV band image are overplotted.

1946-07-25 Great flare RGO 14585

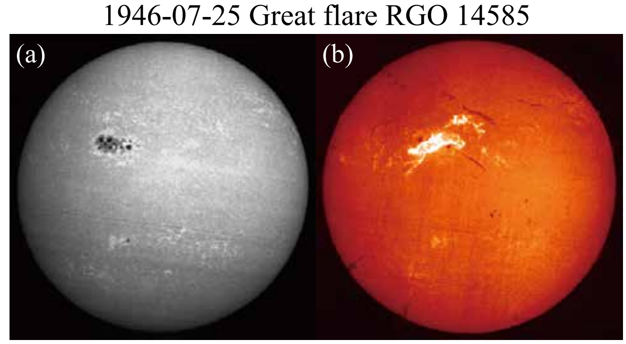

Figure 2: Great flare event in July 25, 1946, in RGO 14585. (Left) Sunspots observed in Ca II K1v. (Right) flare ribbons observed in H-alpha. Images courtesy of Paris Observatory.

References

[1] Toriumi, S., et al.: 2017, *ApJ*, **834**, 56.
[2] Sammis, I., et al.: 2000, *ApJ*, **540**, 583.
[3] Shibata, K., Magara, T.: 2011, *Living Reviews in Solar Physics*, **8**, 6.
[4] Sun, X., et al.: 2015, *ApJL*, **804**, L28.

Various Local Heating Events in the Earliest Phase of Flux Emergence

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Solar active regions (ARs) are formed through the emergence of magnetic flux from the convection zone, and when it emerges to the surface, various sporadic local heating events are observed in the lower atmosphere (chromosphere and transition region). With the aim of understanding the mechanisms of such heating events, we analyzed the coordinated observation data of flux emergence by Hinode and IRIS. As the emergence is hard to predict, there are not many observations of this kind so far, and thus the data set we show here, which is composed of optical and near-UV observations by the two instruments, is particularly rare.

The target emerging region appeared within NOAA AR 12401 on August 19, 2015 (Fig. 1). We first analyzed the Hinode Ca II H images and picked up 151 heating events. Out of the 29 events that are also covered by the Hinode's photospheric magnetic measurement, we found that 7 events occur in the locations where positive and negative polarities are closely nearby (mixed-polarity events), while another 10 are located in unipolar regions (unipolar events).

IRIS UV spectra of the mixed-polarity events show enhanced and broadened profiles with tails reaching ± 150 km s^{-1}, which are suggestive of the strong heatings and bi-directional jets. Each event leaves flare-like light curves with fast rise and extended decay. Moreover, Hinode revealed that most of this group have U-shaped photospheric magnetic fields. From these observational results, we concluded that the mixed-polarity events are caused by magnetic reconnection [2,3].

For the unipolar events, we did not find strong intensity enhancements in the IRIS UV spectra, but they showed systematic red shifts. The Doppler velocities measured from the peaks of the spectra were up to 40 km s^{-1}, which indicates the strong downflow that exceeds the local sound speed. These results suggest that the unipolar heating events are due to shocks or strong compressions caused by fast downflows along the overlying arch filament system [4].

As shown above, the combination of the photospheric vector magnetogram by Hinode and the UV spectroscopic data by IRIS allows us to discuss the mechanisms of a variety of local heating events in the emerging flux regions. Future missions that provide the the detailed field information not only in the photosphere but also in the upper atmosphere may further reveal the relation between the dynamics of magnetic fields and the chromospheric and coronal heating.

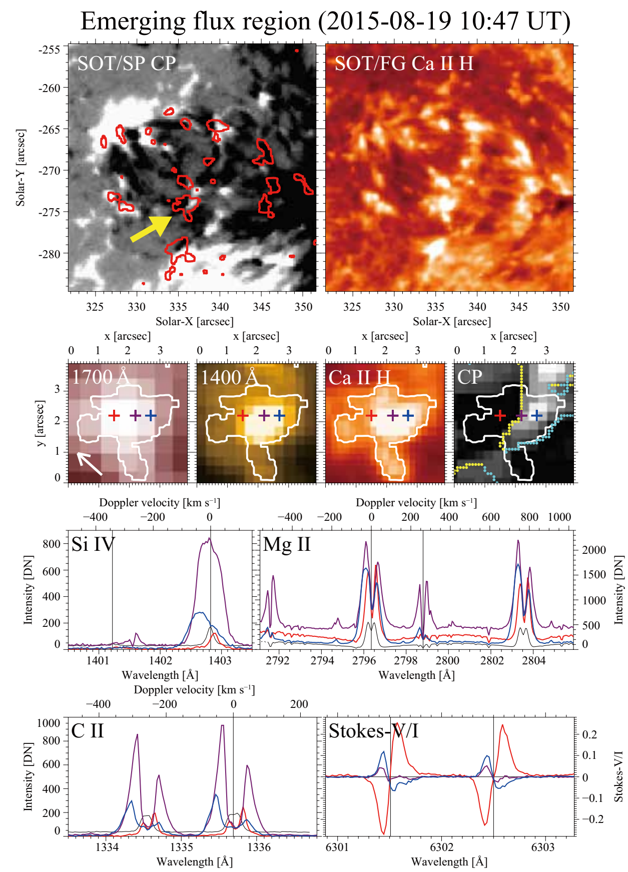

Figure 1: Flux emergence event in NOAA AR 12401. Top row shows Hinode/SOT photospheric magnetogram (left) and Ca II H intensity (right: also red contours in the left image). Sample heating event with yellow arrow is shown in the rows below: The second row shows the near UV and Ca II H intensity images and photospheric magnetogram (yellow and turquoise dots represent where the fields have U- and Ω-shaped configurations, respectively). Bottom two rows are the IRIS UV spectra and photospheric circular polarization (colors correspond to the + signs in the second row).

References

[1] Toriumi, S., et al.: 2017, *ApJ*, **836**, 63.
[2] Ellerman, F.: 1917, *ApJ*, **46**, 298.
[3] Rutten, R. J., et al.: 2013, *J. Phys.: Conf. Ser.*, **440**, 012007.
[4] Shibata, K., et al.: 1989, *ApJ*, **345**, 584.

H0LiCOW - Lens Mass Model of HE 0435-1223 and Blind Measurement of Its Time-delay Distance for Cosmology

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Gravitational lens time delays provide a one-step method to determine the Hubble Constant, H_0. This method is independent of the cosmic distance ladder [1] and serves as a test of systematic effects in individual H_0 probes. This method rests on the fact that light rays from the source take different paths through space-time to each of the image positions. These paths have different lengths and traverse different gravitational potentials before reaching the observer, leading to an offset in arrival times. If the source is variable, the delays can be measured by monitoring the images. The measured time delays can be used to calculate the time-delay distance, $D_{\Delta t}$, a combination of angular diameter distances among the observer, lens and source. $D_{\Delta t}$ is primarily sensitive to H_0 with weaker dependence on other parameters.

The H_0 Lenses in COSMOGRAIL's Wellspring (H0LiCOW) [2] project is modeling five lensed quasars with measured time delays to obtain a robust constraint on H_0 to < 3.5 % precision. The first two lenses have been analyzed [3,4], and analysis of the third lens, HE 0435-1223 (hereafter HE0435), has now been completed [5].

HE0435 is a quad-image lens for which accurate time delays have been measured [6]. We have wide-field imaging and spectroscopy to characterize mass projected along the line of sight [7,8], which can bias the inferred $D_{\Delta t}$ if unaccounted for. We have deep *HST*/WFC3 observations in the F160W filter, along with archival *HST*/ACS imaging in F555W and F814W, for modeling the lens system. This deep, high-resolution imaging is crucial in order to use the full surface brightness distribution of the extended quasar host galaxy as constraints. We have also measured the lens galaxy's velocity dispersion with Keck/LRIS, which helps to break degeneracies in the mass model. We try a range of models with different assumptions such as the parameterization of the mass profile, the region over which the lensed images are fit, etc. to test for systematic effects. Our final result combines the distributions from all of these models.

Throughout our analysis, we blind the $D_{\Delta t}$ and H_0 values by subtracting the median from the distributions. This allows us to evaluate the precision and relative offsets of these distributions and their correlations with other parameters without seeing the absolute value. This is done to remove confirmation bias and the tendency of experimenters to stop investigating systematic errors when they obtain an answer consistent with the "expected" result. After finalizing our analysis and coming to a consensus among the coauthors, we unblind the results and do not make any further changes to the models.

From our analysis, we determine the time-delay distance to be $D_{\Delta t} = 2612^{+208}_{-191}$ Mpc. For a flat ΛCDM cosmology, we constrain the Hubble constant to be $H_0 = 73.1^{+5.7}_{-6.0}\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$. We combine this result with the first two H0LiCOW lenses to obtain a 3.8 % constraint of $H_0 = 71.9^{+2.4}_{-3.0}\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$ for flat ΛCDM, in good agreement with the latest distance ladder results [1] and in tension with *Planck* (Planck Collaboration 2016).

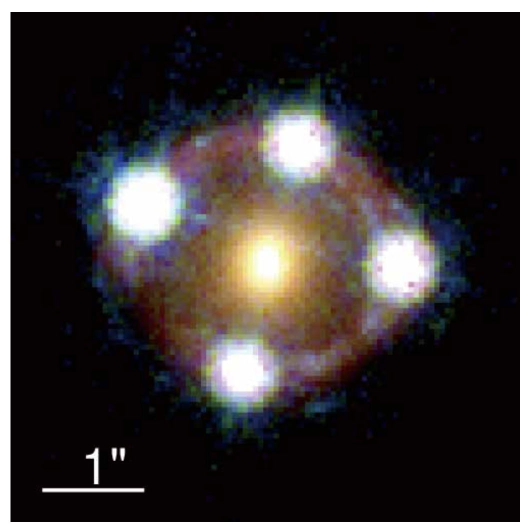

Figure 1: Multicolor *HST* image of HE0435.

References

[1] Riess, A. G., et al.: 2016, *ApJ*, **826**, 56.
[2] Suyu, S. H., et al.: 2017, *MNRAS*, **468**, 2590.
[3] Suyu, S. H., et al.: 2010, *ApJ*, **711**, 201.
[4] Suyu, S. H., et al.: 2013, *ApJ*, **766**, 70.
[5] Wong, K. C., et al.: 2017, *MNRAS*, **465**, 4895.
[6] Bonvin, V., et al.: 2017, *MNRAS*, **465**, 4914.
[7] Sluse, D., et al.: 2017, *MNRAS*, submitted (arXiv:1607.00382)
[8] Rusu, C. E., et al.: 2017, *MNRAS*, **467**, 4220.
[9] Planck Collaboration: 2016, *A&A*, **594**, A13.

Photometric Measurements of H_2O Ice Crystallinity on TNOs

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Trans-neptunian objects (TNOs), a small body population beyond Neptune's orbit, were formed at low temperature of a few 10 K in the distant region from the Sun. H_2O ice is the most abundant volatile material of these bodies and should originally have been in the amorphous phase. However, crystalline H_2O ice has been detected from almost all TNOs of which the near-infrared spectra were obtained in high quality, such as (50000) Quaoar [1]. The transition from amorphous to crystalline ice requires heating up to ~100 K. Although several hypotheses for H_2O ice crystallization on the surface of TNOs have been suggested, including radiogenic heating [2], cryovolcanism [3], and micrometeorite impact annealing [4], the mechanism remains unclear. It is important to investigate homogeneity/diversity of the surface abundance of crystalline H_2O ice among TNOs and its relationships with the orbital elements and body size for revealing the crystallization processes.

Crystallinity of H_2O ice can be determined by strength of the diagnostic absorption at 1.65 μm. However, most TNOs are too faint to acquire the near-infrared spectra with sufficiently high *S/N* ratio even by large-aperture telescopes. Therefore, we introduced a photometric method using Subaru/MOIRCS and the narrow band NB1657 with the center wavelength of 1.657 μm, allowing us to measure the fraction of crystalline H_2O ice on TNOs precisely and efficiently [5]. We obtained the imaging data with *H* and NB1657 filters for six TNOs which were known to contain H_2O ice on the surface. As a result of comparison between the measured *H*–NB1657 indexes and those estimated from the model spectra, all of the target TNOs except for (38682) Huya showed more than 50 % crystallinity (see Figure 1).

It is interesting that crystalline H_2O ice has been detected from not only the large-size TNOs including (136108) Haumea, (50000) Quaoar, and (90482) Orcus, but also from the relatively small objects, (315530) 2008 AP_{129} and (42355) Typhon. It is difficult to explain the surface crystallization of such small-size objects by cryovolcanism or radiogenic heating with long-lived isotopes (e.g., ^{40}K), but, the decay of short-lived isotopes (e.g., ^{26}Al) could induce sufficient heating [2].

We also found that while H_2O ice on Haumea and Quaoar is highly dominated by the crystalline state, Orcus has only ~50 % crystallinity. The low bulk density of Orcus (~1.5 g cm^{-3}) could cause suppression of the surface heating and stagnation in crystallization.

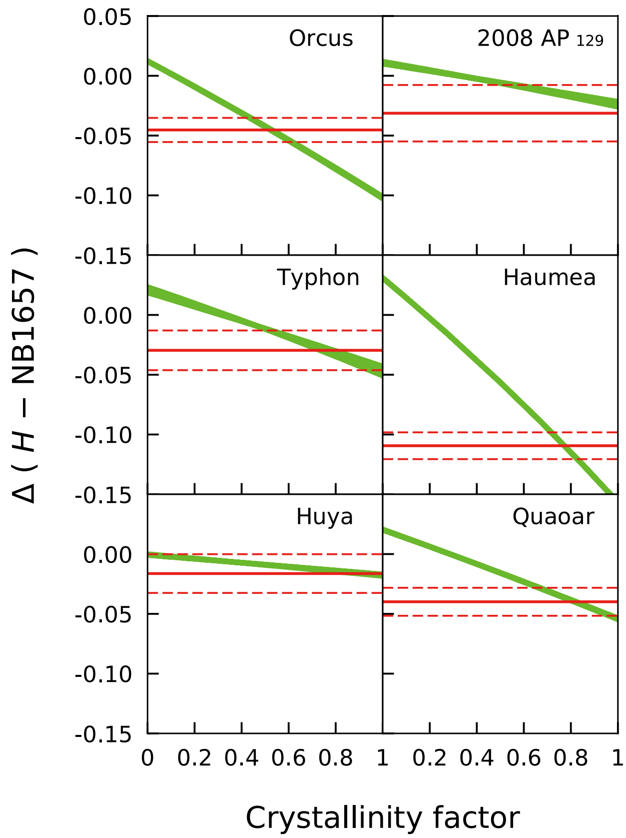

Figure 1: The solid and dotted horizontal lines show the reflective colors in *H*–NB1657 (Δ(*H*–NB1657)) of the observed TNOs and their uncertainties, respectively. The curves represent the relation between the Δ(*H*–NB1657) index and H_2O ice crystallinity estimated from the model spectra.

References

[1] Jewitt, D. C., Luu, J.: 2004, *Nature*, **432**, 731.
[2] Guilbert-Lepoutre, A., et al.: 2011, *A&A*, **529**, A71.
[3] Cook, J. C., et al.: 2007, *ApJ*, **663**, 1406.
[4] Porter, S. B., et al.: 2010, *Icarus*, **208**, 492.
[5] Terai, T., et al.: 2016, *ApJ*, **827**, 65.

ISM Excitation and Metallicity of Star-forming Galaxies at $z \simeq 3.3$ from Near-IR Spectroscopy

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We study the relationship between stellar mass, star formation rate (SFR), ionization state, and gas-phase metallicity for a sample of 41 normal star-forming galaxies at $3 \lesssim z \lesssim 3.7$ [1]. The gas-phase oxygen abundance, ionization parameter, and electron density of ionized gas are derived from rest-frame optical strong emission lines measured on near-infrared spectra obtained with Keck/Multi-Object Spectrograph for Infra-Red Exploration (MOSFIRE). We remove the effect of these strong emission lines in the broadband fluxes to compute stellar masses via spectral energy distribution fitting, while the SFR is derived from the dust-corrected ultraviolet luminosity. The ionization parameter is weakly correlated with the specific SFR, but otherwise the ionization parameter and electron density do not correlate with other global galaxy properties such as stellar mass, SFR, and metallicity. The mass-metallicity relation (MZR) at $z \simeq 3.3$ shows lower metallicity by $\simeq 0.7$ dex than that at $z = 0$ [2,3] at the same stellar mass (Figure 1). Our sample shows an offset by $\simeq 0.3$ dex from the locally defined mass-metallicity-SFR relation [4], indicating that simply extrapolating such a relation to higher redshift may predict an incorrect evolution of MZR. Furthermore, within the uncertainties we find no SFR-metallicity correlation, suggesting a less important role of SFR in controlling the metallicity at high redshift. We finally investigate the redshift evolution of the MZR by using the model by Lilly et al. [5], finding that the observed evolution from $z = 0$ to $z \simeq 3.3$ can be accounted for by the model assuming a weak redshift evolution of the star formation efficiency.

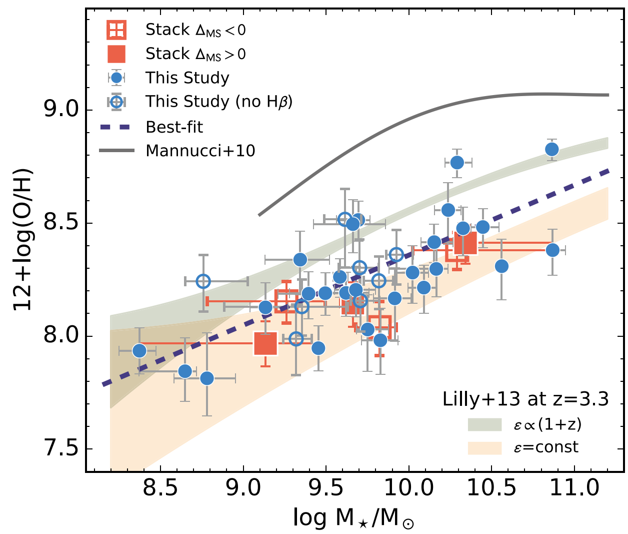

Figure 1: Mass–metallicity relation of our sample, shown with circles [1]. The filled and open circles are those with and without Hβ detection, respectively. Squares represent the measurements on the stacked spectra in bins of stellar mass and SFR. The bins above and below the best-fit main-sequence are shown with filled and open symbols, respectively. The best-fit linear relation for our sample is shown with a dashed line. The solid line is the $z = 0$ relation [4].

References

[1] Onodera, M., et al.: 2016, *ApJ*, **822**, 42.
[2] Maiolino, R., et al.: 2008, *A&A*, **488**, 463.
[3] Tremonti, C. A., et al.: 2004, *ApJ*, **613**, 898.
[4] Mannucci, F., et al.: 2010, *MNRAS*, **408**, 2115.
[5] Lilly, S. J., et al.: 2013, *ApJ*, **772**, 119.

Imaging of Diffuse H I Absorption Structure in the SSA22 Protocluster Region at $z = 3.1$

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When and how galaxies formed and evolved are big questions in the modern astronomy. It is generally considered that gas composed of hydrogen, helium, and so on fell into dark matter overdensity region, the gas was compressed to form stars, and stars were assembled to form galaxies. Unlike the dark matter and stellar component of galaxies whose behaviors are easily predicted theoretically or easily investigated observationally, behaviors of gaseous matter is still mysterious. Comparing spatial distribution of galaxies and gas is important, especially in distant porto-cluster region because galaxy formation at high-redshift is considered to preferentially occur in such a high density environment.

So far, gas in the distant Universe has been investigated through absorption lines (e.g., H I Lyα, Lyβ, C IV, O I) imprinted in the background QSO spectra. In this work, we used galaxies, not QSOs, as background light sources to map gas structure traced by the absorption systems with high spatial resolution. Furthermore, we developed a new scheme to characterize strength of H I Lyα absorption by the foreground gas using multi-band photometry including narrow-band data (we call ΔNB method) [1]. Continuum flux of background light-sources and absorption flux by the foreground H I gas, which are spectroscopically measured in other work [2], are estimated from the broad-band and narrow-band photometry, respectively (Figure 1). This ΔNB method enables us to investigate the absorption systems in wider area with shorter observing time than spectroscopy, while we can investigate only H I gas at a given redshift corresponding to a used narrow-band filter.

We applied the new scheme to imaging data of $z = 3.1$ SSA22 proto-supercluster region, which were taken with the Subaru/S-Cam. We obtained a very wide (~ 50 Mpc) map of H I gas structure with ~ 3 Mpc spatial resolution (Figure 1). The H I gas absorption is significantly strong over the entire SSA22 field, compared with those in the two control fields (SXDS and GOODS-N fields). On the other hand, it is also revealed that gas distribution in the proto-supercluster region does not align with the galaxies' distribution perfectly in relatively small scale (~ 3 Mpc). These suggest that the H I gas not only is associated with the individual galaxies but also spreads out diffusely across intergalactic space only within the proto-supercluster. Such a diffuse gas component may be an ancestor of Warm Hot Intracluster Medium (WHIM[3]) which is associated with nearby superclusters and occupies roughly half of baryons in the Universe.

We also investigated the H I absorption strength as a function of distance from the nearest $z = 3.1$ galaxy. We confirmed that the absorption becomes stronger at the distance less than 100 kpc, which may be due to the H I gas associated with the individual galaxies. Anti-Correlation between strengths of absorption by the circumgalactic H I gas and of Lyα emission from the galaxies themselves is also found, which suggests that observed properties of distant galaxies are affected by the circumgalactic gas distribution and neutrality.

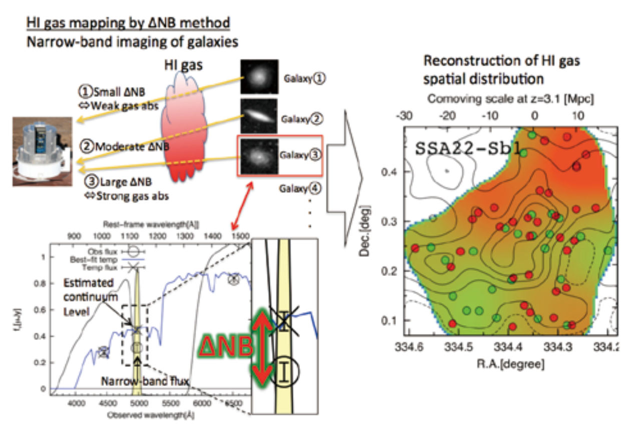

Figure 1: Schematic picture of H I gas mapping by our ΔNB method. We conduct imaging observations of galaxies with multiple filters. Absorption flux by $z = 3.1$ H I gas is evaluated from an offset between the observed narrow-band flux and continuum flux (ΔNB), where the latter is estimated from the broad-band fluxes. Right panel shows spatial distribution of ΔNB values estimated in the SSA22 porto-supercluster region. Redder color means stronger H I Lyα absorption. Contours shows number density of Lyα emitters.

References

[1] Mawatari, K., et al.: 2017, *MNRAS*, **467**, 3951.
[2] Lee, K.-G., et al.: 2014, *ApJ*, **795**, L12.
[3] Zappacosta, L., et al.: 2005, *MNRAS*, **357**, 929.

Properties of Interstellar Dust Responsible for Steep Extinction Curves toward Type Ia Supernovae

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Type Ia supernovae (SNe Ia) show remarkable homogenity in terms of their absolute magnitude and spectral energy distribution. As such, they are ideal objects not only for measuring the cosmic expansion as standard candles but also for extracting the extinction properties caused by interstellar dust in their host galaxies. It has been known, however, that the extinction curves observed for SNe Ia are very steep with unusually low total-to-selective extinction ratios of R_V = 1.0–2.5 [1], compared to the average value of R_V = 3.1 in the Milky Way (MW) [2]. The origin of such highly low R_V values casts challenging problems in modelling the nature and evolution of dust in external galaxies, which has been invoked as one of the critical issues for improving the current precision of cosmological parameters [3].

In order to reveal the properties of interstellar dust that causes steep extinction laws toward SNe Ia, we search for physical dust models that lead to good fits to the extinction curves obtained from the empirical formula (called the CCM formula) by Cardelli et al. (1989) [2] with R_V = 2.0, 1.5, and 1.0 [4]. In the fitting calculations, we apply a two-component dust model composed of graphite and silicate, and consider the power-law grain size distribution. For simplicity, we assume that graphite and silicate grains have the same size distribution, in which the important quantities to be assigned are the power-law index q, the maximum cut-off radius $a_{\max}$, and the graphite-to-silicate mass ratio f_{gs}.

We find that the steep extinction curves with R_V = 2.0, 1.5, and 1.0 can be reasonably explained even by the simple power-law grain size distribution with a fixed index of $q = -3.5$ by taking the maximum cut-off radii of $a_{\max}$ = 0.13 μm, 0.094 μm, and 0.057 μm, respectively (Fig. 1). These maximum cut-off radii are smaller than $a_{\max} \simeq 0.25\,\mu$m considered valid in the MW [5,6], clearly demonstrating that the interstellar dust responsible for steep extinction curves is biased to smaller sizes. The mass ratios of graphite to silicate grains are in a narrow range of f_{gs} = 0.45–0.60, indicating that the chemical composition of interstellar dust is not changed dramatically for different R_V. This is the first study to quantitatively reveal the properties of interstellar dust that arises the steep extinction curves.

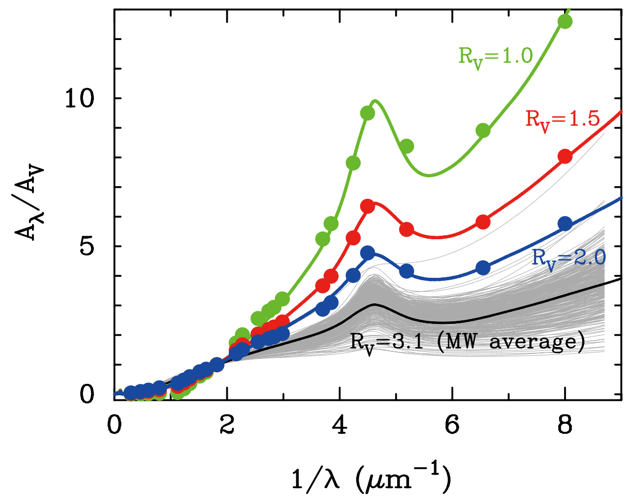

Figure 1: Extinction curves calculated from the best-fit values of $a_{\max}$ and f_{gs} for a two-component dust model following the power-law size distribution with an index of q = −3.5. The filled circles are the data of extinction at wavelengths of representative photometric bands from ultraviolet to near-infrared, derived from the CCM formula [2] for each R_V value. For reference, the average MW extinction curve (R_V = 3.1) is drawn by the black line, and the gray thin lines plot the extinction curves measured along a variety of lines of sight in our Galaxy [7]. The steep extinction curves with R_V = 1.0 (green), 1.5 (red), and 2.0 (blue) as suggested for SNe Ia can be nicely fitted by power-law grain size distributions with the maximum cut-off radii of $a_{\max}$ = 0.057 μm, 0.094 μm, and 0.13 μm, respectively, which indicates that the maximum cut-off radius is an important quantity to describe the variety of extinction curves.

References

[1] Howell, D. A.; 2011, *Natur. Commun.*, **2**, 350.
[2] Cardelli, J. A., Clayton, G. C., Mathis, J. S.; 1989, *ApJ*, **345**, 245.
[3] Conley, A., et al.; 2007, *ApJL*, **664**, L13.
[4] Nozawa, T.; 2016, *Planet. Space Sci.*, **133**, 36.
[5] Mathis, J. S., Rumple, W., Nordsieck, K. H.; 1977, *ApJ*, **217**, 425.
[6] Nozawa, T., Fukugita, M.; 2013, *ApJ*, **770**, 27.
[7] Fitzpatrick, E. L., Massa, D.; 2007, *ApJ*, **663**, 320.

Formation of Overheated Regions and Truncated Disks around Black Holes; Three-dimensional General Relativistic Radiation-magnetohydrodynamics Simulations

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It is believed that the black hole accretion flows are the central engine of the luminous compact objects like active galactic nuclei and black hole binaries (BHBs). The X-ray spectra of such objects are mainly composed of the soft component and the power-low component. The soft component is dominant over the power-low component in the high-soft state as well as in the slim disk state. In contrast, the power-low component is quite prominent in the low-hard state and in the very high state.

The soft component is explained to be multi-color disk blackbody model, which is emitted from the relatively cold, optically thick accretion disk. On the other hand, the power-low component is thought to be produced due to the Compton upscattering in the hot and less-dense regions (so-called disk corona). These features are motivated from observations, but both the structure and the formation mechanism of the hot, rarefied plasma around the cold disk are not understood yet.

In this paper, we perform the three-dimensional General Relativistic Radiation Magnetohydrodynamic simulations to study the formation of the hot, rarefied corona. Figure 1 shows global structure of accretion disk. The radiation pressure dominated accretion flow is formed around the black holes. Due to the strong radiation generated in the accretion disks, strong bipolar jets are formed, which are accelerated by the radiation force. We found that far from the black hole, the gas temperature of the disk gas is about a few 10^7 K. The radiation temperature coincides with the gas temperature due to the strong coupling between the gas and radiation through the absorption and emission processes. Close to the black hole, however, the gas temperature deviates from the radiation temperature and it increases with approaching to the black hole. The maximum gas temperature reaches 10^{11} K close to the black hole. This indicates the fact that the high temperature gas cloud is formed near the black hole. Then we investigate the reason why such a high temperature cloud is formed. We compare the cooling timescale and dynamical timescale that gas falls onto the black hole. Far from the black hole, the cooling time is much shorter than the dynamical time, so that the gas and radiation are in local thermodynamic equilibrium. This situation is violated close to the black hole since the infall timescale becomes shorter as approaching to black hole due to the strong gravity. As a result, high temperature corona is formed around the black hole. This feature is more manifest for the low accretion rate case since the cooling time is reciprocal to the square of the density. Also we find that the coronal temperature is higher for the case of rapidly rotating black hole. We do not have a confidence, but this result would indicate that the black hole rotation energy is transported to the accretion disk and it would be responsible for disk heating.

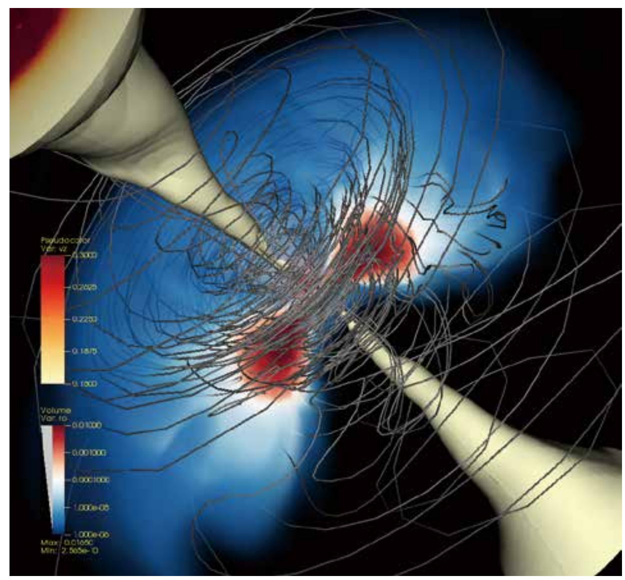

Figure 1: Global structure of radiation dominated accretion disks near the black hole at t = 0.3 s. The Figure shows the density (blue-white-red volume rendering), the outflow velocity (white-red volume data), and the magnetic Field lines (gray lines).

Reference

[1] Takahashi, H. R., et al.: 2016, *ApJ*, **826**, 23.

Chondrule Formation by Planetesimal Collisions

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Chondrules are sub-mm sized spherical materials found in primitive meteorites, chondrites. Chondrules had once heated and melted in the solar nebula. Several theories are proposed for the formation process of chondrules. Planetesimal collisions are one of candidates of chondrule formation: impact jetting, which can be induced by planetesimal-protoplanet collisions, could produce chondrules, when the impact velocity of the collisions exceeds 2.5 km/s [1].

We investigate the abundance of chondrules formed by impact jetting and their formation timing [2]: both of them are derived from semi-analytical calculations of planetesimal-protoplanet collisions and the subsequent formation of protoplanets. We find that the planetesimal-protoplanet collisions with the impact velocity higher than 2.5 km/s would occur around 2 au in the protoplanetary disk at 3 million years. This timing is consistent with the isotopic studies of chondrules [3]. We also constraint on the mass of the disk and planetesimals to trigger impact jetting [4], using the strength of magnetic fields in the solar nebula based on the measurements of chondrules [5].

It is need to consider undifferentiated planetesimal-planetesimal collisions, not potentially differentiated protoplanet-planetesimal ones. This is because chondrules is not differentiated, and their precursors also would be undifferentiated. Thus, we examine whether planetesimal-planetesimal collisions can produce chondrules or not [6]. We perform various kind of collisions with the parameters of the impact velocity and the size of target planetesimal using iSALE-2D shock physics code [7,8,9]. Our numerical results show that planetesimal-planetesimal collisions with 2.5 km/s can also produce chondrules [Figure 1(a)]. The mass of chondrule would increase as the impact velocity increases and it would vary with the size of target planetesimals. We also find that the original position of chondrules is in a region of a few hundreds depth from the surface [Figure 1(b)] and the progenitor of chondrules originates from the impactor planetesimals than the larger target planetesimals.

We also check the fate of produced chondrules semi-analytically and find that the half of produced chondrules accrete on the protoplanet, and the other half would do on the planetesimals [10]. Those results indicate that target planetesimals or protoplanet are very important to consider chondrule formation via impact jetting.

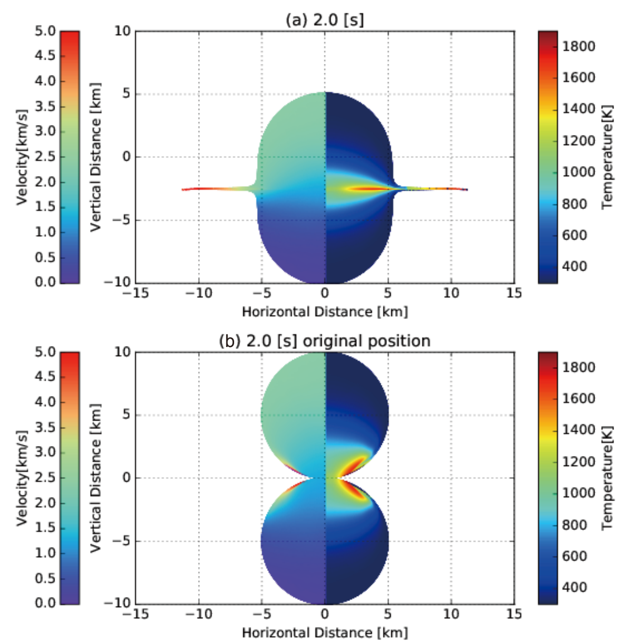

Figure 1: Results of 10 km sized planetesimals colliding each other with a impact velocity of 2.5 km/s. Right side of panels show temperature and left ones show velocity. (a) 2.0 seconds after collision. (b) Tracing back to original position of materials.

References

[1] Johnson, B. C.: 2015, *Nature*, **517**, 339.
[2] Hasegawa, Y., et al.: 2016, *ApJ*, **816**, 8.
[3] Connelly, J. N., et al.: 2012, *Science*, **338**, 651.
[4] Hasegawa, Y., et al.: 2016, *ApJL*, **820**, L12.
[5] Fu, R. R. et al.: 2014, *Science*, **346**, 1089.
[6] Wakita, S., et al.: 2017, *ApJ*, **834**, 125.
[7] Amsden, A., et al.: 1980, *Los Alamos National Laboratories Report*, **LA-8095**, 101.
[8] Collins, G. S., et al.: 2004, *Meteorit. Planet. Sci.*, **39**, 217.
[9] Wünnemann, K., et al.: 2006, *Icarus*, **180**, 514.
[10] Matsumoto, Y., et al.: 2017, *ApJ*, **837**, 103.

Revisiting the Completeness and Luminosity Function in High-redshift Low-luminosity Quasar Surveys

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At the center of most galaxies, there is a supermassive blackhole (SMBH) whose mass is 10^6 – $10^9\,M_\odot$. It is now recognized that SMBHs already existed at $z \sim 7$ [1]. However it is totally unclear how those SMBHs have formed and evolved. To investigate the evolution of SMBHs, quasars who release the huge radiative energy powered by the gravitational energy of SMBHs are useful. The luminosity of quasars correlates with the mass of SMBHs. Therefore, to examine the mass evolution of SMBHs, it is important to measure the evolution of the quasars number densities as a function of the redshift and luminosity (quasar luminosity functions; QLFs). However, the number densities of the low-luminosity quasars at the high redshift derived by the previous studies have large uncertainty [2,3]. This is due to the large systematic error in the quasar selection method based on the imaging data.

To derive the accurate number density of the low-luminosity quasars at the high redshift, we improve the method of the quasar selection. We specifically focus on the luminosity dependence of quasar spectra (the Baldwin effect [4]) whose effect on the quasar selection was ignored in the previous studies. We quantify this luminosity dependence using the Baryon Oscillation Spectroscopic Survey (BOSS) quasar catalog. Based on these obtained results and using the latest model of the inter-galactic medium (IGM) attenuation [5], we establish the new method for deriving the quasar number densities. By this method, we calculate the completeness of quasar survey at $z \sim 4$–5, using the COSMOS deep images observed with Subaru/Suprime-Cam. Based on this result, we revisit the low-luminosity quasar number densities. In the results, the revisited number densities are ~24 % lower and ~43 % higher than that estimated by the conventional method at $z \sim 4$ and 5, respectively (Fig. 1). Recent surveys of high-luminosity quasars have reported that the quasar number densities increase from the early univers to $z \sim 2$ and then decrease to now. Furthermore the higher-luminosity quasars show the peak of their number densities at higher redshifts than lower-luminosity quasars. This indicates that more massive SMBHs grew earlier (i.e., down-sizing). The results of our study suggest that the low-luminosity quasar number density decrease from $z \sim 2$ to $z \sim 5$. This indicates that even at high-redshift the evolution of quasar number densities is consistent with the down-sizing evolutionary picture. See [6] for more details.

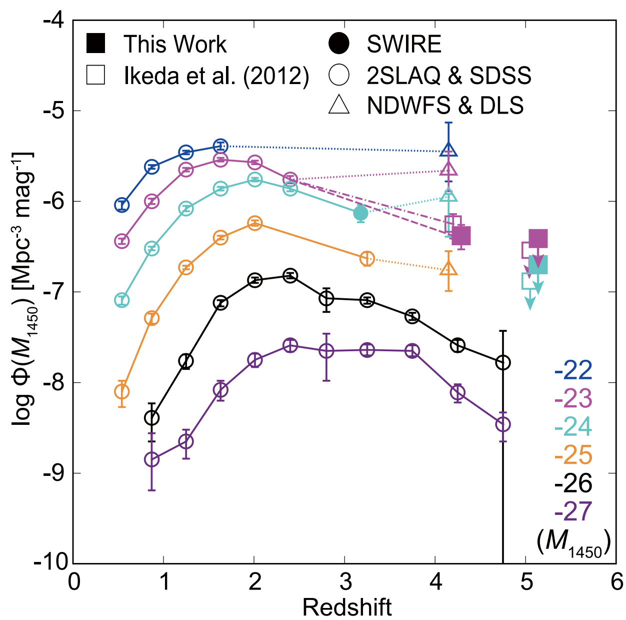

Figure 1: Redshift evolution of the quasar number density for each luminosity. Filled squares and open squares show the results of this study and those of conventional method, respectively. We also show the results of the previous studies for high-luminosity or low redshift quasars as each symbols. The filled squares at $z \sim 4$ and 5 are slightly shifted to the right direction to avoid the overlap with other symbols. Our study makes it possible to measure the low-luminosity quasar number densities at $z \sim 4$, 5 more accurately.

References

[1] Mortlock, D. J., et al.: 2011, *Nature*, **474**, 616.
[2] Ikeda, H., et al.: 2011, *ApJL*, **728**, L25.
[3] Ikeda, H., et al.: 2012, *ApJ*, **756**, 160.
[4] Baldwin, J. A.: 1977, *ApJ*, **214**, 679.
[5] Inoue, A., et al.: 2014, *MNRAS*, **442**, 1805.
[6] Niida, M., et al.: 2016, *ApJ*, **832**, 208.

Near-infrared Spectroscopy of Nearby Seyfert Galaxies for Examinig the Ionization Mechanism of Narrow-line Regions

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The active galactic nucleus (AGN) feedback, which is a negative/positive feedback effect on star formation activity, has been paid a lot more attention recently. A massive galaxy has a supermassive black hole (SMBH) at its center, and the inflow of interstellar medium (ISM) to SMBH invokes its AGN activity, which releases vast gravitational potential energy to the ISM in the suppression of star-formation activity in its host galaxy.

However, how the AGN activity transmits its energy to the ISM remains a serious mystery. We here focus on a shock ionization of the ISM in narrow-line regions (NLRs) as another possible physical mechanism of the AGN feedback, i.e., the AGN activity inputs its energy to the ISM through a shock heating induced by a jet or AGN wind. Therefore it is interesting to explore whether and how the fast shock contributes the NLR ionization in AGNs.

Although it is widely accepted that NLRs in AGNs are mostly photoionized by photons from a central engine, the possibility of shock ionization induced by a jet or AGN wind at off-nucleus regions. The discrimination between the shock-ionization and photoionization of NLRs in AGNs was extremely difficult. As a reason for that in previous studies of NLRs, optical line-ratio diagnostics have failed to discriminate between the two mechanisms, because optical NLR spectra predicted by the photoionization and shock ionization models are very similar in each other [1].

The near-infrared emission-line flux ratio of [Fe II]1.257 μm/[P II]1.188 μm is a very powerful indicator to discriminate the photoionization and shock ionization [2,3]. The [Fe II]/[P II] ratio in fast shock-excited regions is expected to be high (~20) while that in purely photoionized regions is low (~2).

We carried out the near-infrared spectroscopic observations of 26 nearby Seyfert galaxies with a near-infrared spectrograph (ISLE) boarded on the 188 cm telescope at Okayama Astrophysical Observatory. As a result, we measured the [Fe II]/[P II] flux ratio or its lower limit for 19 objects and 22 Seyfert galaxies from the literature. Based on the collected data, we found that the ionization mechanism of the NLR is the photoionization in most cases ([Fe II]/[P II] < 5) but the fast shock contributes in some Seyfert galaxies ([Fe II]/[P II] > 10). We found that these is no significant correlation between the [Fe II]/[P II] and the radio-loudness (Figure 1). We checked the effect of the shocks from star-formation activities using some starburst indicators (far-infrared luminosity and the mid-infrared PAH emission), and confirmed that the [Fe II]/[P II] ratio is independent the starburst activities. These results suggest that the NLR in some Seyfert galaxies is affected by fast shocks whose origin is the radio jet and other mechanisms such as the powerful AGN wind [4].

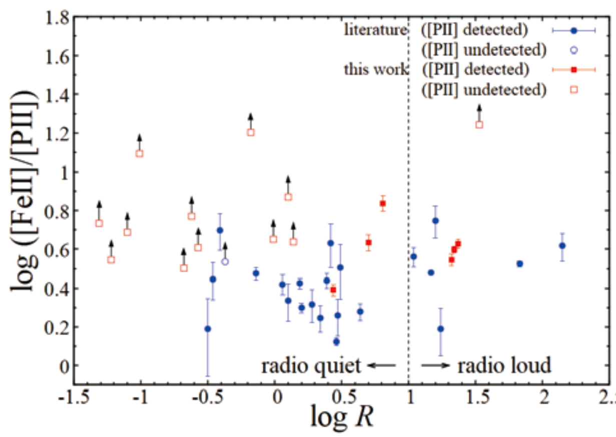

Figure 1: Relation between the [Fe II]/[P II] ratio and the radio-loudness of nearby Seyfert galaxies. Perpendicular dashed line shows the threshold dividing the radio-loud and radio-quiet populations.

References

[1] Allen, M. G., et al.: 2008, *ApJS*, **178**, 20.
[2] Oliva, E., et al.: 2001, *A&A*, **369**, L5.
[3] Hashimoto, T., et al.: 2011, *PASJ*, **63**, L7.
[4] Terao, K., et al.: 2016, *ApJ*, **833**, 190.

Mergers of Accreting Stellar-mass Black Holes

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Recent observations have revealed the existence of supermassive black holes (SMBHs) with masses $\gtrsim 10^9 M_\odot$ at redshifts higher than 6 [1]. However, the formation history of these SMBHs is not still revealed. There are two major competitive scenarios for the growth of SMBHs: one is the mass accretion, and the other is the merger of BHs (or stars). As for the mass accretion, the constraints from observed SMBHs at high redshifts have been argued. Possible building blocks of SMBHs are the remnants of first stars. First stars of several tens $M_\odot$ can leave black holes (BHs) of few tens $M_\odot$ after supernova explosion. If recently discovered high-redshift SMBHs grow via mass accretion from such stellar-mass BHs, the accretion rate is required to be higher than the Eddington accretion rate. However, the continuous accretion is unlikely to be sustained due to feedback, and thus the average mass accretion rates should be lower than the Eddington rate [2]. Then, if the BHs grow via BH mergers by a few orders of magnitude, the high-redshift SMBHs can be formed from stellar-mass BHs.

Then we focus on the promotion of BH mergers in abundant gas at high-redshift epochs. Recent radiation hydrodynamic simulations on the formation of first stars show that multiple massive stars form in a primordial gas cloud of $\sim 10^4$–$10^5 M_\odot$ with the density of around 10^7 cm^{-3} and the extension of ~0.01 pc, where the gas fraction is 99 %. According to the mass function of first stars, multiple BHs of several tens $M_\odot$ may be born as remnants of supernovae, in such a primordial could [3]. In this circumstance, high mass-accretion rates onto BHs are expected. On the other hand, plenty of gas can exert dynamical friction on moving BHs. Recently, we have explored the early merger of BHs through the gas dynamical friction, and have shown that the merger time of multiple BHs merger in the gas number density of $n_{gas} \gtrsim 10^6$ cm^{-3} is ~10^7 yr, which is shorter than the Eddington timescale [4]. However, this study [4] did not consider the effect of the mass accretion onto BHs. Thus, in the competition between the mass accretion and the merger, which mechanism dominates the growth of massive BHs is not clear. Then, we present post-Newtonian N-body simulations on mergers of accreting stellar-mass black holes (BHs), where such general relativistic effects as the pericenter shift and gravitational wave (GW) emission are taken into consideration. The attention is concentrated on the effects of the dynamical friction and the Hoyle-Lyttleton mass accretion by ambient gas. As a result, we show that mergers of accreting stellar-mass BHs are classified into four types: a gas drag-driven, an interplay-driven, a three body-driven, or an accretion-driven merger. Using the simulation results for a wide range of parameters, we derive a critical accretion rate ($\dot{m}_c$), below which the BH growth is promoted faster by mergers (Figure 1). We find that BH mergers proceed before significant mass accretion, even if the accretion rate is ~10 Eddington accretion rate, and then all BHs can merge into one heavy BH [5].

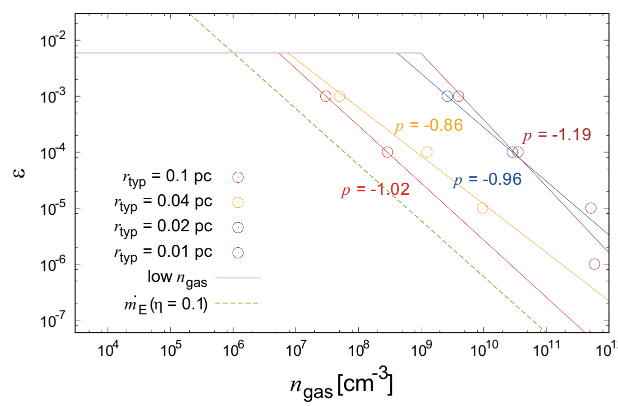

Figure 1: The critical accretion efficiency ($\epsilon_c = \dot{m}_c / \dot{m}_{HL}$) as a function of ambient gas density n_{gas}. Red, orange, blue, and brown plots represent the critical condition in high-density regions for r_{typ} = 0.1, 0.04, 0.02, and 0.01 pc, respectively. Red, orange, blue, and brown lines represent the curves fitted by $n_{gas,c} = a\epsilon^p$ for r_{typ} = 0.1, 0.04, 0.02, and 0.01 pc. Pink line represents the critical condition in low-density regions. The green dashed line represents the Eddington accretion rate $\dot{m}_E$ (η = 0.1), where η is the radiative energy conversion efficiency.

References

1] Fan, X., et al., 2001, *AJ*, **122**, 2833.

[2] Milosavljevic, M., Couch, S. M., Bromm V.: 2009, *ApJ*, **696**, 146.

[3] Susa, H., Hasegawa, K., Tominaga, N.: 2014, *ApJ*, **792**, 32.

[4] Tagawa, H., et al.: 2015, *MNRAS*, **451**, 2174.

[5] Tagawa, H., Umemura, M., Gouda, N.: 2016, *MNRAS*, **462**, 3812.

The Validation of Made-to-measure Method for Reconstruction of Phase Space Distribution Functions

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Investigating the dynamical structures of galaxies is important to infer their formations and evolutions especially in the era of highly precise Galactic survey mission, Gaia [1] and JASMINE [2]. To infer the real phase-space distribution function (DF) of the total of matters in a galaxy by the comparison of the theoretically constructed stellar DFs with precise observational data, accurate theoretical construction of the stellar DFs is very important.

For that purpose, we investigate how accurately phase-space DFs in galactic models can be reconstructed by a made-to-measure (M2M, [3]) method, which constructs *N*-particle models of stellar systems from various observational data, such as photometric and various kinematic data. The advantage of the M2M method is that this method can be applied to various galactic models without assumption of the spatial symmetries of gravitational potentials adopted in galactic models, and furthermore, numerical calculations of the orbits of the stars cannot be severely constrained by the capacities of computer memories. Therefore, when we construct DFs using immense data such as Gaia data, the M2M method is best suitable method among crrently proposed methods.

Although the M2M method has been applied to various galactic models, the degree of accuracy for the recovery of DFs derived by the M2M method in galactic models has never been investigated carefully. Then we investigate the degree of accuracy for the recovery of the DFs for the anisotropic Plummer model and the axisymmetric Stäckel model, which have analytic solutions of the DFs. Furthermore, this study provides the dependence of the degree of accuracy for the recovery of the DFs on various parameters and procedures adopted in this paper. The parameters which we investigate are the total number of particles used in the M2M modelling run, the number of constraints such as the mass or kinematic observables, the initial phase space distribution of the particles, configurations of the kinematic observables, higher order velocity moments, and a temporal smoothing.

As a result, we derive the dependence on the particle number and the data number (Figure 1). We find that the degree of accuracy for the recovery of the DFs derived by the M2M method using N_d observational data is 6.5×10^2 $N_d^{-1.6}$ % for the spherical target model, and 24.3 $N_d^{-0.075}$ % for the axisymmetric target model. Therefore, by using the Gaia data of $N_d \sim 10^9$, the DFs can be constructed with the uncertainty of about 5 % [4].

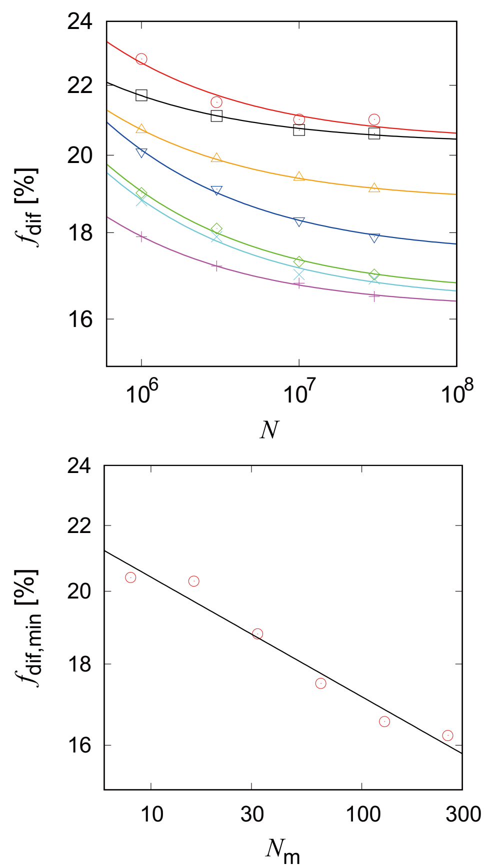

Figure 1: The upper panel shows the degree of accuracy for the recovery of the DFs f_{dif} for the axisymmetric three integral target model as a function of the particle number *N*. Red circle, black square, orange triangle, blue inverted triangle, green diamond, and magenta plus plots represent the results for the kinematic data number N_k = 16 and the mass data number as N_m = 8, 16, 32, 64, 128, and 256, respectively. Cyan cross plot represents the results for N_k = 64 and N_m = 128. Each line represents the curve fitted by $f_{dif} = a \times N^{-0.5} + f_{dif,min}$ for concolorous plots. The lower panel shows $f_{dif,min}$ as a function of N_m for N_k = 16. The line represents the curve fitted by $f_{dif} = a \times N_m^b$.

References

[1] Perryman, M. A. C., et al.: 2001, *A&A*, **369**, 339.
[2] Gouda, N.: 2012, *in Astronomical Society of the Pacific Conference Series*, Vol. **458**, Galactic Archaeology: Near-Field Cosmology and the Formation of the Milky Way, ed. W. Aoki, M. Ishigaki, T. Suda, T. Tsujimoto, N. Arimoto, 417.
[3] Syer, D., Tremaine, S.: 1996, *MNRAS*, **282**, 223.
[4] Tagawa, H., et al.: 2016, *MNRAS*, **463**, 927.

Nitrogen Isotopic Ratio of Cometary Ammonia from High-resolution Optical Spectroscopic Observations of C/2014 Q2 (Lovejoy)

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Icy materials present in comets provide clues for helping us to understand the origin and evolution of our Solar system and planetary systems. In particular, isotopic ratios in cometary molecules provide a diagnostic of the physicochemical conditions, which the molecules formed and were processed during the evolutionary stages from the interstellar medium to the solar nebula. The temperatures at which molecules form control the fractionation of the heavier isotopes (e.g., in the case of deuterium-fractionation in water).

We performed high-resolution optical spectroscopic observations of comet C/2014 Q2 (Lovejoy) on 2015 January 11 (at 1.321 au from the Sun, pre-perihelion) by using the High Dispersion Spectrograph (HDS) mounted on the Subaru Telescope on Maunakea, Hawaii. We derived the $^{14}N/^{15}N$ ratio of NH_2 (126 ± 25), the ortho-to-para abundance ratios (OPRs) of the H_2O^+ ion (2.77 ± 0.24) and NH_2 (1.19 ± 0.04), which correspond to nuclear spin temperatures of >24 K (3σ lower limit) and 27 ± 2 K, respectively, and the intensity ratio of the green to red-doublet of forbidden oxygen lines (0.107 ± 0.007) [1].

Ammonia in the comet have to have formed under low-temperature conditions at ~10 K or less to reproduce the derived $^{14}N/^{15}N$ ratio of ammonia if it is assumed that the ^{15}N-fractionation of ammonia occurred through ion-molecule chemical reactions. However, this temperature is inconsistent with the nuclear spin temperatures of water and ammonia estimated from the OPRs. Therefore, the interpretation of the nuclear spin temperature as the temperature at molecular formation might be incorrect. An isotope-selective photodissociation of molecular nitrogen by protosolar ultraviolet radiation may play an important role in the ^{15}N-fractionation observed in cometary volatiles.

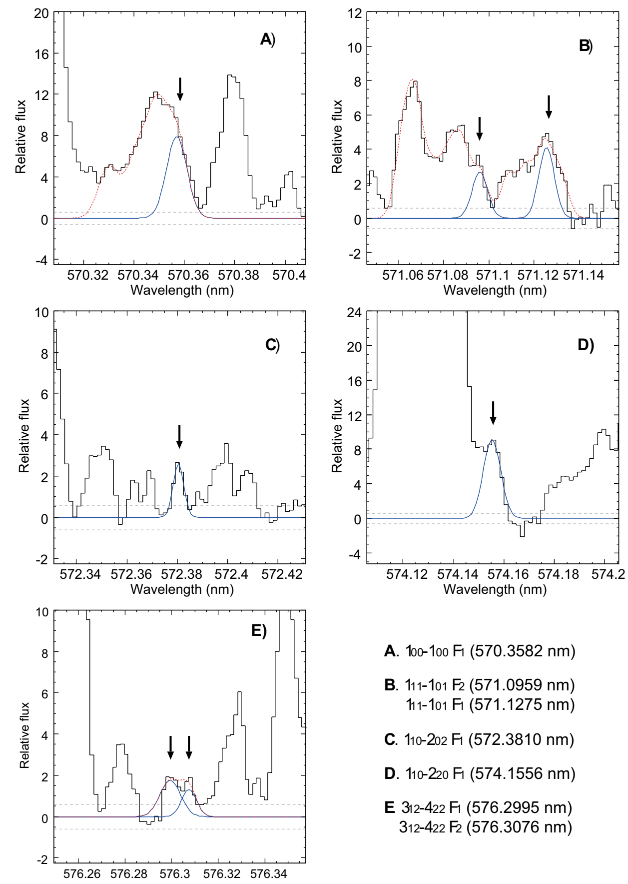

Figure 1: Measurements of seven $^{15}NH_2$ lines (denoted by blue solid lines and black arrows). The red dotted lines is the results of ad hoc fitting. Gray dashed lines indicate the $\pm1\sigma$ error of the continuum levels.

Reference

[1] Shinnaka, Y., Kawakita, H.: 2016, *AJ*, **152**, 145.

Ortho-to-Para Abundance Ratios of NH_2 in 26 Comets: Implications for the Real Meaning of OPRs

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Abundance ratios of nuclear-spin isomers for cometary molecules having identical protons, such as water and ammonia, have been measured and discussed from the viewpoint of primordial characters in comet. In the case of ammonia, its ortho-to-para abundance ratio (OPR) is usually estimated from OPRs of NH_2 because of difficulty in measuring OPR of ammonia directly.

To derive an OPR of NH_2 in a comet, we use the fluorescence excitation model of NH_2 in the optical wavelength region. The OPR of NH_2 is a unique free parameter in the model and is determined from a χ^2 fitting between the observed high-resolution and synthesized spectra based on the assumption that NH_2 is the fluorescence equilibrium condition in the coma. An OPR of NH_2 determined from high-resolution spectra of NH_2 was converted to that of NH_3 by assuming NH_3 as a sole-parent of NH_2 and also by assuming the conservation of total nuclear-spin for the photodissociation reaction of NH_3 to NH_2. We also assume that photodissociation rates are the same for both ortho- and para-NH_3.

We report our survey for OPRs of NH_2 in 26 comets (Fig. 1) [1]. The data were mainly acquired by 8-m telescopes with high-resolution optical spectrographs, the Ultraviolet, Visual Echelle Spectrograph (UVES) mounted on the Very Large Telescope (VLT) and the High Dispersion Spectrograph (HDS) mounted on the Subaru Telescope. A weighted mean of ammonia OPRs for the comets is 1.12 ± 0.01 and no significant difference is found between the Oort Cloud comets and the Jupiter-family comets. These values correspond to ~30 K as nuclear-spin temperatures.

Moreover, based on comparison of OPRs (and nuclear-spin temperatures) of NH_3 with those of water, $^{14}N/^{15}N$ ratios in NH_3, and D/H ratios in water (Fig. 2), The OPRs of NH_3 in comets probably reflect the physico-chemical conditions in cometary coma, rather than the conditions for the molecular formation or condensation in the pre-solar molecular cloud and the solar nebula. Relationship between the OPRs of NH_3 and water is a clue to understanding the real meaning of the OPRs.

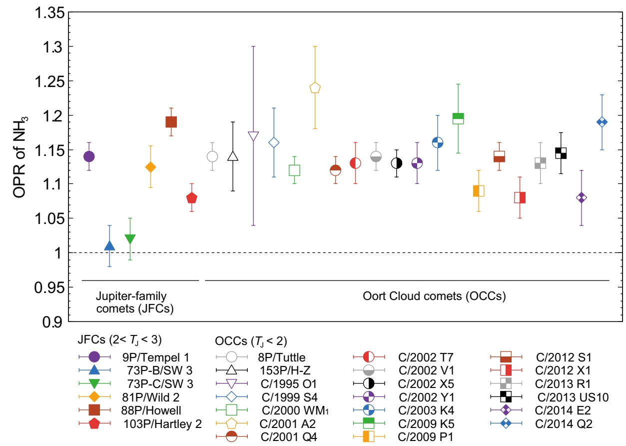

Figure 1: OPR of NH_3 estimated from those of NH_2 in 26 comets. No clear difference in the OPRs for different dynamical classes can be seen. The nuclear-spin statistical weights ratio of NH_3 (1.0) is indicated by the horizontal dashed line.

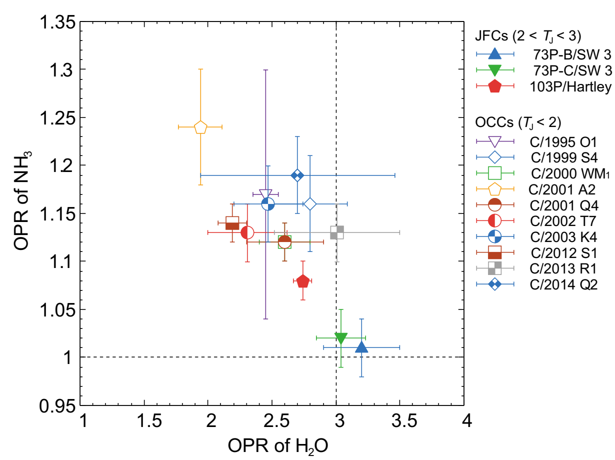

Figure 2: Correlation between OPRs of NH_3 and water. The horizontal and vertical dashed lines show the nuclear-spin statistical weight ratio of NH_3 (1.0) and water (3.0).

Reference

[1] Shinnaka, Y., et al.: 2016, *MNRAS*, **426**, S195.

Nitrogen Isotopic Ratios of NH_2 in Comets: Implication for ^{15}N-Fractionation in Cometary Ammonia

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Comets are remnants of icy planetesimals formed in the solar nebula 4.6 Gyr ago. In general, the icy materials in comets are definitely one of the keys for us to understand the origin and evolution of our Solar system. The isotopic ratios are diagnostics for the physico-chemical conditions governing molecular formation. In comets, $^{14}N/^{15}N$ ratios have been measured from HCN in three comets and from CN in more than 20 comets [1,2,3]. Those ratios are enriched in ^{15}N compared to the elemental abundances of the Sun by a factor of ~3, have a small diversity and do not depend on the dynamical types of the comets. The origin of this high ^{15}N-fractionation is still in debate because CN probably comes not only from HCN, but also from other materials in the coma. Consequently, an interpretation of the isotopic ratios in cometary CN is quite complicated due to the multiple possible parents of CN. In contrast with CN, the isotopic ratios of nitrogen in NH_3 give us a much clearer interpretation than in CN because NH_3 is directly incorporated in the nuclear ices.

To estimate the $^{14}N/^{15}N$ ratios in NH_3, $^{14}N/^{15}N$ ratios have been determined from high-resolution spectra of NH_2 in the optical wavelength region. NH_2 is indeed a dominant photodissociation product of NH_3. These high-S/N ratio high-resolution spectra were taken by the High Dispersion Spectrograph (HDS) mounted on the Subaru Telescope summit of Mauna Kea, Hawaii, USA and the Ultraviolet and Visible Echelle Spectrograph (UVES) mounted on the UT2 of the Very Large Telescopes (VLT) at European Southern Observatory (ESO)'s Paranal Obsrvatory, Chile.

Those ratios were also found to be enriched in ^{15}N compared to the Sun by a factor of ~3 [4]. In this paper, we present $^{14}N/^{15}N$ ratios in NH_2 for 20 comets as total. Our sample includes short-period comets as well as long-period comets. We found that the $^{14}N/^{15}N$ ratios in cometary NH_2 also show a small dispersion and do not depend on the dynamical origin of the comets (Fig. 1).

Interpretation of $^{14}N/^{15}N$ ratio in cometary volatiles is still in debate. In order to reduce the measurement uncertainty for each comet, we should develop the emission model of $^{15}NH_2$ considering the Swings effect as well as need more high-S/N spectra by next-generation large telescopes such as the TMT and E-ELT. We can truly discuss the variation of $^{14}N/^{15}N$ ratios in comets if $^{14}N/^{15}N$ ratios with smaller uncertainties will be obtained for each comet.

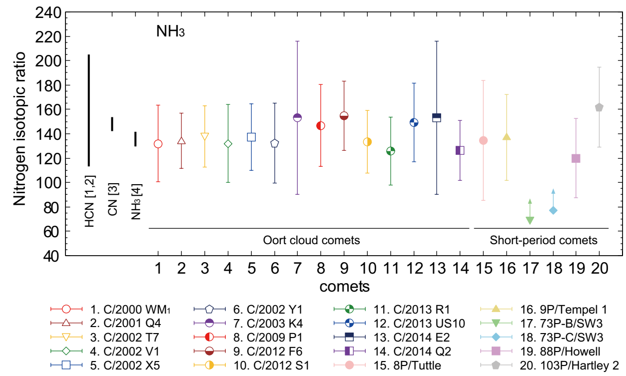

Figure 1: $^{14}N/^{15}N$ ratio in comets. Three black bars indicate the range of $^{14}N/^{15}N$ ratios in HCN and the weighted means of $^{14}N/^{15}N$ ratios in CN and NH_3.

References

[1] Bockelée-Morvan, D., et al.: 2008, *ApJ*, **679**, L49.
[2] Biver, N., et al.: 2016, *A&A*, **589**, A78.
[3] Manfroid, J., et al.: 2009, *A&A*, **503**, 613.
[4] Shinnaka, Y., et al.: 2016, *MNRAS*, **426**, S195.

Imaging Observations of Entire Hydrogen Coma of Comet 67P/Churyumov-Gerasimenko in 2015 September

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The water production rate, Q_{H_2O} of a comet is one of the fundamental parameters to understand cometary activity when a comet approaches the Sun within 2.5 au because water is the most abundant icy material in the cometary nucleus (~70 % of icy materials). For instance, the slopes of the water production rate with respect to heliocentric distance, r_H, of comets seem to depend on dynamical ages of the comets [1].

Comet 67P/Churyumov-Gerasimenko (hereafter 67P) is a Jupiter-family comet with an orbital period of ~6.5 years. During the 2015 apparition of the comet, the comet was the target of ESA's Rosetta mission. Q_{H_2O} of the comet have been derived by various instruments on board the *Rosetta* spacecraft throughout the 2015 apparition. However, measurement of an absolute Q_{H_2O} is difficult because the *Rosetta* spacecraft was located in the cometary coma. Note that an obtained Q_{H_2O} strongly depends on the coma models [2,3].

To derive gas production rates based on in situ measurements by the *Rosetta* instruments at the close distances from the comet 67P, entire coma observations from the ground-based and space observatories can realize the critical calibration for the gas production rates. We performed wide-field imaging observations of Lyα emission in comet 67P by the LAICA telescope on board the micro spacecraft for deep space exploration, the *PROCYON*, on UT 2015 September 7, 12, and 13 [4].

To estimate a Q_{H_2O} from a single Lyα image, we use the two-dimensional axi-symmetric Direct Simulation Monte-Carlo (DSMC) model of atomic hydrogen coma using the Adaptive Mesh Particle Simulator code [5] (Fig. 1). Because there were bad observing conditions during the time the comet could be observed from Earth, our observations were important to test the coma models for the comet. Combined with Rosetta's results, such as water production rates at different r_H and chemical composition, we could accurately estimate the total ejected mass of the comet in the 2015 apparition. Moreover, 67P shows that the activity in the 2015 apparition was comparable to those in the past fourth apparitions at least, and has much icy materials in the nucleus.

This result is the first scientific achievement by a micro spacecraft for deep space exploration. Moreover, this provides an ideal example where observations by a low-cost mission support precise observations by a large mission. We hope this will become one of model cases for micro spacecraft missions.

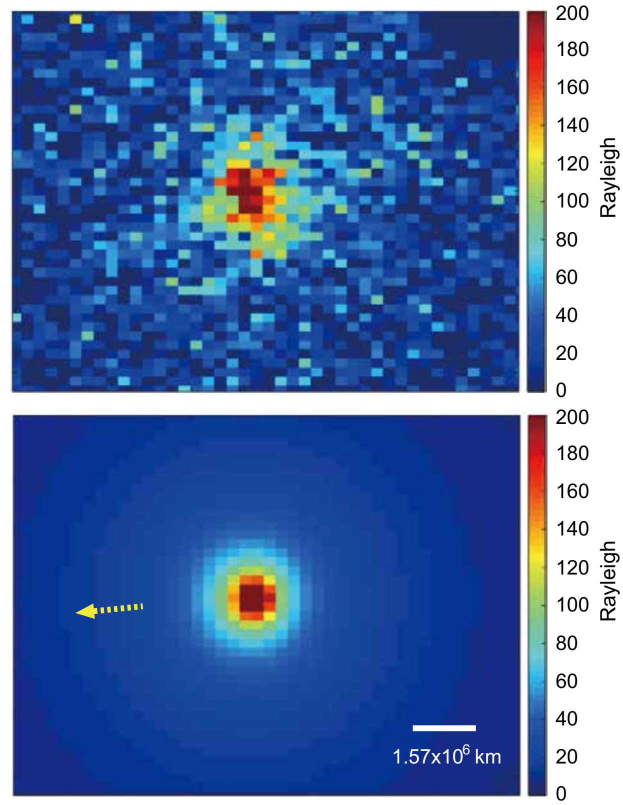

Figure 1: Trimmed reduce Lyα (upper) and reproduced (lower) images of hydrogen coma of comet 67P by 2D axi-symmetric model in Rayleigh units on UT 2015 Sept 13. Yellow allow is solar direction.

References

[1] A'Hearn, M. F., et al.: 1995, *Icarus*, **118**, 223.
[2] Fougere, N., et al.: 2016, *MNRAS*, **462**, S156.
[3] Hansen, K. C., et al.: 2016, *MNRAS*, **462**, S491.
[4] Shinnaka, Y., et al.: 2017, *AJ*, **154**, 76.
[5] Crismani. M. M. J., et al.: 2015, *Geophys. Res. Lett.*, **42**, 8803.

Record-breaking Faint Satellite Galaxy of the Milky Way Discovered

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Currently, some 50 satellite galaxies to the Milky Way have been identified. About 40 of them are faint and diffuse and belong to the category of so-called “dwarf spheroidal galaxies”. Many recently discovered dwarf galaxies, especially those seen in systematic photometric surveys such as the Sloan Digital Sky Survey (SDSS) and the Dark Energy Survey (DES) are very faint with absolute luminosity in the optical waveband below -8 magnitude. However, previous searches made use of telescopes with a diameter of 2.5 to 4 meters, so only satellites relatively close to the Sun or those with higher magnitudes were identified. Those that are more distant or faint ones in the halo of the Milky Way are yet to be detected. We therefore carefully examined the early data of the Subaru Strategic Survey with HSC and searched for very faint dwarf satellites which were overlooked by previous surveys.

By identifying an over density of stars in the sky with characteristic distribution to the old stellar population in the color-magnitude diagram (Fig. 1 and 2), we discovered an extremely faint dwarf satellite galaxy of the Milky Way and named it as Virgo I – the first faint dwarf satellite galaxy located in the direction of the constellation Virgo [1]. Though the absolute magnitude of Virgo I is as faint as −0.8 in the optical waveband, it is identified as a galaxy because it is spatially extended with a radius of 124 light years – systematically larger than a globular cluster with comparable luminosity. The faintest dwarf satellites identified so far was Segue I, discovered by SDSS (−1.5 mag) and Cetus II in DES (0.0 mag). Cetus II is yet to be confirmed, as it is too compact as a galaxy. Virgo I may ultimately turn out to be the faintest one ever discovered. It lies at a distance of 280,000 light years from the Sun, and such a remote galaxy with faint brightness has not been identified in previous surveys.

The Subaru Strategic Survey using HSC will continue to explore much wider areas of the sky and is expected to find more satellites like Virgo I.

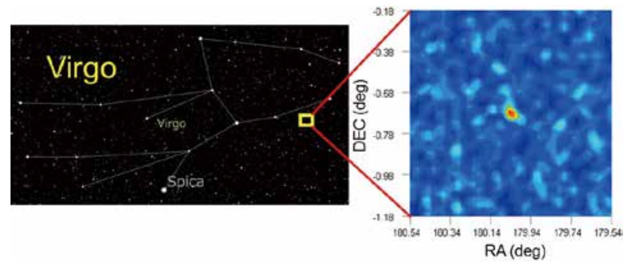

Figure 1: The position of Virgo I in the constellation of Virgo (left) and a density map of Virgo I’s member stars in a 0.1 deg x 0.1 deg area (right).

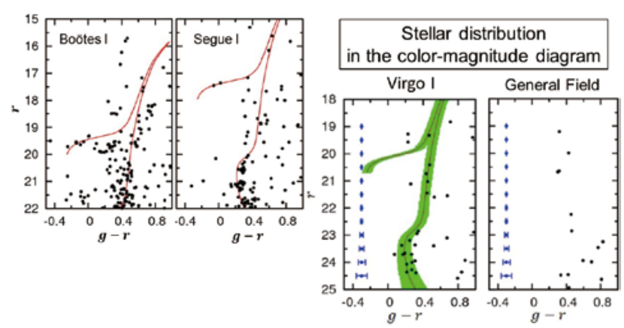

Figure 2: Stars in the color-magnitude diagram. Old stellar populations show a characteristic distribution along the curve seen in the diagram. From left to right: Bootes I, Segue I, Virgo I, and a general field outside Virgo I. The spatial distribution of the stars, which are located inside the green band for Virgo I, is shown in the right panel of Figure 1. Note that stars in a general field outside Virgo I (right panel) show no characteristic feature.

Reference

[1] Homma, D., et al.: 2016, *ApJ*, **832**, 21.

Large Scale Environment of the Most Massive SMBHs

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It has been recognized that most of the galaxies have a supermassive black hole (SMBH) with mass in the range of 10^5–$10^{10}\,M_\odot$ at their center. The mechanism to evolve the BHs up to $10^{10}\,M_\odot$ is still an open question. In order to deliver a large amount of matter to a compact region inside the BH, it is required to remove angular momentum efficiently from the matter. Several mechanisms have been proposed to explain the evolution of the BHs, such as the internal mechanism which relies on the secular evolution due to disk and/or bar instability, the external mechanism which includes the galaxy merger and the interaction with nearby galaxies, and the hot halo model in which quiescent gas accretion from the hot halo and/or recycled gas from evolving stars feeds the BHs. According to the numerical simulation, the secular evolution has a difficulty to evolve the BHs up to the most highest mass ranges ($> 10^9\,M_\odot$), thus large scale environmental effect may mainly contribute to the feeding to the most massive BHs. If this is the case, it could be observed that there is a relation between the BH mass and the properties of galaxies around them.

To investigate the existence of such a relation, we explored the dependence of galaxy clustering around AGNs on the BH mass, and found that there is a tendency that galaxies are more clustered around the most massive BHs than those around the lower mass BHs [1]. The aim of this work [2] is to reveal what kind of galaxies contributes to the increase of clustering, which can be a clue to the understanding the evolutionary history of the most massive BHs and also the surrounding galaxies. To measure the color of galaxies with good precision, we used two catalogs derived from UKIRT Infrared Deep Sky Survey (UKIDSS) Large Area Survey (LAS) and from SDSS DR8 for deriving galaxy samples. The AGN samples for which BH masses are measured are derived from two AGN catalogs [3,4].

By using the nature of galaxy clustering, it is possible to measure in a statistical way the color distribution of galaxies associated with AGNs without knowing the redshift of galaxies if redshifts of the AGNs are known. That is, by measuring the color distributions at high density region around AGN (< 1 Mpc; on region) and at lower density region (3–5 Mpc; off region), and subtracting latter from former, we can obtain the color distribution of the clustering galaxies. The color was measured by fitting the galaxy's spectral energy distribution (SED) to the synthesis model of SED calculated assuming its redshift to be the same as the AGN redshift.

The color distributions obtained in this way are shown in Figure 1. The larger color index ($D_{\text{opt-IR}}$) corresponds to redder color. The top panel is for lower mass BHs ($\log(M_{\text{BH}}/M_\odot) = 7.5$–$9.0$) and the bottom panel is for the most massive BHs ($\log(M_{\text{BH}}/M_\odot) = 9.0$–$10.0$). The redshift range is 0.3–0.6 and the number of AGNs used to derive them is 289 for both. The color distribution is approximated by a double Gaussian distribution, and each Gaussian component is related to a red or blue galaxy. The vertical axis is proportional to the clustering strength, so the relative clustering strength of each component can be inferred from the area of the distribution. By measuring the mixing ratio of the two components, we have obtained the red galaxy fraction of ~60±10 % for lower mass sample and > 90 % for the most massive sample. From this result, we revealed that the environment of the most massive BHs is enriched with red galaxies in which star formation is terminated, which indicates that there is a link between the termination of star formation and the growth of the most massive BHs.

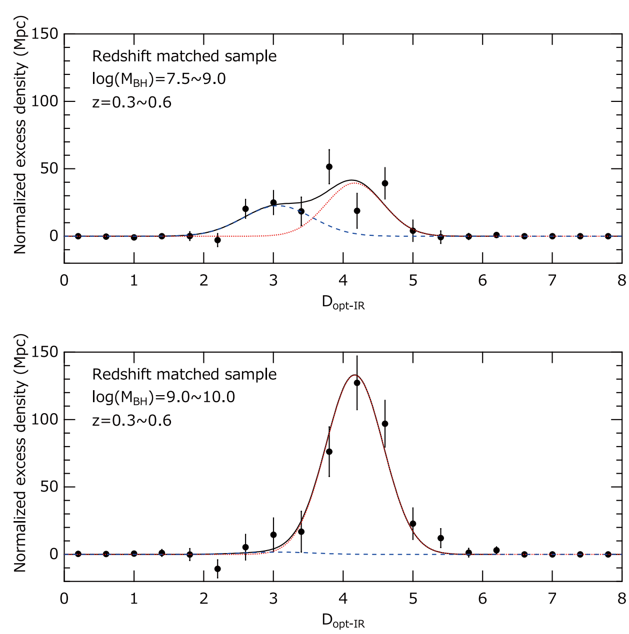

Figure 1: Color distributions of galaxies around AGNs.

References

[1] Komiya, Y., et al.: 2013, *ApJ*, **775**, 43.
[2] Shirasaki, Y., et al.: 2016, *PASJ*, **68**, 23.
[3] Greene, J. E., Ho, L. C.: 2007, *ApJ*, **667**, 131.
[4] Shen, Y., et al.: 2011, *ApJS*, **194**, 45.

The 1.1 mm Continuum Survey of the Small Magellanic Cloud: Physical Properties and Evolution of the Dust-selected Clouds

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The Small Magellanic Cloud (SMC) is a dwarf galaxy that provides a unique opportunity to study the physics of the interstellar medium (ISM) because of its proximity (~60 kpc) and low metallicity (~1/5 $Z_{\odot}$). These peculiarities make the SMC an ideal laboratory to investigate the physics of the ISM under the extreme conditions such as galaxies forming in the early Universe. Previously, observations of giant molecular clouds (GMCs) in the SMC has been conducted by CO lines (e.g., [1]). On the other hand, recent study suggests that, in a low-metallicity environment, the fraction of "CO-dark" gas in the GMCs can be a dominant component [2]. Therefore, it is essential to investigate GMCs in low-metallicity environments by means other than CO line observations, and dust continuum observations using a submillimeter imager can provide an alternative method to investigate the GMC.

In this study, we conducted a 1.1 mm continuum survey using the AzTEC instrument on the ASTE telescope to investigate the physical properties of the GMCs in the SMC. The observations covered a total of a 4.5 deg^2 field of the SMC, and noise levels of 5–12 mJy beam^{-1} are achieved with a effective resolution of 40″, which corresponds to 12 pc.

Figure 1 shows the obtained 1.1 mm continuum map. Most of the representative star-forming regions in the SMC, such as N27, N66, N81, N83, N84, and N88, were detected with sufficient S/N ratios of > 10 at the peak positions. We identified a total of 44 objects, and the physical properties were derived by the SED analysis under the assumption of single-temperature thermal dust emission using 1.1 mm and *Herschel* bands. As the result, the 1.1 mm objects displayed masses of 4×10^3–3×10^5 $M_{\odot}$, and dust temperatures of 17–45 K.

We found three important facts from the detail investigation of the 1.1 mm objects. First, the dust temperature of the 1.1 mm objects show good correlation with the *Spitzer* 24 μm, and this supports that the heating source of the cold dust is mainly local star-formation activity. Second, the 1.1 mm objects in the SMC should trace dense gas objects corresponding to the GMC in our galaxy or nearby galaxies, because the mass, size, density, and mass function are very similar to those of GMCs in our galaxy and the Large Magellanic Cloud. In addition, the 1.1 mm objects displayed good spatial correlation with the 24 μm and CO emission. Third, the classification of the 1.1 mm objects in terms of star-formation activity revealed that the starless objects harbor lower dust temperatures and smaller gas masses and radii compared to those of the star-forming objects, suggesting that starless objects are younger evolution phase of the GMC.

These results were published in the Astrophysical Journal [3].

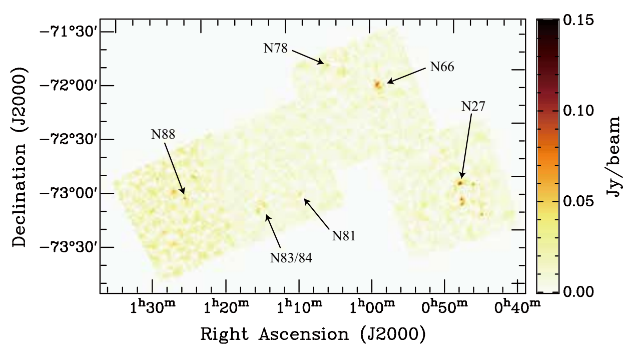

Figure 1: The 1.1 mm continuum map of the SMC.

References

[1] Mizuno, N., et al.: 2001, *PASJ*, **53**, L45.
[2] Glover, S. C. O., Clark, P. C.: 2012, *MNRAS*, **426**, 377.
[3] Takekoshi, T., et al.: 2017, *ApJ*, **835**, 55.

Circumstellar and Explosion Properties of Type Ibn Supernovae

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Type Ibn supernovae (SNe) are SNe with narrow helium emission lines and they are a subtype of Type Ib SNe. The narrow emission lines typically have the velocity of about 1000 km/s and the velocity is too small to originate from SN ejecta. Therefore, the narrow lines are considered to originate from dense circumstellar media (CSM) around the progenitors and Type Ibn SNe appear when the progenitors of Type Ib SNe (Wolf-Rayet stars) somehow experience huge mass loss shortly before their explosions. Studying Type Ibn SNe are important to understand the mass loss from massive stars that are not understood well. There are many studies of Type IIn SNe that show narrow hydrogen emission lines but few studies are performed for Type Ibn SNe.

So far, individual Type Ibn SNe have been studied in details but no studies are performed to have a general picture of Type Ibn SNe. Therefore, we gathered all the available Type Ibn SNe in the literature and investigated their general properties. We got the following findings [1]. Figs. 1 and 2 summarize the light curves (LCs).

First, the peak luminosities of Type Ibn SNe are higher than normal Type Ib SNe on average. This can be explained by the existence of dense CSM. If the SN ejecta collide to the dense CSM, kinetic energy of the SN ejecta can be efficiently converted to radiation. Therefore, Type Ibn SNe have a different luminosity source than Type Ib SNe that are powered by the nuclear decay of ^{56}Ni.

Secondly, the amount of ^{56}Ni produced by the explosions is found to be less in Type Ibn SNe than Type Ib SNe. The amount of ^{56}Ni can be constrained by the late-phase LCs. Type Ibn SNe are brighter than Type Ib SNe at around the peak but Type Ibn SNe become fainter than Type Ib SNe at the late phase. Therefore, the amount of ^{56}Ni produced in Type Ibn SNe are smaller than that in Type~Ib SNe. This may be due to the smaller ^{56}Ni production at the explosions or large fallback.

Finally, we found Type Ibn SNe are bright for much shorter periods than Type IIn SNe. Both Type Ibn and Type IIn SNe are considered to be powered by the interaction between SN ejecta and dense CSM. Because Type IIn SNe are bright for more than 100 days due to the long-lasting interaction, their progenitors somehow need to have high mass-loss rates at least for 100 years before their explosions. However, Type Ibn SNe shine only for several tens of days and their CSM do not extend as in Type IIn SNe. Type Ibn SNe and Type IIn SNe are estimated to have similar CSM densities but their progenitors' enhanced mass-loss periods may significantly differ, which may indicate their mass-loss mechanisms are different even though both SNe are characterized by the narrow emission lines.

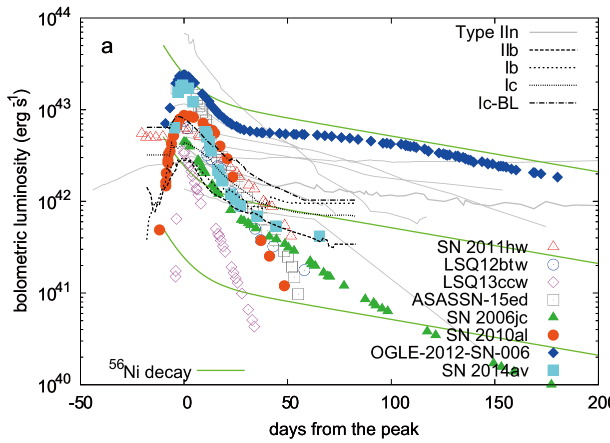

Figure 1: LCs of Type Ibn SNe and other SNe.

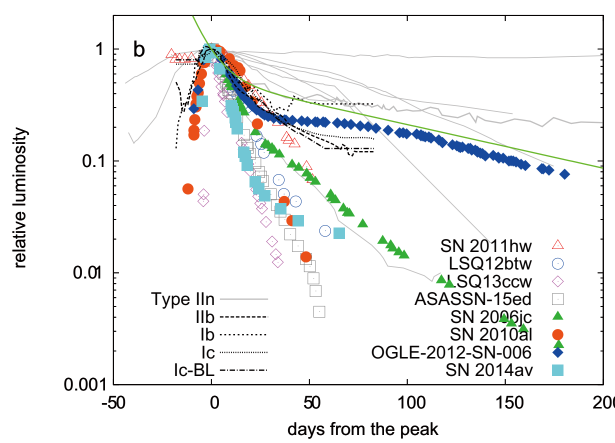

Figure 2: The same as Fig. 1 but scaled at the peak luminosity.

Reference

[1] Moriya, T. J., Maeda, K.: 2016, *ApJ*, **824**, 100.

Radio Transients Associated with Accretion-induced Collapse of White Dwarfs

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Accretion-induced collapse (AIC) is a theoretically predicted fate of white dwarfs (WDs). If a WD composed of oxygen, neon, and magnesium has a companion star which accretes matter onto the WD, the WD's mass can eventually become close to the Chandrasekhar mass limit. At this moment, the electron-capture reactions of magnesium can be triggered at the WD center and the WD collapses to be a neutron star (NS). (When a WD composed of carbon and oxygen becomes closer to the Chandrasekhar mass limit, the explosive burning of carbon leads to Type Ia supernovae). Merger of two WDs can also lead to the formation of a NS if a WD is left after the merger. For example, if a WD heavier than the Chandrasekhar mass limit that is composed of carbon and oxygen is formed after the merger and a carbon burning flame propagates from the surface to the center of the new massive WD, the WD is eventually composed of oxygen, neon, and magnesium. When the temperature becomes sufficiently low and the central density becomes high enough, the electron-capture reactions of magnesium can be triggered to transform the WD to a NS.

It is known that AIC ejects less than 0.1 $M_\odot$. However, little amount of radio active elements like ^{56}Ni are contained in the ejecta and AIC is considered not to be accompanied by a bright transient. However, the velocity of the ejecta from AIC is more than a few times faster than that in typical supernovae. The fast shock can accelerate electrons and the shock can be bright in radio thanks to the synchrotron emission from the accelerated electrons. In this study, radio light curves (LCs) of AIC that has fast shock waves are investigated.

Fig. 1 is an example of radio LCs obtained in this study [1]. The maximum peak luminosities in radio from SNe are about 10^{28} erg s^{-1} Hz^{-1}. Therefore, AIC can be as bright as or even brighter than SNe in radio wavelengths. AIC does not become bright in optical so transients very faint in optical but very bright in radio are promising candidates of AIC.

Because AIC is bright in radio, AIC can be discovered by performing transient surveys in radio. However, the expected event rate of AIC is small and a deep and wide radio transient survey is required to find it. We investigate expected numbers of AIC detections in the future planned radio transient surveys. As a result, we found that a planned transient survey with Square Kilometer Array can find a few AIC in a year. If we are able to perform a radio transient survey with a optical transient survey, we can efficiently discover radio-bright but optical-faint transients that are promising candidates of AIC.

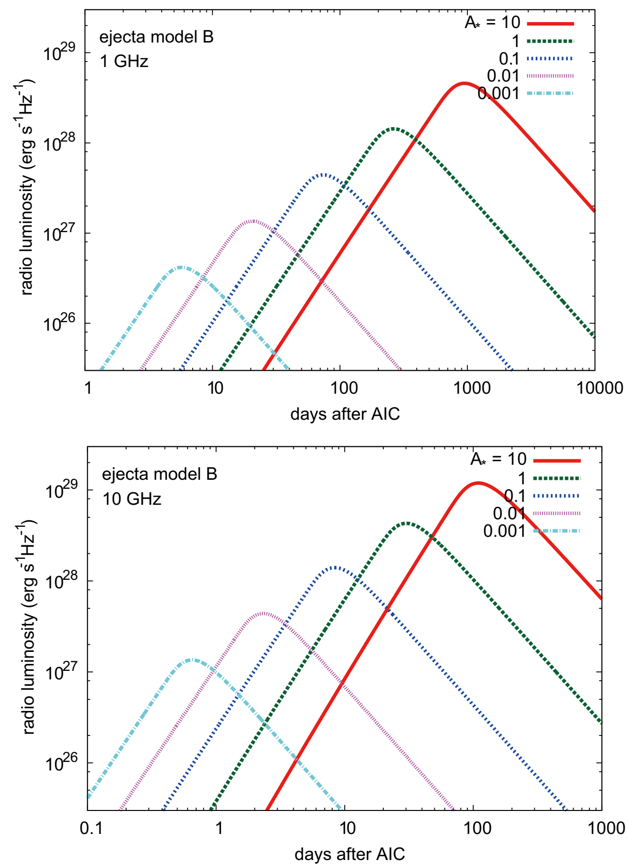

Figure 1: Examples of radio LCs of AIC at 1 and 10 GHz. $A_\star$=1 corresponds to AIC that explodes with in a circumstellar medium made by the mass-loss rate of $10^{-5}\,M_\odot\,\mathrm{yr}^{-1}$ and the wind velocity of 1000 km/s. $A_\star$ is proportional to the mass-loss rate and is inversely proportional to the wind velocity.

Reference

[1] Moriya, T. J.: 2016, *ApJL*, **830**, L38.

Supernovae Powered by Magnetars That Transform into Black Holes

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New kinds of supernovae (SNe) are starting to be discovered thanks to the recent large transient surveys. One of them is so-called superluminous SNe that are more than about 10 times brighter than normal SNe. The mechanism to make superluminous SNe so bright is not yet revealed. The most popular model is to make SNe superluminous with rapidly-rotating strongly-magnetized neutron stars (magnetars) that are formed during the SN explosions. If a magnetar that has a rotation period of less than a few ms and a dipole magnetic field of about 10^{14} G is formed during a SN explosion, the rotation energy of the magnetar (about 10^{52} erg) is released as a dipole radiation in a timescale of several days. It is known that observational properties of superluminous SNe can be explained if the magnetar can release its rotational energy and the released energy is efficiently thermalized.

Neutron stars have the maximum mass to support themselves and the neutron stars whose mass exceeds the maximum mass transform into black holes. The maximum mass depends on the rotation velocity of neutron stars. The maximum mass of non-rotating neutron stars is about 2.2 $M_\odot$ and that of rapidly-rotating neutron stars is about 2.7 $M_\odot$, depending on the equation of state. If a magnetar whose mass is between about 2.2 $M_\odot$ and about 2.7 $M_\odot$ is formed during a SN explosion, it can heat up the SN at first when it rotates rapidly. However, when it loses a lot of rotational energy and its rotational energy becomes less than that required to support itself, the magnetar transforms into a black hole and the SN suddenly loses its central heating source. In this study, we investigate observational properties of such SNe that are powered by magnetars that need rotational energy to support themselves and suddenly lose their central heating source due to the black-hole formation [1].

Fig. 1 presents how SN light curves (LCs) are affected by the transformation of magnetars into black holes. Because the black-hole formation leads to the sudden loss of the central heating sources, LCs become fainter when the black-hole formation occurs. In addition, if the black holes are formed shortly after the SN explosion, the shock breakout signals caused by the shock wave launched by the magnetar energy input can be clearly seen in the LCs.

Fig. 2 shows comparisons between LCs of the SNe powered by magnetars transforming into black holes and those of some observed SNe. SNe powered by magnetars that transform into black holes do not become as bright as superluminous SNe but their LCs are consistent with those of recently-found rapidly-evolving transients that have the peak luminosities between superluminous SNe and normal SNe.

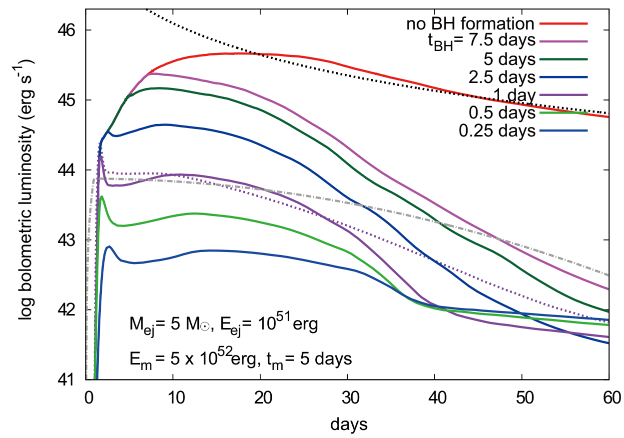

Figure 1: SN LCs in which magnetars powering the SNe transform into black holes. t_{BH} is the time when magnetars transform into black holes.

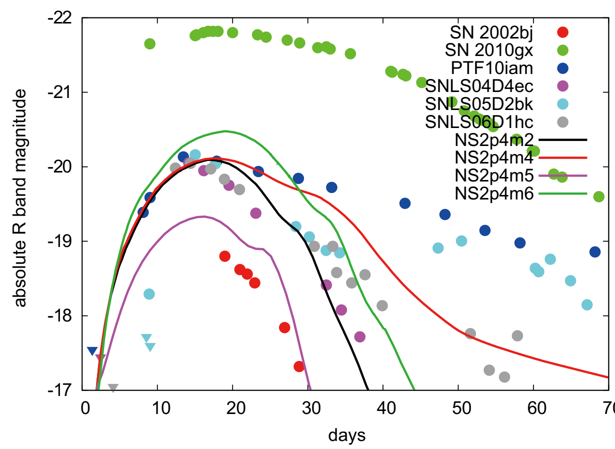

Figure 2: Comparison between model SN LCs in which magnetars powering the SNe transform into black holes and some observed SN LCs.

Reference

[1] Moriya, T. J., Metzger, B. D., Blinnikov, S. I.: 2016, *ApJ*, **833**, 64.

Properties of Magnetars Mimicking ^{56}Ni

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LANGER, Norbert (University of Bonn)

Recent large-scale transient surveys revealed the existence of extremely luminous supernovae (SNe) that are called superluminous SNe. The luminosities of canonical SNe can be explained by the energy provided by the nuclear decay of ^{56}Ni that is synthesized during the SN explosions. However, while the required amount of ^{56}Ni to explain the luminosities of canonical SNe is of the order of 0.1 $M_\odot$ at most, superluminous SNe require more than 5 $M_\odot$ of ^{56}Ni to account for their luminosities. It is difficult to synthesize this amount of ^{56}Ni during the SN explosions. Thus, to replace the ^{56}Ni heating mechanism, an alternative scenario to explain the huge luminosities of superluminous SNe, i.e., the formation of the rapidly-rotating strongly-magnetized neutron stars (magnetars) that can release their huge rotational energy through the radiation caused by the strong magnetic fields and efficiently thermalize the radiation is suggested. On the other hand, if we look into the light curves (LCs) of superluminous SNe, it is known that the decline rates of their LCs are often consistent with that is expected from the nuclear decay of ^{56}Co made by the nuclear decay of ^{56}Ni. Thus, if magnetars are actually the major heating source to make superluminous SNe bright, magnetars should be able to reproduce the LC decline rates that are consistent with those of ^{56}Co. In this study, we investigated the conditions for magnetars to reproduce SN LCs that look as if they are powered by ^{56}Ni [1]. As a result, it is found that magnetars need to emit their radiation almost by the pure dipole radiation to mimic ^{56}Ni. In addition, it is found that, for magnetars that release their rotational energy through dipole radiation to mimic a LC powered by a certain amount of ^{56}Ni, only their dipole magnetic fields need to be in a certain range and the condition does not depend on their initial rotational periods. In Fig. 1, we present the require magnetic field strength to mimic a given amount of ^{56}Ni. For example, a typical amount of ^{56}Ni required to explain the peak luminosities of superluminous SNe are about 10 $M_\odot$ and it can be found that about 10^{14} G is required for magnetars to mimic LCs powered by this amount of ^{56}Ni. Interestingly, the required magnetic field strengths for magnetars to explain the early LCs of superluminous SNe are also about 10^{14} G. Fig. 2 shows rise times and peak luminosities of SN LCs that can be powered by magnetars as if ^{56}Ni is powering them. The gray region indicates all the LC properties that magnetars can mimic ^{56}Ni. However, if a LC requires more ^{56}Ni than ejecta, for example, we can clearly say that the LC is not powered by ^{56}Ni. If we exclude this kind of region, the black region remains. In other words, the SN LCs that fall into the black region may actually be powered by magnetars even if they look as if they are powered by ^{56}Ni. The dots in Fig. 2 are LC properties of superluminous SNe and they locate in the region where magnetars can mimic ^{56}Ni.

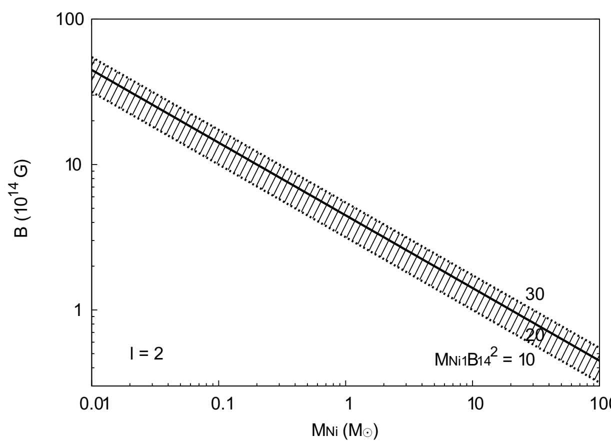

Figure 1: Dipole magnetic fields that magnetars require to mimic given amounts of ^{56}Ni.

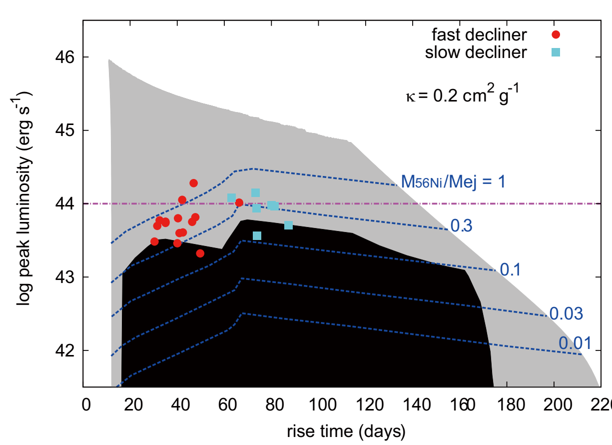

Figure 2: SN LC properties for which magnetars can power like ^{56}Ni.

Reference

[1] Moriya, T. J., Chen, T.-W., Langer, N.: 2017, *ApJ*, **835**, 177.

Catalog of Ultra Diffuse Galaxies in the Coma Cluster

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Ultra Diffuse Galaxy(UDG) is a new category of galaxy population proposed by [1]. They are low surface brightness galaxies (LSBs) with a large spatial extents. [1] adopted the selection criteria that the central surface brightness in g-band is fainter than 24 mag/arcsec^2 and the effective radius (half-light radius) is larger than 1.5 kpc. They reported 48 UDGs in the Coma cluster. If we assume a typical mass-to-luminosity ratio of galaxies, UDGs in cluster environment cannot maintain their large extensions by their self-gravity alone. Thus, they are expected to have a lot of dark matter. The nature of UDGs (e.g., their formation mechanism) is still full of mysteries.

We analyzed wide survey data of the Coma cluster in R-band obtained with the Subaru Prime Focus Camera(Suprime-Cam) in the public archive data of SMOKA [2]. UDGs were detected with high S/N in the Suprime-Cam data [2]. As the spatial resolution is much higher in data used in [2] than that of [1], we can resolve UDGs near brighter neighbors. We also detected the region near the cluster center where background lights and the bright tails of galaxies affect. Though the observed band is different, [2] detected 854 UDGs in the Coma cluster. We also revisited the other data of our own (e.g., [3]) that overlap the survey region. Our previous studies didn't pay special attention to this galaxy population, as their foci were on the statistical nature of the galaxies in the cluster (e.g., luminosity function) not on individual galaxy types. We obtained color information of a subset of the UDGs from the previous studies.

After [2], we continued the study and reported the UDG catalog as [4] with several new results. The radial density profile of UDGs is comparable to that of high surface-brightness members in general, but a sign of excess of UDGs exists at 1.0–1.7 Mpc from the center (Figure 1). We also found that the major axes of UDGs tend to align to the radial direction toward the galaxy center, which is statistically significant. The Coma cluster is elongated along the large-scale filament toward the southwest, and the radial alignment of UDGs are significantly high around the direction (Figure 2).

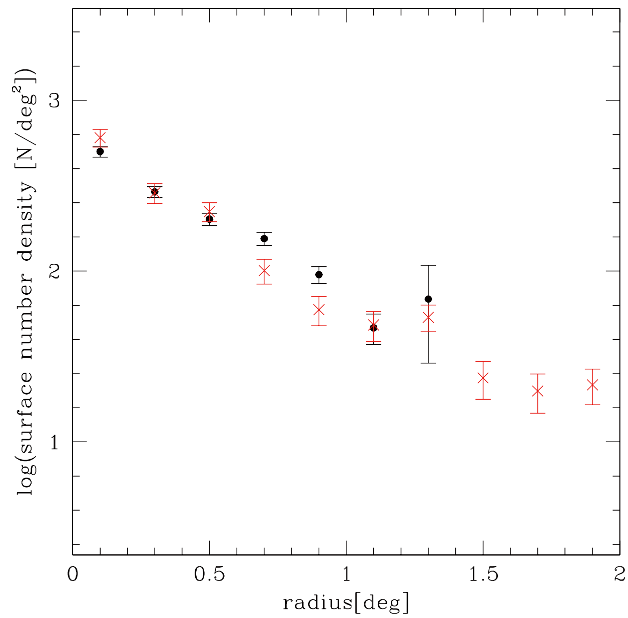

Figure 1: The radial profile of the galaxy number density of UDGs (black dots), and member galaxies from SDSS DR7 (red Xs; shifted by +0.5 dex for comparison.) The overdensity of UDGs around 0.6–1.0 degree (1.0–1.7 Mpc) is recognized.

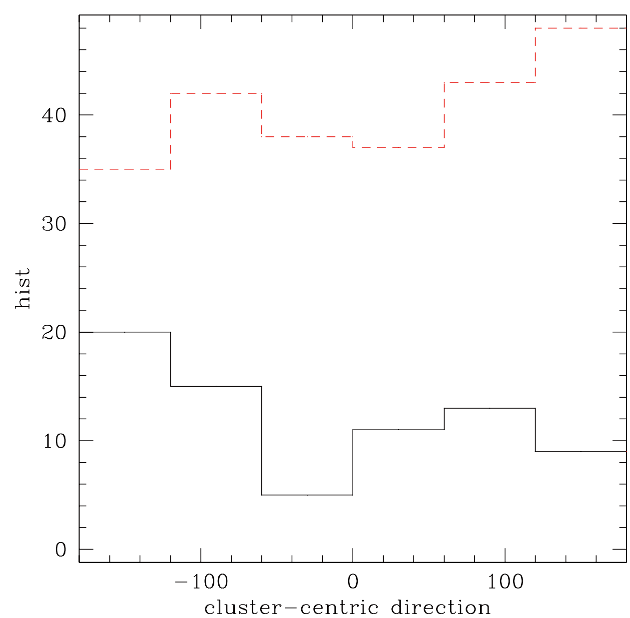

Figure 2: Histograms of the azimuthal angle of UDG positions from the cluster center. UDGs elongated along the radial direction toward the cluster center are shown in black, and and others are in red. The number of the elongated UDGs are significantly large around −150(southwest) direction.

References

[1] van Dokkum, P., et al.: 2015, *ApJL*, **798**, L45.
[2] Koda, J., et al.: 2015, *ApJL*, **807**, L2.
[3] Yamanoi, H., et al.: 2012, *AJ*, **144**, 40.
[4] Yagi, M., et al.: 2016, *ApJS*, **225**, 11.

Lyα Rate of UV-bright Star-forming Galaxies at Redshift 7

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SHIMASAKU, Kazuhiro[5], TAKATA, Tadafumi[2/1], SEKIGUCHI, Kazuhiro[2/1], NAITO, Yoshiaki[5]
FURUSAWA, Junko[1], OUCHI, Masami[5], NAKATA, Fumiaki[1], YASUDA, Naoki[5], OKURA, Yuki[6]
TANIGUCHI, Yoshiaki[7], YAMADA, Toru[8], KAJISAWA, Masaru[9], FYNBO, Johan P. U.[10], Le FÈVRE, Olivier[11]

1: NAOJ, 2: Graduate University for Advanced Studies, 3: National Institute of Technology, Kure College, 4: Edinburgh University, 5: University of Tokyo, 6: Riken, 7: The Open University of Japan, 8: ISAS, 9: Ehime University, 10: Copenhagen University, 11: LAM

We perform a survey of star-formaing galaxies that are very bright in UV luminosities at redshift 7. Follow-up spectroscopy on these high-z galaxies is conducted, determining rest-frame equivalent widths (EW_0s) of the Lyα emissions, and the Lyα rate, which is a franction of star-formation galaxies showing strong Lyα emission of these galaxies [1]. Recent observational studies have revealed that the number density of bright star-formation galaxies may be larger than expected in previous observations. Also, the very bright galaxies may include metal-poor galaxies comprising a primordial stellar population [2]. It is crucial to increase the sample volume of such bright galaxies to discuss galaxy formation at this epoch.

We select star-forming galaxies (LBGs) using the public near-infrared (NIR) data set by UKIRT-UKIDSS and VISTA-UltraVISTA($J = 25.5$; 5σ) covering 1.65 square degrees. In order to apply z-dropout search, we conduct very deep z'-band imaging ($z \sim 26.5$; 5σ) with Subaru/Suprime-Cam. This data set enables us to investigate the very-bright LBGs at $z = 7$ with quite a low number density. We find 18 candidates of very bright galaxies ($M_{UV} < -21.75$). An optical follow-up spectroscopy was performed with Subaru/FOCAS on 9 candidates, in which a galaxy shows possible Lyα emission at $z = 7.168$ at S/N = 5.5 with EW_0 = 3.7 Å (Fig. 1). The other candidates show no significant emission lines ($EW_0 < 10$ Å).

Previous studies have suggested that the Lyα rate increases from $z = 4$ to $z = 6$. The Lyα rate is higher and more rapidly increases towards high redshifts for fainter star-forming galaxies. For galaxies with $M_{UV} > -21.75$, the Lyα rate may stop increasing and possibly decrease from $z = 6$ to $z \sim 7$ [3]. Our study for the first time discusses the Lyα rate ($EW_0 > 50$ or 55) for the very bright galaxies ($-23 < M_{UV} < -21.75$) (Fig. 2), deriving the following results: (1) An increase of the Lyα rate of the very-bright galaxies may level off at $z = 7$ and may be close to or lower than that at $z = 4$–6. (2) The Lyα rate of the very-bright galaxies at $z = 7$ may be at the same level or higher than that for fainter galaxies ($M_{UV} > -21.75$) at the same redshifts.

The very-bright galaxies are also important components to discuss cosmic reionization. The EW_0 distribution of our very-bright galaxy sample implies high neutral hydrogen rate at $z = 7$. An increase of a sample volume of the very-bright galaxies at this epoch is desiable to statistaically understand formation and evolution history and roles of this very bright population in the reionization.

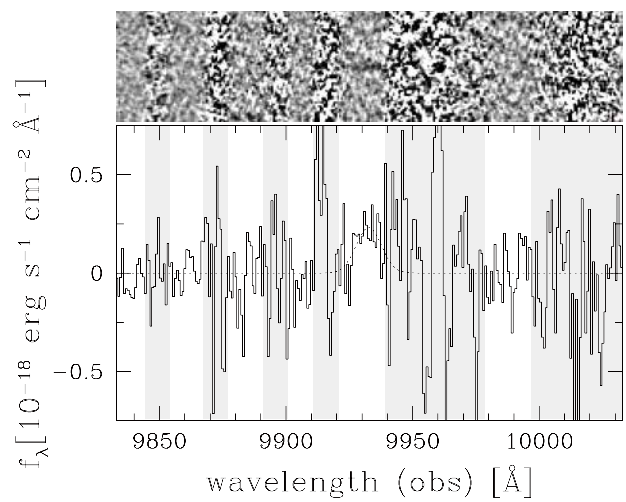

Figure 1: Spectrum of a Lyα emitter at z = 7.168.

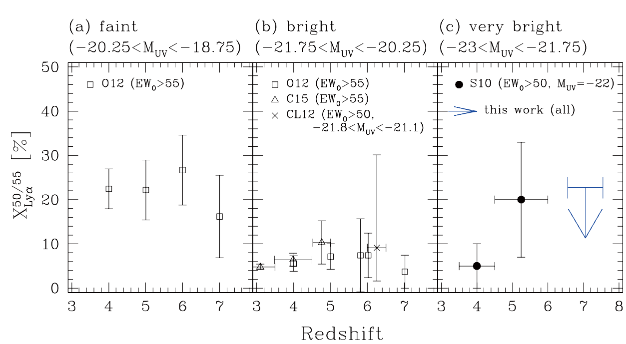

Figure 2: Evolution of Lyα rate in different magnitude ranges.

References

[1] Furusawa, H., et al.: 2016, *ApJ*, **822**, 46.
[2] Sobral, D., et al.: 2015, *ApJ*, **808**, 139.
[3] Ono, Y., et al.: 2012, *ApJ*, **744**, 83.

A Spectroscopically Confirmed Double Source Plane Lens System in the Hyper Suprime-Cam Subaru Strategic Program

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1: NAOJ, 2: Kavli Institute for the Physics and Mathematics of the universe (Kavli IPMU, WPI), 3: University of Kyoto, 4: Steward Observatory, University of Arizona, 5: University of Tokyo, 6: Research Center for the Early universe, University of Tokyo, 7: Max Planck Institute for Astrophysics, 8: Institute of Astronomy and Astrophysics, Academia Sinica, 9: Institute for Cosmic Ray Research, The University of Tokyo, 10: SOKENDAI (The Graduate University for Advanced Studies), 11: Japan Women's University, 12: Hiroshima Astrophysical Science Center, Hiroshima University

Strong gravitational lensing of distant objects provides us with powerful constrains on the matter distribution of the lens galaxy. The vast majority of the known strong lensing systems have a single background source, but in very rare cases, two background sources can be simultaneously lensed by the same foreground galaxy. Such double source-plane lens systems are extremely rare, but they are a very valuable probe of cosmology as they are sensitive to the cosmic expansion.

Currently, there are only a few known double source-plane lens systems. We have discovered another one in Hyper Suprime-Cam Subaru Strategic Program (HSC-SSP) as reported in Tanaka et al. [1]. Fig. 1 shows the system. The lens galaxy at the center is a very massive galaxy at $z = 0.79$ likely at the center of a cluster. On the bottom-right of the lens, there is a red arc (S1) with a counter image just on the left of the lens galaxy (H). The second source is the blue Einstein ring (S2) with several knots (A-G). The system is dubbed 'Eye of Horus' due to its resemblance to the symbol of ancient Egyptian god.

We have made a follow-up spectroscopic observation of the background sources with FIRE on Magellan. We confirm that the red inner arc is a galaxy at $z = 1.3$ and the blue ring at $z = 2.0$ using several emission lines from the galaxies. In all of the previously known systems, the second galaxy is too faint to confirm spectroscopically. Our system is the first double source-plane lens system with spectroscopic redshifts of both sources. This is important because the spectroscopic redshifts are essential to derive cosmological constraints from the system.

We have modeled the system with two independent methods. Both models successfully reproduce the overall configuration of the system. However, any smooth models do not reproduce the A+C split, implying the existence of a subhalo or foreground structure. We do not observe a clear hint of a satellite galaxy in the HSC images, but we have been awarded further follow-up observations with ALMA and LGSAO-assisted near-IR imaging observations. These observations may be able to detect the satellite galaxy responsible for the split, allowing us to model the system more precisely.

We expect to find 10 more such double source-plane lens systems in HSC-SSP. Combining all of them together, we expect to place a very strong, highly complementary constraints to other probes on the cosmological parameters.

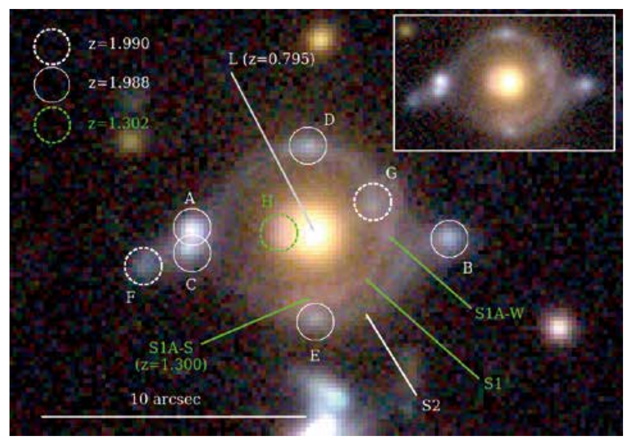

Figure 1: Pseudo-color image of the lens system. The prominent knots in inner arc (green) and outer ring (white) are labeled and the measured spectroscopic redshifts are indicated. The inset shows the image without symbols. The horizontal bar shows a scale of 10 arcsec.

Reference

[1] Tanaka, M., et al.: 2016, *ApJL*, **826**, L19.

Thermo-optical Simulation and Experiment for the Assessment of Single, Hollow, and Large Aperture Retroreflector for LLR

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1: NAOJ, 2: NICT, 3: Iwate University, 4: Hitotsubashi University, 5: PTI Co., Ltd., 6: JAXA, 7: Chiba Institute of Technology

Lunar laser ranging (LLR) has made a significant contribution especially to Selenodesy and General Relativity. The accuracy of LLR is less than 2 cm due to the improvement of the ground station. However, the lunar retroreflector has room for improvement on the ranging accuracy [1].

The single element retroreflector (SERR) has an advantage on the accuracy over the arrayed corner cube on the Moon because it has no internal optical path difference. SERR whose aperture is 20 cm can yield two times reflection performance compared with the A15 retroreflector [2]. Thus we investigated the thermal deformation and optical degradation of the hollow type SERR (hereafter CCM; Corner Cube Mirror) with 20 cm aperture through the thermo-optical simulation, because the prism type SERR with the same aperture made of synthetic quarts shows severe optical degradation due to the inhomogeneity of the refractive index as well as the weight problem.

Mathematical model of CCM (Figure 1) is prepared on the lunar surface with its optical axis aligned to the Earth at −43.3 degrees in the lunar latitude (the same latitude as Tycho crater) to simulate the equilibrium temperature and thermal deformation of the CCM. Single crystal silicon (Si) and the CLEARCERAM™-Z EX (OHARA Inc.; hereafter CCZ-EX®) are selected as CCM material for higher thermal diffusivity, lower thermal expansion, and higher specific stiffness. Other parts are made of carbon fiber reinforced plastics (CFRP). Thermal Desktop®, ANSYS®12, and CodeV10.6SR1 are used for the temperature, deformation, and optical evaluation, respectively.

The deformation of CCM is 40–50 μm (Si) or 1 μm (CCZ-EX®) at the lunar noon if the CCM is fixed perfectly to the structure on multi-points, while the deformation is less than 0.25 μm at most if the perfectly fixed point of the CCM is limited to one. The optical performance of the former CCM is quite poor (Strehl ratio < 0.1; Figure 2), while it is excellent for the latter case (Strehl ratio > 0.9; Figure 2). Through this simulation, it has turned out for the first time that 20-cm aperture CCM made of single-crystal Si or "ultra-low expansion glass–ceramics" such as CCZ-EX® can be used for CCM with no thermal control if the perfectly fixed point of CCM is limited to one.

In addition, high temperature annealing from 100 to 1000 °C is confirmed effective experimentally to enhance the adhesive strength between optically contacted Si surfaces, which is an important knowledge for the fabrication process of CCM.

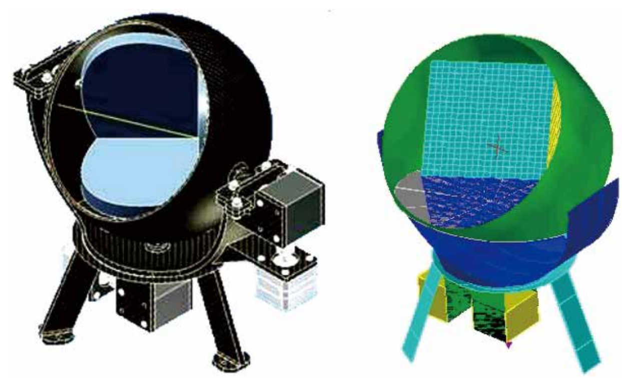

Figure 1: [left] General view of the CCM system. [right] Mathematical model of the CCM system for Thermal Desktop®. CCM aperture is 20 cm.

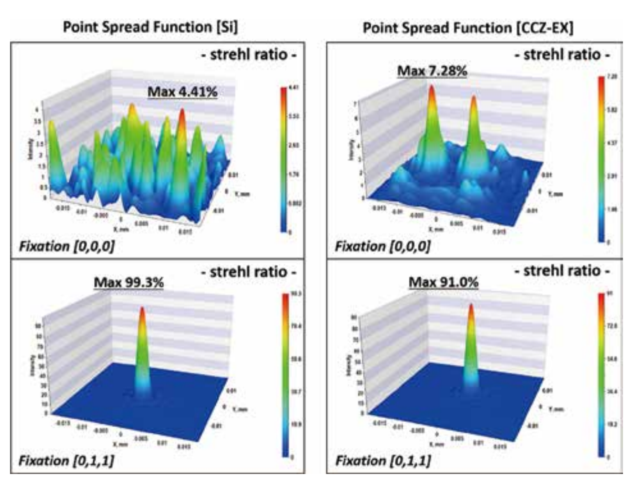

Figure 2: Strehl ratios of the aberrated focus image by CCM. [Upper left] CCM made of Si fixed on 3 points perfectly. [Lower left] CCM made of Si fixed on 3 points and one of them is perfectly. [Upper right] CCM made of CCZ-EX® fixed on 3 points perfectly. [Lower right] CCM made of CCZ-EX® fixed on 3 points and one of them is perfectly.

References

[1] Araki, H., et al.: 2016, *Earth Planets Space*, **68**, 101.
[2] Otsubo, T., et al.: 2011, *Earth Planets Space*, **63**, e13-16.

The Far Distance to G7.47+0.06 from Proper Motion Measurement of H_2O Masers

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We report a distance measurement of an ultra-compact H_{II} region G7.47+0.06 associated with IRAS 17591-2228. The kinematic distances obtained from its radial velocity suggest that G7.47+0.06 may be farther away than the distance between the Galactic center and the Sun, ≈ 8 kpc (e.g., $25.1^{+10.8}_{-4.2}$ kpc, Wink et al. 1982 [1]).

We applied a new method to determine a source distance based on absolute proper motions proposed by Sofue (2011) [2]. Given a rotation curve, and assuming circular motion of an object, a distance to the object is obtained from not only the radial velocity but also the proper motion kinematically. The distance of an object with its galactic longitude $l \approx 0°$ located farther from the Galactic center than seen from the Sun is more accurately obtained by using the proper motion rather than using the radial velocity.

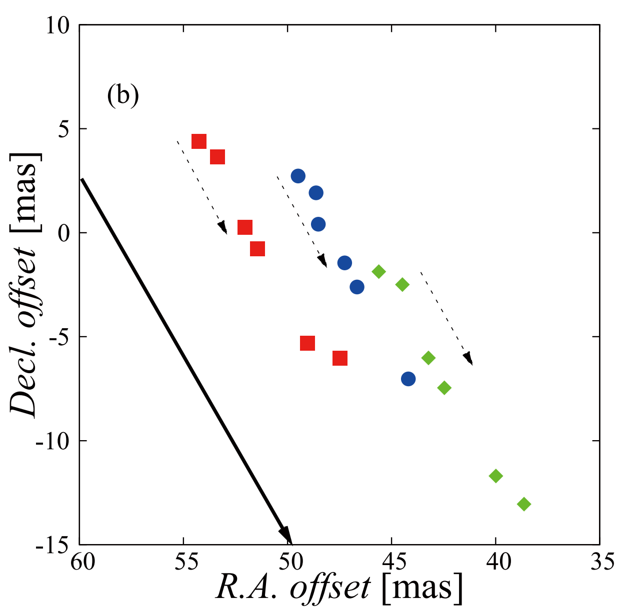

Figure 1: Yamauchi et al. (2016) [3]. Distribution of maser features ($v_{LSR} = -17 - -15$ km s^{-1}) throughout all epochs. Thin dashed arrows indicate proper motions per year of individual maser features. A thick arrow is parallel to the Galactic plane, and its head points to the Galactic center.

Observations of the 22-GHz H_2O maser line associated with G7.47+0.06 were conducted with VERA (VLBI Exploration of Radio Astrometry) from 2009 March to 2011 December. As a result of analysis, it turned out to be difficult to derive the distance from annual parallax measurement. Meanwhile, we clearly detected the source's proper motion parallel to the Galactic plane. The proper motion is $\mu = -5.03 \pm 0.07$ mas yr^{-1} and is approaching the Galactic center (Figure 1).

Considering uncertainties of the Galactic rotation curve and the solar peculiar motion, the detected proper motion leads to a source distance of $D = 20 \pm 2$ kpc (Figure 2), demonstrating that astrometric observation can provide an accurate distance measurement at 10 % level even for sources too far to measure the annual parallax.

Garay et al. (1993) estimated the physical parameters of the H_{II} region using the near kinematic distance of $D = 6.3$ kpc [4]. Scaling their parameters from $D = 6.3$ kpc to 20 kpc, the H_2O maser features are associated with a massive star-forming region corresponding to the spectral type of O5.5.

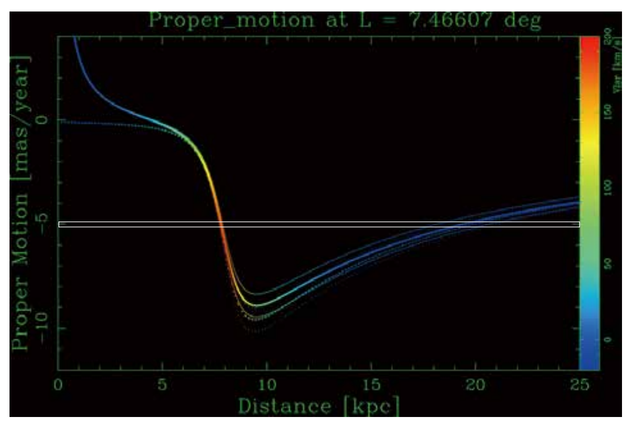

Figure 2: Yamauchi et al. (2016) [3]. Proper motion as a function of distance. Color scale indicates line-of-sight velocity. Dashed curves indicate the distances from the LSR in the cases of flat rotation. Solid curves indicate the distance from the Sun in the case of $\Theta = \Theta_0 (R/R_0)^{\alpha}$ and $\alpha = 0.05$. The intersections of the curves and a white rectangle corresponding to $\mu = -5.03 \pm 0.07$ mas yr^{-1} give a source distance.

References

[1] Wink, J. E., Altenhoff, W. J., Mezger, P. G.: 1982, *A&A*, **108**, 227.
[2] Sofue, Y.: 2011, *PASJ*, **63**, 81.
[3] Yamauchi, A., et al.: 2016, *PASJ*, **68**, 60.
[4] Garay, G., et al.: 1993, *ApJ*, **413**, 368.

Enhanced Star Formation of Less Massive Galaxies in a Proto-Cluster at $z = 2.5$

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We investigate a correlation between star-formation rate (SFR) and stellar mass for Hα emission line galaxies (HAEs) in one of the richest proto-clusters ever known at $z \sim 2.5$, USS 1558-003 proto-cluster. A positive correlation between SFR and stellar mass in star-forming galaxies is called the main sequence of star-forming galaxies. The well-known tight correlation provides us with perspectives of how the star-forming galaxies evolve over cosmic time. We find that while the star-forming galaxies with $> 10^{9.3}\,M_\odot$ are located on the universal SFR-mass main sequence irrespective of the environment, less massive star-forming galaxies with $< 10^{9.3}\,M_\odot$ show a significant upward scatter from the main sequence in this proto-cluster (see Figure 1). We here summarize the results. Please refer to [1] for more details.

This study is based on a 9.7-hour narrow-band imaging data with MOIRCS on the Subaru telescope. Thanks to the very deep narrow-band data, we are able to construct a sample, in combination with additional H-band data taken with WFC3 on Hubble Space Telescope (HST), of 100 HAEs reaching the dust-corrected SFRs down to $3\,M_\odot\,\mathrm{yr}^{-1}$ and the stellar masses down to $10^{8.0}\,M_\odot$, allowing us to access less massive galaxies in the proto-cluster. Our results suggest that while the majority of massive galaxies are already settled in a secular evolution phase and are thus found on the main sequence, some less massive galaxies are in a starburst phase and they are significantly up-scattered from the main sequence. This may be consistent with the down-sizing scenario of mass-dependent galaxy evolution, or since they are located in a dense proto-cluster, they may be experiencing some influences from the surrounding environment such as galaxy-galaxy interactions.

The existence of the less massive HAEs with $< 10^{9.3}\,M_\odot$ up-scattered above the main sequence may imply that a scatter around the main sequence increases at lower stellar masses. Diversity of star-formation history in early phase of galaxy evolution and/or sensitivity to the fluctuation of starburst activity at short time scales in individual H_{II} regions could cause the increased scatter.

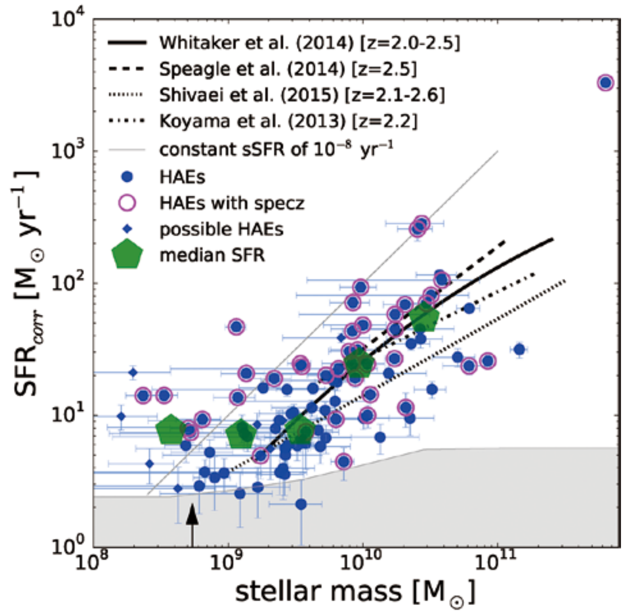

Figure 1: Main sequence of HAEs in the USS1558-003 proto-cluster at $z = 2.53$. The blue-filled circles represent the probable member HAEs at $z \approx 2.53$, while blue-filled diamonds represent the possible HAEs. The HAEs spectroscopically confirmed are marked with magenta open circles. The error bars are derived from the 1σ photometric error. The uncertainties of stellar masses derived from the SED fitting are estimated from a standard deviation of 100 iterations. Pentagons show the median SFRs in each mass bin. The gray region shows the SFRs under the limit reachable. The curves are main sequences from the literature [2,3,4,5]. A gray line shows a constant specific SFR of $10^{-8}\,\mathrm{yr}^{-1}$, and an arrow roughly shows the stellar mass limit which is estimated with the 3σ limiting magnitude in K_s and J–K_s color of 0.36.

References

[1] Hayashi, M., et al.: 2016, *ApJL*, **826**, L28.
[2] Koyama, Y., et al.: 2013, *MNRAS*, **434**, 423.
[3] Speagle, J. S., et al.: 2014, *ApJS*, **214**, 15.
[4] Whitaker, K. E., et al.: 2014, *ApJ*, **795**, 104.
[5] Shivaei, I., et al.: 2015, *ApJ*, **815**, 98.

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Transit Observation of Potentially Habitable Super-Earth K2-3d with Okayama188 cm/MuSCAT

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A transiting exoplanet, which has an orbit crossing in front of its host star, allows us to probe the planetary atmosphere by means of measuring the wavelength dependence of the transit depths. The *Kepler* space craft, which had continuously monitored a specific sky region from 2009 for four years, discovered about 30 small transiting planets within habitable zones. However, all of their host stars are too far from us (> 300 pc) and thus too faint to observe the atmospheres of the planets. On the other hand, the extended *Kepler* mission, K2, which has surveyed different sky regions along the ecliptic plane since 2014, has an advantage on discovering nearby transiting planets.

K2-3d is a transiting super-Earth (1.5 Earth radii) orbiting a nearby (45 pc) M dwarf with a period of 45 days, discovered by the K2 mission in 2015 [1]. The planet is thought to be within the habitable zone of the host star. The host star is bright enough (K_s = 8.6) that next-generation telescopes can search for molecules related to life in the planetary atmosphere. However, K2 observed only two transits of K2-3d because the survey period of K2 per field is only 80 days. As a result, the orbital period of the planet was only poorly measured, preventing us from predicting future transit times with high enough precisions for followup observations. After the discovery, two additional transits were observed by *Spitzer* space telescope [2], which, however, suffered from instrumental systematics, leaving large room for improvement.

We observed a transit of K2-3d with the Okayama 188cm telescope equipped with the three-band simultaneous imager MuSCAT [3]. The transit depth of this planet is just 0.06 %, which is close to the detection limit from the ground. However, by utilizing the multiband simultaneity of MuSCAT to reduce the systematics of Earth's atmospheric origin, we successfully detected the tiny transit signal. We also reanalyzed the K2 and *Spitzer* data, which, combined with the MuSCAT data, drastically improved the transit ephemeris. With this new ephemeris, we will be able to observe future transits at the best timings by e.g., JWST and TMT, which opens the way for biomarker searches in the potentially habitable planet.

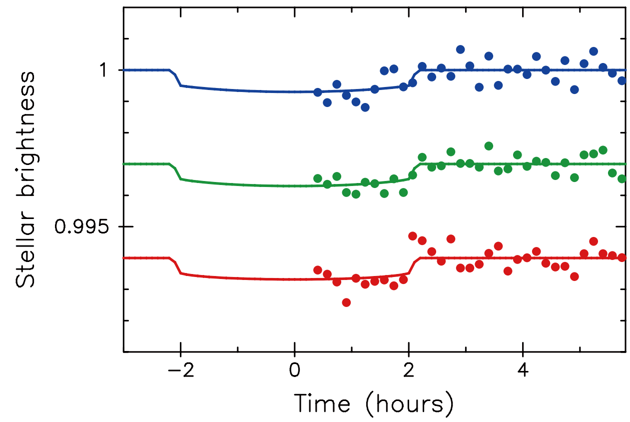

Figure 1: The transit light curves of K2-3d observed by the Okayama 188 cm telescope with MuSCAT. The top, middle, and bottom light curves are in g, r, and z-band, respectively. The circle points and solid lines show 10-minutes binning data and best-fit theoretical lines, respectively.

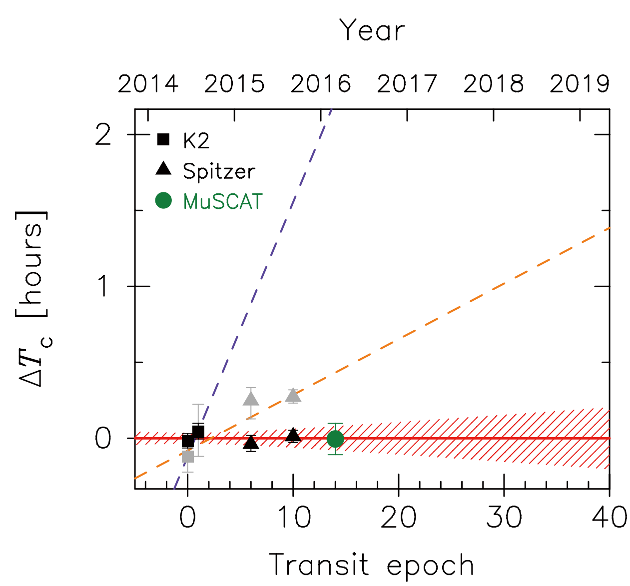

Figure 2: Residuals of the mid-transit times from the refined linear ephemeris. The square, triangle, and circle points represents the observed data of K2, *Spitzer*, and MuSCAT, respectively. The gray and black points are for the values in literature ([1,2]) and those refined in this work, respectively. The purple and orange dashed lines show the ephemerides provided by [1] and [2], respectively. The red shaded area shows 1-σ uncertainties of our new ephemeris.

References

[1] Crosseld, I. J. M., et al.: 2015, *ApJ*, **804**, 10.
[2] Beichman, C., et al.: 2016, *ApJ*, **822**, 39.
[3] Fukui, A., et al.: 2016, *AJ*, **152**, 171.

Astrometry of H_2O Masers in Massive Star-forming Region S255IR-SMA1

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We report the astrometric results of H_2O masers in S255IR-SMA1 with VERA (VLBI Exploration of Radio Astrometry). The anuual parallax was measured to be 0.563 ± 0.036 mas, corresponding to the source distance of $D = 1.78^{+0.12}_{-0.11}$ kpc. Maser morphology and its proper motion appear to trace a U-shaped bow shock propagating away from MYSO. These results are reported in Burns et al. (2016) [1], in detail.

Whether or not the outflows of low- and high-mass stars are produced in the same way is not well known. S255IR-SMA1 is the brightest source of molecular line emission in the S255IR star-forming region and its stellar mass is estimated to be ~ 20 $M_{\odot}$. S255IR-SMA1 is an ideal target to study the relationship between outflows and jets in an MYSO. We pursue VLBI observations aimed at measuring the annual parallax, distribution and proper motions of H_2O masers in S255IR-SMA1.

The observations were carried out using VERA from 23 Nov. 2008 to 11 Aug. 2010. S255IR-SMA1 and the positional reference source J0613+1708 with the separation of 0.87° were simultaneosly observed with the dual beam. The correlation processing was done using Mitaka FX correlator.

Figure 1 shows the anuual parallax of S255IR-SMA1. Th parallax was obtained to be $\pi = 0.563 \pm 0.036$ mas, corresponding to a source distance of $D = 1.78^{+0.12}_{-0.11}$ kpc. Figure 2 shows the ditributios and internal proper motions of H_2O masers. The elongated NE-SW morphology and bipolar outward motions of masers suggest that they are associated with an ejection event from an MYSO. The 3D velocity of each jet lobe is estimated to be 19 km s^{-1} with respect to the MYSO, with a position angle of 49°. The maser group in SW appear to trace a U-shaped bow shock structure. Ths structure is well reproduced by the jet-driven outflow model with a jet radius of about 6 AU.

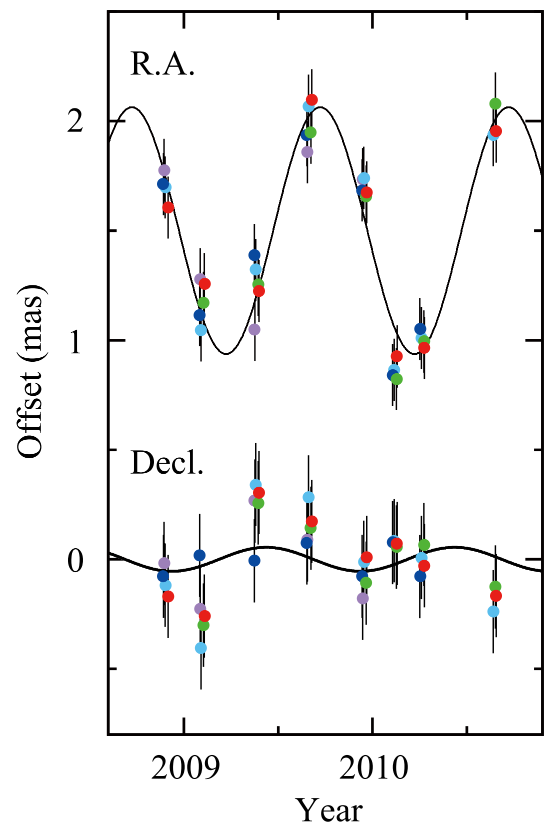

Figure 1: Anuual parallax of S255IR-SMA1.

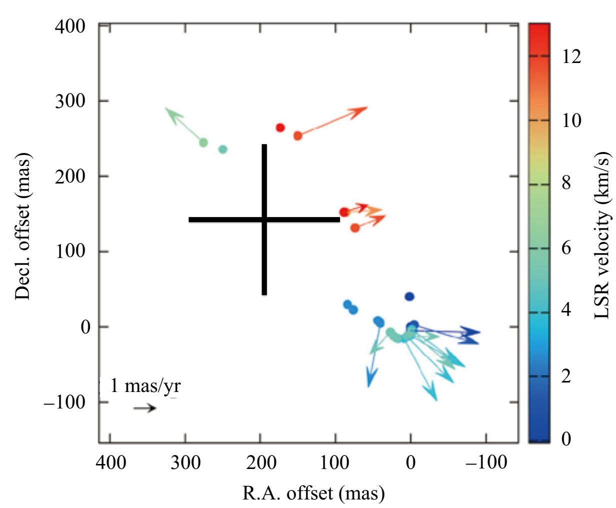

Figure 2: Distributions and internal proper motions of H_2O masers in S255IR-SMA1. The color indicates the LSR velocity. The black cross indicates the position of the centimetre continuum source. 1 mas yr^{-1} corresponds to 8.4 km s^{-1} at 1.78 kpc.

Reference

[1] Burns, R. A., et al.: 2016, *MNRAS*, **460**, 283.

Developments of Millimeter-wave MKID Camera

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MKID (Microwave Kinetic Inductance Detector) group of Advanced Technology Center is developing superconductive camera in millimeter and terahertz wavelengths for Antarctica terahertz telescope/Nobeyama 45 m telescope which observes distant galaxies with wide field-of-view and for CMB B-mode polarization in collaboration with University of Tsukuba, Saitama University, ISAS/JAXA, KEK, and Riken. Four papers related to millimeter/submillimeter MKID instruments were published in 2016 fiscal year.

1. Broadband corrugated horn array [1]

We are developing a broadband corrugated horn array to observe millimeter-wave polarization with high sensitivity and high accuracy. An 80–180 GHz horn array exceeding the octave band has been fabricated as shown in Fig. 1 and characterized with millimeter waves. The geometry of corrugations is so simple that the horn array can be directly machined from a bulk of aluminum with an end-mill.The cross-polarization and near side-lobe levels are less than -20 dB and -30 dB, respectively.The return loss is less than -15 dB in most design frequency bands, and the beam pattern is symmetric.The beam pattern and the return loss are measured in the 120–170 GHz range at room temperature.They are in good agreement with the simulation. It is possible to reduce reflection at the aperture surface and to reduce the weight by carving the unnecessary part.This design provides an octave bandwidth of the corrugated horn array at reasonable machining time.

Figure 1: A broadband corrugated horn array [1].

2. Broadband anti-reflective structures for silicon [2]

A broadband antireflective sub-wavelength structure was developed for large diameter silicon lenses used in the optical systems of superconducting cameras. In this study, a broadband antireflective sub-wavelength structure that can be easily fabricated with a dicing blade was designed. Pyramid structure (depth 550 μm) and straight section (depth 150 μm) have been fabricated with a special V-shaped dicing blade and a normal blade, respectively (Fig. 2). The structure was fabricated on a flat surface, and transmittance at cryogenic temperatures was measured using a Fourier transform spectrometer. The measured average transmittance between 186 and 346 GHz was approximately 95 %, and the experimental result is in good agreement with the simulation results.

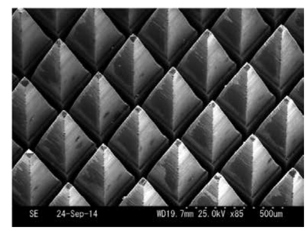

Figure 2: Broadband anti-reflective structure for Silicon [2].

3. Octave-band OMT with MKID [3]

We demonstrate a design of octave-band circular waveguide coupled planar ortho-mode transducer (OMT) with MKIDs. In our 4-pixel prototype design, each single pixel is sensitive to two frequency bands (90 GHz and 150 GHz) corresponding to atmospheric window. Silicon on insulator (SOI) has been used for the OMT backshort structure and a broadband coplanar waveguide (CPW) 180-degree hybrid is designed to cancel higher modes of a circular waveguide and add two signals from the fundamental mode together. After a microstrip bandpass diplexer, a microstrip line to coplanar waveguide transition structure couples signals to an MKID. MKIDs are designed with Nb ground plane and Al/Ti bilayer center strip line to achieve low frequency response and high sensitivity.

4. LiteBIRD MKID focal plane design [4]

Observations of large scale B-mode polarization of cosmic microwave background radiation (CMB) explore the inflation theory (K. Sato 1981), which explains the hot big-bang. This paper shows a focal plane design with corrugated horn coupled OMT-MKID for LiteBIRD, which observes CMB B-mode polarization from the cosmological gravitational wave.

References

[1] Sekiguchi S., et al.: 2017, *IEEE TST*, **7**, 36.
[2] Nitta, T., et al.: 2017, *IEEE TST*, **7**, 295.
[3] Shu, S., et al.: 2016, *SPIE proceedings*, 99142C.
[4] Sekimoto, Y., et al.: 2016, *SPIE proceedings*, 99142A.

Formation of Spiral Arm in Galaxies by Swing Amplification

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The origin and evolution of spiral arms in disk galaxies is a fundamental problem in astrophysics. One theory to explain the spiral arms is swing amplification. In a differentially rotating disk, a leading density pattern rotates to a trailing one due to the shear. During the rotation, the leading mode is amplified into spiral arms due to the self-gravity if the Toomre's Q is 1–2.

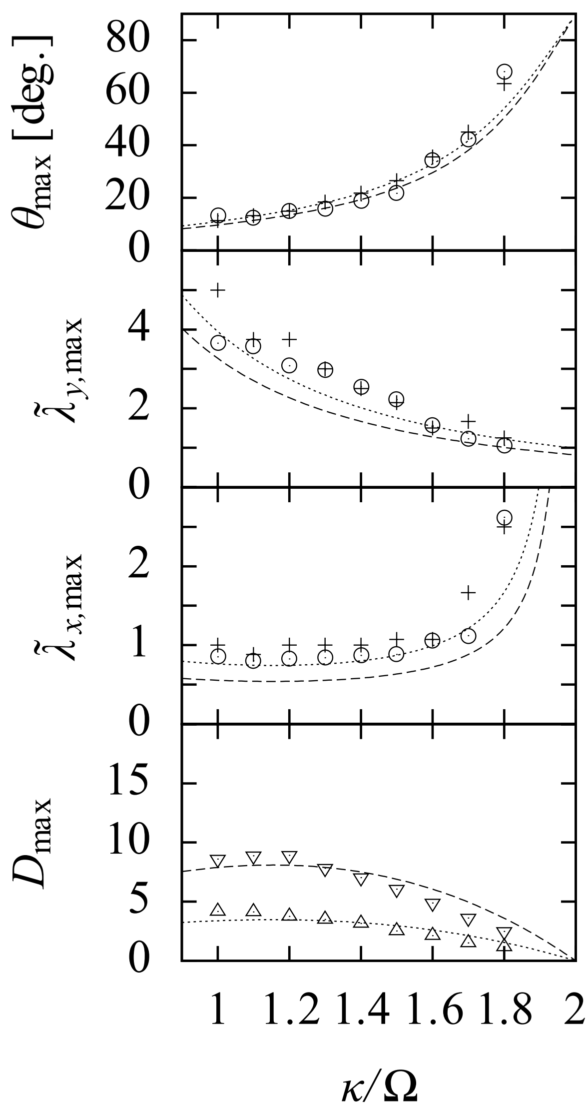

Figure 1: Comparison between the theory and the simulations. Circles and pluses denote the results of N-body simulations. The dotted and dashed curves show the estimates from the linear theory with $Q = 1.5$ and $Q = 1.8$, respectively. Triangles show the lower and upper limit of the amplification factor from the simulations.

In our previous work, we investigated the pitch angle of spiral arms by the local linear theory and simulations [1]. The derived pitch angle formula well agrees with N-body simulations.

We extended the our previous work and calculated the pitch angle, the wavelengths, and amplification factor of the most amplified mode [2]. The derived formulae of the pitch angle, the radial wavelength, the azimuthal wavelength, and the amplification factor are

$$\tan\theta_{\rm JT} = \frac{1}{2\pi}\left(1+\frac{2.095}{Q^{5.3}}\right)^{-1}\frac{\kappa}{A}, \quad (1)$$

$$\tilde{\lambda}_{x,\rm JT} = \frac{0.581Q^2 - 1.558Q + 1.547}{1+2.095Q^{-5.3}}\frac{\Omega^2}{A\kappa}, \quad (2)$$

$$\tilde{\lambda}_{y,\rm JT} = (3.653Q^2 - 9.789Q + 9.721)\left(\frac{\Omega}{\kappa}\right)^2, \quad (3)$$

$$D_{\max} = 0.0657\exp\left(\frac{7.61}{Q}\right)\frac{\kappa A}{\Omega^2}. \quad (4)$$

where κ is the epicycle frequency, Ω is the orbital frequency, A is the Oort constant, Q is the Toomre's Q.

Figure 1 shows the results. We confirmed that the formulae derived from the linear theory well agree with N-body simulations.

Next, in order to understand the physics of the swing amplification, we revisited the swing amplification model [3]. We carefully considered its derivation and we found that the naive treatment of the model leads to breakdown of the model in the strong shear case such as a Keplerian rotation. Therefore we modified the model for avoiding the breakdown. Using the modified model we investigated the motion of stars in spiral arms. We found that the phases of the epicycle motion of stars are synchronized during the amplification. Based on the phase synchronization we derived the pitch angle formula by the order-of-magnitude discussion. The phase synchronization may be a key process to understand the swing amplification.

References

[1] Michikoshi, S., Kokubo, E.: 2014, *ApJ*, **787**, 174.
[2] Michikoshi, S., Kokubo, E.: 2016, *ApJ*, **821**, 35.
[3] Michikoshi, S., Kokubo, E.: 2016, *ApJ*, **823**, 121.

Planetesimal Formation by Gravitational Instability of Porous-Dust Aggregates

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(NAOJ)

In a protoplanetary disk, small dust grains grow to kilometer-sized objects called planetesimals. The formation mechanism of planetesimals is one of today's most important unsolved problems. Recent studies on the dust growth showed that the icy dust aggregates formed by coagulation are not compact but significantly porous. The internal density of dust aggregates is much smaller than the material density. A compression mechanism is necessary to form compact planetesimals.

It was found that the dust aggregates can be compressed by the ram pressure when the dust aggregate mass is less than 10^{11} g [1]. The dust aggregates with the mass $\gtrsim 10^{11}$ g are compressed by the self-gravity. Due to these compression mechanisms, the compact planetesimals may be formed.

We focused on the final stage of dust aggregate compression. We investigated the dynamics of porous dust aggregates by using the detailed model. We considered the self-gravity, mutual collisions, aerodynamic drag, turbulent stirring, and scattering due to gas and calculated the equilibrium random velocity. From the equilibrium random velocity we calculated the Toomre's Q to examine the gravitational instability (GI) [2].

For the axisymmetric mode, the instability condition is $Q < 1$ [3]. For $1 < Q < 2$, the non-axisymmetric mode can grow due to the swing amplification mechanism [4,5]. Thus, we adopt the GI condition as $Q < 2$. In the minimum mass solar nebular model with $\alpha = 10^{-3}$, we found that the GI condition is finally satisfied. In other words, the porous dust disk becomes gravitational unstable to fragment to form planetesimals.

However, if the turbulent strength is sufficiently strong, the GI would be suppressed. Thus it depends on α whether the GI takes place. We assumed the various parameters and checked whether GI occurs. Figure 1 shows the summary of the results. The GI is more prone to occur for larger f_g, where f_g is the normalized disk mass. Thus, the upper limit of α for the GI exists.

Using the approximations we derived the condition for GI

$$\alpha < \alpha_{\rm cr} = 5.34 \times 10^4 \frac{a^2 \Sigma_{\rm d}^3}{C_{\rm D} \eta M_* \Sigma_{\rm g}^2}. \quad (1)$$

where a is the distance from the central star, $C_{\rm D}$ is the gas drag coefficient, M_* is the central star mass, η is the gas pressure gradient parameter, $\Sigma_{\rm d}$ is the dust surface density, $\Sigma_{\rm g}$ is the dust surface density. Figure 1 shows this estimate, which well agrees with the numerical result.

We found that if the turbulence is not strong ($\alpha \lesssim 10^{-3}$), the GI takes place. The GI accelerates the planetesimal formation significantly.

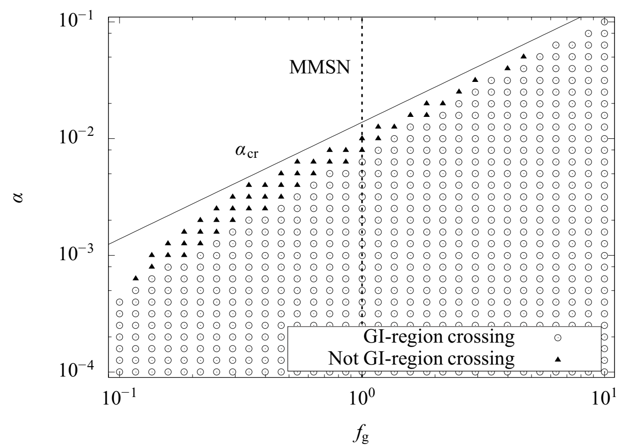

Figure 1: Parameter region for the GI on the normalized disk mass f_g and the turbulent strength α plane. The open circle points show the cases where the GI takes place. The filled triangles show the cases where the GI does not take place. The solid line represents the estimate of the critical α. The minimum mass solar nebular model (MMSN) corresponds to $f_g = 1$.

References

[1] Kataoka, A., et al.: 2013, *A&A*, **557**, 4.
[2] Michikoshi, S., Kokubo, E.: 2016, *ApJL*, **825**, L28.
[3] Toomre, A.: 1964, *ApJ*, **139**, 1217
[4] Michikoshi, S., Kokubo, E.: 2016, *ApJ*, **821**, 35.
[5] Michikoshi, S., Kokubo, E.: 2016, *ApJ*, **823**, 121.

N-Body Simulation of Chariklo's Ring

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Recently, two dense narrow rings around Centaur Chariklo were discovered [1]. The existence of a ring around Centaur Chiron was also proposed [2]. These observations suggest that rings around large Centaurs may not be rare.

Chariklo's ring has the large optical depth which is about 0.3–0.4. In Saturn's ring, the gravitational instability takes place in the region where the ring has the large optical depth and the self-gravity wakes form. The self-gravity wakes are small spiral structures, which cause the efficient angular momentum transfer. Thus, in order to investigate the detailed structure of the ring, we performed the global *N*-body simulations.

We developed the simulation code using the *N*-body simulation library, FDPS [3]. We considered the gravitational interaction, and mutual collisions.

Figure 1 shows the typical result of the simulation. We adopted the particle density $\rho_p/\rho_C = 0.5$ and the radius $r_p = 5$ m, where ρ_p is the particle density, ρ_C is the Chariklo's density, and r_p is the particle radius. The large scale structures are not visible. For the dynamical timescales, the ring keeps its original global shape. However, we find small scale structures, namely, self-gravity wakes in the inner ring.

We performed the simulations with various parameters. If $\rho_p/\rho_C > 0.5$, the rapid large aggregate formation takes place. Thus, this case does not correspond to the real ring. For suppressing the self-gravity wakes, the very low density particles, such as $\rho_p/\rho_C < 0.1$, are necessary.

Next we examined the long term evolution of the ring with the self-gravity wakes. The wakes accelerate the viscous spreading of the ring significantly and it typically occurs on timescales of about 100 years, which is considerably shorter than the timescales suggested in previous studies. Thus, the existence of these narrow rings implies the existence of shepherding satellites.

References

[1] Braga-Ribas, F., et al.: 2014, *Nature*, **508**, 72.
[2] Ortiz, J. L., et al.: 2015, *A&A*, **576**, A18.
[3] Michikoshi, S., Kokubo, E.: 2017, *ApJL*, **837**, L13.
[4] Iwasawa, M., et al.: 2016, *PASJ*, **68**, 54.

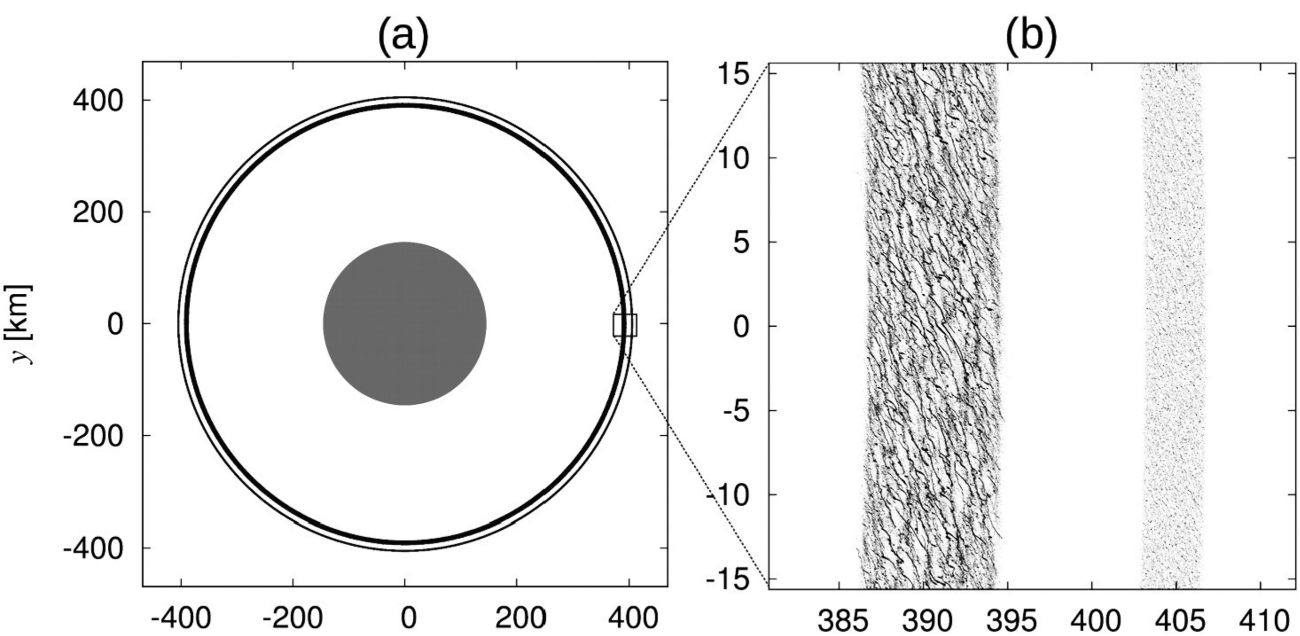

Figure 1: Particle distribution of the simulated ring in the x-y plane where the particle density and radius are $\rho_p/\rho_C = 0.5$ and $r_p = 5$ m, respectively. The panel (a) shows the overall structure of the ring, while the panel (b) shows enlarged view of ring section.

Mid-Infrared Spectroscopic Observations of the Classical Nova V2676 Oph with Subaru/COMICS

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A classical nova is an explosive event with a sudden increase in brightness that occurs on a white dwarf (WD) star. The explosion of the gas envelope of the WD (accreted from the companion star) is powered by thermonuclear runaway reactions that occur at the base of the envelope. The nature of the WD star is essential to the chemistry of the ejected material in novae. A dust-forming nova V2676 Oph (discovered in Mar 2012) was the first nova to provide evidence of both C_2 and CN molecules during its near-maximum phase and evidence of CO molecules during its early decline phase [1]. The derived carbon- and nitrogen-isotopic ratios in the nova [2] are consistent with that the nova explosion was hosted by a CO-rich WD rather than an ONe-rich WD. The existence of both C_2 and CN radicals in the photosphere indicates that the nova envelope was C-rich, with $C/O > 1$ [3]. To confirm a type of the hosting WD (CO-rich or ONe-rich), we performed the mid-infrared imaging and low-resolution spectroscopic observations of V2676 Oph with COMICS mounted on the Subaru telescope in June 2013 and May 2014 (482 days and 782 days respectively after its discovery) [4]. No clear [Ne II] emission line at 12.8 μm was observed in either the 2013 or 2014 observations. Based on the absence of [Ne II] emission, the WD hosting V2676 Oph is considered a CO-rich WD. Both types of dust grain, carbon-rich and oxygen-rich, were detected on both dates, although this nova is considered as a Carbon-rich ($C/O > 1$) based on the presence of C_2 observed earlier. The 11.4 μm unidentified infrared (UIR) emission was also detected on these dates. The coexistence of UIR carriers and carbon-rich grains in V2676 Oph supports the formation of UIR carriers from amorphous carbon grains. Non-equilibrium processes are likely to be responsible for the grain formation in the nova.

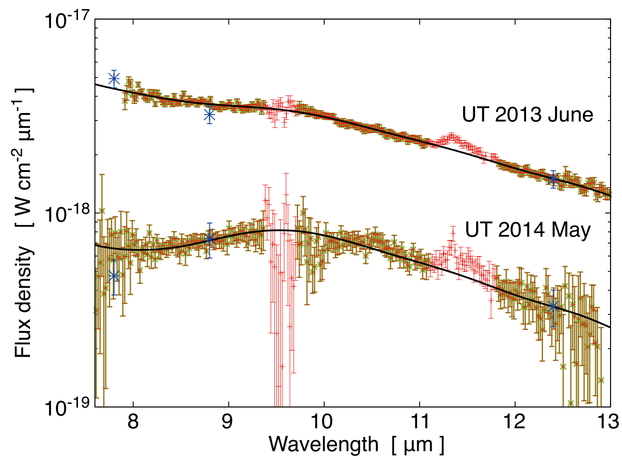

Figure 1: Low-resolution N-band spectra of V2676 Oph taken on UT 2013 June 20 and UT 2014 May 16. We assumed the grain radii for amorphous carbon and astronomical silicate to be 0.1 μm to reproduce the observed spectra. The UIR emission at 11.4 μm is clearly detected in both spectra [4].

References

[1] Nagashima, M., et al.: 2014, *ApJL*, **780**, L26.
[2] Kawakita, H., et al.: 2015, *PASJ*, **67**, 17.
[3] Kawakita, H., et al.: 2016, *PASJ*, **68**, 87.
[4] Kawakita, H., et al.: 2017, *AJ*, **153**, 74.

Success of a Laser Link Experiment with the Hayabusa2 Laser Altimeter

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OGAWA, Naoko[3], TAKEUCHI, Hiroshi[3], MOORE, Chris[5], POLLARD Alex[5]
YAMAGUCHI, Tomohiro[3], NAMIKI, Noriyuki[1], KASE, Teiji[6], SAIKI, Takanao[3], TSUDA, Yuichi[3]

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The Hayabusa2 spacecraft, launched on December 3, 2014, is equipped with a laser altimeter called LIDAR. The laser altimeter is a ranging instrument which measures time of flight of laser pulses between spacecraft and celestial bodies with solid surface. Laser link experiments between the LIDAR and ground-based satellite laser ranging stations were conducted when the spacecraft was near the Earth before and after the gravity assist operation in December 2015, and uplink laser pulses from a ground station were successfully detected [1]. In addition to the main purpose of this experiment, which is the demonstration of the time transfer technique for onboard clock calibration, it was also a unique opportunity for the performance check of the instrument before arrival at the asteroid, including the alignment determination of the LIDAR field of view (FOV) axis with respect to the spacecraft.

To determine the FOV direction, the spacecraft was scanned spirally with 1 *mrad* step. Number of detection of the laser pulses at each spacecraft attitude by LIDAR is shown in Fig. 1. The yellow tiles correspond to the spacecraft attitudes where maximum number of laser pulses were detected. With this information, the FOV direction was determined with the accuracy of scan step size. Fig. 2 shows the reception level of the laser pulses by the LIDAR when we set the LIDAR to another observational mode (range mode). Because the intensity varied with the change of receiver gain and pointing shift of the ground-based telescope, we confirmed that the signals came from the ground-based laser, not from other sources such as Earth background radiation.

Hayabusa2 became the third spacecraft to establish a laser link at a distance farther than the Moon with a ground station, following the MESSENGER [2] and Mars Global Surveyor missions [3]. The farthest distance of successful experiment was 6.6 million km on December 19, 2015.

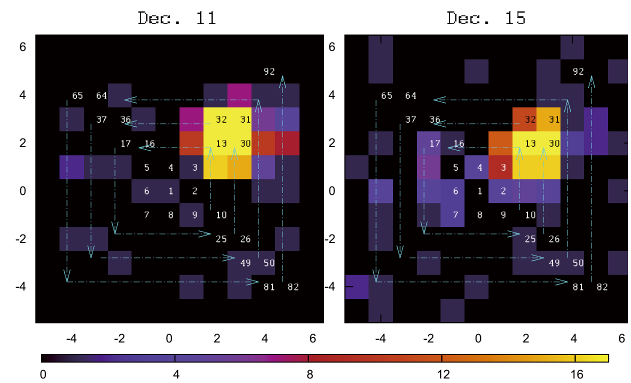

Figure 1: Number of signal detection with respect to the spacecraft scan direction on December 11 (left) and 15 (right), 2015 respectively [1]. Color shows the number of detection. The horizontal and vertical axes are the step sizes of the spacecraft scan, the directions of which nearly correspond to the right ascension and declination of the pointing direction, and the origin is the best-estimated direction of the boresight obtained during the ground-based prelaunch test. The maximum detection number for one tile is 17, because one data point was obtained within 2 seconds and spacecraft stayed one attitude for about 35 seconds.

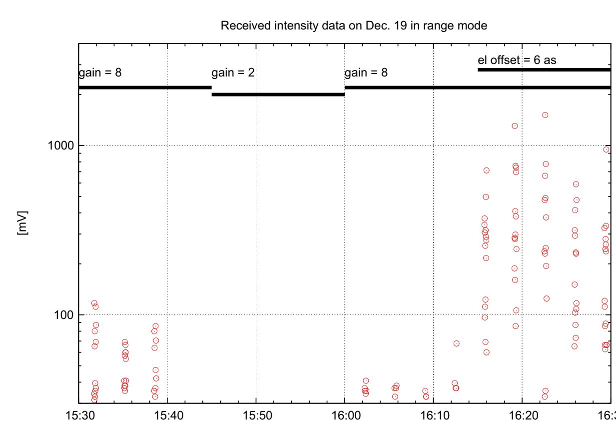

Figure 2: Intensity of the received pulses by LIDAR [1]. Experimental conditions of receiver gain (“high” = 8, “low” = 2) and the pointing offset of the ground telescope (el offset = 6 as) are drawn at the top. It is obvious that the reception level changes according to the changes of the observational conditions.

References

[1] Noda, H., et al.: 2017, *Earth, Planets and Space*, **69**, 2.
[2] Smith, D., et al.: 2006, *Science*, **311**, 53.
[3] Abshire, J., et al.: 2006, *Proceedings of the conference on lasers and electro-optics*.

Spiral Structure and Differential Dust Size Distribution in the LkHα 330 Disk

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1: NAOJ, 2: Astrobiology Center, 3: European Southern Observatory, 4: Academia Sinica, 5: University of Illinois at Urbana-Champaign, 6: University of Grenoble Alpes, 7: Max Planck Institute, 8: University of Arizona, 9: California Institute of Technology, 10: Space Science Institute, 11: University of Cincinnati, 12: Stockholm University, 13: The University of Oklahoma, 14: Ibaraki University, 15: Kogakuin University, 16: Tokyo Institute of Technology, 17: The Graduate University for Advance Studies, 18: NASA, 19: Eureka Scientific, 20: The University of Tokyo, 21: ETH Zurich, 22: Universite de Nice, 23: Princeton University, 24: College of Charleston, 25: Universitäts-Sternwarte München, 26: University of Hawaii, 27: Kyoto University, 28: Hiroshima University, 29: Space Telescope Science Institute, 30: Johns Hopkins University, 31: Hokkaido University, 32: Tohoku University

Dust trapping accelerates the coagulation of dust particles, and thus it represents an initial step toward the formation of planetesimals. We report *H*-band (1.6 μm) linear polarimetric observations by Subaru telescope and 0.87 mm interferometric continuum observations by Submillimeter Array (SMA) toward a transitional disk around LkHα 330 [1]. As results, a pair of spiral arms were detected in the *H*-band emission and an asymmetric (potentially arm-like) structure was detected in the 0.87 mm continuum emission. We discuss the origin of the spiral arm and the asymmetric structure, and suggest that a massive unseen planet is the most plausible explanation [2].

The possibility of dust trapping and grain growth causing the asymmetric structure was also investigated through the opacity index (β) by plotting the observed SED slope between 0.87 mm from our SMA observation and 1.3 mm from literature [3,4]. The results imply that grains are indistinguishable from ISM-like dust in the east side ($\beta = 2.0 \pm 0.5$) [5], but much smaller in the west side $\beta = 0.7^{+0.5}_{-0.4}$, indicating differential dust size distribution between the two sides of the disk. That is dust grains grow to millimeter size in the west side, while they remain 0.1–1 micron size in the east side.

Future observations at centimeter wavelengths and differential polarization imaging in other bands (Y to K) with extreme AO imagers are required to understand how large dust grains form and to further explore the dust distribution in the disk.

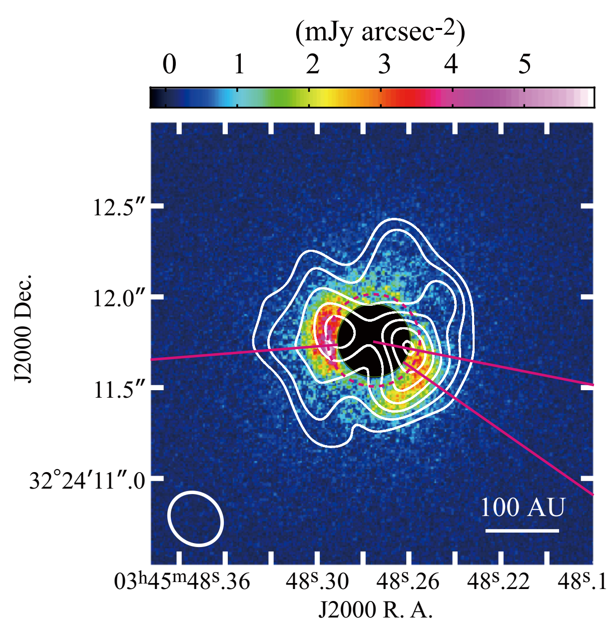

Figure 1: It represents a superposed SMA 0.87 mm continuum image on the Subaru *H*-band (1.6 μm) polarized intensity image. The first contour is 8σ and increases up to 20σ with 2σ steps.

References

[1] Akiyama, E., et al.: 2016, *AJ*, **818**, 158.
[2] Dong, R., et al.: 2015, *ApJ*, **809**, L5.
[3] Brown, J. M., et al.: 2008, *ApJL*, **675**, L109.
[4] Isella, A., et al.: 2013, *ApJ*, **775**, 30.
[5] Dranie, B. T.: 2016, *ApJ*, **636**, 1114.

Seasonal Variation of the Radial Brightness Contrast of Saturn's Rings Viewed in Mid-infrared

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To investigate the mid-infrared (MIR) characteristics of Saturn's rings, we collected and analyzed MIR high spatial resolution images of Saturn's rings obtained in January 2008 and April 2005 with COMICS mounted on Subaru Telescope (Figure 1), and investigated the spatial variation in the surface brightness of the rings in multiple bands in the MIR (Figure 2). We also composed the spectral energy distributions (SEDs) of the C, B, and A rings and the Cassini Division, and estimated the temperatures of the rings from the SEDs assuming the optical depths measured from stellar occultation observations by Cassini/UVIS.

We find that the C ring and the Cassini Division were warmer than the B and A rings in 2008. This could be accounted for by the lower albedos, lower optical depths, and smaller self-shadowing effect in the C ring and the Cassini Division than the B and A rings.

We also find that the C ring and the Cassini Division were considerably brighter than the B and A rings in the MIR in 2008, and the radial contrast of the ring brightness is the inverse of that in 2005. This temporal variation is probably caused by seasonal changes of the elevations of the Sun and observer above the ring plane as varying angles will lead to differing filling factors and temperatures of the particles in the rings.

Reference

[1] Fujiwara, H., et al.: 2017, *A&A*, **599**, A29.

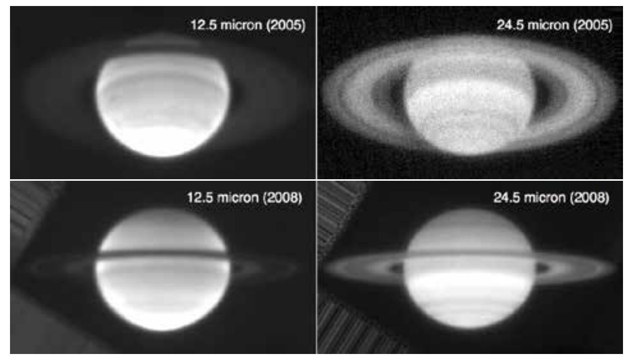

Figure 1: Comparison of MIR images of Saturn's rings in April 2005 (top) and January 2008 (bottom). 12.5 μm (left) and 24.5 μm (right).

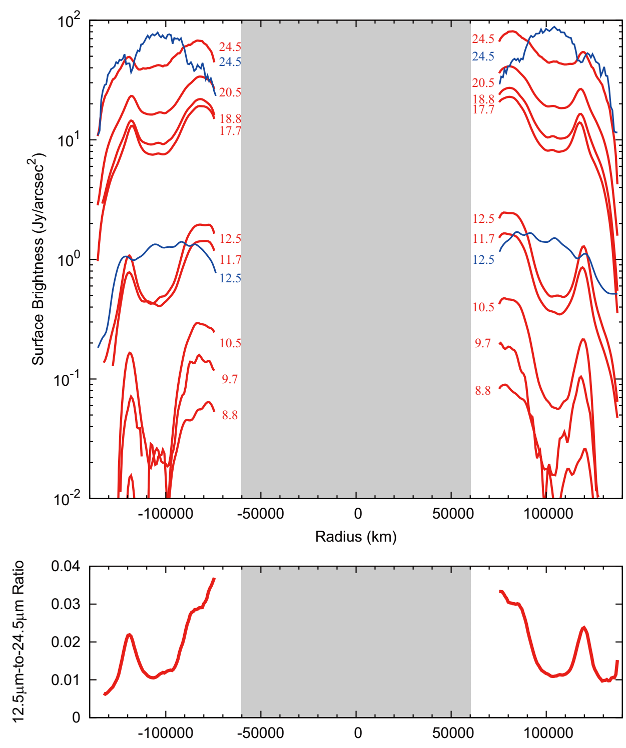

Figure 2: Top: profiles of surface brightness in all the bands in January 2008 (red) and April 2005 (blue). Bottom: profile of 12.5 μm-to-24.5 μm brightness ratio for Saturn's rings in 2008. Negative and positive value of the radius is for the east and west side, respectively. Region of the planetary body is shown in gray.

Discovery of Ubiquitous Fast-propagating Intensity Disturbances by the Chromospheric Lyman Alpha Spectropolarimeter (CLASP)

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KOBAYASHI, Ken[4], CIRTAIN, Jonathan W.[5], CHAMPEY, Patrick R.[6], AUCHÈRE, Frédéric[7]
TRUJILLO BUENO, Javier[8], ASENSIO RAMOS, Andrés[8], ŠTĚPÁN, Jiří[9], BELLUZZI, Luca[10/11]
MANSO SAINZ, Rafael[12], De PONTIEU, Bart[13], ICHIMOTO, Kiyoshi[1/14], CARLSSON, Mats[15]
CASINI, Roberto[16], GOTOU, Motoshi[17]

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High-cadence and high-sensitivity observations by the slit-jaw (SJ) optics system of the CLASP sounding rocket experiment [1] reveal ubiquitous intensity disturbances that recurrently propagate in either the chromosphere or the transition region or both at a speed much higher than the speed of sound [2]. The CLASP/SJ instrument provides a time series of two-dimensional images taken with broadband filters centered on the Lyα line (121.6 nm) at a 0.6 s cadence. The sky-blue arrows in Figure 1 point out one example of the fast-propagating intensity disturbances at the outer boundary of an active region. In this case, the propagation speed is about 300 km/s, and the similar moving patterns appear at least four times in the same area. The multiple fast-propagating intensity disturbances appear in the quiet Sun and in the active region, and they are clearly detected in at least 20 areas in a field of view of 527″ × 527″ during the 5 minute observing time, as shown by the green boxes in Figure 2. The apparent speeds of the intensity disturbances range from 150 to 350 km/s. These speeds are much faster than the speed of sound in the chromosphere or the transition region (< 50 km/s), and comparable to the local Alfvén speed in the transition region. The intensity disturbances tend to propagate along bright elongated structures away from areas with strong photospheric magnetic fields. This suggests that the observed fast-propagating intensity disturbances are related to the magnetic canopy structures. The maximum distance traveled by the intensity disturbances is about 10″, and the widths are a few arcseconds, which are almost determined by a pixel size of 1.″03. The timescale of each intensity pulse is shorter than 30 s. One possible explanation for the fast-propagating intensity disturbances observed by CLASP is magnetohydrodynamic fast-mode waves.

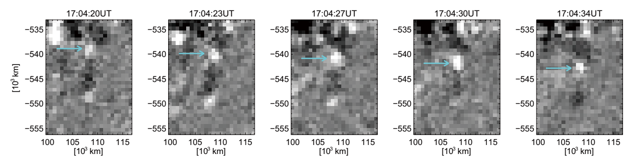

Figure 1: One example of the fast-propagating intensity disturbances (sky-blue arrows). This event occurs in Box 1 of Figure 2. The background is Lyα image with the CLASP/SJ after removal of the 30 s running temporal average.

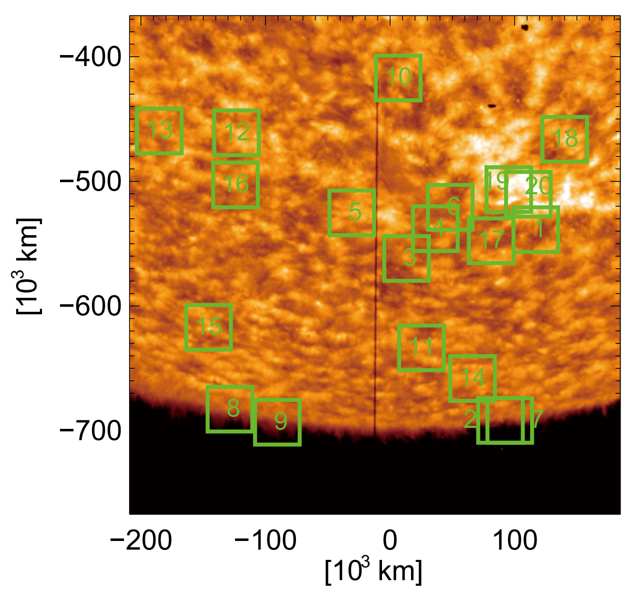

Figure 2: Fast propagating intensity disturbances are clearly observed around the centers of the green boxes. The background image is Lyα image taken by the CLASP/SJ.

References

[1] Kano, R., et al.: 2017, *ApJL*, **839**, L10.
[2] Kubo, M., et al.: 2016, *ApJ*, **832**, 141.

High-contrast Imaging of Intermediate-mass Giants with Long-term Radial Velocity Trends

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The radial velocity (RV) technique has been used as one of the methods to search for exoplanets, discovering more than 500 planets in last 20 years. However, this technique is less sensitive to wide-orbit (>10 au) planets and inefficient to examine the occurrence rate of such wide-orbit planets, even though it is crucial information to test planet formation/evolution theories.

A long-term RV acceleration (RV trend) suggests the presence of a possible planetary companion in a wide orbit. However, such an RV trend could be caused not only by a planet but also by a distant stellar or brown dwarf companion. Direct-imaging technique is sensitive to such wide-orbit companions and can help us to clarify the cause of an RV trend through a detection or non-detection of companion.

Our RV survey conducted at Okayama Astrophysical Observatory (OAO) has targeted intermediate-mass giants (1.5–5 $M_\odot$) for over a decade [1], finding the long-term RV trends around several targets. To clarify the nature of the RV trends observed in the OAO and another different RV survey [2], we performed direct-imaging observations for the six OAO targets as part of the SEEDS project [3]. (γ Hya, ι Dra, 18 Del, HD 5608, HD 14067, HD 109272).

We detected three stellar companions ($0.61^{+0.12}_{-0.14}$ $M_\odot$, $0.10 \pm 0.01\,M_\odot$, $0.28 \pm 0.06\,M_\odot$) in three systems (γ Hya, HD 5608, and HD 109272) and rule out the presence of stellar companions in the other three systems (ι Dra, 18 Del, HD 14067).

Combining the direct imaging and the RV data, we found that the detected companions are responsible for the observed RV trends and the causes of RV trends for non-detection systems are low-mass stars or brown dwarfs.

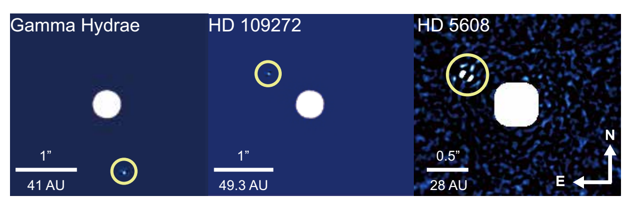

Figure 1: The detected companions are indicated by the yellow circles. The central white areas around central the stars were removed in analysis.

References

[1] Sato, B., et al.: 2003, *ApJ*, **597L**, 157S
[2] Kane, S. R., et al.: 2010, *ApJ*, **720**, 1644K.
[3] Ryu, T., et al.: 2016, *ApJ*, **825**, 127.

New Neutrino Source for the Study of Solar Neutrino Physics in the Vacuum-matter Oscillation Transition Region [1]

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PARK, Tae-Sun (Sungkyunkwan University)
KAJINO, Toshitaka (NAOJ/University of Tokyo/Beihang University)

One of open issues related to the vacuum-matter oscillation transition region in the solar neutrino physics is the determination of electron-neutrino survival probability $P(\nu_e \rightarrow \nu_e)$ in that region, which is also closely related to the questions such as existence of sterile neutrinos and/or non-standard neutrino interactions (NSI), roles of CNO cycle in the Sun (metallicity problem), etc.

In this work [1], we propose a new artificial accelerator-based electron-neutrino source for experiments of the vacuum-matter oscillation transition region. By adjusting incident proton energy, we can produce a specific unstable isotope as an efficient electron-neutrino source. Unstable isotope, ^{27}Si, is our main neutrino source, which can be produced through ^{27}Al(p,n)^{27}Si reaction and emits electron-neutrinos through radioactive decay processes. In this case, the neutrinos can have an energy range, $0 < E_\nu < 5$ MeV, corresponding to the transition region.

Productions of ^{27}Si through p+^{27}Al reaction are simulated by using GEANT4 code [2] with JENDL-4.0/HE data [3]. Incident proton energy is chosen to be 15 MeV due to the following reasons. (1) There exist only limited numbers of experimental data in the EXFOR database. (2) By choosing this energy, we can suppress productions of unnecessary unstable isotopes (^{23}Mg, ^{25}Al, ^{26}Si, etc.) which can emit ν_e or $\bar{\nu}_e$ backgrounds. A schematic diagram of the target geometry is drawn in Fig. 1. For a 15 MeV proton beam with 10 mA, 3.55×10^{13} ^{27}Si per second (^{27}Si/s) in the ^{27}Al target are expected.

Reaction rates with respect to the neutrino energy generated for the neutrino source are plotted in Fig. 2. For both ^{37}Cl and ^{71}Ga, neutrinos having the continuous energy ($E_{th} < E_{\nu_e} \lesssim 3.79$ MeV) and monoenergies (3.97 MeV and 4.813 MeV) interact with the isotopes. Contributions of the neutrino with two mono-energies are marginal. Consequently, we can obtain the reaction rates or flux-averaged cross sections for both ^{37}Cl(ν_e,e$^-$)^{37}Ar and ^{71}Ga(ν_e,e$^-$)^{71}Ge reactions in the neutrino energy region less than ~3.79 MeV. This energy region is close to the vacuum-matter oscillation transition region in the solar neutrino physics. One can see that widths of energy distributions of reaction rates for deuteron targets are more narrow than those for both ^{37}Cl and ^{71}Ga because of the reaction thresholds. With this feature, we can also have a chance to obtain reaction rates or energy averaged cross sections for ^{2}H(ν_e,e$^-$pp) and ^{2}H(ν_e,$\nu_e$np) reactions with narrow neutrino energy region. This is a unique feature in the present work because most experimental data were obtained by using neutrino sources from pion decay where the neutrino has broad energy region 0 ~ 55 MeV.

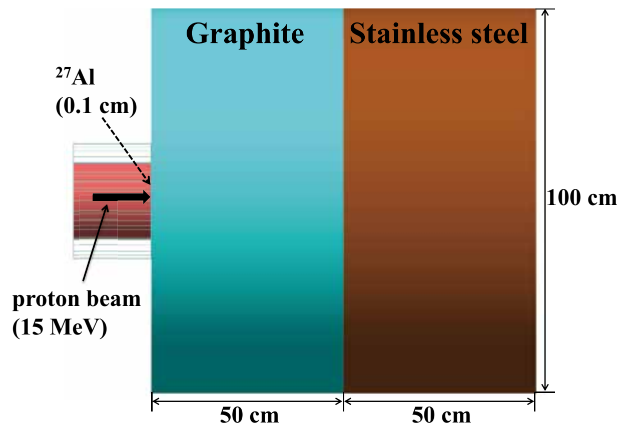

Figure 1: Schematic diagram of the ^{27}Si production target geometry.

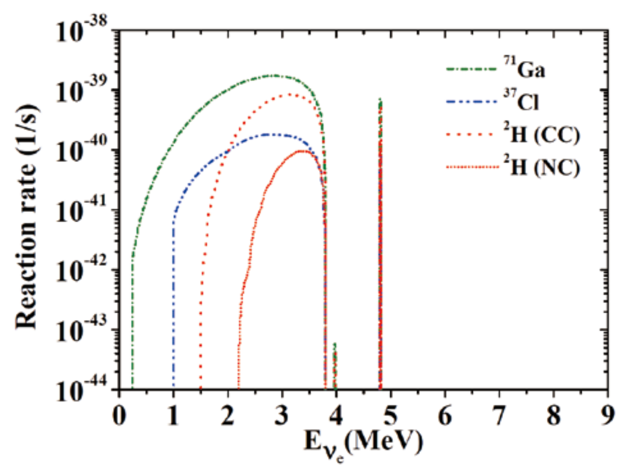

Figure 2: Reaction rates via ^{37}Cl(ν_e,e$^-$)^{37}Ar, ^{71}Ga(ν_e,e$^-$)^{71}Ge, ^{2}H(ν_e,e$^-$pp) and ^{2}H(ν_e,$\nu_e$np) reactions. The neutrinos are generated from decay of ^{27}Si which are produced by the 15 MeV and 10 mA proton beam on a ^{27}Al target.

References

[1] Shin, J. W., et al.: 2016, *Phys. Rev. C*, **94**, 045804.
[2] Agostinelli, S., et al.: 2003, *Nucl. Instrum. Meth. A*, **506**, 250.
[3] JENDL-4.0/HE, http://wwwndc.jaea.go.jp/index.html.

Heavy Element Synthesis in Type II Supernovae: Sensitivity to Nuclear Equation of States [1]

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A phenomenological model has been developed in which the enrichment of light r-process elements (relative to heavy r-process elements) in metal-poor and extremely-metal-poor stars (EMPs) is found to depend on the stiffness of the nuclear equation of state. Here, an r-process is assumed in which an explosion scenario is halted due to an accretion-induced collapse and a subsequent failed or partial explosion, followed by partial ejection of r-process material. Nucleosynthesis then results in an abundance distribution enriched in the light r-process elements. Initial results suggest that a possible upper limit on the stiffness of the EOS may be constrained by observations, which could complement results of neutron star masses which place lower limits on the EOS stiffness.

We have explored a previously-proposed model, referred to as the tr-process [1], which assumes an r-process in a core-collapse scenario which is halted due to an accretion-induced collapse into a BH or a stalled shock. The model attempts to explain the maximum [Sr/Ba] ejected in a single r-process event; we note that reductions in this ratio may result from mixing between outer and inner ejecta in the explosion or from asymmetric explosion mechanisms. We also note that the observed large values of [Sr/Fe], [Ba/Fe], and [Eu/Fe] (so-called r-II stars) can be reproduced by turbulent ejection (as suggested in [2]). The results presented here represent one potential avenue for producing these extremes.

The calculated [Sr/Ba] values are also shown in Figure 1 compared to observed values in the galaxy. The significant changes in the Ba ejection in a collapse scenario results in a dramatic change in the [Sr/Ba] (and [Sr/Eu]) ratios. In a previous paper [2], changes in [Sr/Ba] were suggested to be caused at least in part by turbulent ejection of material in a collapse scenario. It is seen that for a softer EOS, the maximum values in [Sr/Ba] as a function of metallicity can be achieved in a tr-process for partial enrichment of r-process elements in a GCE model. As noted above, the GCE results shown in these figures represent extremes in these ratios as they are produced in collapse scenarios corresponding to the minimum collapse time to a BH. In examining the abundance ratios of [Sr/Ba] as they relate to the EOS, one sees that these ratios generally increase as the EOS softens. However, at some point, the EOS becomes so soft that the collapse time becomes early enough to prohibit Sr ejection, and the ratios of [Sr/Ba] begin to decrease with the softness of the EOS. This may occur for an EOS with a softness somewhere between the Shen EOS and the LS220 EOS, as one sees that the [Sr/Ba] ratios calculated using an LS220 EOS drop below those calculated using a Shen EOS at metallicities $-2.5 < \mathrm{[Fe/H]} < -2$.

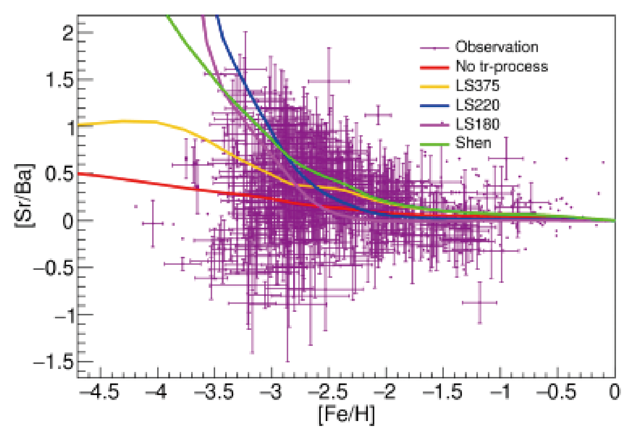

Figure 1: [Sr/Ba] as a function of [Fe/H] for several EOS assumptions compared to observation.

References

[1] Famiano, M. A., et al.: 2016, *ApJ*, **830**, 61.
[2] Aoki, W., et al.: 2013, *ApJ*, **766**, L13.

Relativistic Screening Effects on Big Bang Nucleosynthesis and Low-lying Resonances [1]

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If an astrophysical environment is hot enough (greater than approximately 0.5 MeV or so), screening in the associated nuclear reactions can be modified by the presence of a relativistic electron-positron plasma. For non-zero electron chemical potentials, the effect is compounded as the Debye length (which creates an additional decrease in Coulomb energy with radius between two reacting nuclei) in a plasma can drop significantly, resulting in amplified reaction rates.

In a relativistic model, the Debye length decreases with temperature, as shown in Figure 1. The effect of screening is to shift the reaction energy in the cross-section. This can result in an enhancement of nuclear reaction rates, and the reaction rate enhancement factor is studied in several relevant scenarios. For sub- or near-threshold resonances, this could potentially change the reaction rates by a significant amount as the reaction energy effectively shifts the resonance above or below threshold.

Possible sites where relativistic plasma screening could have a significant effect on observed results include Big Bang Nucleosynthesis, α-rich freezeout in the r-process, x-ray bursts, and type Ia supernovae in white dwarfs. Most recently, the effects of the screening due to the relativistic electron-positron plasma during the Big Bang Nucleosynthesis have been explored. While the effects of relativistic screening were found to be relatively small in the standard Early Universe models, further work is being done to explore the same effects in the above-mentioned astrophysical sites. Additional work is currently focused on possible effects on the production of ^{56}Ni in type Ia supernovae, effects on light curves (both frequency and duration) in X-ray bursts, and effects on the electron fraction in the astrophysical r-process following α-rich freezeout.

In this work we explored in detail the consequences of the screening due to the relativistic electron-positron plasma on non-resonant and possible resonances on the secondary reactions destroying $A = 7$ nuclei during the Big Bang Nucleosynthesis. We found that effects of screening from the relativistic plasma are small even for the reaction with the largest charge , namely ^{3}He+^{7}Be. We note that this reaction is the least experimentally explored one in the network of BBN reactions.

Even though the effects we find are small, it still is worthwhile to demonstrate how robust our current understanding of the BBN is to effects not previously considered. This is especially important since the instruments scheduled to go online in the future, such as the Thirty Meter Telescope [2], will measure the abundances of the light elements resulting from the BBN with greater precision.

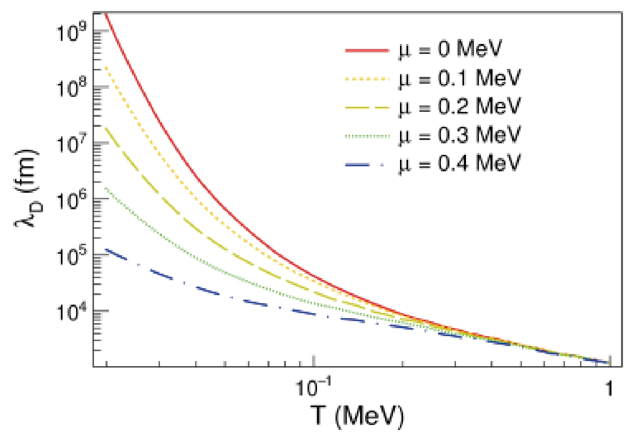

Figure 1: The Debye length for the ^{3}He+^{7}Be reaction as a function of temperature (in MeV) for several electron chemical potential assumptions.

References

[1] Famiano, M. A., Balantekin, A. B., Kajino, T.: 2016, *Phys. Rev. C*, **93**, 045804.
[2] Skidmore, W., et al.: 2015, *Research in Astron. Astrophys.*, **15**, 1945.

Detectability of Cosmic Dark Flow in the Type Ia Supernova Redshift-Distance Relation

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We have re-analyzed [1] the detectability of large scale dark flow (or local bulk flow) with respect to the CMB background based upon the redshift-distance relation for Type Ia supernovae (SN Ia). If a universal CMB dipole exists it would be exceedingly interesting. Such apparent large scale motion could provide a probe into the instants before cosmic inflation, either as a remnant of multiple field inflation, pre-inflation fluctuations entering the horizon [2], or a remnant of the birth of the universe out of the mini-superspace of SUSY vacua in the M-theory landscape. Such possibilities lead to a remnant dipole curvature in the present expanding universe that would appear as coherent velocity flow relative to the frame of the cosmic microwave background . Hence, this has been dubbed [3] "cosmic dark flow."

We made two independent analyses: one based upon identifying the three Cartesian velocity components; and the other based upon the cosine dependence of the deviation from Hubble flow on the sky. We applied these analyses to the Union2.1 SN Ia data [4] and to the *SDSS*-II supernova survey [5]. For both methods, results for low redshift, $z < 0.05$, are consistent with previous searches. We find a local bulk flow of $v_{\rm bf} \sim 300\ {\rm km\ s^{-1}}$ in the direction of $(l, b) \sim (270, 35)°$. However, the search for a dark flow at $z > 0.05$ is inconclusive. The reason that the dark flow is difficult to detect for $z > 0.05$ can be traced to the large errors in the determined distance moduli of the SN Ia data. For a fixed error in the distance modulus, the actual error in the velocity increases with redshift.

Figure 1 from [1] illustrates the result of simulating surveys that accumulate SNIa events at redshift bins with $\Delta z = z/3$ centered at $z = 0.05$, 0.1, and 0.3. The intersection of the horizontal dashed line with the curves indicates the number of supernovae in Union2.1 low redshift sample.

Based upon simulated data sets, we deduce that the difficulty in detecting a dark flow at high redshifts arises mostly from the observational error in the distance modulus. Thus, even if it exists, a dark flow is not detectable at large redshift with current SN Ia data sets. We estimate that a detection would require both significant sky coverage of SN Ia out to $z = 0.3$ and a reduction in the effective distance modulus error from 0.2 mag to < 0.02 mag. We estimate that a greatly expanded data sample of $\sim 10^4$ SN Ia might detect a dark flow as small as $300\ {\rm km\ s^{-1}}$ out to $z = 0.3$ even with a distance modulus error of 0.2 mag. This may be achievable in a next generation large survey like *LSST*.

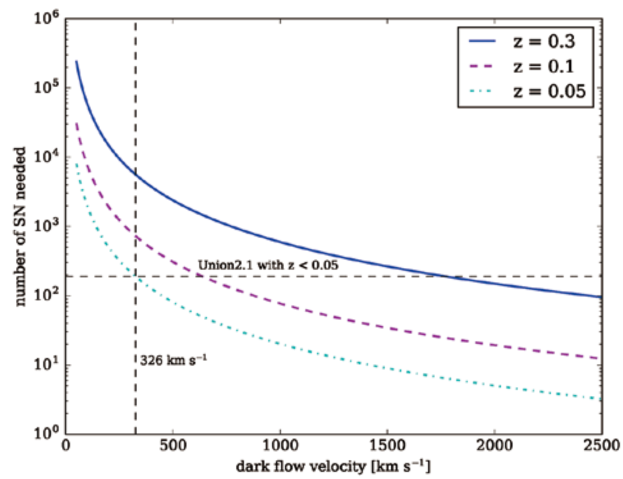

Figure 1: Illustration of the number of SN Ia required for a 3σ detection in redshift bins centered at $z = 0.05$ (dot-dashed line), $z = 0.1$ (thick dashed line), or $z = 0.3$ (thick solid line). The vertical dashed line denotes a bulk flow velocity of $326\ {\rm km\ s^{-1}}$ as inferred in our analysis of the low redshift Union2.1 sample. The intersection of this line with the lower $z = 0.05$ curve suggests that a flow was detectable in the low redshift Union2.1 sample. The intersection of this line with the upper curve, however, indicates that to detect a dark flow in at $z = 0.3$ the one needs $N > 4582$ SN Ia events.

References

[1] Mathews, G. J., et al.: 2016, *ApJ*, **827**, 60.
[2] Mathews, G. J., et al.: 2015, *Phys. Rev. D*, **92**, 123514.
[3] Kashlinsky, A., et al.: 2008, *ApJ*, **686**, L49.
[4] Suzuki, N., et al.: 2012, *ApJ*, **746**, 85.
[5] Sako, M., et al.: 2008, *AJ*, **135**, 348.

Impact of Sterile Neutrino Dark Matter on Core-collapse Supernova Explosion

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The nature of dark matter remains one of the biggest open questions in physics. One viable dark matter candidate is a sterile neutrino. Sterile neutrino dark matter is an electroweak singlet that does not participate in the strong, weak, or electromagnetic interaction.

We have re-analyzed [1] the impact of sterile neutrino dark matter on core-collapse supernova explosions. We considered sterile neutrino masses and mixing angles that are consistent with sterile neutrino dark matter candidates as indicated by recent X-ray flux measurements [2]. We found that the interpretation of the observed 3.5 keV X-ray excess as due to a decaying 7 keV sterile neutrino that comprises 100 % of the dark matter would have almost no observable effect on supernova explosions. However, in the more realistic case in which the decaying sterile neutrino comprises only a small fraction of the total dark matter density due to the presence of other sterile neutrino flavors, WIMPs, etc., a larger mixing angle is allowed. In this case a 7 keV sterile neutrino could have a significant impact on core-collapse supernovae.

Figure 1 from [1] shows the electron neutrino luminosity versus time post-bounce, both with and without a sterile neutrino present. The neutrino luminosities of all neutrino and antineutrino flavors are enhanced from about 0.2 s to 0.4 s post-bounce. This increase in the neutrino luminosities increases the neutrino reheating behind the stalled shock, and thus enhances the explosion energy. The timescale of the increase of the neutrino luminosities corresponds to the time post-bounce when the explosion energy becomes enhanced.

A striking feature is the appearance of episodic neutrino bursts with a period of 40–50 ms in the luminosity and flux with a 7keV sterile neutrino. This is due to the fact that the neutrino photospheric luminosity is fixed by the ratio of the total internal energy to the neutrino diffusion time. When the neutrino chemical potential falls above the resonance energy, those neutrinos in the energy groups corresponding to the resonance energy and width immediately have a diffusion time scale drastically shortened by the free streaming of the sterile neutrinos to just below the neutrinosphere [3,4]. However, once a significant fraction of available neutrinos is depleted, the process is shut off and the luminosity actually decreases until neutrinos can diffuse back into the depleted energy and spatial groups. The amplitude and period of the luminosity spikes scale roughly linearly with neutrino mass. Hence, should an oscillation of the type shown here be detected in a next generation neutrino detector such as Hyper-kamiokande, its amplitude and period could be used to infer the mass of the oscillating sterile neutrino.

Thus, a multi-component model is required to accommodate a sterile neutrino mass and mixing angle that leads to an enhanced explosion. if the decaying sterile neutrino makes up (< 1 %) of the dark matter density, a shorter decay lifetime is allowed corresponding to the larger mixing angle needed to impact the explosion.

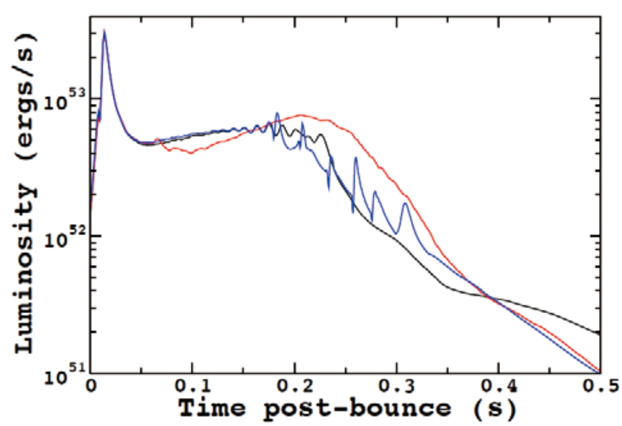

Figure 1: Neutrino luminosity versus time post-bounce. The black line is for a simulation without a sterile neutrino, the red line is for a sterile neutrino with mass m_s = 1 keV and mixing angle $\sin^2 2\theta_s = 10^{-5}$, and the blue line is for a sterile neutrino with mass m_s = 7 keV and mixing angle $\sin^2 2\theta_s = 10^{-5}$.

References

[1] Warren, M. L., et al.: 2016, *Int. J. Mod. Phys.*, **A31**, 1650137.
[2] Boyarsky, A., et al.: 2014, *Phys. Rev. Lett.*, **113**, 251301.
[3] Hidaka, J., Fuller, G. M.: 2007, *Phys. Rev. D*, **76**, 083516.
[4] Hidaka, J., Fuller, G. M.: 2006, *Phys. Rev. D*, **74**, 125015.

Neutrino Antineutrino Pair Emissions in Strongly Magnetized Neutron-Star-Matter in Relativistic Quantum Approach

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Magnetic fields in neutron stars play an important role in the interpretation of many observed phenomena. Magnetar, which is associated with a super strong magnetic field, show properties different than normal neutron stars.

Many people have paid attention into cooling processes of neutron stars because it must give important information of neutron stars structure [1]. The neutron stars are cooled by the neutrino emission, and the magnetic field is expected to affect the emission mechanism largely because the strong magnetic field can supply energy and momentum into the process.

In this work [2] we study the $\nu\bar{\nu}$- pair production from electron and proton, which occur only under the strong magnetic field.

We assume a uniform magnetic field along the z-direction, $\boldsymbol{B} = (0, 0, B)$, and take the electro-magnetic vector potential A^μ to be $A = (0, 0, xB, 0)$ at the position $\boldsymbol{r} \equiv (x, y, z)$. The relativistic proton wave function $\tilde{\Psi}$ is obtained from the following Dirac equation:

$$[(i\partial\!\!\!/ - eA\!\!\!/) - m]\tilde{\psi}(t, r) = 0\,, \qquad (1)$$

where m is the particle mass. By solving Eq. (1), we then obtain the energy eigenvalues as

$$e(n, p_z, s) = \sqrt{p_z^2 + 2neB + m_N^2}, \qquad (2)$$

where n is the Landau level number and p_z is z-component of the proton momentum. Then, we calculate $\nu\bar{\nu}$-pair emissions from the transition between the different Landau levels for electrons and protons in the relativistic quantum mechanical way [2].

In Fig. 1 we show the calculation results of $\nu\bar{\nu}$-pair luminosity per volume, L/V at the baryon density $\rho_B = 0.2\,\rho_0$, where ρ_0 is normal nuclear matter density. The solid circles and open squares represent the calculation results when $B = 10^{15}$ G and $B = 2 \times 10^{15}$ G, respectively.

Since $\sqrt{eB} = 2.4$ MeV when $B = 10^{15}$ G, the transition energy is a few MeV and much larger than the magnetar temperature $T \approx 280$–720 eV [3], and we cannot use the low temperature expansion in the actual calculations. So, we make the calculations at several temperatures in a few keV temperature regions and extrapolate them up to a realistic temperature.

The solid and long-dashed lines represent result of the fitting function $L/V = cT^a$ at $B = 10^{15}$ G and $B = 2 \times 10^{15}$ G, respectively, . For comparison, we give the neutrino luminosity per volume in the modified Urca (MU) process [4] with the dashed line.

Our results show the powers of the temperature are $a = 1.6$ when $B = 10^{15}$ G and $a = 1.2$ when $B = 2 \times 10^{15}$ G, while its power is $a = 8$ in the MU process. At the realistic temperatures, $T = 700$ eV, and $B = 10^{15}$ G, our results give $L/V \sim 10^{21}$ (erg/cm^3·s), while the MU process gives $L/V \sim 10^{11}$ (erg/cm^3·s). Our emission process is expected to be much larger than the usual emission process such as the MU process in the strong magnetic field $B \sim 10^{15}$ G and the realistic temperature region.

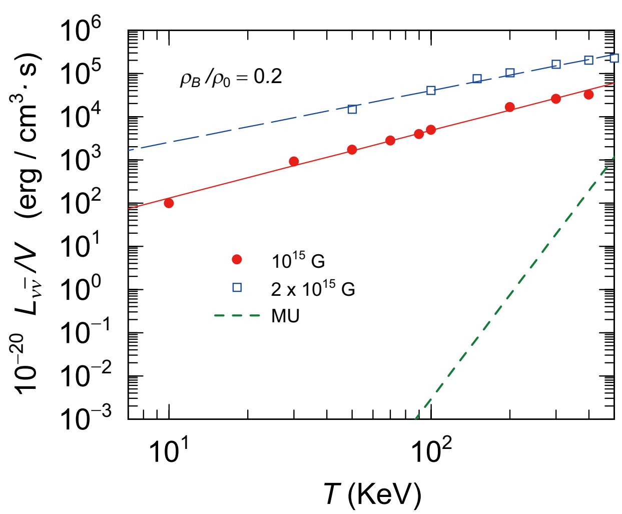

Figure 1: $\nu\bar{\nu}$-pair emission luminosity per volume at the baryon density $\rho_B = 0.2\,\rho_0$.

References

[1] Yakolev, D. G., Pethick, C. J.: 2004, *Ann. Rev. Astron. Astrophys*, **42**, 169.
[2] Maruyama, T., et al.: 2015, *Phys. Rev. D*, **91**, 123007.; 2016, *Phys. Lett. B*, **757**, 125.
[3] Kaminker, A. D., et al.: 2009, *MNRAS*, **395**, 2257.
[4] Maxwell, O. V.: 1987, *ApJ*, **319**, 691.; Yakolev, D. G., Levensh, K. P.: 1995, *A&A*, **297**, 717.

Possible Measurements of Reaction Cross Sections for Explosive Nucleosynthesis using Laser -Driven γ-ray Pulses

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Progress in laser physics enabled us to produce various quantum beams such as electrons, gamma-rays, and ion beams from high field plasma generated from the interaction between high peak power laser and materials. The energies of these radiations become higher than 10 MeV and thus they can interact with nuclei. The quantum beams generated by high peak power laser have a potential to be used for the study of nuclear physics. These laser driven quantum beams have the following features: high flux, ultra-short pulse in a range from femtosecond to nanosecond, and continuous energy distribution.

A pioneering nuclear experiment with high peak power laser for the Big-Bang nucleosynthesis was performed at University of Texas at Austin [1]; the astrophysical cross section of the ^{3}He(d, p)^{4}He reaction in the plasma generated by the Texas Petawatt Laser was measured. In the Extreme Light Infrastructure Nuclear Physics (ELI-NP), it was proposed to produce extremely neutron rich unstable isotopes using fusion reactions of neutron rich fission products on multi-targets including ^{232}Th with high peak power laser to study the r process [2]. It was also proposed to study the s process and photodisintegration reactions in supernova explosions (γ process) using highly intense neutron pulse provided from laser driven D-T nuclear fusion reactions at the Nuclear Ignition Facility (NIF) in LLNL [3].

We have proposed nuclear experiments using laser driven γ-ray pulses to simulate stellar nuclear photoreactions [4]. We have proposed new concepts of three types of experiments using laser driven γ pulses with stellar energy distribution. First, the direct measurement of the stellar (γ, n) reaction cross section on the ground state of atomic nuclei using γ-ray pulse with stellar distribution. Second, the direct measurement of the (γ, n) cross section on exited states. As shown in Fig. 1, the main target is irradiated by the first laser and the nuclei are exited in plasma generated by the laser; the second laser irradiate the target to generated γ-ray pulse with stellar energy distribution. Third, the direct measurement of the transition probability between the ground state and an isomer of astrophysical interest via (γ, γ') reactions using the γ-ray pulse generated by the high peak power laser. An important point to consider in these methods is the generation of γ-ray pulse with energy distribution approximately identical with stellar photon distribution. We have concluded that it is possible to generate Planckian γ-ray pulse by bremsstrahlung on the solid gold target with electron beams with continues energy distributions generated by the laser plasma.

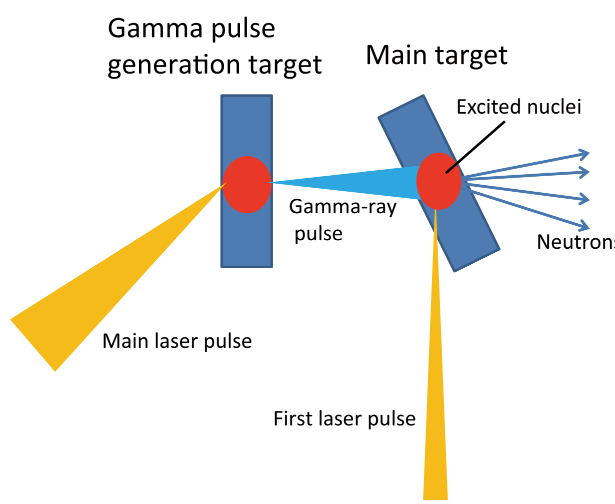

Figure 1: Schematic view of experiment.

References

[1] Barbui, M., et al.: 2013, *Phys. Rev. Lett.*, **111**, 082502.
[2] Habs, D., et al.: 2011, *Applied Physics B*, **103**, 471.
[3] Berstein, L., et al.: 2014, *Plasma and Fusion Research*, **9**, 4404101.
[4] Hayakawa, T., et al.: 2017, *Quantum Beam Science*, **1**(1), 3.

Isomer Producution Ratio of ^{113}Cd Following Neutron-Capture Reactions to Investigate the Origin of ^{115}Sn

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The astrophysical origin of a rare isotope ^{115}Sn has remained still an open question [1,2]. An isomer ^{113}Cd^{m} ($T_{1/2}$ = 14.1 y) in ^{113}Cd is an *s*-process branching point from which a nucleosynthesis flow reaches to ^{115}Sn (see Fig. 1). The *s*-process abundance of ^{115}Sn depends on the isomer production ratio in the ^{112}Cd(n, γ)^{113}Cd reaction. Hayakawa *et al.* [3] measured the ^{112}Cd(n, γ)^{113}Cd^{m} reaction cross section at the thermal energy with neutrons provided from a nuclear reactor, and pointed out that the *s*-process abundance of ^{115}Sn depends on the ratio of the ^{112}Cd(n, γ)^{113}Cd^{m} reaction cross section to the ^{112}Cd(n, γ)^{113}Cd^{gs} reaction cross section in typical *s*-process energies of 1–50 keV. However, the isomer production ratio has not been measured in the energy region higher than the thermal energy. Thus, we have measured γ rays following neutron capture reactions on ^{112}Cd using two cluster HPGe detectors in conjunction with a time-of-flight method at J-PARC [4].

The experiment was performed using the accurate neutron-nucleus reaction measurement instrument (ANNRI) installed at a neutron beam line of BL04 at the MLF in the J-PARC. Proton beams with an average beam power of 200 kW were injected into the mercury target at a repetition rate of 25 Hz. The proton beams were operated with the double bunch mode. High flux pulsed neutrons were generated by spallation reactions on the mercury target. A ^{112}Cd foil enriched to 98.27 % was placed at the center of the γ-ray detector array. The γ-rays from the ^{112}Cd target were measured by two cluster HPGe detectors. In the neutron energy region higher than the thermal energy, we observed both γ rays decaying to the ground state and the isomer of ^{113}Cd. The γ rays decaying to the ground state with energies of 299 and 316 keV were clearly observed, whereas a γ ray with an energy of 259 keV which decays to the isomer was also observed. We have obtained the result that the relative γ-ray intensity ratio of the isomer except for 737 eV is almost constant in the energy region of up to 5 keV. The isomer production ratios calculated by a statistical model were consistented with these ratios. The present result supports the previous conclusion that the contribution of the *s*-process from the ^{113}Cd isomer to the solar abundance of ^{115}Sn is minor in the previous study [3]. The astrophysical origin of ^{115}Sn has remained still an open question.

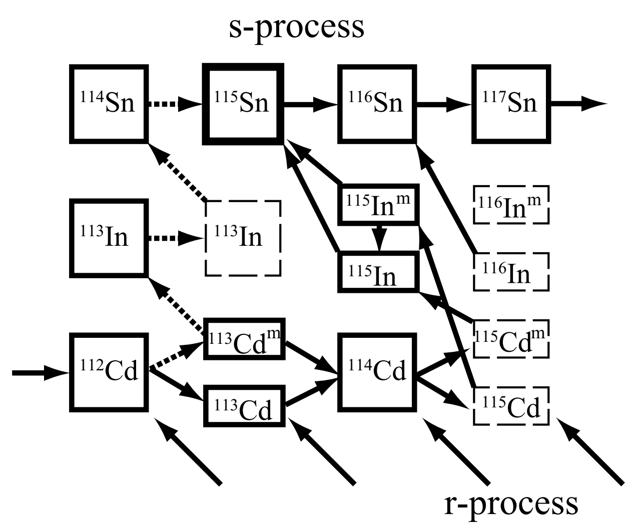

Figure 1: Nuclear chart around ^{113}Cd.

References

[1] Nemeth, Zs., et al.: 1994, *ApJ*, **426**, 357.
[2] Theis, Ch., et al.: 1998, *ApJ*, **500**, 1039.
[3] Hayakawa, T., et al.: 2009, *ApJ*, **707**, 859.
[4] Hayakawa, T., et al.: 2016, *Phys. Rev. C*, **94**, 055803.

Solving the Red Supergiant and Supernova Rate Problems via Relic Supernova Neutrino Spectrum

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Recent observations suggested that the maximum mass of the red supergiant progenitors of core-collapse SNe may be as small as 16.5–18 $M_\odot$ instead of 25 $M_\odot$ (RSG problem). It has been also recognized that the observational supernova rate is smaller than the theoretical estimate (SNR problem). We have investigated these two astronomical problems via the cosmic relic supernova neutrinos (RSNs) [1].

According to the RSG problem, we assumed the possibility that red supergiants with $M > 16.5$–$18\,M_\odot$ end their lives as failed supernovae ($M_{\rm min}^{\rm fSN}$ =16.5, 18 $M_\odot$) and analyzed their contribution to the RSN spectrum. This change in population of different types of SNe can be seen as the deviation in RSN spectrum. SN explosion mechanism is sensitive to the nuclear equation of state (EoS), which affects the temperature of the neutrino sphere. Therefore it is expected that this mass limit influences the RSN energy spectrum. Under the assumption of a initial mass function, lowering mass limit of progenitors for fSNe decreases the relative abundance of luminous SNe and then reduces the supernova rate. Our results showed these features.

Figure 1 shows the ratio bewteen the theoretical and observational supernova rate ($R_{\rm SN}^{\rm Thr}/R_{\rm SN}^{\rm Obs}$). Dotted lines indicate the upper and lower limits due to the uncertainties of star formation rate. Adopted value $M_{\rm min}^{\rm fSN}$ = 16.5–18 $M_\odot$ clearly solves the SNR problem. The RSN spectrum was evaluated by assuming 10 years of running time in a Hyper-Kamiokande detector, i.e., a 10^6 ton water Čerenkov detector. The result is presented in Figure 2. It shows the RSN detection rate for two cases of $M_{\rm min}^{\rm fSN}$= 16.5, 18 $M_\odot$. In addition, the figure includes the results of $M_{\rm min}^{\rm fSN}$ = 25 $M_\odot$ for comparison. The figure clearly shows the EoS dependence of RSN spectrum in the energy range of $E_{e^+} > 30$ MeV, and the locations where the event rates exceed the atmospheric background are well separated. This finding suggests a detection of the RSN spectrum can give insight into the SN explosion mechanism in terms of the nuclear matter properties.

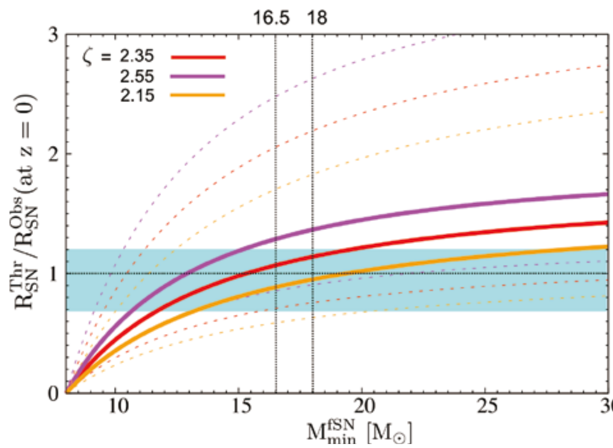

Figure 1: Relationship between $M_{\rm min}^{\rm fSN}$ and $R_{\rm SN}^{\rm Thr}/R_{\rm SN}^{\rm Obs}$ at z = 0 by adopting $R_{\rm SN}^{\rm Obs} \approx 0.6 \pm 0.2 \times 10^{-4}\,{\rm yr^{-1}\,Mpc^{-3}}$. Three lines are shown due to the uncertainties of IMF. The horizontal blue band indicates the range of uncertainty caused by $R_{\rm SN}^{\rm Obs}$.

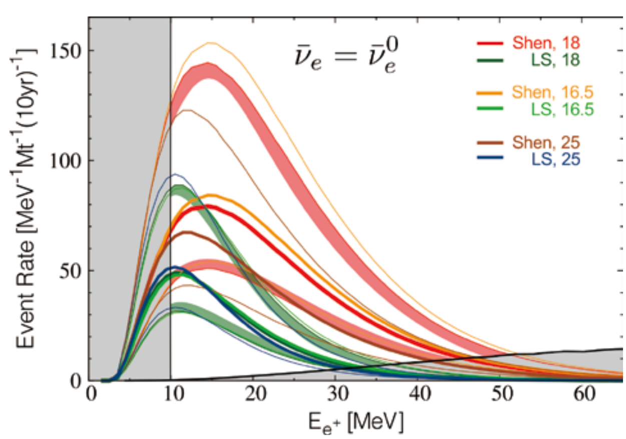

Figure 2: Predicted e^+ energy spectra for the cases of $M_{\rm min}^{\rm fSN}$= 16.5, 18 or 25 $M_\odot$ without neutrino oscillation. The results for two different fSNe models based upon the stiff EoS (Shen) and the soft EoS (LS) are included. The shaded energy range below 10 MeV indicates the region where the background noise due to reactor $\bar{\nu}_e$ may dominate. The shaded energy range near the horizontal axis indicates the region where the background may be dominated by noise from atmospheric neutrinos.

Reference

[1] Hidaka, J., Kajino, T., Mathews, G. J.: 2016, *ApJ*, **827**, 85.

Non-Extensive Statistics Solution to the Cosmological Lithium Problem

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First proposed in 1946 by George Gamow [1], the hot Big-Bang theory is now the most widely accepted cosmological model of the universe. The theory has been vindicated by the observation of the cosmic microwave background, our emerging knowledge on the large-scale structure of the universe, and the rough consistency between calculations and observations of primordial abundances of the lightest elements in nature. The primordial Big-Bang Nucleosynthesis (BBN) began when the universe was 3-minutes old and ended less than half an hour later when nuclear reactions were quenched by the low temperature and density conditions in the expanding universe. Big Bang nucleosynthesis (BBN) theory predicts the abundances of the light elements D, ^{3}He, ^{4}He and ^{7}Li produced in the early universe. The primordial abundances of D and ^{4}He inferred from observational data are in good agreement with predictions, however, the BBN theory overestimates the primordial ^{7}Li abundance by about a factor of three [2,3,4,5]. This is the so-called “cosmological lithium problem”. Solutions to this problem using conventional astrophysics and nuclear physics have not been successful over the past decades, probably indicating new physics during the era of BBN [6,7].

We have investigated [8] the impact on BBN predictions of adopting a generalized distribution to describe the velocities of nucleons in the framework of Tsallis non-extensive statistics [9]. This generalized velocity distribution is characterized by a parameter q, and reduces to the usually assumed Maxwell-Boltzmann distribution for q = 1. We find excellent agreement between predicted and observed primordial abundances of D, ^{4}He and ^{7}Li for $1.069 \le q \le 1.082$, which is shown in Fig. 1, suggesting a new solution to the cosmological lithium problem.

We encourage studies to examine sources for departures from classical thermodynamics during the BBN era so as to assess the viability of this mechanism. Furthermore, the implications of non-extensive statistics in other astrophysical environments should be explored as this may offer new insight into stellar nucleosynthesis. The Tsallis statistics has already applied to the stellar distribution and dynamics in the galaxies, and enjoyed a success in the description of various phenomena induced by plasma fluctuations.

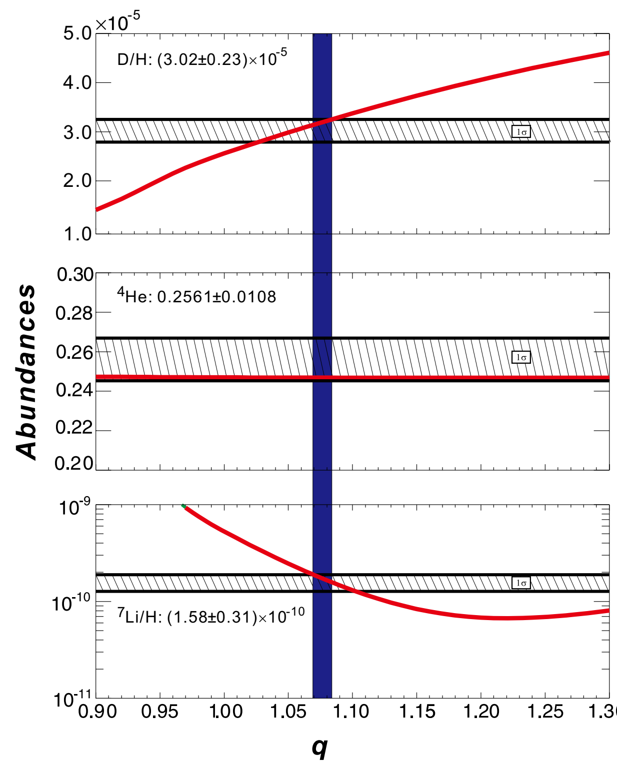

Figure 1: Predicted primordial abundances as a function of parameter q (in red solid lines). The observed primordial abundances [10,11,5] with 1σ uncertainty for D, ^{4}He, and ^{7}Li are indicated as hatched horizontal bands. The vertical (blue) band constrains the range of the parameter q to $1.069 \le q \le 1.082$.

References

[1] Gamow, G.: 1946, *Phys. Rev.*, **70**, 572.
[2] Cyburt, R. H., et al.: 2003, *Phys. Lett. B*, **567**, 227.
[3] Coc, A., et al.: 2004, *ApJ*, **600**, 544.
[4] Asplund, M., et al.: 2006, *ApJ*, **644**, 229.
[5] Sbordone, L., et al.: 2010, *A&A*, **522**, A26.
[6] Fields, B. D.: 2011, *Ann. Rev. Nucl. Part. Sci.*, **61**, 47.
[7] Cyburt, R. H., et al.: 2016, *Rev. Mod. Phys.*, **88**, 015004.
[8] Hou, S. Q., et al.: 2017, *ApJ*, **834**, 165.
[9] Tsallis, C.: 1988, *J. Stat. Phys.*, **52**, 479.
[10] Olive, K. A., et al.: 2012, *MNRAS*, **426**, 1427.
[11] Aver, E., et al.: 2010, *J. Cosmol. Astro-Particle Phys.*, **5**, 003.

Detection of an Ionized Oxygen Emission Line from a High Redshift Galaxy in the Reionization Era

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The Bing Bang radiation confirmed by cosmic microwave background (CMB) is originated from thermal emission of ionized gas. The ionized gas is then neutralized by atoms/electrons recombination, and our universe became transparent. However, it is known that our intergalactic space, at redshift less than 6, is filled with low density ionized gas again. Detailed observations of CMB suggest that our universe was reionized at redshift around 10. Our observation of an ionized oxygen [OIII]88 μm line has identified a candidate of such galaxies in the early universe [1], as shown in figures 1 and 2.

First stars in our universe are thought to be massive and short lived, which distributed heavy elements into interstellar space by supernovae. A cluster of such massive stars could be a strong source of UV radiation and ionized emission from the heavy elements. Our ALMA observation of a high redshift galaxy (SXDF-NB1006-2, $z = 7.2$) is one of such galaxies discovered by Subaru telescope having strong Lyα emission in the middle of reionization era.

Preceding to our ALMA observation, we estimated the emission strengths of far-infrared atomic fine structure lines from high redshift galaxies [2]. As a result, the ionized oxygen [OIII]88 μm line could be the brightest emission line under strong UV radiation and low metallicity conditions. This is also consistent with [OIII]88 μm observations by AKARI infrared satellite towards the Tarantula Nebula in the Large Magellanic Cloud.

The most interesting discovery from the ALMA observation of SXDF-NB1006-2 is that ionized carbon [CII]158 μm and dust emissions were not detected [1]. This indicates that the galaxy is deficient of neutral gas but dominated by ionized gas. Then UV radiation from massive stars are not absorbed by the interstellar medium and penetrate into intergalactic space, and we estimated that the UV radiation from the galaxy could contribute to the cosmic reionization. Our observation not only discovered the most distant oxygen, but also proposed a new tool to study the early history of our universe. With coming ALMA observations, we will be observing more on far-infrared atomic fine structure lines from the most distant objects to identify the cosmic reionization and structure formation in the early universe.

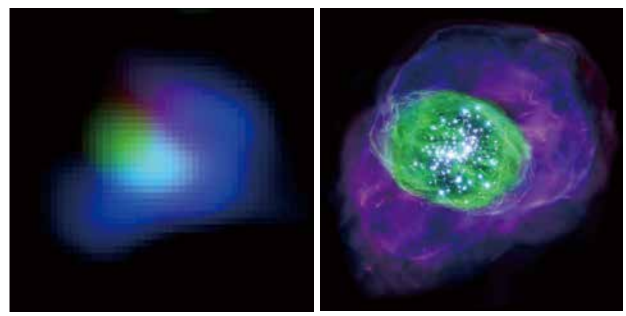

Figure 1: (left) 3-color image from observations: green for ALMA [OIII]88 μm, purple for Subaru Lyα and red for UKIRT UV radiation. (right) artist's illustration of SXDF-NB1006-2 showing that the UV emission from a massive star cluster is penetrating into intergalactic space and ionizing the neutral gas around.

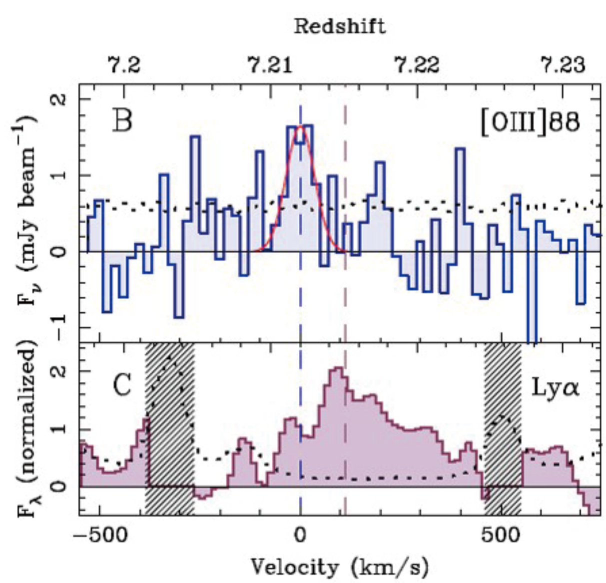

Figure 2: (upper) [OIII]88 μm emission spectrum observed by ALMA. (lower) Lyα emission by Subaru telescope. Peak is shifted due to absorption by neutral gas.

References

[1] Inoue, A. K., et al.: 2016, *Science*, **352**, 1559.
[2] Inoue, A. K., et al.: 2014, *ApJL*, **780**, L18.

Terahertz and Far-Infrared Windows Opened at Dome A in Antarctica

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Astronomers are seeking for higher and dryer sites on earth for better observing condition especially in infrared to terahertz frequency region, where absorption by water vapor dominates atmospheric transmission. Here, we show the measurement of atmospheric transmission from Dome A, Antarctica, using Fourier transform spectrometer in infrared to terahertz frequency region [1]. Because of the low temperature of antarctic plateau, as low as −80 °C in winter time, atmospheric water vapor is scarce and the Dome A can be the best observing site on earth.

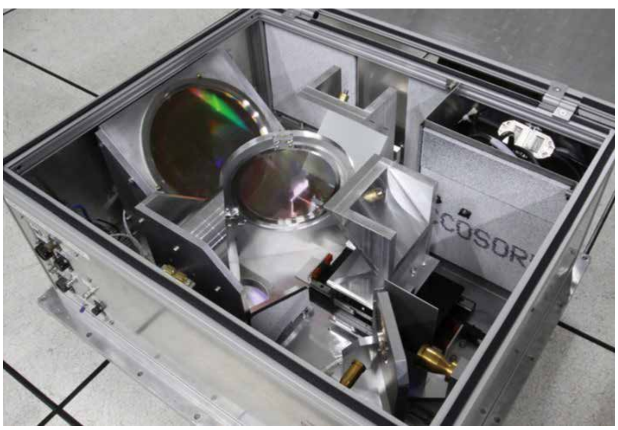

Figure 1: Picture of Fourier transform spectrometer for Dome A atmospheric measurement.

Figure 1 shows the Fourier transform spectrometer used for the atmospheric measurements [2]. Room temperature thermal detectors are used and the spectrometer was calibrated according to two temperature blackbody sources; one at room temperature in the spectrometer and another at outside in cold. Figure 2 shows the measured atmospheric transmittance in the site testing campaign at Dome A during 2010–2011. The transmittance at the supra-terahertz windows reaches as high as 30 %, whereas the best transmittance in ALMA site is as high as 20 % [3]. Furthermore, we observe numerous atmospheric windows all through the terahertz frequencies as shown in figure 1, including 10–20 % transmittance at 2 THz, 3 THz and 5–6 THz windows where astronomical atomic fine structure lines could be observed from ground. The 7 THz window shows median transmittance of about 40 % in winter, which would be important for observing thermal emission from protoplanetary disks and exoplanets. Since variation of atmospheric transmittance is small in Dome A as well as low wind speed, the site is suitable for long baseline terahertz interferometers.

Our atmospheric measurements were used to make detailed comparison to existing atmospheric model and satellite data. We have found the existing model underestimate continuum absorption by water vapor and new constraints on the spectral absorption lead to better understanding of upper troposphere in relation to our climate on the earth.

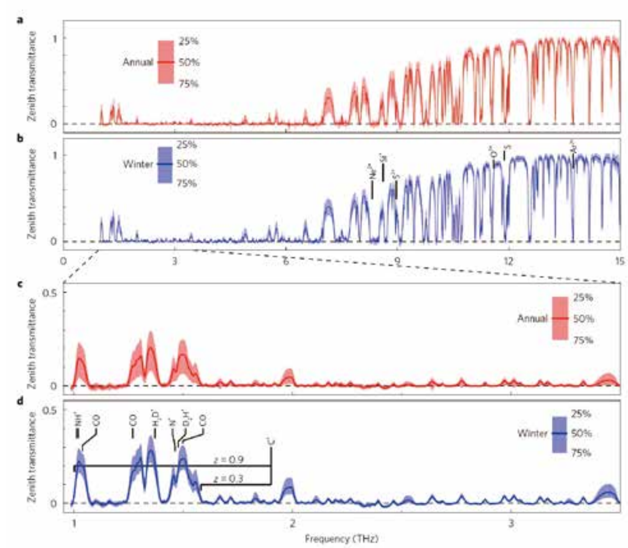

Figure 2: Zenith atmospheric transmittance spectra measured at Dome A. Spectra are shown for the entire year (a,c) and for winter (April-September) only (b,d).

References

[1] Shi, S.-C., et al.: 2016, *Nature Astronomy*, **1**, 1.
[2] Li, X.-X., et al.: 2009, *Proc. SPIE*, **7385**, 73851D.
[3] Matsushita, S., et al.: 1999, *PASJ*, **51**, 603.

Development of Terahertz Photon Counting Detectors

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For future terahertz astronomy, we are working on a new interferometer technology based on the Hanbury-Brown and Twiss intensity interferometers. The intensity interferometers can be used with direct detectors and their correlation is stable against phase fluctuation. For application to space interferometers, direct detectors can operate under background limited performance which surpass the sensitivity of heterodyne receivers. Figure 1 shows the requirements on detector noise equivalent power (NEP) to achieve the background limited performance as a function of detector time response [1].

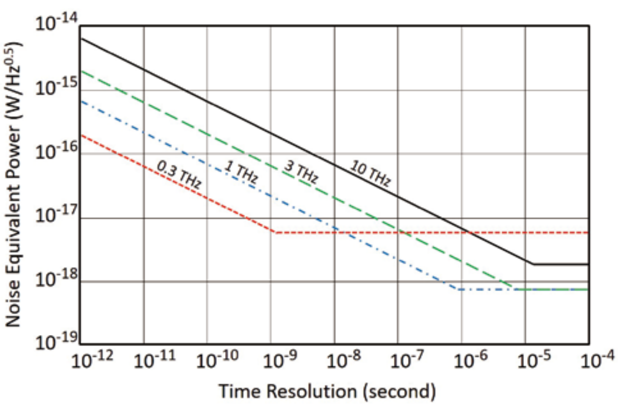


Figure 1: Requirements on background limited detector NEP as a function of the detector time response [1].

When the detector response is slower than a photon arrival rate, the required NEP is a function of input radiation power (right hand side in Figure 1). On the other hand, when the detector response is fast enough to resolve each photon arrival, the requirement on detector NEP is reduced in proportion to square root of the time resolution. For example at 1 THz, 1 ns time resolution enables the usage of detectors with NEP less than 10^{-17} W/$\sqrt{\text{Hz}}$. Under lower background conditions using grating spectrometers, the requirement on NEP do not change, and background limited performance is realized relatively easily.

We are developing terahertz photon counting detectors with high time resolution using superconducting tunnel junction detectors, similar to SIS receivers for ALMA. When niobium tunnel junctions are cooled below 0.8 K, they can be used as high sensitivity photon detectors [2]. Our group in NAOJ collaborating with AIST is developing low leakage tunnel junctions made of Nb/Al-AlOx/Al/Nb, and achieved 7 pA leakage current for 10 μm × 10 μm junctions. With smaller junction sizes, we expect to achieve as low as 1 pA leakage current as well as NEP less than 10^{-17} W/$\sqrt{\text{Hz}}$.

We have made an experiment using Nobeyama Radioheliograph to demonstrate the capability of the intensity interferometers [3]. Figure 2 shows the cross-correlation of signals from two 17 GHz receivers; one in amplitude and another in intensity (amplitude squared) correlations.

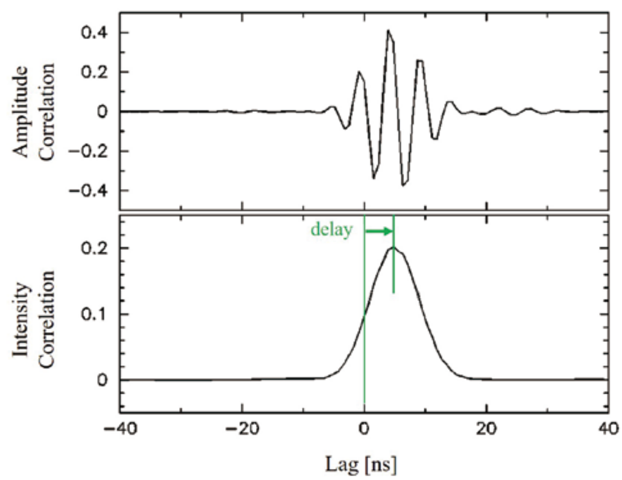


Figure 2: Amplitude and intensity (amplitude squared) cross correlation using Nobeyama Radioheliograph 17 GHz receivers [3].

Although in intensity there are no phase information, delay time can be measured by the intensity cross correlation, which can be used to define the complex visibilities. The same principle can be used in terahertz intensity interferometry, where fast photon counting detector are used to measure the intensity cross correlation and realize wide bandwidth and high sensitivity interferometers.

Astronomical observation using photon counting detectors can be a new tool to study photon statistics of astronomical sources [1]. In case of thermal source, Bose-Einstein statistics is expected which can be a precision measure of the source temperature, whereas in maser and synchrotron sources the photon statistics could tell us the physical condition of the sources.

References

[1] Matsuo, H., Ezawa, H.: 2016, *J. Low Temp. Phys.*, **184**, 718.
[2] Ezawa, H., et al.: 2016, *J. Low Temp. Phys.*, **184**, 244.
[3] Ezawa, H., et al.: 2015, *Proc. ISSTT-2015*, W2-2.

II Status Reports of Research Activities

1. Subaru Telescope

1. Subaru Telescope Staff

As of the end of FY 2016, the Subaru Telescope Project staff consisted of 19 dedicated faculty members including five stationed at Mitaka, four engineers, one specially appointed senior specialist and three administrative staff members. Additional staff members include three specially appointed research staff, three specially appointed senior specialist, five research experts, and six administration associates, all of whom are stationed at Mitaka. Moreover, 14 research/teaching staff members, 13 of whom are stationed at Mitaka and one of whom is stationed at Pasadena, and three engineers, two of whom are stationed at Mitaka and one of whom is stationed at Nobeyama are appointed concurrently. The project also has 73 local staff members dispatched from the Research Corporation of the University of Hawaii (RCUH), including scientific assistants; engineers in charge of software and observational instruments; technicians for facilities, machinery, vehicles, and laboratories; telescope/instrument operators; secretaries; librarians; administrative staff; researchers employed through Grants-in-Aid for Scientific Research; and graduate students. These staff members work together in operating the telescope, observational instruments, and observational facilities; and in conducting open-use observations, R&D, public outreach, and educational activities.

2. Science Highlights

In FY 2016, Subaru Telescope produced many outstanding scientific outcomes which were published in major international journals. Below are some examples:

(1) Using the Fiber Multi-Object Spectrograph (FMOS), a 3D map of as many as 3000 galaxies was created at the redshift of 1.2–1.5. The estimated expansion of the Universe is consistent with the general relativity proposed by Einstein. Using Hyper Suprime-Cam (HSC), (a) an extremely rare, double source plane gravitational lensing system, in which two distant galaxies are simultaneously lensed by a foreground galaxy, was discovered, which will help us understand the history of the Universe, and (b) it was found that star-forming galaxies in the distant Universe (about 5 billion years ago) show more similarity in spatial distribution to mysterious invisible “dark matter” than those in the nearby Universe (about 3 billion years ago).

(2) In HSC survey data, an extremely faint dwarf galaxy was discovered at the distance of 280 thousands light-years away, thanks to the very high sensitivity of the Subaru Telescope. This discovery suggests the presence of a large number of yet-undetected dwarf satellites in the halo of the Milky Way and provides important insights into galaxy formation through hierarchical assembly of dark matter.

(3) Observations of Saturn using COMICS revealed that the optically faint Cassini Division and the C ring were sometimes brighter than the other rings in the mid-infrared light. The data give important insights into the nature of Saturn’s rings.

3. Open-use

We continued to solicit proposals for observation topics for each semester: S16A (February 1 - July 31) and S16B (August 1 - January 21). Proposals were collected by the Mitaka office and adopted or rejected by the Subaru Time Allocation Committee (under the Advisory Committee for Optical and Infrared Astronomy) based on reviews by Japanese and international referees. In S16A, 41 programs (86 nights) were accepted out of 184 submitted proposals, requesting 451.7 nights in total. In S16B, 31 proposals (49 nights) were accepted out of 142 submitted proposals, requesting 409.8 nights in total. Service observations were made for 10 nights. In S16A and S16B, 2 and 1 accepted open-use proposals were by foreign principal investigators, excluding University of Hawai`i observing time. The number of applicants in submitted proposals was 2063 for Japanese researchers (Japanese astronomers at any institute and non-Japanese astronomers belonging to Japanese institutes) and 794 for foreign researchers. The number of researchers in accepted proposals was 651 for Japanese astronomers and 232 for foreign astronomers.

In S16A and S16B, the number of open-use visiting observers was 308, of which 43 were foreign astronomers. 104 astronomers observed remotely from Mitaka. Observing proposals were solicited and collected, the procedures for Japanese researchers to travel for observations, and travel expense reimbursement were handled by the Mitaka Office. Subaru Telescope made the observing schedule and provided support for the observers’ lodging, transportation, and observations while in Hawai`i. In S16A and S16B, 91.9 % of the open-use time (including University of Hawai`i time) was used for actual astronomical observations, after excluding the weather factor and scheduled maintenance downtime. About 1.7 %, 0.3 %, and 6.1 % of observing time was lost due to instrument trouble, communication trouble, and telescope trouble, respectively.

In S16A and S16B, remote observations from Hilo were conducted for 2 programs with 2 nights. However, remote observations from Mitaka, where observers in Mitaka can participate in observations remotely in addition to on-site observers at the summit, were conducted for 22 programs with 68 nights. The service observations were conducted for 11.55 nights. The number of time exchange nights between Subaru Telescope and Keck was 5.5 in S16A and 8.5 in S16B. That between Subaru Telescope and Gemini was 5 in S16A and 2 in S16B.

4. Telescope Maintenance and Performance Improvement

Repair plans for the optical-side mirror hatch, which broke down in February of last year (FY 2015) were considered. Some experiments and preparation were carried out for the repair work during 7 days in August. The mirror hatch repair is scheduled for June and July of next year, requiring 14 days down-time in each month (total 28 days).

Primary mirror recoating work which was planned for this year was postponed to autumn of next year (FY 2017) due to the mirror hatch incident. During the next year it will be required to repair the mirror hatch reliably and recoat the primary mirror. The primary mirror recoating work is scheduled for a total of 73 days down-time, with some other maintenance work.

Other general functions and capabilities of the Subaru Telescope are continuing to be maintained the same as the previous year.

In this year, electrical boards for the Auto Guider and Shack-Hartmann CEU (Central Electric Unit) Board, DPA (Driver and Power Assembly unit) for the tip and tilt secondary mirror, bogie rubber spring for dome AZ rotation, and slip-ring for dome electrical power were replaced. Maintenance work for the primary mirror transporter and primary mirror washing facility were done. TWS (Telescope Work Station) user interfaces and barcode tape for dome AZ angle detection were updated. Long-term maintenance plan were drawn up. The Hitomi satellite (ASTRO-H) which had severe incidents unfortunately was observed at the request of ISAS. Function tests of the primary mirror actuator prototype, welding repair work on the dome bogie rail were also done in the year.

In addition, while promoting the improved performance and operational efficiency of the Subaru Telescope, renovation to the telescope control units, which were installed more than 10 years ago, proceeded. The local control units that were renovated or modified in this year were the balance control unit (BLCU) and tertiary mirror control unit (TMCU). By finishing BLCU and TMCU replacement work this year, all renovation of the telescope control units which has been carried out sequentially over 10 years was completed. It is planned to start the second round updating the aging TSC (Telescope System Computer) server from next year.

The major causes of the telescope trouble this year were, aging, maintenance error (human error), and defective design. Aging on UPS2 (Uninterruptible power supply #2), maintenance error during PIR unit (FMOS) installation, manufacturing failure in FRCU (PF) (Filed Rotation Control Unit for Prime Focus) local unit, POpt (Suprime-cam) Hexa-pod trouble (random failure?), aging of the man-basket PLC (Programmable Logic Controller), operational error in barcode value readings, aging of the TUE (Top Unit Exchanger) gripper 2 motor encoder, shoddy workmanship on cabling of the tip-tilt secondary mirror, shoddy workmanship in assembling work of dome AZ slip-ring, defective design in EL cable wrapper, aging of the AZ cable wrapper, defective design on IR-side Main Shutter, and maintenance error for operating of the safety switch #15 occurred causing observations to be canceled.

Additionally, we developed a mechanism to remotely obtain status logs on the local machine. We would like to continue to utilize the telescope status log and work on preventive maintenance for the telescope and the enclosure.

5. Instrumentation

The eight open-use facility instruments of Subaru Telescope have been operated stably in FY 2016. Those instruments are Hyper Suprime-Cam (HSC), Subaru Prime Focus Camera (Suprime-Cam), Faint Object Camera And Spectrograph (FOCAS), High Dispersion Spectrograph (HDS), Infrared Camera and Spectrograph (IRCS), Cooled Mid-infrared Camera and Spectrograph (COMICS), Multi-Object Infrared Camera and Spectrograph (MOIRCS), and 188-elements Adaptive Optics and Laser Guide Star system (AO188/LGS).

In these years, there have been discussions on how we will maintain or cease operation of the facility instruments, except for HSC. As reported in last year, FMOS was decommissioned in April, 2016. Also, it was decided to decommission Suprime-Cam after the observations in May, 2017. In addition, possible decommissioning of FOCAS was discussed because assigning dark nights to FOCAS has been almost impossible and the situation will get worse after the commissioning of PFS. The discussions have been held within Subaru, in SAC, and in the Subaru users' meeting. It was basically agreed to stop the operation of FOCAS in early 2019 (in the earliest case), or after the commissioning of PFS (in the latest case).

The operation of HSC has been stable, similar to the last fiscal year. In this fiscal year, HSC observations have been made for approximately two weeks in almost in every month except for May and October. Although these frequent observations did not create problems in HSC operation, there were a few problems with the filter exchange unit (FEU) around the end of this fiscal year which led to cancellations of the observations. Those troubles were all recovered on the next day and further maintenance work was made after the observing runs to remove the cause of the troubles. We are carefully monitoring the operation of the FEU and will work on its stabilization. For HSC, installation of the filter transmission measurement system, installation of the new on-axis dome-flat system, and a test of FEU reinstallation to exchange filters during an observing run have been made in this fiscal year.

The ongoing upgrade projects for the other facility instruments are the fiber MOS unit for HDS; the polarimetric function in thermal infrared for IRCS and in mid-infrared for COMICS; the integral field units (IFU) for FOCAS and MOIRCS; the Transponder-Based Aircraft Detector (TBAD) for the LGS system; and an upgrade of the real-time control system for AO188. In addition, upgrades of the aging control computers and devices of the first generation instruments are ongoing.

In FY 2016, four carry-in (PI-type) instruments HiCIAO (high-contrast coronagraph imager), Kyoto-3DII (optical integral field spectrograph), SCExAO (Subaru Coronagraphic Extreme Adaptive Optics) and CHARIS (high-contrast integral-field spectrograph) have been offered to the Subaru open-use program. Operation of Kyoto-3DII at the Subaru telescope ended in S17A. Among the instrument modules of SCExAO, VAMPIRES (visible interferometric imager with differential polarimetry) was open for public use.

A new PI-type instrument, IRD (InfraRed Doppler instrument) was under construction, aiming to have the first-light observation in June 2017. Two other PI-type instruments proposed by the University of Tokyo team, SWIMS (Simultaneous-color Wide-field Infrared Multi-object Spectrograph) and MIMIZUKU (mid-infrared multi-field imager and spectrograph), which are to be used on the 6.5 m University of Tokyo Atacama Observatory (TAO) telescope, were approved but only for engineering observations.

The Prime-Focus Spectrograph (PFS) is an optical/near-infrared multi-object spectrograph at the prime focus of the Subaru Telescope, which will be the next facility instrument following the successful implementation of Hyper Suprime-Cam (HSC). PFS is being developed through international collaboration including seven countries, led by Tokyo IMPU. The PFS has about 2400 optical fibers distributed over the 1.3 degree field of view of the prime focus that feed the light of the astronomical objects to four identical spectrographs which will be placed in the telescope dome. The spectrograph modules simultaneously cover the wavelength range from 0.38 μm to 1.26 μm. The subcomponents of PFS were developing at each partner institute aiming towards engineering first-light in 2018. Science operation is expected to begin in 2020. Subaru Telescope is responsible for modifying the telescope and enclosure to accept PFS; the design work and reinforcement of the spectrograph floor have been conducted. Efforts to develop a database that combines HSC and PFS data, so that users can access both instruments' data seamlessly, has started as a US-Japan collaboration. Peking University (though the Chinese consortium) and Max-Plank Institut für Extraterrestrishe Physik (MPE) officially joined PFS collaboration and NAOJ will handle their funds for PFS development.

We are conducting a conceptual study of "ULTIMATE-Subaru", Subaru Telescope's next large facility instrument following HSC and PFS, which will be one of the flagship instruments at the Subaru Telescope in the 2020's. We are studying the concept of a wide-field near-infrared imager, multi-object spectrograph, and multi-object integral field unit (IFU) spectrograph, assisted by a ground-layer adaptive optics (GLAO) system. The GLAO will allow us to uniformly improve the image quality over a wide field of view by correcting the turbulence at the ground layer of the Earth's atmosphere by using an adaptive secondary mirror. In FY 2016, we had an ULTIMATE-Subaru science workshop at NAOJ Mitaka Campus by inviting scientists from Japan and potential partner countries. We are also working on the conceptual study of the GLAO system and wide-field near-infrared instruments in collaboration with Australia and Canada. We have now an official (short-term) agreement with Australia to collaborate in the GLAO feasibility studies.

6. Computers and Network

One of our goals of this year was the same as a goal of the previous year - to stably operate the fourth generation system of computers and network called STN4. Stable operation was achieved without serious trouble or attacks/intrusions such as illegal access.

The observation data archive was continued from the previous year. The archive is operational without serious problems. The data archive system in Mitaka also showed stable performance.

We officially rolled out remote observations from Mitaka using the Remote Observation Monitor System for limited instruments in 2015. An increasing number of observers are using the Remote Observation Monitor System in Mitaka. During the observation semesters from February 2016 through January 2017, about 40 observation programs utilized the remote observation monitor system for about 100 nights. The Proposal Management System (ProMS) also worked very well.

Computers for HSC data analysis (HSC On-site Data Analysis System) were procured in fiscal years 2010 and 2011. We added storage to the system in FY 2016.

We purchased a test system for the HSC On-site Data Analysis System that comprises a filesystem that surpasses NFS in access speed. We are currently configuring the test system toward real-time data analysis during observations in the next fiscal year.

The online visitor forms for those who visit Subaru Telescope in Hilo for observation and for those who visit NAOJ in Mitaka for remote observation monitoring are operating.

Since the current rental contract for our computer and network infrastructure comes to an end in February 2018, we spent a sizable amount of time for the procurement of computers and network systems for continuous service after March 2018. We created the specification draft for a new rental contract from March 2018 to February 2023 and requested information. We always studied ways to keep the performance and functions as well as to reduce cost and updated the specifications.

7. Education (Under-graduate and Graduate Courses)

The number of Subaru Telescope staff members in Hilo who were concurrently appointed by SOKENDAI (graduate school) was eleven. The number of SOKENDAI students who had primary supervisors affiliated with Subaru Telescope (including those concurrently belonging to Subaru Telescope) was 16, which constituted half of the total 32 Sokendai students hosted in NAOJ. Of which five had supervisors who belonged primarily to Subaru Telescope.

In FY 2016, Subaru Telescope hosted four graduate students for long stays, of which one was a SOKENDAI student. On top of that, intensive education activities were seen also in Mitaka in cooperation with the Division of Optical and IR Astronomy. The numbers of graduate course students in all of Japan who obtained master's degrees and PhD's based on Subaru Telescope data were 14 and 8, respectively, of which two and four belonged to the Division of Optical and IR Astronomy.

We also regularly hosted a series of educational programs at Subaru Telescope. In December 2016, we hosted a Subaru Winter School at National Central University in Taoyuan, Taiwan. There were 23 participants from Japan, Taiwan, China, and South Korea (four were from Japanese institutes). They learned the reduction and analysis of Subaru Telescope data and heard a series of lectures. Moreover, we hosted two Subaru Telescope observation training courses. One was for eight undergraduate students from all over Japan held in September 2016, and the other was for six new SOKENDAI students at NAOJ held in January 2017. In the Hilo office, we had regular Subaru Telescope seminars in English 2–3 times per month, where open-use observers, visitors, and Subaru Telescope staff members presented their own new research. Also in the Subaru Telescope Mitaka office, we had many official and informal seminars, many of which were jointly organized with other divisions in NAOJ and/or neighboring universities.

8. Public Information and Outreach (PIO)

The Public Information and Outreach (PIO) office is tasked with addressing the accountability for what the Subaru Telescope does and is keenly aware of the importance of citizens understanding our work, for both the short-term and long-term success of the project. The increased importance of positive awareness in the local community has profound meaning for the next generation telescope project on Maunakea. Therefore PIO pays more attention to the interaction with the local community, in its three major areas of tasks.

Task 1: Disseminating information about the results from the Subaru Telescope and the work at the Subaru Telescope. The primary tools are the postings on our own website; providing press releases to the Japanese, local, and international media; and holding press conferences. During Fiscal Year 2016, there were 19 web-postings (9 in Japanese, 10 in English) about discoveries from the Subaru Telescope. Articles about instrument development; the work and the activities at the Subaru Telescope; and other announcement totaled 76 (46 in Japanese, 30 in English). Some postings are also distributed through the media as well as posting services such as the American Astronomical Society's mailing exploder. Many articles appeared in Japanese newspapers, and some in the local newspapers; with more prevailing in the on-line postings.

In addition, newer tools such as Twitter, Facebook, and YouTube are becoming more useful in spreading awareness in a timely manner. The PIO office is making extra effort in providing striking visuals for such social media postings. Filming requests from outside totaled more than 23 from Japanese media (including 1 for an English language production), in addition to the numerous inquiries/questions from the media, educational institutions, and museums.

Task 2: Provide escorted tours for the public and special groups to see the facility. The public tour program that started in 2004 continues to provide opportunities to see the telescope up-close for guests from Japan and from around the world. Dedicated full-time staff leads tours and provided timely communication to those requesting tours. It is possible to register for the general tours program on-line. Except for summer months when the tour program was suspended due to the inclement weather related access issues on Maunakea, a total of 456 people visited through this program. There were 127 additional groups who visited through special tour programs and resulted in a total head count of 1048 people who visited the summit facility. The tours are all escorted by the assigned staff, in either Japanese or English language. The telescope tours include 8 tours (2 per day on 4 days) specifically targeting the residents of the State of Hawaii, in the hope of increasing the positive awareness of what the telescope does.

Facility tours of the Hilo Base Facility are most of the time accompanied by other activities described in the next major task area, namely: special lectures, hands-on sessions, or presentations by the student group. A total of 40 groups, with 398 people, visited the base facility this year.

Task 3: Public outreach includes lectures in the local community, special presentations in the schools, and remote presentations for Japanese schools or museums. PIO provided/coordinated 75 lectures at the Hilo Base Facility or in its vicinity such as at the ‘Imiloa Astronomy Center. There were 17 lectures outside of the island, and 11 remote lectures for off-site locations. The local lectures included 37 classroom presentations during the Journey through the Universe program over the course of a week.

In place of an open house, the staff of the Subaru Telescope participated in the annual AstroDay event at the local shopping mall. Observatories on Maunakea, ‘Imiloa Astronomy Center, Maunakea Visitor Information Station, and other astronomy-related groups participated in this event. More than 2000 people visited this family-friendly event.

Another special local event where many astronomy observatories participate is the annual Onizuka Science Day at the University of Hawai`i at Hilo. Six hundred selected students between grades 4 and 12 (upper elementary school to high school) with families and teachers from all over the island gathered for this event. PIO provided 2 hands-on workshops and an exhibit booth.

Events like these where Subaru Telescope staff meet and interact with students and members of the local community are effective for improving the recognition of the Subaru Telescopes activities. Of course material about these events is distributed via the website and social media.

A special effort was made in the following two areas: posting articles summarizing Subaru Telescope's achievement, and faculty development seminars. In the summary series, there are 22 articles published on the Subaru Telescope's website. The seminar speakers included prominent leaders from the local community, so that the staff of the Subaru Telescope has better understandings of the cultural and historical aspects of the place where they work.

2. Okayama Astrophysical Observatory

Okayama Astrophysical Observatory, (hereafter the Observatory) serves as the observing and research base of the optical and infrared astronomy in Japan, and it promotes open use, primarily of the 188-cm telescope, to universities throughout the country. It also pursues joint R&D projects with universities, contributing toward forming stronger foundations for astronomy research at the universities. Concurrently, the Observatory pursues its own research activities, taking advantage of its location and observational environment.

Every year, about 240 nights at the 188-cm telescope are exploited for observations by researchers from across the country through the open use. The Observatory maintains and operates the observing instruments and provides the observers with support for observations, travel expenses, accommodations, everyday needs, etc. It also engages in improving the open-use observing instruments, developing new open-use instruments, and supporting carry-in instruments from other institutions.

Several joint projects with universities have been conducted, including Kyoto University's Okayama 3.8-m New Technology Optical and Infrared Telescope Project, the Tokyo Institute of Technology's Gamma-Ray Burst Optical Afterglow Follow-up Project, and "The Optical & Near-Infrared Astronomy Inter-University Cooperation Program" supported by MEXT.

The Observatory's unique research activities include a project designed to convert the 91-cm telescope into an ultra-wide-field near-infrared camera (OAO-WFC) in order to engage in a comprehensive survey of infrared-variable objects in the Galactic plane. A new project has just begun this FY to make the 188-cm telescope robotic and to improve the stability and sensitivity of the high dispersion spectrograph through a Grant-in-Aid for Scientific Research (Basic Research (A), FY 2016–2020). This project aims at establishing a large sample of exoplanets by Doppler technique. Collaborations with foreign researchers are also continued actively.

The personnel breakdown as of March 2017 was five full-time staff members without term limits, including two associate professors, one assistant professor, one engineer, and one Chief of the Administration Office; eleven contract employees, including one specially appointed associate professor, two research experts, one specially appointed research staff member, one specially appointed senior specialist, one research supporter, three administrative supporters, and two administrative maintenance staff members; and one temporary staff member.

1. Open Use

(1) Overview

The numbers of nights allotted to open use in 2016 were 118 for the first semester (2016A, January to June) and 108.5 for the second semester (2016B, July to December). Observing proposals submitted in response to the calls for proposals were reviewed by the Okayama program subcommittee and 1 project observation program, 0 academic degree support program, 15 general observation proposals, and 2 miscellaneous observation proposals were accepted for 2016A, and 1, 0, 13, and 2 were accepted for 2016B. One and one observing proposals were approved for the category "Target of Opportunity (ToO)" observations introduced since 2016A for 2016A and 2016B, respectively. Three proposals, one from each of China, Hawai`i, and Turkey, were accepted in 2016A, and one from Hawai`i was accepted in 2016B. The Observatory supported their observations with human resources. Open-use observation generally proceeded without incident.

(2) Observation/Research Results

The majority of objects observed through the open use in 2016 were stellar sources and exoplanets. Others included Solar System objects, the Milky Way Galaxy, galaxies outside the Milky Way, and quasi-stellar objects. The following primary observation themes were noted: exoplanet search and binary-mass determination via precise radial velocity measurements; exploration of the physical properties and activities of single and binary stars via high-dispersion spectroscopy; and the observation of exoplanet transits by precise differential photometry. Optical low-dispersion spectroscopic observations of stars for classification remained significant. As in previous years, a number of observational studies were conducted by individual groups of researchers within the open-use framework, and their respective research results were reported in meetings and conferences or were published in peer-reviewed journals.

(3) Facility and Instrument Maintenance/Management

The 188-cm telescope and its dome had evolved into a stable and high-functioning observing system by FY 2014 after the major refurbishment in FY 2012. Efforts were made to automate the high dispersion spectroscopic observations with the fiber-feeding system in this FY 2016. The remote observing environment provided to the open use with some limitations last year has been available for open use with no conditions since 2016A. During the maintenance period in June, the annual re-aluminization of the primary mirror of the 188-cm telescope and lubrication of the telescope and dome were completed. Efforts were continued to simplify the re-aluminization process as were done in the last year. The 1.5-m primary of KANATA Telescope at Hiroshima University was also accepted for re-aluminization in the maintenance period. Participants in the aluminization work from that organization were given NAOJ-mandated safety and hygiene training as necessary. Utmost efforts were made to maintain high observing efficiency by conducting monthly cleanings of the primary, secondary, and tertiary mirrors of the 188-cm telescope after September.

The dome was checked daily. The replacement of the wire rope for driving the slit door, scheduled once every 4 years, was done successfully in November. The front sheaves for the wire were replaced just before that. Other maintenance work was also performed, including repair of the worn-down guiding rails for the slit doors, maintenance of the dome rotation driver, and replacement of the old power lines, in order to achieve smooth open-use operation and prolonged life-time of the facility and equipment. Safe storage of the acquired observing data and appropriate maintenance of the computer and network environment were carried out.

Work safety was given priority in accomplishing the aforementioned maintenance work and observing instrument exchanges.

(4) Conferences

The program subcommittee for the 188-cm telescope met on May 30 and November 18 in 2016 and March 23 in 2017 to evaluate proposals for the open use of 2016B, 2017A (first semester of 2017) and 2017B (second semester of 2017), respectively, and formulated an observation program for each semester.

The third one was held ahead of the usual schedule, conventionally at the end of May in the next FY year, in order to devote the activity of the Okayama program subcommittee during FY 2017 to the Kyoto University 3.8-m telescope project. The Okayama Users Meeting, also known as the 27th Optical and Infrared Users Meeting, was held in the Large Seminar Room of NAOJ Mitaka Campus on September 7 and 8. Various reports were made: current status of the Observatory including the telescope and dome, execution summary of the program subcommittee, status of the open-use observing instruments and remote observing environment, development status of the queue observing system for the HIDES Fiber-Feeding mode, etc. Reports on the status of and scientific results from the two new user-led instruments for the 188-cm telescope were also made. Reports were made on the progress of the Kyoto University 3.8-m telescope project including observing instruments. Reports were done on the research results from the open use of the 188-cm telescope and on the operations of other optical and infrared observational facilities such as the Hiroshima Astrophysical Science Center.

A special session was arranged to discuss in more detail than last year the practical policy and plan for the transfer of the open-use observations from the 188-cm telescope to the Kyoto 3.8-m Telescope comprehensively. Detailed discussions were held among interested domestic researchers including Okayama open-use users, Kyoto University staff, NAOJ staff, and others.

The policy agreed upon at the Users Meeting was reported later at the general meeting of the Group of Optical and Infrared Astronomers (GOPIRA), the GOPIRA symposium and the Advisory Committee for Optical and Infrared Astronomy at NAOJ. Last of all, the policy that includes the following items was reported at the Advisory Committee for Research and Management at NAOJ on October 31, 2016. These reports included that the operation of the open use of the 188-cm telescope will be terminated by semester 2017B, that the open-use of the 3.8-m telescope will open in August 2018, that the Okayama program subcommittee is given the role of the scientific committee for the operation of the open use at the 3.8-m telescope, and that NAOJ continues to hold the 188-cm and smaller existing telescopes and facilities for the time being, etc.

The Director General of NAOJ requested the Advisory Committee for Optical and Infrared Astronomy make "Plans for the transfer to and operation of the open use of the Kyoto University 3.8-m telescope." The Okayama program subcommittee made the report draft upon a request from the Advisory Committee and submitted it to the committee at the end of March 2017.

2. Developing and Maintaining Open-Use Observing Instruments

(1) HIDES (High-Dispersion Echelle Spectrograph)

The instrument HIDES is a cross-dispersed high-dispersion echelle spectrograph, provided for open use. Development of the fiber-link system (HIDES-F) since FY 2006 has continued to improve its observing capabilities. Open use of the high-efficiency (HE) fiber link with approximately 50-K wavelength resolution has continued since 2011A. The HE link offers an improvement in throughput of nearly one magnitude over the previous value and radial velocity measurement precision of approximately 2 m/s, which is comparable to the case of the Coudé light path. The high-resolution (HR) link with nearly 120-K wavelength resolution has been offered as a PI-type open-use instrument since 2016A. The HR link provides a 4 times better sensitivity at maximum than the case of the Coudé light path. Control software was adjusted to deal with queue and automated observations. An astro-comb developed by researchers at the National Institute of Advanced Industrial Science and Technology (AIST) and their collaborators as a next generation astronomical wavelength standard was installed into the Coudé room of the 188-cm telescope, and the tuning and tests were carried out. This year the total numbers of accepted proposals to HIDES were 8 and 6 in 2016A and 2016B, including 1 and 1 project observations, respectively.

(2) ISLE (Near-Infrared Imager/Spectrograph)

ISLE is a near-infrared imager and low- or mid-dispersion spectrograph. It has been available for open use with no conditions since 2011B. It is the only open-use instrument in East Asia that offers near-infrared spectroscopic capability and is characterized as having the world's best low-noise readout capability (less than 10 electrons). Relative photometry at the one milli-magnitude level is regularly achievable with its imaging mode for bright sources. A carry-in YJH-band filter from a user and the HK-band filter as standard equipment enable it to obtain a well-connected spectrum from Y-band to K-band. The numbers of open-use programs using ISLE conducted in semesters 2016A and 2016B were 5 and 6, respectively; which included 1 and 1 miscellaneous category programs, respectively. Nine of them were spectroscopy and the other two were imaging photometry.

(3) KOOLS (Kyoto-Okayama Optical Low-dispersion Spectrograph)

This instrument provides imaging and spectroscopic capability in the optical. It has been available for open use as a PI-type instrument since 2008A. It is equipped with an offset-guider and CCD charge shuffling functionality. Non-sidereal motion objects can be tracked for long integration times. The integral field unit using a fiber-bundle developed by a team at Kyoto University has been made available as a PI-type open-use instrument since 2015B. When it is used, its input part is installed into the Cassegrain unit of the HIDES fiber link and its output part is installed into KOOLS (KOOLS-IFU). Accepted proposals were 4 and 1 for 2016A and 2016B including 1 and 1 ToO programs, respectively. The open use of KOOLS ended in 2016B. After that KOOLS was overhauled by the Observatory together with researchers at Kyoto University to be a first-light instrument for the 3.8-m telescope.

(4) Others

MuSCAT (MUlti-color Simultaneous Camera for studying Atmospheres of Transiting exoplanets), which was previously a carry-in observing instrument, was made available to the open use as a PI-type instrument from 2016B. It can achieve 0.05% accuracy in relative photometry for a star of 10-th magnitude at V-band when it performs a series of one-minute exposures. Four programs, which included one miscellaneous category program, were conducted with MuSCAT in 2016A and four open-use observing programs, which included one miscellaneous one, were accepted in 2016B.

3. Joint Research with Universities

(1) Kyoto University's Okayama 3.8-m New Technology Optical and Infrared Telescope Project

The Observatory has participated in a cooperative implementation framework for the 3.8-m telescope project, which is spearheaded by Kyoto University, together with Astro-Aerospace, Inc., regarding the 3.8-m telescope project as part of the future plan of the Observatory. Discussions were held on technological issues regarding the telescope and observing instruments through weekly TV conferences and in-person meetings held every three months. Kyoto University has completed the construction of the dome that houses the telescope. The Observatory hired a specially appointed associate professor to be in charge of transferring the open use from the 188-cm telescope to the 3.8-m telescope and strengthened the cooperative implementation framework. The Observatory also hired a Specially Appointed Research Staff Member to prepare open-use observing instruments and advance the conversion and refinement of the KOOLS-IFU system, for which open use at the 188-cm telescope has been terminated, to be an initial open-use observing instrument for the 3.8-m telescope. Kyoto University and the Observatory jointly collected input about the observing instruments planned for the 3.8-m telescope from the domestic astronomical community in order to fix the specifications of the equipment around the focal planes where observing instruments will be attached. A research program has been approved in which one observatory staff member participates as a co-investigator on the grant-in-aid for scientific research from the Japan Society for the Promotion of Sciences (Basic Research A (General), FY 2016-2019) applied for by researchers at Kyoto University. The grant allows us to develop a near-infrared fiber-fed spectrograph for the telescope.

(2) The Optical & Near-Infrared Astronomy Inter-University Cooperation Program

The Program has entered its sixth (and final) year since its commencement in 2011. The Observatory has contributed the 188-cm, 91-cm, and 50-cm telescopes to the Program, and has taken a leading role along with the Office of International Relations. Through the cooperative observational and educational network, OISTER, established by the Program, the Observatory performed observations for one campaign as a PI and provided a total of 22 nights worth of observational data on three objects this year. As for the immediate follow-ups of gamma-ray bursts, which are the main targets of the program, there were 12 alerts that were observable from the Observatory, observations were performed four times and afterglow was detected in one of them. Three peer-reviewed papers were published utilizing OISTER. Another 18 peer-reviewed papers that have something to do with the Program were published. The seventh workshop on the Program was held.

(3) Gamma Ray Burst (GRB) Optical Follow-up Project

Optical follow-up observations of GRBs using the 50-cm telescope are in progress in cooperation with the Tokyo Institute of Technology's Kawai Laboratory. During FY 2016, the automatic observation scheduler performed observations on nearly every possible night; 24 GRBs were observed, with optical afterglows successfully detected in two. Observation results were published as 9 GRB Coordinates Network (GCN) circulars. In addition, follow-up observations of candidate gravitational wave sources and monitoring of 9 objects that include dwarf novae, eclipsing binaries, asteroids, and comets were concurrently performed, which resulted in publication of four peer-reviewed papers.

(4) Other

The Observatory welcomed four third-year undergraduate students and their supervisor from the University of Tokyo between August 30 and 31 and provided them with an opportunity to conduct high-dispersion spectroscopic observations using the 188-cm telescope during the early half-night on August 30. Test observations were conducted with the near-infrared observing system with the 30-mm aperture dedicated to bright star photometry (IR-TMT) having been placed at the Observatory during the last FY in collaboration with researchers at Tohoku University. The observations were carried out from the main building of the Observatory or from Tohoku University remotely by way of the internet.

4. Unique Research Projects

(1) Detection of afterglow from distant GRBs and survey of variable stars in the Galactic plane using the ultra-wide-field

infrared camera.

With the 91-cm reflector having been converted into an infrared camera with an ultra-wide field of view, observations were conducted to identify infrared counterparts for objects such as GRBs and gravitational wave sources. Along with them, a comprehensive survey of infrared variable stars in the Galactic plane was carried out. In FY 2016 monitoring in the Ks-band of two regions of 20 square-degrees each centered at L=30 degrees and 80 degrees were nearly completed. In addition, automatic monitoring of other objects, such as the Orion star forming region and bright blazars were carried out.

(2) Development of a far larger scale exoplanet search

Through a Grant-in-Aid for Scientific Research (Basic Research (A), “Large scale exoplanet search with a robotic telescope for high dispersion spectroscopy,” representative: Hideyuki Izumiura, FY 2016–2020), a project has begun aiming at establishing an original large scale sample of exoplanets. For that purpose, activities have begun to develop robotic operation of spectroscopic observations with the 188-cm telescope and to improve the sensitivity and stability of the spectrograph.

(3) East Asian Planet Search Network

The Observatory also conducts studies focusing on the search for exoplanetary systems, involving researchers from South Korea, China, Turkey, and Russia. Efforts continued in FY 2016 to secure telescope time on the Korean 1.8-m telescope, Chinese 2.16-m telescope, Turkish 1.5-m telescope, and the Observatory’s own 188-cm telescope for continued searches for exoplanetary systems around G-type giant stars.

5. PR/Awareness Promotion Activities

In this FY about 40 astronomy-related questions from the public were posed irregularly to the Observatory and were answered appropriately. The 4D2U screenings, co-hosted with the Okayama Astronomical Museum, attracted 3,847 visitors. Fifteen Observatory tours were conducted, including those for pupils from local elementary schools in Asakuchi City and Yakage Town. The Observatory also responded to four lecture requests made by local boards of education and community centers. The Observatory posted four research result web releases and 1 press release.

The yearly special open-day was suspended again following the last FY because a serious shortage of parking space was anticipated due to the construction of the Kyoto University 3.8-m Telescope and there was some concern about being able to ensure the safety of the guests.

6. Contract Staff Transfers

The following transfers of contract staff members took place in FY 2016:

Eiji Kambe resigned as a research expert on June 30. Eiji Kambe joined as a specially appointed associate professor on July 1. Akihiko Fukui resigned as Specially Appointed Research Staff due to the expiration of his contract on September 30. Akihiko Fukui jointed as a Specially Appointed Senior Specialist on October 1. Kazuya Matsubayashi joined as Specially Appointed Research Staff on November 1.

3. Nobeyama Radio Observatory

1. Nobeyama 45-m Radio Telescope

(1) Open Use Observations

The 35th open use observations period started on December 1, 2016 as scheduled. The full capabilities of the new four-pixel receiver FOREST and limited capabilities of the Z45 receiver are offered.

The statistics of the proposals are as follows, "General Proposals": 23 accepted including 5 from abroad (29 submitted), "Joint Proposals" with ASTE telescope: 4 accepted with 1 from abroad (6 submitted), "Short Programs": 12 accepted with 1 from abroad (29 submitted), "Backup Programs", which are carried out when weather is not acceptable for the main observations: 1 accepted (1 submitted), "DDT Programs", which are submitted after the deadline: 2 accepted (3 submitted). In addition, the 45-m telescope joined the VERA open use observations for 2 proposals. There were no applications for "Large Programs." The S40 receiver was decommissioned.

Open use observations have been halted since March 17, 2017, when the master collimator driving system went out of order. Most of the observations scheduled after this issue arose will be carried over to the next observing season.

(2) Improvements and Developments

Maintenance of the 45-m telescope, the receiver systems, the cryogenics, etc. were performed.

- The replacement of the millimeter calibrator driving system was completed. The design work for the mirror exchange systems was done.
- The Spectral Window mode with the FOREST receiver was implemented, and flexible setting of the spectrometer was realized.
- Development of the new data archive system and the data reduction procedure with the CASA pipeline started. These will lead to automation of the observing system in the future.
- Preventive and corrective painting of the antenna mount structure was done.
- NRO supported user instruments including the digital spectrometer ROACH, a 90 GHz continuum camera, and the simultaneous 22/43/86 GHz VLBI observation system.

(3) Scientific Results

We are carrying out the (a) Star Formation Legacy Project, (b) Galactic Plane Survey, and (c) Nearby Galaxy Project as legacy projects with the 45-m telescope, and their results are described below. Research results from open-use observations are given separately in the Scientific Highlights section of this document.

(a) Star Formation Legacy Project

In the Star Formation Legacy Project, we conducted large-scale mapping observations toward three nearby star-forming regions, Orion A, Aquila Rift, and M17 in ^{12}CO(1–0), ^{13}CO (1–0), C^{18}O(1–0), and N$_2$H$^+$(1–0). Many cores and clumps have been identified from structure analysis of these data. In particular, thanks to the high sensitivity a protostellar molecular outflow was found in the Orion molecular cloud data that was not in the data from BEARS.

(b) Galactic Plane Survey Project (FUGIN: FOREST Unbiased Galactic plane Imaging survey with the Nobeyama 45-m telescope)

We are conducting a simultaneous survey of the ^{12}CO(1–0), ^{13}CO(1–0), and C^{18}O(1–0) emission lines in the Galactic Plane using FOREST aboard the 45-m telescope. We plan to make maps of the inner Galaxy and the outer Galaxy including the spiral arms and bar structure. In 2016, we covered areas with 22 and 2 square degree for a total of 24 square degree. Now, 130 square degrees have been mapped. As a result, we have revealed a wide range of molecular clouds and their fine structures; we also found the most distant molecular cloud, new cloud-cloud collision systems, and an interacting region with a supernova.

(c) Nearby Galaxy Project (COMING: CO Multiline Imaging of Nearby Galaxies)

We started COMING (CO Multiline Imaging of Nearby Galaxies) in April 2015 to map more than 200 nearby galaxies in ^{12}CO(1–0), ^{13}CO(1–0), and C^{18}O(1–0) emission lines using FOREST. Up to now, mapping observations of 129 galaxies have been completed (54 % of the original plan). A paper on the relation between molecular gas density and star formation efficiency was published (Muraoka et al. 2016, PASJ, 68, 89) and one on a dwarf spiral galaxy, NGC 2976, is in press. In addition, two master theses and five undergraduate theses were published. We also developed a data reduction pipe-line system.

2. Radio Polarimeters

- Operations and maintenance were performed.
- On a monthly basis, the data are examined by solar research groups in Kyoto University, Ibaraki University, NICT, and NAOJ Solar Observatory, and are archived as public data in the NAOJ Astronomy Data Center so that researchers all over the world can access them.
- The polar axis gears of the 1, 2, 9.4, and 17 GHz antennas were replaced, and their pointing accuracies were improved.

3. Research Support

(1) SPART (10-m telescope) (Osaka prefecture Univ.)

To better understand the influence of the activities of host stars on the atmospheric environment of habitable planets, we have been carrying out monitoring observations at 100 and 200 GHz bands with a 10-m telescope, the Solar Planetary Atmosphere Research Telescope (SPART). This year we continued the observations with SPART. To investigate short-term changes of the CO abundance in the Venusian middle atmosphere revealed by SPART, we started simultaneous and synergetic observations with the Atacama Large Millimeter/Submillimeter Array, Japanese Venus Climate Orbiter AKATSUKI (JAXA/ISAS), and the 1.6-m Pirka Telescope employing the Near Infrared Echelle Spectrograph (Nayoro Observatory, Faculty of science, Hokkaido University). Through this approach we address the links between the photochemical reaction networks and the circulation of materials induced by the dynamics between the Venusian upper and lower atmosphere. In addition, the purpose-built console and display room of SPART was completed. This room is opened to the public where visitors can study the terrestrial planets of the Solar System, the aim of SPART, and the history of the Nobeyama Millimeter Array.

(2) Radio Heliograph (Nagoya Univ.)

In FY 2015, an international consortium (ICCON) assumed operation of the Nobeyama Radioheliograph (NoRH, see https://hinode.isee.nagoya-u.ac.jp/ICCON/). The remote operating system via the internet has functioned very well. About 30 researchers from seven countries (China, Germany, Japan, South Korea, Russia, the UK, and the USA) participated in operation, including the system health check and data verification. Observational data are automatically transferred to NAOJ and/or Nagoya Univ. and are stored, maintained, and made public there. In September 2016, an international workshop, ‘Physics with Radio Observations - Continued Operation of Nobeyama Radioheliograph - ’, was held and 36 researchers (including 20 from overseas) attended it. In addition to science results from NoRH, we discussed research topics during this continued operation by ICCON, and how to collaborate with a new solar radio telescope in China.

4. Public Outreach

(1) PR activities at Nobeyama Campus

Nobeyama Campus received a cumulative total of 46,636 visitors throughout the year, including participants in special open house events. Staff members conducted 40 guided tours, including ones for Super Science High School (SSH) students and the Campus Tour Week, while 4 requests for lectures and 20 requests for on-site filming and interviews were granted. These requests, especially those by some local broadcast stations in Nagano prefecture but also from national broadcasting media such as NHK, increased due to efforts to strengthen cooperation with local communities. The Campus Tour Week for educational institutions was scheduled during the summer. Eight groups took advantage of this opportunity, and many students in the groups enjoyed the visit. For the workplace visits, 4 students from 3 schools, primarily local junior-high schools, visited the observatory. For the SSH initiative, three schools visited NRO and participated in lectures.

In the area for permanent public access, an antenna experience facility and some introduction movies are available along with posters and panel displays. In this year, we tentatively opened the Nobeyama NINS exhibition room. Also, in order to familiarize the public with NRO, we renovated the website to accommodate smartphones as well as personal computers.

A photography event for the Nobeyama starry sky was carried out at NRO because many requests to take pictures in Nobeyama Campus at night have been received. We held the event during the period when it does not affect radio observations, with 31 participants who were selected from about 100 applicants. We used some pictures taken at the event, which were offered by the participants, for an original calendar, displays during the Special Open House, and so on.

(2) Cooperation with Local Communities

The annual Nobeyama Special Open House was held with contributions by Nagano Prefecture as well as Minamimaki Village, the Minamimaki Chamber of Commerce, and its youth division. Moreover, Jimoto Kansha Day (Thanks Day for the Locals) was held as the Special Open House for locals (Minamimaki and Kawakami Village) at the Vegetaball With by Shinshu University as the main host. Special sponsorship was made to the sora-girl event “Tebura de Hoshizora Kansho-kai (Drop-by Star Gazing Event),” hosted by the Minamimaki Tourism Association. Also, a training course and examinations were carried out through a special partnership with Shinshu-Saku Hoshizora Annai-nin, which was managed by Saku Koiki Rengo (the union of local governments in the Saku area).

Moreover, the conference of “Nagano-ken ha Uchuu-ken (Nagano prefecture is Astro-Prefecture)” was founded with Kiso Observatory, IoA, The Universoty of Tokyo, etc. The first meeting was held at Matsumoto Campus of Shinshu University on November 23 with about 100 participants. The webpage and mailing list were set up and some activities started.

(3) The Nobeyama NINS exhibition room

After the improvement work of the building of the Nobeyama Millimeter Array and installation of the 4D2U theater in last year, the Nobeyama NINS exhibition room was tentatively operated in the summer season from July to September. From questionnaire results, about 8,000 guests visited the room and their degree of recognition of other institutes as well as NAOJ was improved.

(4) NRO Conference Workshops

- July 20-21, 2016
  NRO-ALMA Joint Science/Development Workshop 2016 (representatives: Masao Saito (NRO), Daisuke Iono (Chile Observatory))
- October 20-22, 2016
  ALMA/45m/ASTE Users Meeting 2016 (representatives: Eiji Akiyama, Daisuke Iono, Ken’ichi Tatematsu (Chile Observatory), Masao Saito (NRO))
- March 28-29, 2017
  NRO Galactic Plane Survey Workshop 2016 (representative: Tetsuhiro Minamidani)

5. Education

NRO accepted three postgraduate students. The one is a second-year Ph.D. student in SOKENDAI studying carbon chain molecule chemical reactions. The others are visiting students from Kagoshima University and the University of Tsukuba, and they received Ph.D. degrees from their respective universities based on the studies using the Nobeyama 45-m Radio Telescope.

SOKENDAI held the workshop on Radio Astronomical Observation using the Nobeyama 45-m Radio Telescope form June 6 to 10, with 12 undergraduate students in attendance. One third of the participants were 4th year students, just about to decide their course after graduation. While guiding the students, from observations to presentation of the results requires significant effort, the event offers an invaluable opportunity for undergraduates to experience observations using a radio telescope and think of their future career.

6. Misc. Activities

(1) Hiring

Kazufumi Torii: Specially Appointed Assistant Professor

(2) Resignation, Transfer

Masao Saito: Associate Professor to TMT-J Project
Hitoshi Arai: Research Supporter
Yoshio Tatamitani: Research Expert

4. Mizusawa VLBI Observatory

NAOJ Mizusawa VLBI Observatory operates VLBI (Very Long Baseline Interferometry) facilities such as VERA (VLBI Exploration of Radio Astrometry) and KaVA (KVN and VERA Array), and provides these unique facilities to the international user community to support the research activities at universities and research institutes. In the meantime, astronomical research using these VLBI arrays is conducted mainly on the Galactic structure, celestial masers, AGNs, and so on. Using the unique dual-beam system which is capable of phase referencing by observing two sources simultaneously, VERA conducts high-accuracy astrometry of maser sources and determines the detailed structure of the Milky Way. In addition to the operation of VERA, maintenance and operation support were provided to the Yamaguchi 32-m Radio Telescope and two Ibaraki 32-m radio telescopes in collaboration with the local universities. International collaboration has been promoted particularly in the East Asia region through the joint operation of KaVA and the East Asian VLBI Network, the latter of which is a joint VLBI array between the People's Republic of China, Japan, and the Republic of Korea.

In addition to VLBI related activities, "The Central Standard Time" is kept at the observatory as an obligation of NAOJ, Esashi Earth Tides Station is operated for geophysical research, and Ishigakijima Astronomical Observatory is jointly operated with the local city for public outreach and astronomical research.

1. VERA

(1) Observations and Common Use Observations

The four stations of VERA were operated by remote control from AOC (Array Operation Center) at NAOJ Mizusawa Campus. In FY 2016, a total of 536 VLBI observations (4410 hours) were conducted with VERA, such as common use observations, VERA project observations, fringe detection observations for maser and reference sources, geodesy observations, JVN (Japanese VLBI Network) observations, KaVA (KVN and VERA Array) observations, and others. These VLBI data, except for KaVA, were processed at the Mizusawa correlation center in NAOJ Mizusawa Campus. The correlated data were sent to each researcher for the case of common-use and JVN observations and to persons in charge of data analyses in the case of project data and geodesy data.

VERA common-use calls-for-proposals with the 43, 22, and 6.7 GHz bands for semesters 2016B and 2017A were released in May and October, respectively. A total of 9 proposals, which requested a total time of 224 hours, were submitted, including 4 proposals for 82 hours from overseas. Based on the evaluations by referees elected from scientists in related fields, the VLBI program committee decided to accept a total of 5 proposals (138 hours) in 2016B and 2017A.

(2) Science Research

In FY 2016, Mizusawa VLBI Observatory published a total of 40 refereed journal papers for scientific achievements. Among them, four papers were published by the Observatory staff as PIs. Nine papers were scientific results directly related to VERA astrometry observations, one was the results from KaVA, and two were from the Japanese VLBI Network (JVN). In addition, various scientific results from other VLBI arrays, ALMA, and multi-wavelength time-domain studies on active galactic nuclei (AGN) were published, which were developed based on previous VERA sciences. It should be noted that there were 31 papers published through international collaboration.

For the VERA project results, a new research method for distance measurements was reported. It utilized the accurate proper motion and radial velocity measurements for the H_2O masers associated with a high-mass star-forming region G7.47+0.06. The high accuracy (10 % error) distance, 20 ± 2 kpc, was successfully determined demonstrating that the method can be applied to sources farther than 10 kpc whose annual parallax is barely measurable with VLBI. For star-formation studies, a research group lead by Kagoshima University detected the jet-driven bow-shock structure in the outflow associated with the high-mass young stellar object S255. In the research field of late-type stars, the first simultaneous VLBI observations of SiO masers in four frequency bands were reported using the newly developed wide-band VLBI backend system developed by the Mizusawa VLBI Observatory. It is expected that the system will be employed for combined VLBI observations with the NRO 45-m Telescope and KVN. There was a paper that reported the first KaVA imaging result for the SiO masers around a late-type star. The AGN research group reported the new synthesis imaging method for interferometers utilizing the sparse modelling.

2. The Japanese VLBI Network (JVN)

The university VLBI collaboration observation project is carried out as a joint research project between NAOJ and six universities. We organize the radio telescopes of VERA, universities, and research institutes (JAXA / ISAS, NICT, GSI) to make the Japanese VLBI Network (JVN), which is operated at 3 bands of 6.7 GHz, 8 GHz, and 22 GHz. VLBI observations were carried out for about 300 hours in total in 2016. In addition, single-dish observations of up to 4,000 hours were carried out as research related to JVN. The main research subjects are active galactic nuclei and maser / star formation.

In October 2016, the Astronomical Society of Japan released a special issue of PASJ on university collaboration. This volume includes 8 papers based on JVN operations such as the results of VLBI survey observations with small-number high-sensitivity baselines (Fujinaga et al.), results of 6.7 GHz methanol-maser monitoring by the East Asian VLBI network (EAVN) (Sugiyama et al.), and a report on the Ibaraki telescopes (Yonekura et al.).

More than 10 papers including other related papers have been published in 2016. Since the activities of university VLBI collaboration have been appreciated, an Assistant Professor position was established at Yamaguchi University, and filled by Dr. Motoki, who obtained a Ph.D. by doing research using JVN at Hokkaido University and worked as a postdoc at Mizusawa VLBI.

In July 2016, the university collaborative workshop was held at Ibaraki. Many participants attended, and white papers for the future direction were created based on this discussion. A project, entitled “high spatial resolution / time-domain astronomy in the centimeter band,” was approved as a baseline of the university collaboration. It is planned that maser / star formation study will be mainly carried out at Ibaraki University, while active galactic nuclei / black hole science will be mainly done at Yamaguchi University. In particular, observations with a small number of baselines; time variation observations; and research with the Ibaraki and Yamaguchi interferometers will play an important role in the future of the project.

3. Japan-Korea VLBI

(1) Observations and Common Use Observations

In 2016, a total of 158 VLBI observations (1234 hours), common use observations, large program observations, and test observations, were conducted by KaVA (KVN and VERA Array) with the 43 and 22 GHz bands. The data of the seven VLBI stations were correlated at the Korea-Japan Correlation Center at KASI Daejeon Campus in Korea.

KaVA common-use calls-for-proposals for semesters 2016B and 2017A were made in May and October of 2016, respectively. In total, 17 proposals requesting a total time of 582 hours were submitted. Through the evaluations by referees elected from scientists in related fields and subsequent decisions made by the VERA and KVN combined Time Allocation Committee, a total of 12 proposals (377 hours) were accepted in 2016B and 2017A.

(2) Results of Research

The number of science outcomes based on KaVA data is steadily increasing since the opening of the KaVA common use in FY 2014. In FY 2016, three research papers that made use of KaVA common-use data were published in peer-reviewed journals. These are all related to AGN, where a variety of AGN topics were explored: a follow-up monitoring of an optically-violent quasar (CGRsBS J0809+5341); radio imaging of high-redshift ($z > 5$) quasars (e.g., J0131-0321); and a high-cadence monitoring of a jet acceleration region (M87). In particular, the former two are the first papers that were led by research groups external to Korea/Japan, indicating that users of KaVA are spreading into the world.

The three KaVA Large Programs (LP), which were launched in late FY 2015, are continuing smoothly, and the analyses of these data are actively ongoing by each KaVA Science Working Group (AGN, star-formation regions, late-type stars). For the AGN LP, the acceleration profile of the M87 jet is beginning to be determined in higher detail. For the SFR LP, surveys of 87 water masers (22 GHz) and methanol masers (43 GHz) are actively going on. For the LTS LP, roughly 90 % of the survey of approximately 80 circum-nuclear masers was completed; work to narrow down the observational targets is ongoing. Some of these LP preliminary results were presented at international conferences.

4. EAVN

To expand the capability of international VLBI throughout East Asia, the commissioning of the East-Asian VLBI Network (EAVN) is actively ongoing through collaboration between Japan, Korea, and China. In FY 2016, a total of 8 test observations were conducted with EAVN, and the first EAVN image was successfully obtained (with KaVA plus Tianma at Shanghai). The 9th EAVN Workshop was held at Guiyang, China. Direct discussions were held with Chinese researchers, particularly ones from Shanghai and Urumqi; and we reached a consensus on the further acceleration of EAVN activities and collaboration. As a result, the KaVA Science Working Groups were expanded into the "EAVN Science Working Groups" by inviting Chinese researchers.

While the technical commissioning of the EAVN array is progressing, some science-oriented observations were also launched, such as an EAVN monitoring of nearby supermassive black holes near in time to the Event Horizon Telescope observations. The program was performed with KaVA+CVN+JVN at a high cadence of 1-2 weeks, and the array operation went well without any major troubles. The common use of EAVN is planned to open by 2018.

5. Geodesy and Geophysics

The regular geodetic sessions of VERA are allocated two or three times every month to maintain the orientation and shape of the array. VERA internal geodetic observations are performed once or twice per month using K-band, and Mizusawa participate in IVS sessions using S- and X-bands on a once-per-month basis. The 1-Gbps recording system of S/X bands was newly developed to widen the recording bandwidth in IVS sessions.

In FY 2016, we participated in 9 IVS sessions and performed 19 VERA internal geodetic sessions. The final estimation of geodetic parameters is derived by using the software developed by the VERA team.

After “The 2011 Earthquake off the Tohoku Pacific coast” ($Mw = 9.0$), VERA Mizusawa was displaced by co-seismic crustal movement, and continuous post-seismic creeping was detected in FY 2016. According to the newest analysis, the co-seismic steps are $X = -2.020$ m, $Y = -1.389$ m, and $Z = -1.060$ m, and displacement by creeping during FY 2016 is $X = -0.075$ m, $Y = -0.059$ m, and $Z = -0.014$ m.

Continuous GPS observations at VERA stations are carried out in order to detect short term coordinate variations and to estimate atmospheric propagation delays. The results of GPS positioning also show a post-seismic motion to the East-

Southeast of Mizusawa even though 6 years have passed since the occurrence of the 2011 Earthquake off the Tohoku Pacific coast. Continuous gravity observations with super-conducting gravimeters were carried out at Mizusawa and Kamioka. The observation at Kamioka was terminated in 2016. Gravity change observation is also carried out at Ishigakijima as a joint project with other institutes and university groups. The features of the annual change are observed and studied by several techniques including VLBI, GPS, and gravimeters. The strain and tilt observation data obtained at the Esashi Earth Tides Station are distributed in real time to several institutes based on the research agreement between the Earthquake Research Institute, the University of Tokyo and Mizusawa VLBI Observatory.

6. System Development

In 2016, we have developed two down-converters for dual polarization receiving of the Q-band. We have performed a VLBI experiment between KVN and VERA using OCTAD and OCTADISK2 installed in KVN. The fringes of the experiments are detected successfully in cooperation with VERA, KVN, and the manufacturer. Fringes of an experiment between Italy and VERA are also detected in all channels after data conversion between domestic and international data formats. Upgrades to OCTAD made AOV observations possible. We started discussion of the SKA project and high frequency VLBI as future plans of the observatory. We performed various basic design and development, including a low power consumption optical transmitter/correlator and balloon-borne radio interferometry.

7. Timekeeping Office Operations

The Timekeeping Office operates four cesium atomic clocks together with a hydrogen maser atomic clock at Mizusawa VERA Station. The facilities have been operating stably, contributing to the determination of UTC (Coordinated Universal Time) through continuous management and operation of the time system. The NTP (Network Time Protocol) Server at the Timekeeping Office provides “Japan Central Standard Time” on a network. This service has been in great demand; more than 1,500,000 daily visits have been recorded last year.

8. Ishigakijima Astronomical Observatory

FY 2016 was the 10th year of the Ishigakijima Astronomical Observatory (IAO). In FY 2013, the “Starry Sky Study Room” was established as an annex to screen the 4D2U (Four-Dimensional Digital Universe) theater by Ishigaki City, and the number of visitors has increased to more than 15,000 people per year. The total number of visitors since FY 2006 has exceeded 100,000. The observatory missions such as conducting observational study, public outreach, and regional promotion have been accomplished well. The 10th anniversary ceremony was held in November. Special events including a science cafe, photograph exhibition, and stargazing party were also given.

In terms of the research, observations of transient objects such as gamma-ray bursts, supernovae, and Solar System objects were performed in collaboration with Japanese universities. Three refereed papers using the observational data of IAO were published, including studies of supernova SN 2016coi and comet 15P/Finlay. The total number of the papers has reached 19.

In FY 2016, the 15th “Southern Island Star Festival” was held. The number of participants has also been increasing, and about 11,000 people attended the light-down stargazing party. Special events to mark the 15th anniversary were held, including a movie screening of “Welcome Home, HAYABUSA” and the starry sky photo contest. The Japanese Tanka contest on “Beautiful Stars” for which the judge was a famous Tanka poet Machi Tawara was also held. In total, about 13,000 people participated in the festival.

In terms of the education, the Chura-boshi Research Team Workshop for high school students and the observational experiment for undergraduate students of the University of the Ryukyus were held. In the workshop, three new minor planets candidates were found by the observations of the high school students. One of these three objects was assigned the provisional designation 2016 PH14 and was recognized as a discovery of IAO by the IAU Minor Planet Center.

On the other hand, active interaction and collaboration with Japanese public astronomical observatories was performed. The Nayoro Observatory in Hokkaido, with which IAO concluded an agreement for cooperation, held a star festival in July; IAO assisted with the star festival by providing a live relay of the landscape and the starry sky from IAO.

9. Public Relations (PR) and Awareness Promotion Activities

(1) Open House Events

On April 17, 2016: the Seventh Open Observatory Event held at the Ibaraki University Center for Astronomy, and NAOJ Mizusawa VLBI Observatory, Ibaraki Station, with approximately 348 visitors in attendance.

On July 17: The Star Festival at the site of the 6 m antenna at Kinko Bay Park in Kagoshima City co-hosted with Kagoshima City and Kagoshima University, with approximately 200 visitors.

On August 6–14: The Southern Island Star Festival 2016 held together with a special open house event at the VERA Ishigakijima Station and Ishigakijima Astronomical Observatory with approximately 11,000 visitors to the whole Star Festival. Events included an astronomical observation party at Ishigakijima Astronomical Observatory, attended by 338 visitors; and a special public opening of the VERA Station attended by 252 visitors.

On August 7: Special open house of VERA Iriki station held jointly with the Yaeyama Highland Star Festival 2016, with approximately 4,500 visitors in attendance.

On August 20: Iwate Galaxy Festival 2016, open house of NAOJ Mizusawa Campus, held with 2500 visitors in attendance.

On February 12, 2017: “Star Island 16”, open house event of VERA Ogasawara Station held, with 227 visitors in attendance.

(2) Regular Public Visiting

Throughout the year, the following stations are open to the public on a regular basis. The four VERA stations are open to the public every day, 9 a.m. to 5 p.m., except during the New Year's season. Ishigakijima Astronomical Observatory is open 10 a.m. to 5 p.m. except during the New Year's season and other closures.

The numbers of visitors to each facility is as follows,

a) VERA Mizusawa Observatory 18,100
The campus is regularly open to the general public with the cooperation of the Oshu Space and Astronomy Museum (OSAM: Yugakukan) located in the campus.
b) VERA Iriki Station 5,949
c) VERA Ogasawara Station 9,930
d) VERA Ishigakijima Station 2,442
e) Ishigakijima Astronomical Observatory 15,061
Stargazing sessions: Evenings on Saturdays, Sundays.
The "Starry Sky Study Room" (featuring the 4D2U "Four-Dimensional Digital Universe"), constructed adjacent to the observatory in 2013 by Ishigaki City, was very popular, welcoming 4,317 guests.

10. Education

(1) University and Post-Graduate Education

Regarding postgraduate education, Mizusawa VLBI Observatory assisted two graduate students from the University of Tokyo and two from SOKENDAI for their Ph.D. research. In addition, one Ph.D. student from oversees started Ph.D. courses in SOKENDAI from autumn. One of the students from SOKENDAI completed his Ph.D. thesis, and another Ph.D. student found a job as a science communicator before graduation. An undergraduate student from Nihon University was accepted as a summer student of SOKENDAI. The University of the Ryukyus and NAOJ have offered a joint course on astronomy from FY 2009. Classroom lectures at the university took place August 22–25 at the Nishihara main campus and were opened to the public at the satellite campuses. Observational workshops were held in Ishigakijima from August 29 to September 1, with about 30 participants. In addition, staff members of Mizusawa VLBI Observatory give lectures at the University of Tokyo, Tohoku University, and Teikyo University of Science as visiting professors.

(2) Research Experience for High School Students

During August 3–5, the VERA Ishigakijima station and the Ishigakijima Astronomical Observatory held "The Churaboshi Research Team Workshop" for 17 high school students from Ishigakijima, Okinawa main island, and Hyogo prefecture. It was organized under support from JSPS. It is noteworthy that observations carried out at Ishigakijima Astronomical Observatory produced results including the discovery of a new minor planet candidate which was assigned a provisional designation. (Please refer to 8: Ishigakijima Astronomical Observatory for more details.) "The 10th Z Star Research Team Event" was held August 8–10 to use the VERA Mizusawa antenna for observation. A total of 15 high school students from the Tohoku region were accepted for research experience. Continued from previous years, Mizusawa VLBI Observatory supported the SSH (Super-Science High-school) research activities for Yokote Seiryo High School in Akita Prefecture to use the Mizusawa 20-m antenna.

5. Solar Observatory

The Solar Observatory primarily engages in the operation of solar observational facilities on the west side of Mitaka Campus and in the development of new observational instruments. It conducts both observational and theoretical studies of the structure of the solar outer atmosphere, including the photosphere, chromosphere, corona, and solar wind; and active phenomena such as sunspots, faculae, prominences, and flares. This observatory performs regular observations using instruments such as the Solar Flare Telescope (SFT) and also conducts expeditions to observe total solar eclipses. It is also engaged in the planning of future ground-based solar observations. Regular observations of sunspots and flares have been carried out for prolonged periods, and the resulting data are provided to inter-university researchers.

1. Observational Facilities in Mitaka

(1) Magnetic Field Observation

The SFT, which has been the main instrument of the Observatory at Mitaka Campus, has kept observing photospheric vector magnetic fields at active regions and H-alpha flares since its completion of 1992. The main instrument on the SFT was updated to an infrared Stokes polarimeter in 2010. Whereas previous magnetic field observations covered part of the solar surface, this new instrument was designed to obtain high accuracy vector magnetic field information over the full solar disk in order to elucidate the origins of the solar activity cycle. This polarimeter is equipped with a 15-cm infrared lens and performs slit scanning observations using infrared spectral lines (photosphere: iron, 1.565 μm line; chromosphere: helium, 1.083 μm line), which are sensitive to the magnetic field on the Sun. This allows for constant acquisition of unprecedented infrared polarization data for the photosphere and chromosphere of the entire solar disk. It had taken about two hours to cover the full-disk Sun with a slit scan for each wavelength range, but a two-camera system renewed in 2014 enables us to observe both wavelength ranges simultaneously. The data acquisition is now conducted more efficiently. However the system had a problem in light path design; a camera could not sit in an optimal position as designed and it was renovated this year by suspending the regular observations for several months. To further improve the polarimetric data quality, the installation of an advanced infrared camera with a large format and low read-out noise is being conducted, and this year, the infrared detector H2RG EG-C and its control electric circuit SIDECAR+MACIE were procured using a grant from the Project for Solar-Terrestrial Environment Prediction (PSTEP), Grants-in-Aid for Scientific Research on Innovative Areas.

(2) Regular Observation of Sunspots/Faculae/H-alpha Flares

Sunspot observations have been performed continuously since 1929. These observations are currently conducted via automatic detection of sunspots in digital images captured with a 10-cm refractor and a 2 k × 2 k pixel charge coupled device (CCD) camera mounted on the new (full-disk) sunspot telescope. Observations were conducted for 241 days in FY 2016, from April 2016 to March 2017.

Because full-disk solar image data are a widely demanded resource in the astrophysics/geophysics researcher community, some out-of-date synoptic instruments need to be upgraded. Efforts are underway to update the photospheric and chromospheric imaging instruments and to further flesh out the data. For instance, the SFT has started advanced observations in the H-alpha line to acquire full-disk, high-resolution images. It can obtain Doppler velocity information based on imaging at multiple wavelengths around the H-alpha line center. High temporal resolution enables the more complete capture of active phenomena, and a combination of multiple exposure times allows for a wide dynamic range. Further improvement in dynamic range and read-out noise was accomplished using sCMOS cameras installed in FY 2015. This advancement has enabled us to observe many phenomena, such as flares and prominence eruptions, even during the recent downturn in solar activity. The Observatory also uses the SFT to conduct regular full-disk imaging observations in the G-band (430 nm) and continuum wavelengths. In addition, CaII K (393 nm) filter observation started in FY 2015.

The regular observational data described above, including real-time images, are available on the website of the Observatory. A spectrograph system with a coelostat is under development to perform long-term and full-disk observations. An improvement to the spectrograph room was conducted this year. The Observatory maintains a coelostat and other existing equipment to allow for velocity and magnetic field observations more quantitative than everyday observation, as well as experimental use.

2. Opening of Data Archives to the Public

The Solar Observatory has made nearly 16.2 TB of data available to the public online, including data from the current observations of white light, H-alpha, and magnetic fields as well as those from nearly 100 years of various types of solar observations. The various phenomena occurring in the solar-terrestrial environment must be studied in terms of both sudden, short-term events (space weather) and in terms of gradual changes occurring over years or decades (space climate). The Observatory will continue providing fundamental data for these studies. The Observatory possesses nearly 100 years of accumulated records, including continuum images, Ca II K-line images, and H-alpha images recorded on film, photographic plates, and hand-drawn sketches, all of which have an importance of their own. The Observatory will make these available to the public as well as soon as they are digitized and organized. It is noted that there exist some of the world's oldest records of solar activities, which are expected to add particular insight into future research. Higher bit digitization of old Ca II K line images improving the data quality was conducted this year as a part of research activity for the PSTEP, Grants-in-Aid for Scientific Research on Innovative Areas.

Data publicized via the website were previously stored on a server owned by the Observatory. The data have since been transferred to the Astronomy Data Center, where all relevant data servers have been managed in an integrated fashion. The same data are stored at multiple locations in the data center, serving as a backup in case of disaster.

The Observatory is also contributing to scientific verification of data from the Nobeyama Solar Radio Polarimeters which have been maintained by Nobeyama Radio Observatory since Nobeyama Solar Radio Observatory was shut down at the end of FY 2014. To ensure the same data quality as before, a monthly meeting is held for members from inter-university users, Nobeyama Radio Observatory, and the Solar Observatory to check the obtained data.

3. Other Activities/Personnel Transfers

International cooperation includes support for the Japan–Peru collaborative solar observations, with which the Solar Observatory has been involved since 2004. In addition to the collaboration in solar spectrograph installation and operation in Peru, relocation of the 10-cm coronagraph which had been used in Norikura Solar Observatory is envisioned. For this purpose, reassembling the coronagraph in the Observatory and site selection in Peru are undergoing. The Solar Observatory also supports the operation of another 10-cm coronagraph with a NOGIS filter system in a Chinese observatory (3200 m elevation) in the Yunnan province. This coronagraph was relocated from Norikura in 2013 to observe two dimensional intensity and velocity fields of the solar corona in the coronal green line of Fe XIV (530.3 nm). The Observatory supported repair of a broken electric circuit board of the coronagraph this year. A new coronagraph reusing a 25 cm diameter lens from the coronagraph of Norikura Solar Observatory is planned in China. The lens which has been displayed in a visitor facility of Mitaka Campus was cleaned and stored in a container in case of transportation to China in the near future. The Observatory is participating the JSPS bilateral cooperative program between Japan and Russia for FY 2016–2017 (Japanese representative: Dr. Y. Yokoi, University of Tokyo) and is carrying out bilateral joint research project in solar physics, by exchanging scientists between the two countries.

The solar optical observations carried out at Hiraiso Solar Observatory of the National Institute of Information and Communications Technology are considered to be terminated. To examine the possibility of utilizing the instruments in the future at other institutes, the relevant equipment (H-alpha Lyot filter and the telescope/coelostat for solar magnetic field measurements) were placed in storage at Mitaka until it has been decided where to send them.

The solar research symposium for the entire solar community was held at ISAS between February 20 and 22, 2017. It included a session which served as the users meeting for the Observatory where topics related to open use and future plans were discussed.

Because the Observatory deals with fundamental solar data, there are often requests to use images from the Solar Observatory database in school textbooks, to contribute to articles in newspapers or magazines, and to help public events held by museums. The Observatory actively responded to these requests.

Regarding personnel transfers, Dr. Satoshi Morita was selected as a specially appointed research specialist after the end of his term as a research expert at the end of FY 2016. It was decided to start a new project “Solar Science Observatory” by unifying the Solar Observatory with Hinode Science Center from FY 2017 to promote more efficient research activity in the field of solar physics.

6. NAOJ Chile Observatory

The ALMA Project is a global partnership of East Asia (led by Japan), Europe, and North America (led by the United States) in cooperation with other nations to operate a gigantic millimeter/submillimeter radio telescope deploying 66 high-precision parabolic antennas in the 5000-m altitude Atacama highlands in northern Chile. ALMA aims to achieve a spatial resolution of nearly ten times higher than that of the Subaru Telescope or the Hubble Space Telescope. Early scientific observations with ALMA began in FY 2011 with a partial number of antennas and full operation commenced in FY 2012. This report describes the progress of the project, which includes results of the open-use scientific observations and public outreach activities. The ASTE telescope is a single-dish 10-m submillimeter telescope located in the Atacama highlands and has been operated to make headway into southern-hemisphere submillimeter observations toward the ALMA Era. This report also describes the progress of the ASTE telescope.

1. Progress of ALMA Project

ALMA scientific observations and commissioning observations are currently underway. Commissioning observations include polarization tests, solar observation tests and observation tests using the newly installed Band 5 receiver, which are all making good progress. In these activities, East Asian researchers have been taking initiatives in international teams, as demonstrated by Koichiro Nakanishi and Hiroshi Nagai for polarization, and Masumi Shimojo for solar observation tests. Also, the sub-components developed by Japan, such as the antennas, correlators, and receivers (Bands 4, 8, and 10), are working properly.

2. ALMA Open-Use and Scientific Observations

The fifth round of ALMA open-use observations commenced in October 2016 as Cycle 4. The main capabilities of Cycle 4 include: interferometric observations using forty 12-m antennas; Atacama Compact Array (ACA) observations (interferometric observation with ten 7-m antennas and single-dish observations with three 12-m antennas); seven frequency bands (Bands 3, 4, 6, 7, 8, 9 and 10); and maximum baselines extended to 12.6 km (for Bands 3 to 6), 6.8 km (for Band 7), and 3.7 km (for Bands 8 to 10). In addition to these, Cycle 4 also provides new opportunities for large programs that require long observations over 50 hours, millimeter-wavelength VLBI, ACA stand-alone mode, solar observations, and polarization for spectral line observations. In response to the Cycle 4 call for proposals, 1,571 proposals were submitted from all over the world.

The call for the sixth round of open-use observations was issued as Cycle 5. The Cycle 5 capabilities will include: interferometric observations using forty-three 12-m antennas; ACA observations (interferometric observation with ten 7-m antennas and single-dish observations with three 12-m antennas); eight frequency bands (Bands 3, 4, 6, 7, 8, 9, 10 and newly-added Band 5), and maximum baselines of 16.2 km (for Bands 3 to 6), 8.5 km (for Band 7), and 3.6 km (for Bands 8 to 10). It should also be noted as a remarkable development that the ALMA maximum baseline will be made available for open-use observation with Bands 3 to 6. The call for proposals for Cycle 5 is set to be closed at 00:00 JST on April 21, 2017. Cycle 5 is scheduled to start in October 2017.

Open-use of ALMA has already produced a number of scientific results. This section describes some of the achievements, focusing mainly on East Asian projects. An international team led by Akio Inoue at Osaka Sangyo University detected emission lines from ionized oxygen in a distant galaxy 13.1 billion light-years away. The galaxy was first discovered with the Subaru Telescope and observed with ALMA this time. This is the most distant galaxy in which oxygen has ever been detected and thought to be one type of source that triggered “cosmic reionization” in the early history of the Universe just several hundred millions of years to one billion years after the birth of the Universe. This observation result is a very important step towards understanding the cosmic reionization which has yet to be explored. A team of Japanese astronomers led by Takashi Shimonishi at Tohoku University revealed a hot core containing various molecular gases around a newborn massive star in the Large Magellanic Cloud using ALMA. This is the first hot molecular core that has ever been detected outside the Milky Way Galaxy and has a very different composition than similar objects found in the Milky Way. Studying complex organic molecules contained in hot cores will be a key to unveiling the chemical diversity of the Universe. Since the Large Magellanic Cloud is known to have lower metallicity compared with the Milky Way, this result provides an important clue to revealing the distribution of organic molecules in the early Universe with low metallicity. A research team led by Takashi Tsukagoshi at Ibaraki University observed the young star TW Hydrae using ALMA and revealed the detailed distribution of dust in its protoplanetary disk. They made comparative analysis of observation results in two frequencies and found that larger dust particles are absent in the most prominent gap with a radius of 22 astronomical units. Based on a theoretical model, the result indicates that a possible Neptune-like planet is forming in the gap. These findings will help scientist identify what type of planet is forming in a specific location of a protoplanetary disk.

3. Educational Activities and Internship

During the summer vacation of universities, the NAOJ Chile Observatory accepted five undergraduate students, three of which conducted research activities in Mitaka and other two in Chile, as well as four visiting researchers in total which include: one Japanese graduate student each from Osaka Prefecture University and the University of Tokyo and internationally one post-doctoral fellow each from the University of Chile and

Leiden University of Netherlands for a period of one month.

4. Public Outreach Activities

Achievements of ALMA scientific observations and test observations were covered by nearly 40 newspaper/journal articles and 11 television/radio programs, reporting ALMA observation results in various fields of astronomy. In particular, a news program called "Good Morning Japan" on NHK G channel featured ALMA's detection of the most distant oxygen in the Universe in June 2016, and another NHK program called "News Watch 9" introduced ALMA observation results of a protostar in March 2017. The detection of the most distant oxygen was covered by more than 400 news websites worldwide and the BBC website featured the observation results of TW Hydrae achieved by Takashi Tsukagoshi (Ibaraki University) et al. As seen in these examples, the scientific results by Japanese researchers have been increasingly broadcast worldwide.

The NAOJ ALMA website posted 51 news articles and eight press releases. A mailing-list-based newsletter has been issued on a monthly basis with approximately 2,500 subscribers. Updated, detailed information is available on Twitter (@ALMA_Japan), with nearly 33,250 followers as of the end of FY 2016.

In May 2016, the NAOJ Chile Observatory hosted a week-long ALMA booth at the Japanese Geoscience Union Meeting held in Makuhari Messe. The NAOJ Chile Observatory organized public lectures and Science Cafe events on 17 occasions in FY 2016 and gave talks on the progress of ALMA to a large number of visitors. In particular, the 22nd ALMA Public Lecture "Star and Planet Formation Explored by ALMA" held in Nagoya City Science Museum on November 26, 2016 attracted a big audience of over 200, which was a great opportunity to introduce the latest scientific results of ALMA to the public.

The NAOJ Newsletter featured ALMA's semiannual achievements in the April and November 2016 issues.

From the mid-March 2015, ALMA started to accept public visitors at the ALMA Operations Support Facility (OSF) at an altitude of 2900 meters. Every Saturday and Sunday, ALMA is open to the public up to 40 people/day (advance registration is required). Visitors to the OSF can have a guided tour of the OSF including the control room and watch videos on ALMA. The registration often reaches the full capacity soon after the start of registration every weekend. Public visits to ALMA are now becoming a good opportunity to provide many people live experience at the workplace of ALMA researchers.

5. International Collaboration (committees, etc.)

On November 17, 2016, the Management Agreement Concerning Operations of ALMA was signed in Santiago by the representatives of NAOJ, the European Organization for Astronomical Research in the Southern Hemisphere (ESO), and Associated Universities Inc. (AUI) of the United States.

In the international ALMA project, meetings are held frequently by various committees. In FY 2016, the ALMA Board met face-to-face once, and the ALMA Scientific Advisory Committee (ASAC) twice. In addition to these, teleconferences have been held on a near-monthly basis among the members of the ALMA Board and ASAC. The ALMA East Asian Science Advisory Committee (EASAC) had meetings face-to-face or via teleconferences on a quarterly basis. Each working group holds meetings and teleconferences more frequently to maintain close communication in implementing their respective tasks in the international project.

6. Workshops and Town Meetings

- July 20 to 21, 2016 NAOJ Nobeyama Radio Observatory (NRO)
  NRO-ALMA Science/Development Workshop 2016
- September 20 to 23, 2016 Renaissance Indian Wells Resort & Spa, Indian Wells, CA, USA
  Half a Decade of ALMA: Cosmic Dawns Transformed
- December 19 to 20, 2016 NAOJ Mitaka
  ALMA/45 m/ASTE Users Meeting 2016
- March 24, 2017 Okayama University of Science
  ALMA Cycle 4 Town Meeting

7. Obtained External Grants Other Than Grants-in-Aid for Scientific Research including Industry –University Collaboration Expenses

- Satoru Iguchi: Grant for Basic Science Research Projects by the Sumitomo Foundation
- Seiji Kameno: International Research Support Program by Foundation for Promotion of Astronomy
- Hitoshi Kiuchi: Funded externally by the Ministry of Internal Affairs and Communications (Strategic Information and Communications R&D Promotion Programme: SCOPE) R&D for Promotion of Effective Radio Use (Advanced Effective Radio Use-Phase 1)

8. Research Staff Changes

(1) Hired
- Xing Walker Lu: Specially Appointed Research Staff
- Naslim Neelamkodan: Specially Appointed Research Staff
- Natsuko Izumi: Specially Appointed Research Staff
- Kazuki Tokuda: Specially Appointed Research Staff (assigned to Osaka Prefecture University)
- Sarolta Zahorecz: Specially Appointed Research Staff (assigned to Osaka Prefecture University)
- Takuya Hashimoto: Specially Appointed Research Staff (assigned to Osaka Sangyo University)
- Sanemichi Takahashi: Specially Appointed Research Staff (assigned to Kogakuin University)

(2) Departed or Transferred
- Kana Morokuma: Specially Appointed Research Staff
- Tatsuya Takekoshi: Specially Appointed Research Staff

9. Main Visitors

- September 15, 2016
  Mr. Toshiei Mizuochi, Vice Minister of Education, Culture, Sports Science and Technology, visited the Santiago Office of the Joint ALMA Observatory (JAO).
- October 13, 2016
  Mr. Shigeharu Orihara, Counselor of the Japanese Embassy in Chile, visited the OSF and AOS.
- October 18, 2016
  Mr. Hiroshi Nagano (National Graduate Institute for Policy Studies; former Chair of the OECD Global Science Forum) visited the OSF and AOS.
- November 23, 2016
  Director General of the National Astronomical Observatories of the Chinese Academy of Sciences (NAOC) and his party visited the NAOJ Santiago Office.

10. Progress of ASTE Telescope

The ASTE telescope has been operated to promote full-fledged submillimeter astronomical research in the southern hemisphere and develop/verify observational equipment and methods required for the submillimeter astronomy. Since ALMA entered its operation phase in FY 2012, ASTE is used mainly to provide observational evidence for strengthening ALMA observation proposals and promote development for the enhancement of ALMA's future performance.

Except for ALMA, there are only two large-scale submillimeter telescopes in the world with a 10-meter-class antenna that can observe the southern sky: one is ASTE and the other is APEX operated by Europe. Therefore, having ASTE operated by Japan will be a big advantage for strengthening ALMA proposals and for implementing our strategies for further extended capabilities with new observing instruments. For the future, ASTE is also important since it provides opportunities for nurturing young researchers who will play key roles in the equipment development for the next generation. In the near future, ASTE will be incorporated into the open-use program to have organic collaboration with the Nobeyama 45-m Telescope.

The open-use program in FY 2016 provided spectroscopic observations in 345 GHz and 460 GHz bands for a period of three months. To render support for researchers contributing to the observational performance enhancement of ASTE, the Guaranteed Time Observation (GTO) scheme has been offered since FY 2013, which allows them to exclusively make proposals for the GTO slots. In addition to this, Joint slots have been newly established to allow researchers to jointly request observation time with ASTE and the Nobeyama 45-m Telescope at the same time. A total of 14 proposals for open-use observations and GTO slots were submitted (including 9 for open-use, 4 for Joint slots, and one for GTO). These proposals were reviewed by the Millimeter/submillimeter Program Subcommittee and 11 proposals were adopted including 6 for open use, 4 for Joint slots, and one for GTO in the first call. Open-use observations were carried out from the ASTE Mitaka operations room or from other universities and research institutes from September 26 to December 8, 2016.

7. Center for Computational Astrophysics (CfCA)

1. Overview

The Center for Computational Astrophysics (CfCA) has been operating a system of open-use computers for simulations centered around a general-purpose supercomputer and the special-purpose computers for gravitational many-body problems, carrying out research and development of computational astrophysics, and performing astronomical research with simulations. The main supercomputer of the present system, ATERUI (Cray XC30), has the theoretical peak performance of 1 Pflops, which is the world's fastest supercomputer for astronomy. The center also continued operation of other computers such as GRAPE-DR and GRAPE-9 that are dedicated for gravitational many-body problems, in addition to general-purpose servers (PC clusters) for small-scale calculations.. Efforts in visualizing astronomical data also continue.

2. Open Use

(1) Computer Systems

This year marked the fourth year of the upgraded astronomical simulation system, which includes the open-use supercomputer Cray XC30. All the CPUs of the main supercomputer which is installed and under operation at Mizusawa VLBI Observatory had been upgraded last year, and the supercomputer's theoretical peak performance is now as high as 1 Pflops. The users have been making academically significant progress as before.

While XC30 is leased for five years from Cray Japan Inc., the center has built the following equipment to aid the open-use computer operations: a series of dedicated computers for gravitational N-body problems, known as GRAPEs; PC clusters for small to medium-scale computation; large-scale file servers; a group of servers for processing computational output data; and networking instruments to encompass the overall computer system. These components are central to numerical simulations by researchers in Japan and overseas. In particular, the GRAPE system is promoted for its effective open use. The center undertook development, improvement, and maintenance for both hardware and software for the system this year.

Computational resources are allocated to the XC30, GRAPEs, and smaller computational PC clusters in accordance with a formal review process. The statistics of applications and approvals for this year are listed below. Our center conducted a survey this year on the number of peer-reviewed papers published in English in FY 2015 on studies that involved the project's open-use computers. It turned out that 112 refereed papers (written in English) were published in this fiscal year.

The center uses Drupal, a content management system introduced for data exchange with users of open-use computers. The acceptance of various applications and the management of the users' personal information are all handled through Drupal. The regular CfCA News is an additional channel of information dissemination. The center leverages this newsletter to inform people of all useful and necessary information regarding the computer system. A subsidy system for publishing and advertising is continuing this year for research papers whose major results were obtained by using the center's computers. Two papers were accepted in FY 2015 for payout in FY 2016, while two papers were accepted in FY 2016 for payout in the same year at approximately 90,000 JPY.

□ Statistics on the Cray XC30

Operating hours
- Annual operating hours: 8550.7
- Annual core operating ratio: 89.84 %

Users
- Category S: 0 adopted in the first term, 0 in the second term; total 0
- Category A: 12 adopted at the beginning of the year, 1 in the second term; total 13
- Category B+: 8 adopted at the beginning of the year, 1 in the second term; total 9
- Category B: 91 adopted at the beginning of the year, 10 in the second term; total 101
- Category MD: 13 adopted at the beginning of the year, 4 in the second term; total 17
- Category Trial: 34, year total

□ Statistics on the GRAPE system

Users
- Category A: 2 adopted at the beginning of the year, 1 in the second term; total 3
- Category B: 6 adopted at the beginning of the year, 0 in the second term; total 6
- Category Trial: 1, year total

□ Statistics on PC cluster

Operating hours
- Annual operating hours: 8597.4
- Annual job operating ratio: 72.9 %

Total users: 41, year total

(2) Tutorials and Users Meeting

The center organized various lectures and workshops to provide the users of the open-use computer system with educational and promotional opportunities, as well as to train young researchers. The details are shown below. In addition, the CfCA Users Meeting was held to serve as a forum for direct information exchange. Many participated in the meeting, and discussions were fruitful.

□ Cray XC30 workshop for beginning users: August 29, 2016, 5 attendees

□ IDL visualization workshop: August 30, 2016, 6 attendees

□ Cray XC30 workshop for intermediate users: August 31, 2016, 7 attendees

□ Hydrodynamics simulation school: February 18–21, 2017, 40 attendees

□ N-body simulation Spring School: February 8–12, 2017, 12 attendees

□ Users meeting: November 29–30, 2016, 67 attendees

3. PR Activities

In FY 2016, two press releases were issued from CfCA; “Avoiding ‘Traffic Jam’ Creates Impossibly Bright ‘Lighthouse’” (September 8, 2016, Tomohisa Kawashima and Ken Ohsuga, CfCA/NAOJ), and “Mystery Solved Behind Birth of Saturn’s Rings” (October 31, 2016, Ryuki Hyodo, Kobe University). A Twitter account @CfCA_NAOJ and YouTube channel have been operated to provide the information on CfCA.

CfCA took part in the special open house of Mizusawa Campus, Iwate Galaxy Festival 2015, held on August 20, 2016. About 150 visitors attended the ATERUI guided tours and experienced a close-up observation of the facility. In addition CfCA assistant professor Ken Osuga gave one of the special lectures, presenting the latest results of black hole research using ATERUI. At the Mitaka open house held on October 22, 2016, CfCA made the computer room accessible to the public and introduced simulation astronomy with GRAPE and the PC cluster. At this open house, the image panels which cover the ATERUI body were displayed to introduce ATERUI to those visiting Mitaka. In addition to the open house, CfCA accepted a group of high school students to tour the computer room in the Mitaka Campus. Moreover, in the NINS exhibition room in Nobeyama Campus, CfCA displayed GRAPE boards and posters to introduce research results from simulation astronomy calculated by the CfCA system.

4. 4D2U Project

In FY 2016, the 4D2U project continued to develop and provide the movie contents and software. Simulation movies titled “Dynamics of Saturn's Ring (II. Propeller Structure),” “Giant Impact of Protoplanets,” and “Formation of Planetesimals” were released on the 4D2U website in July 2016. Two of these movies, "Giant Impact of Protoplanets" and “Formation of Planetesimals”, as well as “Formation and Evolution of Dark Matter Halos (II. Formation of the Large-Scale Structure of the Universe) ver. 2” were published on the 4D2U YouTube channel with a format for VR on smartphones.

The updated version of the four-dimensional digital universe viewer, “Mitaka,” was released in July 2016 (ver.1.3.2). This version of Mitaka included new functions, e.g. displaying probes like Juno and Kepler; and the topographic and toponomastic data of Mercury. Moreover, four languages (Italian, Indonesian, Portuguese, and Thai) were added. In February, 2017, the 4D2U project put out a news release “Mitaka for VR” designed to operate with VR headsets, like Oculus Rift CV1 and HTC Vive. Mitaka for VR enabled us to enjoy the all-around view of the virtual universe while walking through the virtual universe freely and looking around celestial objects and space probes.

In FY 2016, demonstrations of Mitaka VR were given during the open campus days of Mizusawa, Nobeyama, and Mitaka; and the Inter-University Research Institute Corporation Symposium. Many people were able to enjoy Mitaka outside of the 4D2U Dome Theater.

4D2U contents were provided both domestically and internationally for TV programs, planetarium programs, lecture presentations, books, and so on. In FY 2016, all of the 4D2U contents were provided to the 3D planetarium of Kurobe Yoshida Science Museum in Toyama prefecture, which was upgraded to stereoscopic projection in April 2016. In addition, the 4D2U Theater of the NINS exhibition room in Nobeyama Campus installed all of the 4D2U contents.

A Twitter account @4d2u and YouTube Channel have been operated to provide the information on 4D2U.

5. External Activities

(1) Joint Institute for Computational Fundamental Science

The Joint Institute for Computational Fundamental Science (JICFuS) is an inter-organizational institute established in February 2009 as a collaboration base between three organizations including the Center for Computational Sciences (CCS) of the University of Tsukuba; the High Energy Accelerator Research Organization, known as KEK; and NAOJ to provide active support for computational scientific research (it has now expanded to include eight institutes). CfCA forms the core of NAOJ’s contribution to JICFuS. In particular, the institute engages primarily in computer-aided theoretical research into the fundamental physics in elementary particle physics, nuclear physics, and astrophysics. The scientific goal of the institute is to promote fundamental research based on computational science by encouraging interdisciplinary research between elementary particle physics and astrophysics. In addition to its ability as a single organization, a major feature of the institute is the cooperation of their community to provide considerate and rigorous support to present and future researchers. Another important mission of the institute is to provide researchers around Japan with advice regarding efficient supercomputer use and the development of novel algorithms for high-performance computing to meet research goals from the perspective of computer specialists. In addition, JICFuS was chosen as the organization responsible for ‘Research and Development, Application Development of scientific/social issues that require particular attention by the use of the Post K-computer’ in FY 2014. The program started last year.

In order to implement research plans, Hiroyuki Takahashi was engaged as a project assistant professor. Takahashi performed general relativistic radiation magnetohydrodynamics

(MHD) simulations of accretion disks and jets around black holes/neutron stars. The simulation revealed that supercritical accretion is possible onto not just black holes, but neutron stars as well. In the case of a strongly magnetized neutron star, a magnetosphere forms around the neutrons star. Then, the gas of the disk finally falls onto the magnetic poles and strong jets appear around the rotation axis.

Representing CfCA, Professor Kohji Tomisaka and Assistant Professors Ken Ohsuga of NAOJ participate in bimonthly JICFuS steering committee meetings to engage in deliberations on spurring computational science-based developments in astrophysics research through discussions with other committee members who specialize in nuclear and elementary particle physics.

(2) HPCI Consortium

As a participant in the government-led High-Performance Computing Infrastructure (HPCI) project since its planning stage in FY 2010, the center has engaged in the promotion of the HPC research field in Japan, centering on the use of the national "K" supercomputer and the "Post-K" plan. Note that although the center is involved with the JICFuS-led HPCI Strategic Program Field 5 as well as Priority Issue 9 to be tackled using the Post-K Computer as mentioned in (1), the activity in the HPCI consortium is basically independent from them. The HPCI consortium is an incorporated association established in April 2012, and the center is currently an associate member that is able to express views, obtain information, and observe overall trends in the planning, although we are devoid of voting rights as well as the obligation to pay membership fees. Continuing from last year, a number of conferences and WGs have been held where participants discuss a next-generation national supercomputing framework to follow the "K". The Post-K project has already started with some budget from the Ministry of Education, Culture, Sports, Science, and Technology (MEXT). The primary institutes and groups responsible for its development have been established. Now the detailed discussions as to how we fully exploit the resources of the post-K system have begun in relevant communities and organizations. The post-K generation equipment is scheduled to commence operation in FY 2019 or later. In principle, therefore, it is possible for the NAOJ to play a central role in the post-K generation HPCI through participation in this discourse.

6. Contract Staff Transfers

The following staff members were hired on a contract basis in this FY:
(Research experts) n/a
(Postdoctoral fellows) Yukari Ohtani
(Research associates) Tomohisa Kawashima, Tetsuo Taki, Yuki Tanaka, Satoki Hasegawa

The following contract staff members departed in this FY:
(Research experts) Shoichi Oshino
(Postdoctoral fellows) n/a
(Research associates) Tomohisa Kawashima

8. Hinode Science Center

The scientific satellite Hinode is an artificial satellite that was launched on September 23, 2006, by the ISAS division of JAXA, as Japan's third solar observational satellite following Hinotori (1981) and Yohkoh (1991). NAOJ implemented this satellite project under a joint research agreement with ISAS/JAXA. A major theme of the scientific goals of the Hinode mission is to shed light on the coronal heating mechanism through a more multifaceted understanding of magnetohydrodynamic (MHD) phenomena occurring in the solar atmosphere. The satellite has actually made a lot of discoveries related to these subjects.

Hinode is equipped with three telescopes including the solar optical telescope (SOT), the X-ray telescope (XRT), and the extreme ultraviolet (EUV) imaging spectrometer (EIS). It engages in simultaneous observations of the detailed magnetic fields and velocity fields on the surface of the photosphere and the brightness and velocity fields from the chromosphere to the corona. The onboard telescopes were developed as part of a wide-ranging international collaboration with assistance from ISAS/JAXA. SOT was developed mainly by NAOJ, and the focal plane package (FPP) was developed by the US National Aeronautics and Space Administration (NASA) and Lockheed Martin.

With regard to the XRT, NASA and the Smithsonian Astrophysical Observatory (SAO) are responsible for the optics system and frame, and Japan (ISAS/JAXA, NAOJ) is responsible for the focal plane camera. EIS is the result of an even broader international cooperation. The structure and electrical system were developed by the UK Science and Technology Facilities Council (STFC) and University College London; the optics system was developed by NASA and the Naval Research Laboratory (NRL); and the University of Oslo in Norway assisted with the terrestrial testing equipment and the Quick Look system. NAOJ actively participated in the development of the EIS/satellite interface, satellite integration testing, and launch experiments. After a successful launch, NAOJ has continued its active involvement by acting as the main institution for collecting and analyzing data acquired by the satellite.

The Hinode Science Working Group (SWG), composed of representatives from the international team, offers support in scientific operation and data analysis. Together with two members from the European Space Agency (ESA), the WG has a total of 15 members, including two from the Hinode Science Center (HSC): Suematsu, SOT; and Watanabe, EIS. Science Schedule Coordinators have been organized to leverage the open-use observation system. Many of the Japanese coordinators are NAOJ staff members, including Watanabe (Co-chairman/EIS) and Sekii (SOT).

FY 2016 marks the tenth year since the satellite's launch. The mission extension has been approved in JAXA for four more years until FY 2021. The NASA Senior Review is expected to be held in July 2017 to approve the request of the NASA mission extension for three more years. The ESA Science Program Committee also approved support at the current level of funding until the end of FY 2018, possibly to be extended to the end of FY 2020. The funding from STFC will be requested in FY 2017 for an extension of two more years.

1. The Hinode Satellite: Onboard Telescopes and Scientific Operation

The SOT is a telescope used for obtaining photospheric magnetic field vectors via polarimetric observations of absorption lines. It has the capacity for continuous observation at the diffraction limit with a spatial resolution of 0.2–0.3 arcsec and an effective aperture of 50 cm without atmospheric seeing. The focal plane package consists of three types of optics systems and imaging functions for maintaining the desired performance level. Operational modifications have enabled long-term maintenance of a sound field of view even in the narrow band filter imager system, in which image degradation was initially detected in part of the field of view. The power supply for the filtergraph (FG) camera failed on February 25, 2016. The FG system has been powered off, and ceased operation since then. The cause of the trouble was identified as a short circuit in the FG power supply.

The XRT has the capacity of capturing the solar coronal plasma via soft X-rays. The telescope has inherited the grazing incidence optics system and has improved in spatial resolution. Its wavelength characteristics have been improved to allow for observation of the solar coronal plasma over a broader temperature range. Resolution is close to 1 arcsec. Calibration is now possible for temporal variations in spectral characteristics due to surface contamination on the detector, and the telescope is available for analysis via its spectral characteristics.

The EIS obtains temperatures, densities, and velocities of the chromosphere, transition region, and coronal plasma thorough the spectroscopic observation of EUV emission lines. The instrument allows for spectroscopy and imaging at multiple wavelengths via the operation of slits and slots. Its purpose is to investigate the manner in which energy is conveyed from its generation in the photosphere until its dissipation in the corona by observing from the chromosphere (located between the photosphere and the corona) through the transition region to the corona.

A mission data processor (MDP) was installed to manage observations and to acquire data via the three telescopes. Coordinated observations using the three telescopes, in which the MDP plays a crucial oversight role, are vital to achieve the scientific goals of the Hinode satellite. Particularly for the XRT, functions such as the exposure time adjustment, the region of interest (ROI) selection, and the flare detection logic are handled by the MDP, which requires close coordination with the telescopes.

Data from the Hinode satellite is primarily downlinked at the Kagoshima station (USC) and at Norway's Svalsat station through collaboration with ESA, allowing for data acquisition for every orbit. Scientific operation was again performed in FY 2016 via S-band data reception. The S-band reception frequency was increased with help from ESA and NASA, allowing for continuation of regular, stable scientific operation.

Obtained data is collected at ISAS/JAXA, converted into the FITS format, and provided to researchers around the world in the form of Level-0 data, which is close to raw data. HSC staff members and students took part in satellite operation for a total of 218 days in FY 2016, 76 days of which were for contracted work. Moreover, the contribution rates to the scientific operation of the HSC were 27.1% (domestic) and 17.1% (overall). Instantaneous publication of all data acquired by Hinode began on May 27, 2007, with stable continuation, implemented by HSC.

Calls for Hinode Operation Plans (HOP), which encourage proposals for open-use observations together with other satellites and terrestrial observational equipment, promote joint observations among solar researchers worldwide. As of March 2017, a total of 337 applications have been accepted. In particular, core HOP proposals made by members of the scientific instrument team became refined over multiple implementations. Through systematic observations they have produced results which increase in significance as the solar cycle progresses. And new HOPs were added aiming for collaborative observations with the ALMA cycle-4 solar campaign.

2. Hinode Satellite Data Analysis

NAOJ HSC aims to construct an analytical environment and database for scientific analysis of data from the Hinode satellite in a central organization, allowing it to function as a research center. The goals are to maximize the scientific outputs gained from the Hinode satellite by offering researchers in Japan and other countries a data analysis environment; and to promote rigorous collaborative research between researchers in Japan and abroad by facilitating access to Hinode observational data through distribution of the analyzed data and construction of a data search system.

As part of its educational and public outreach (E/PO) activities, HSC also uses the latest observational data to raise public awareness of the relationship between solar research and everyday life so that the importance of solar research is appreciated. The Center has offered press releases, web releases, and media appearances; responded to interview requests from television programs and journals; and provided materials for publicizing scientific results.

In FY 2015, HSC staff members and students published 10 peer-reviewed papers related to Hinode, bringing the total to 260 papers by the end of March 2017. Cumulatively, a total of 942 peer-reviewed papers have been published on Hinode-related topics in the six major journals (ApJ, AAP, SP, PASJ, Nature, and Science). Intensified collaborative research with newly launched missions (SDO and IRIS) and advanced ground-based facilities (ALMA) will further enhance the number of research papers for pursuing the essence of solar activity.

3. Other Activities

In FY 2016, one postdoctoral fellow was engaged as a member of HSC.

The Hinode Science meetings for Japanese and international researchers have been held regularly to advance research in fields related to solar physics thorough use of the Hinode satellite. We have taken turns at organizing the meetings, and the tenth Hinode Science meeting took place during September 5 – 9, 2016, at Nagoya University, Nagoya (Japan). The number of participants amounted to 153 from 14 overseas countries, and a total of 161 papers were presented at the meeting.

To celebrate the tenth anniversary of the launch of the Hinode mission, we have:

1. produced a movie (https://www.youtube.com/embed/dqoIqXiz1Dk).
2. renewed the web pages of the project (http://hinode.nao.ac.jp/).
3. held a public lecture on September 10, 2016 at Nagoya University.
4. published a special issue of the Astronomical Herald (vol 109, August-October edition).
5. published a special issue of NAOJ News (No. 282, 2017 January issue).
6. produced a poster as an insert in the above NAOJ News.

In addition to the aforementioned activities, HSC research and educational staff members have presented scientific observation results at numerous symposia on solar-related subjects either by invitation or by active participation. HSC has also invited international researchers to engage in collaborative research. The following researchers have visited the Center from overseas on a long-term stay of at least one month:

Name	Organization (Country)
Rutten, Robert J.	Universiteit Utrecht (The Netherlands)

Table 1. Long-term Visitors.

9. Gravitational Wave Project Office

2016 has been marked by the announcement of the first two detections of gravitational waves from the coalescence and merger of black holes binaries and by the operation iKAGRA, the first 3-km long laser interferometer located underground at Kamioka. These first detections demonstrate that KAGRA will be able to detect the coalescence of binary black holes as soon as its sensitivity reaches the order of 1 Gpc distance for stellar mass binary black holes. The Gravitational Wave Project Office (GWPO) of NAOJ has pursued the construction of KAGRA at Kamioka. In particular the office was one of the leading groups in the operation of iKAGRA. The group has now entered an intense phase of work on site to install the vibration isolation system, one of the largest detector subsystems. To this end more than ten NAOJ staff members are working at Kamioka on a regular basis.

1. Development of KAGRA

KAGRA is an interferometric gravitational wave detector being constructed at an underground site in Kamioka, Gifu prefecture. In addition to the quiet underground environment, the use of cryogenic mirrors to reduce the thermal noise makes KAGRA a unique instrument among other large gravitational wave detectors.

KAGRA's construction is planned to proceed in several stages. Initial KAGRA (iKAGRA) was the first step of the phased development of the KAGRA detector, in which a room-temperature Michelson interferometer was constructed. In March 2016, iKAGRA detector installation was completed and we successfully operated the first km-scale underground interferometer ever built on the Earth. The test operation of the iKAGRA interferometer started on March 25, 2016 and continued until April 25 with a short commissioning break in the middle. This operation gave us an opportunity to check the validity of the KAGRA facility as well as accumulate a lot of experience in installing and commissioning a large-scale precision instrument underground. The next step of the KAGRA development is called bKAGRA phase 1, in which we will build a cryogenic Michelson interferometer. The efforts of the NAOJ GWPO are now focused on the realization of bKAGRA phase 1.

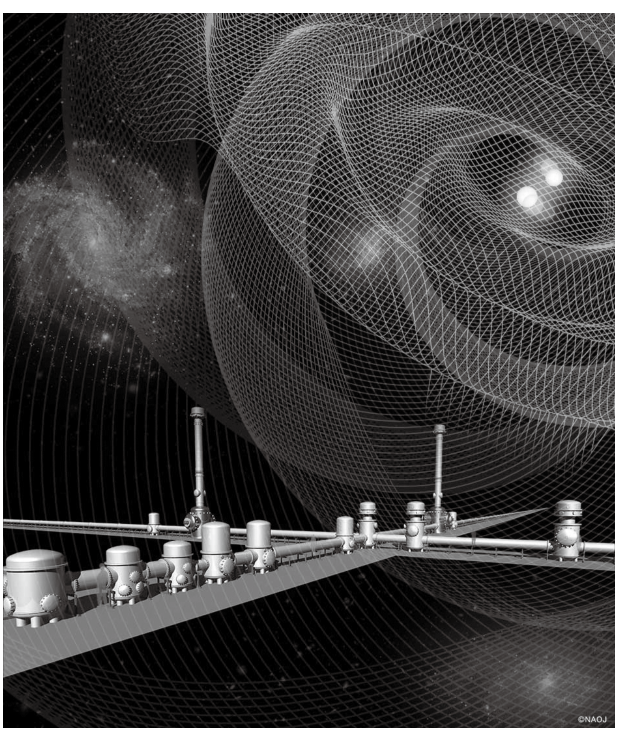


Figure 1: Sketch of gravitational wave space-time ripples impinging upon the KAGRA detector.

The NAOJ GWPO is contributing to the project in several aspects. The largest responsibilities are development and installation of ultra-high performance vibration isolation systems for the interferometer mirrors. Other technical contributions include the auxiliary optics, mirror characterization facility, and the design of the optical configuration and the control strategy for the main interferometer. NAOJ is also contributing to the project management through the activities of the executive office, the systems engineering office, the committee for publication control, the publication relation committee, the safety committee, and the KAGRA Scientific Congress (KSC) board.

(1) Vibration Isolation Systems

The vibration isolation system (VIS) is composed of the suspensions required to isolate all the interferometer mirrors and some other optical components from ground vibrations. Four different types of suspensions, having different complexities to meet the varied isolation requirements of different components, have been developed at NAOJ for this purpose. We are now installing mirror suspensions necessary for bKAGRA phase 1, including two 14-meter-long suspensions for cryogenic mirrors, five large room-temperature suspensions, and two small suspensions. Preparation of those suspensions progressed well in FY 2016. In the latter half of the fiscal year, we started the installation of some of the suspensions. Currently more than 10 members of the GWPO are regularly working in Kamioka for the installation works of the VIS.

(2) Auxiliary Optics

The Auxiliary Optics (AOS) subsystem is responsible for providing optical components for stray light control, optical angular sensors, beam reducing telescopes (BRTs), beam monitoring cameras and optical windows. Highlights of the activities in FY 2016 are relevant to the BRT and some of the large optical baffles. Prototyping of the BRT as well as the design of the vibration isolation stage for the BRT were mostly finished by ATC. Two optical baffles with diameters of 1 m were installed into KAGRA. Design of the wide-angle baffles was mostly completed in collaboration with ATC and KEK. Two papers were published on the optical baffles, and one of them was nominated as a monthly highlighted paper by the Optical Society of America (OSA).

(3) Mirror Characterization

We are also developing a system to accurately measure the optical absorption of mirrors, which is a critical characteristic for the cryogenic mirrors of KAGRA. The system was originally capable of measuring samples of up to 2-inch diameter. We are now upgrading the system to be able to produce scanned absorption maps of KAGRA sized (22 cm diameter) mirrors. We made calibration checks on sapphire bulk absorption using different measurement methods in collaboration with LMA (Laboratoire des Matériaux Avancés) in Lyon.

2. R&D

(1) R&D for upgrades of KAGRA

While building bKAGRA, the GWPO pursues research and development to investigate and prepare future upgrades of KAGRA. In this context the TAMA infrastructure is being used to develop frequency dependent squeezing, one of the most promising solutions to improve the sensitivity of detectors like KAGRA that are limited by quantum noise. To this purpose a 300-meter-long high-finesse cavity and a squeezed vacuum source are being built. Thanks to this experiment we established collaborations and received students from abroad. The absorption measurement bench developed to characterize the KAGRA mirror is also used to study the performances of crystalline coatings, a possible solution to reduce coating thermal noise. Thermal noise investigation is also the objective of another experiment now starting at ATC and aiming at the direct measurement of mirror thermal noise at cryogenic temperatures. Finally, crackling noise is being investigated in collaboration with ICRR.

(2) DECIGO

In this fiscal year, the DECIGO working group compiled the Pre-DECIGO project; its scientific objectives and targets along with the conceptual design of the satellite were published in a summary paper. After that, Pre-DECIGO was renamed “B-DECIGO” for some reasons including an attempt to show it will have sufficient sensitivity to detect gravitational waves with a meaningful event rate (and so not just a simple precursor of DECIGO). Taking advantage of outcomes from LISA Pathfinder, the working group started to define several subprojects (or experiments) to show/enhance technical feasibility of a B-DECIGO satellite; in the near future, the working group will propose B-DECIGO to JAXA by summarizing those efforts.

3. Education

In FY 2016 the office included two PhD students and two master students among its members. In addition we received two undergraduate students under the SOKENDAI summer students program and we hosted three graduate students from the University of Tokyo/ICRR. We also received a master student from Beijing Normal University for six months and we had three visits by a Ph.D. student from CNRS/APC for a total duration of three months. Finally, two of the GWPO members taught at the Department of Astronomy of the University of Tokyo, at Hosei University, and at the Osaka City University.

4. Outreach

Since the first detection of the gravitational waves, the public interest in GW has increased significantly. In order to better share and promote our activities to the public, we have opened a completely renewed website for our group with a modern design. We also updated the leaflet of GWPO with professional graphics and design.

We organized a Workshop for Popularizing Cutting-Edge Astronomy in Toyama and Kamioka to provide the latest developments in astronomy with emphasis on the GW to high school teachers, curators of scientific museums, and so on. In addition to this workshop, the members of the GWPO gave more than 10 public lectures and talks about the GW astronomy and wrote 3 articles for popular magazines as well as 1 web article about the first detection of the GW in the FY 2016.

The TAMA and KAGRA sites continued to get attention from various people. We accepted more than 200 visitors for TAMA (excluding the open-day visitors) and the GWPO members took care of more than 150 visitors to KAGRA. Among them are journalists from National Geographic Magazine, NHK, and so on.

5. International Collaboration and Visitors

The GWPO is a member of the KAGRA collaboration, a scientific collaboration which includes also members from abroad. Apart from KAGRA, the GWPO has a collaboration with CNRS, Beijing Normal University (BNU), the University of Hamburg, and University of Trento in the context of R&D for future upgrades to KAGRA. In this framework we received the visits of Prof. Zhu from BNU, Dr. Leonardi from Trento, and Dr. Tacca from CNRS. We also had several exchanges with the Virgo collaboration with which one of the office members is affiliated. We received short visits from Dr. Vocca and Dr. Travasso (University of Perugia) and from Dr. Arai (Caltech). As usual we received several visitors at TAMA including the MEXT financial Director, a delegation from the ministry of Economy and the ministry of Education, the association of students in Mathematics and/or Physics and Astronomy at the University of Amsterdam, and the Japan Scientific Instruments Association.

6. Publications, Presentations, and Workshop Organization

The members of the office have authored 32 peer reviewed publications including the paper reporting about “GW151226: Observation of Gravitational Waves from a 22-Solar-Mass Binary Black Hole Coalescence” which received a lot of interest in the scientific community and a paper about "Vacuum and cryogenic compatible black surface for large optical baffles in advanced gravitational-wave telescopes" which was highlighted by OSA. Moreover 16 presentations were given by the office members at international conferences.

7. Acquisition of external funds

GWPO did not receive external funds apart from those related to 6 grants allocated by JSPS.

8. Staff

One assistant professor moved to another group of NAOJ and a new position was opened in the GWPO. One JSPS postdoc moved to a specially appointed assistant professor position and a specially appointed specialist was hired. Overall in FY 2016 the project included 1 professor, 1 associate professor, 8 research staff, 5 engineers, 3 administrative staff, and 4 graduate students.

10. TMT-J Project Office

The TMT Project is a project to build an extremely large 30-meter telescope under the collaboration of five partner countries including Japan, the United States of America, Canada, China, and India. Heading the project for NAOJ is the TMT-J Project Office. In 2014, an agreement was executed between the participating organizations, TMT International Observatory was founded to assume the construction and operation of the observatory, and construction was commenced. Japan is responsible for the fabrication of the telescope primary mirror; the design and fabrication of the telescope structure as well as performing its onsite installation and adjustment; and the design and production of science instruments.

Maunakea on Hawai`i is the planned construction site for TMT. The approval process for the use of the land in the Maunakea Conservation District for TMT has proceeded. In Fiscal Year 2016, with onsite construction scheduled to commence in April 2018, Japan proceeded with the mass production of the telescope primary mirror segments, detailed design of the telescope structure, and the design and development of the science instruments.

By the end of the fiscal year, 3 Professors, 4 Associate Professors, 1 Chief Research Engineer, 1 Specially Appointed Associate Professor, 1 Assistant Professor, 3 Specially Appointed Senior Specialists, 1 Research Administrator Staff, 1 Special Senior Specialist, 1 Research Expert, 1 Research Supporter, 3 Specially Appointed Research Staff, 2 Administrative Supporters, and 1 RCUH Staff held full-time positions. In addition, 1 Professor, 5 Associate Professors, 2 Assistant Professors, and 1 Research Engineer primarily assigned to the Advanced Technology Center, Subaru Telescope, and the RISE Project have concurrent positions in the TMT-J Project Office and take part in activities that include the development of TMT science instruments at the Advanced Technology Center.

1. TMT Project Progress and Status of the Hawai`i Construction Site

The construction of TMT is spearheaded by participating countries and organizations under the TMT International Observatory established in 2014. The current officially participating countries and organizations are the National Institute of Natural Sciences (Japan), National Astronomical Observatories of Chinese Academy of Sciences, University of California, California Institute of Technology, Department of Science and Technology of India, and National Research Council of Canada. The Association of Universities for Research in Astronomy (AURA, USA), participating as an Associate Member, is currently taking steps for the U.S. to eventually become an official participant. TMT International Observatory, operated according to deliberations and decisions made in quarterly Board meetings of the TMT Board of Governors, is overseeing the construction work performed in each country as well as developing the onsite infrastructure. The board meetings are attended by 3 representatives from Japan.

Figure 1: Conceptual image of a constructed TMT.

In December 2015, as the protest movement at Maunakea continued to gain momentum, the supreme court of Hawai`i ruled the permit approval process for the use of the land in the Maunakea Conservation District, the site of planned construction, to be flawed and consequently invalidated the permit, although full-fledged construction at the summit of Maunakea was expected to have commenced by April 2015. As a result of the judgment, a review process for permit approval was reopened by the State of Hawai`i in February 2016. After a period of preparation that included the appointment of a hearing officer and approval of interested parties, hearings, which are a particularly important step in the review process, were held a total of 44 times between October 2016 and March 2017. At the conclusion of the hearings, a judgment regarding permit approval is submitted by the hearing officer to the Hawai`i Board of Land and Natural Resources where the final judgment is expected to be made. The TMT-J Project Office, with efforts that included actual attendance at the hearing, collected detailed information about the approval process and the hearing in order to prepare for conferences concerning the TMT International Observatory. The year 2016 also brought a surge in support for TMT construction in Hawai`i. The TMT-J Project Office put in its own effort as well to garner more understanding by holding dialogues with local stakeholders.

In parallel with this process, the TMT International Observatory initiated a selection process for a backup construction site in case construction at Maunakea becomes impossible. Candidate sites included Spain, Mexico, China, India, and 2 locations in Chile for a total of 6 locations. The criteria for consideration included favorable conditions for science observation, as well as the availability of the site for construction to commence by April 2018. Based on these criteria, TMT International Observatory selected La Palma in the Canary Islands as the backup construction site. Japan, as part of this process, held meetings in 5 locations (Sendai, Tokyo, Kyoto, Hiroshima, and Hilo) to explain the current situation in Hawai`i and to evaluate the alternate candidate construction sites. At the GOPIRA (Group of Optical and Infrared Astronomers) Symposium, the issue was deliberated and votes were cast by affiliated researchers for the selection of a backup site. Based on the result of this process, Japan came to agree with the selection of La Palma as the backup construction site.

2. Japan's Progress on Its Work Share – the Telescope Structure, the Primary Mirror, and Science Instruments

For the construction of TMT, Japan is leading the design/fabrication of the telescope structure and a portion of the fabrication of the primary mirror and science instruments. In Fiscal Year 2016, the following progress was made.

(1) Fabrication of the mirror segments of the primary mirror

The TMT primary mirror is comprised of 492 mirror segments. With replacements included, a total of 574 mirror segments must be fabricated. The processes required in the fabrication of mirror segments are: fabrication of the mirror blanks, spherical grinding of the front and back surfaces, aspherical grinding and polishing of the front surface, machining, and mounting of the mirror segments onto a support assembly. These processes are followed by final surface finish completed in the U.S. and coating with reflective metal performed onsite before the mirror segments are finally installed on the telescope.

Of these processes, the plan calls for Japan to fabricate the mirror blanks and to perform spherical grinding on all 574 segment mirrors. In Fiscal Year 2016, 49 mirror blanks were fabricated and spherical grinding was completed on 60 mirror blanks. With the share of work for the processes beginning from aspherical grinding/polishing and ending with mounting the mirror segment on a support assembly distributed among 4 countries, the plan calls for Japan to be leading this work for 175 of the mirror segments. In Fiscal Year 2016, ashperical grinding was performed on 8 mirror segments and 5 were ashperically polished. In addition, with the U.S. scheduled to begin their share of work to make the mirror segments aspherical, shipment of spherical mirror blanks to the U.S. was commenced.

Figure 2: Mirror segment blanks which have started to be shipped overseas (Courtesy of Canon Inc.)

(2) Design of the telescope structure and its control system

Japan is leading the design and production of the telescope structure which functions as the mount for the science instruments and optics systems, including the primary mirror, and points them in the direction of a target astronomical object. Work on the detailed design of the telescope structure was initiated in Fiscal Year 2014 using the baseline design received in Fiscal Year 2013. In continuation of the 3 international reviews conducted by Fiscal Year 2015, an international review was conducted for the Segment Handling System, Aerial Service Platform, and Elevator in Fiscal Year 2016. With the completion of these reviews, the detailed design of the telescope structure was completed.

(3) Science instruments

As part of the international collaboration, Japan is leading the fabricating for a portion of 2 out of the 3 first-light science instruments.

The Infrared Imaging Spectrometer (IRIS), for which Japan is assigned the task of creating its imaging components, is currently in the preliminary design phase. In Fiscal Year 2016, the first preliminary design review was conducted for IRIS with the focus primarily on its optics and mechanics. Preparation work was performed to be ready for the final review of the preliminary design, scheduled for the next fiscal year, which will cover electronics, software, schedule, budget requirement, and issues indicated in the first review that require further study.

For the Wide Field Optical Spectrometer (WFOS), its conceptual study is underway with Japan expected to take the lead on its camera system. In Fiscal Year 2016, design work for the optics of the camera system was performed, and material quality and polishing were studied for the optical elements considered for selection.

3. Evaluation of Scientific Research by TMT and Public Relations Activities

In 2016, the TMT Science Forum, held once a year since 2013, was convened in Japan. This forum is a gathering to discuss topics such as scientific research, science instrument development, and the operation plan for the TMT. For the last 3 years, the forum was held in the U.S. with an important goal of developing a cooperative relationship with U.S. scientists for the TMT Project with funding from the U.S. National Science Foundation. This was the first time the TMT Forum was held outside of the U.S. It was held in Kyoto from May 24 to 26 and was attended by 140 participants who actively deliberated on topics including 2nd generation science instruments.

The study of scientific research for TMT was facilitated with the Science Advisory Committee of TMT International Observatory leading the way. Japan also made important contributions through its continued participation in the International Science Development Teams (ISDTs) established in 2013.

In Japan, continued effort has been made for the project to better reflect the opinions of the science community communicated through forums such as the TMT-J Science Advisory Committee. In Fiscal Year 2016, the effect of moving the construction site elsewhere, particularly on scientific research and observatory operation, was evaluated through the aforementioned backup construction site candidate selection process. Also, with the continuation of the strategic fundamental research fund for the purpose of fundamental technology research for the development and design of 2nd generation science instruments, support funding for development was made available and provided to 6 universities and other institutions that applied to the public offering for the funding support.

Information on the TMT Project is provided in the TMT-J Project Office website, including updates particularly regarding the situation at the Maunakea construction site and the work share progress made by Japan. Additionally, TMT Newsletters No.46 through 50 were delivered. Efforts were made in public relation through lectures held in various areas throughout Japan and exhibits at the National Institutes of Natural Sciences Symposium and Inter-University Research Institute Symposium. Approximately 50 lectures and requested classes were held for the public.

Contributions were also made by making available an on-demand lecturer for the science/technology education and public outreach event “Journey through the Universe” (March 2016) held in Hawai`i where TMT is to be constructed.

TMT also assembled an international team that includes Japan to study topics such as education and personnel training, and as part of this project. In December, an international workshop was held in Hilo, Hawai`i catering to the young researchers and engineers that will lead the next generation. 40 graduate students and young researchers, that include 6 participants from Japan, learned about a wide range of topics that encompassed not only scientific research and development, but also international cooperation with people of different cultural backgrounds and management and operation of large scale projects.

Donations to the TMT Project have been raised continually; 2 corporations and 302 individuals provided donations in 2016 (from January to December).

Figure 3: TMT Science Forum in Kyoto.

11. JASMINE Project Office

1. Planning and Development of the JASMINE (Japan Astrometry Satellite Mission for Infrared Exploration) Project

(1) Overview

The JASMINE mission seeks to survey virtually the entire 20° × 10° Galactic Bulge around the center of the Galaxy and to perform infrared (Kw-band: 1.5–2.5 μm) measurements of the annual parallaxes, proper motions, and celestial coordinates of the stars at a high precision of 1/100,000 arcsecond (10 μas) in order to determine with high reliability the distances and transverse velocities of stars within approximately 10 kpc of the Earth in the surveyed direction. Nearly 1 million stars can be measured with a high precision in the Galactic Bulge with a relative error for annual parallaxes less than 10 %. This is necessary for accurate distance determination. By using observational data to construct a phase space distribution of gravitational matter, astrometric surveys of the bulge of the Milky Way promise to make major scientific breakthroughs in our understanding of the structure of galactic bulges and the causes of their formation; the history of star formation within bulges; and the co-evolution of bulges and supermassive black holes, which is closely related to the aforementioned phenomena.

Prior to commencement of the JASMINE mid-sized scientific satellite project, an ultra-small size project and a small size project were implemented to progressively build up scientific results and to accumulate the necessary technical knowledge and expertise. The Nano-JASMINE micro-satellite project, with a primary mirror aperture of 5 cm is currently underway. It aims to test part of the technologies to be used in JASMINE and to produce scientific results based on the astrometric information for bright objects in nearby space. Despite its small aperture, the satellite is capable of observational precision comparable to the Hipparcos satellite. The combination of observational data from Nano-JASMINE and the Hipparcos Catalogue is expected to produce more precise data on proper motions and annual parallaxes. The satellite is scheduled for launch in the near future. An additional plan is underway to launch a small-scale JASMINE satellite (Small-JASMINE), with a primary mirror aperture of about 30 cm, in FY 2022. This satellite will engage in observations of a limited area around the nuclear bulge and certain specific astronomical objects. This small-sized version has the goal of obtaining advanced scientific results at an early stage. The mid-sized JASMINE satellite, with a main aperture of approximately 80 cm, is designed for surveying the entire bulge and is targeted for launch in the 2030's. Internationally, Japan shares responsibilities with ESA. With the Gaia Project, ESA performs visible-light observation of the entire sky at a precision of 10 μas, while Japan engages in infrared observation of the bulge, which is a method suitable for observations in the direction of the Galactic Center.

(2) Major Progress in FY 2016

1) Organization of the Office

The JASMINE Project Office is composed of five full-time staff members, six staff members with concurrent posts, one research associate, one technical associate, and three graduate students. Significant contributions were made by members of the following organizations: Kyoto University's Graduate School of Science; ISAS at JAXA; the University of Tokyo's School of Engineering; Tokyo University of Marine Science and Technology; the University of Tsukuba; and the Institute of Statistical Mathematics.

2) Progress of the Nano-JASMINE Project

The project will engage in spaceborne observations using an ultra-small satellite to accomplish the following objectives: to make Japan's first foray into space astrometry; to accumulate the technical experience in onboard data acquisition, and the like, necessary for the upcoming JASMINE project; to achieve scientific results in the study of dynamical structures in the vicinity of the Solar System; and to analyze star formation based on stellar motions in star formation regions.

The satellite was scheduled to be launched from a Brazilian launch site operated by Alcantara Cyclone Space using a Cyclone-4 rocket built by Yuzhnoye, a Ukrainian rocket developer. The launch has been impossible due to the adverse influence of international situations. On the other hand, we now have the possibility that the Europena Space Agency (ESA) can launch the Nano-JASMINE satellite, as well as another possibility for the launch. We are now negotiating for the launch. Assembly of the flight model that will actually be launched into space was completed in FY 2010. The extra time yielded by the launch delay has been used for additional testing to further ensure project success. Maintenance of the satellite has also been performed. Steady progress was also made in the development of the algorithms and software required to determine astrometric information from raw observational data at the required level of precision. International cooperation with the data analysis team for the Gaia Project has been conducted smoothly. A Japanese WG led by Ryoichi Nishi of Niigata University continued to actively engage in investigating the scientific results to be obtained in the future by Nano-JASMINE.

3) Overview of Planning and Developing the Small-JASMINE Project

The objective of the small-sized JASMINE project is to use a three-mirror optical system telescope with a primary mirror aperture of 30 cm to perform infrared astrometric observations (Hw band: 1.1–1.7 μm). A goal is to measure annual parallaxes at a precision of less than or equal to 20 μas and proper motions, or transverse angular velocities across the celestial sphere, at a precision of less than or equal to 50 μas/year in the direction of an area of a few degrees around the Galactic Center within the bulge and in the directions of a number of specific astronomical objects of interest in order to create a catalogue of the positions and movements of stars within these regions. The project is unique in that unlike the Gaia Project, the same astronomical object can be observed frequently and observation will be performed in the near-infrared band, in which the effect of absorption by dust is weak. This project will help to achieve revolutionary breakthroughs in astronomy and basic physics, including the formation history of the superrmassive black hole at the Galactic Center; the gravitational field in the Galactic Nuclear Bulge and the activity around the Galactic Center; the orbital elements of X-ray binary stars and the identification of the compact object in an X-ray binary; the physics of fixed stars; star formation; planetary systems; and gravitational lensing. Such data will allow for the compilation of a more meaningful catalog when combined with data from terrestrial observations of the line-of-sight velocities and chemical compositions of stars in the bulge. Conceptual planning and design of the Small-JASMINE satellite system and detailed planning of the subsystems began in November 2008 with cooperation from nearly 10 engineers from JAXA's SE Office (the Systems Engineering Office), ARD (Aerospace R&D Directorate), and ISAS with a focus on the satellite's vital elements such as thermal structure, attitude control, and orbit.

Against this background, in-house discussions and manufacturers' propositions, which started in 2009, had continued to consider the design of the satellite system to ascertain the target precision in astrometric measurement as a general objective. The SWG, led by Masayuki Umemura of the University of Tsukuba and including volunteers from diverse fields in Japan, continued to make scientific considerations. Other activities such as conceptual planning, design, technical testing, and international project collaboration have been continued.

International partnerships to gain further understanding of the Galactic Bulge have been formed with multiple overseas groups engaging in terrestrial high-dispersion spectroscopic observation to determine the line-of-sight velocities and chemical compositions for bulge stars. In particular, Steven Majewski of the University of Virginia, the principal investigator (PI) of the US Apache Point Observatory (APO) Galactic Evolution Experiment (APOGEE) Project, offered a joint proposal for the APOGEE-2 project as an extension of the original APOGEE project to engage in bulge observations in the southern hemisphere because the project is suitable for bulge observations. The telescope employed will be equipped with a high-dispersion spectroscope, identical to that of APOGEE. The joint proposal has been submitted. An official memorandum of understanding has been exchanged among the APOGEE-2 team, members of the fourth Sloan Digital Sky Survey (SDSS-IV) Collaboration, and Small-JASMINE to strengthen international partnerships and to achieve scientific goals related to the Galactic Bulge.

As planning has progressed so far, the full mission proposal was prepared and submitted in January 2016 to the ISAS call for small-sized scientific satellite mission proposals and the Small-JASMINE mission is going through the ISAS selection process.

12. Extra-Solar Planet Detection Project Office (Exoplanet Project Office, EPO)

The Extra-Solar Planet Detection Project Office cooperates with researchers interested in extra-solar planet at various universities, centered around NAOJ to promote the development of overall technologies and organize related observations with the goal of observing exoplanets and their formation sites. We conduct observational instrument development, research promotion, mission planning, and R&D to develop common basic technologies. We also promote international partnerships related to exoplanets, which are the focus of this project office. Specifically, research and development have continued centered around the following 4 themes:

(1) The development/maintenance/operation of high-contrast observational instruments using the Subaru Telescope to directly observe exoplanets: HiCIAO, SCExAO, and CHARIS; and the promotion of the SEEDS survey and post-SEEDS projects.
(2) The development of the new IR Doppler instrument IRD and planning its observations.
(3) The development of the high-contrast instrument TMT/SEIT, and promoting technological review and related international collaborations for the WFIRST/CGI, and HabEx missions.
(4) Research into star and planet formation and the interstellar medium through wide field-of-view polarimetric imaging with the IRSF telescope located in South Africa.

This project office is progressively dissolving and moving to the Astrobiology Center. There have been 42 refereed papers in English, 10 non-refereed papers in English, 13 presentations in English, 5 non-refereed papers in Japanese, 3 books in Japanese, and 39 presentations in Japanese.

1. Development of the Subaru next generation exoplanet instruments and exoplanet observational research

(1) HiCIAO (High Contrast Instrument for the Subaru Next Generation Adaptive Optics)

HiCIAO is a coronagraph camera for direct imaging of exoplanets and circumstellar disks for the 8.2-m Subaru Telescope, which can simultaneously utilize various imaging modes to differentiate by polarizations, multi-bands, and angle. It is a high-contrast, modular instrument. The first Subaru Strategic Program SEEDS (Strategic Explorations of Exoplanets and Disks with Subaru) with more than 100 participants continued from October 2009 to January 2015 without any serious troubles. Currently, we are continuing with the development, maintenance and use of the extreme adaptive optics instrument SCExAO and the CHARIS integral field unit (IFU) as post-SEEDS activities.

(2) IRD (Infrared Doppler Instrument)

IRD is a high precision (~1 m/s) radial velocity spectrometer working at near-infrared wavelengths, whose aim is to detect habitable Earth-like planets around M dwarfs and brown dwarfs. The budget is based on JSPS Grant-in-Aid for Specially Promoted Research FY 2010–2014 (PI: Motohide Tamura). Spectrograph, fiber experiments, laser frequency comb completion, and total assemble were conducted. Science discussions on habitable planets around M dwarfs are also proceeding.

(3) SCExAO (Subaru Coronagraphic Extreme Adaptive Optics) and CHARIS IFU

SCExAO is a 2000 element extreme adaptive optics system. CHARIS IFU is an exoplanet observation instrument for spectroscopy of giant exoplanets. EPO has been involved in the development of these next-generation high-contrast instrumentations.

2. Exoplanet instrument development for future space and ground-based telescopes and international collaborations

(1) WFIRST Coronagraph and HabEx (Habitable Planet Explorer)

These missions aim to directly image and characterize the Earth-like planets and super-Earths for signatures of life. As a member of the WACO working group (now the WFIRST WG), a coronagraph performance test at the JPL testbed is being conducted with collaborators.

(2) SEIT (Second Earth Imager for TMT)

The aim of this project is the direct imaging and characterization with the SEIT instrument on the Thirty Meter Telescope (TMT). Both technical and science discussions are made. The components have been considered and conceptual design is proceeding.

3. Science research, education, and outreach

The SEEDS project successfully finished in January 2015 without any major troubles. Now we are expanding observations using SCExAO and CHARIS. This fiscal year, 14 papers were published on SEEDS alone. Highlights are given below.

SEEDS has discovered spiral arms in the disk of LkHα330 and revealed the distribution of large/small dust in them. High-contrast direct imaging of intermediate-mass giants has discovered 3 companions that cause long-term radial velocity trends and set upper limits on any companions around 2 stars. A comprehensive direct imaging survey of young (< 1 Myrs) stars using the SEEDS data has indicated the frequency of wide-orbit giant planets. A new companion brown dwarf has been discovered in the Pleiades cluster.

About ten graduate students are supervised for exoplanets and related topics. Many public talks, publication, and press releases are made on exoplanets, disks, and other astronomical fields.

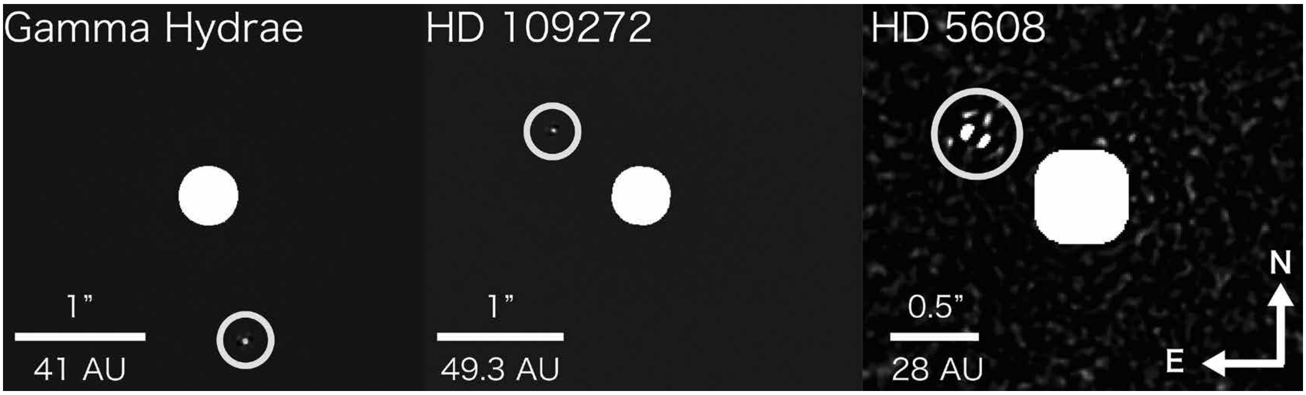


Figure 1: HiCIAO high contrast imaging of intermediate-mass giants with long-term radial velocity trends. Central stars are within the white regions, while the dots in circles are the newly discovered companions. Observing wavelength is near-infrared.

13. RISE (Research of Interior Structure and Evolution of Solar System Bodies) Project Office

1. Project Overview

In FY 2016, operation preparation for the Laser Altimeter (LIDAR) of Hayabusa2 was carried out. And, a thermal test of the APD detector of the Ganymede Laser Altimeter (GALA) for the Jupiter Icy Moon Explorer (JUICE) mission was made. Also the RISE Project Office proposed four option plans as future directions for planetary sciences within NAOJ. The Hayabusa2 asteroid explorer was launched on December 3, 2014; initial test operations finished in January; and Hayabusa2 is underway to C-type asteroid Ryugu. Before rendezvous with the target asteroid start in the summer of 2018, the RISE Project Office developed a scientific data production/analysis tool as a preparation necessary for operation of the laser altimeter. The tool has been implemented, however a test using simulated data has not been completed due to a delay in the Hayabusa2 project supplying the simulated data. For GALA, the RISE Project Office members intensively tested an APD to confirm its suitable temperature range, and acquired basic data for GALA development. As for future directions for planetary science, the RISE Project Office held discussions and proposed 4 options to the Planetary Science Subcommittee: (1) Lunar deep interior exploration, (2) Small body studies, (3) Oscillation of planetary atmospheres, and (4) Cosmo-hydrology. For lunar deep interior exploration, we investigated the merits of 3 observational methods to measure the lunar Q value and the size of the solid/liquid core with high accuracy using lunar surface observation instruments by making the most of the heritage of Kaguya and the Geodetic research of RISE. For small body studies, we considered research into the evolution of primitive Solar System bodies and the delivery of water to the inner planets by investigating main belt comets (MBC) with ground-based observations and space probes by using the ongoing Martian Moon Explorer mission as a springboard. In the oscillation of planetary atmospheres, we are fostering the possibility of collaborative observations between France, Tokyo Institute of Technology, and NAOJ to measure Jupituer's free oscillation. For cosmo-hydrology we promoted Solar System bodies research within NAOJ based on a long-term vision of planetary science activity in NAOJ.

2. Educational Activities/Internship

Seven RISE members delivered 18 lectures on a part-time basis to graduate students at the University of Aizu. Also the Office accepted four third-year undergraduate students of Iwate University and Iwate Prefectual University for a week.

3. Outreach/PR

In FY 2016, one of the Office members volunteered for the Kirari Oshu Astronomy class of Oshu City. Three members participated in the 4D2U Astronomer's Talks; lectures were given 3 times. And 4 members participated in Fureai (Friendly) Astronomy classes 6 times. One member was sent to the open campus of VERA Ogasawara station to provide an introduction to the research and 2 mini-lectures. Members also gave public presentations at Anan City Science Center and Mitaka Astronomy Pub.

4. Joint Research/International Collaborations

From Russia, Professor Alexander Gusev and Ms. Ekaterina Kronrod visited the Office for three months and two months, respectively, for joint research on thermo-mineralogical modeling of the lunar interior and future lunar and planetary explorations. Jointly with The People's Republic of China and the Republic of Korea, the Offi ce member held a summer school for planetary science and exploration in East Asia in June in Wuhan City, China. Five Japanese graduate students participated in the summer school to promote international exchange of young scientists.

5. Career Development

One research staff member left the RISE Project Office in September as his term ended. To fill this vacancy, the Office opened an announcement of a job opportunity. The retired research staff member is now employed as a specially appointed associate professor at Aizu University.

14. Solar-C Project Office

The SOLAR-C Project Office has engaged in planning the next solar observation satellite project SOLAR-C, promoting the sounding rocket experiment CLASP (the Chromospheric Lyman-Alpha SpectroPolarimeter), and also preparing for participation in the large balloon-borne experiment Sunrise3. In addition, the activity for participation in the U.S. sounding rocket experiment FOXSI3 has started since Fiscal Year (FY) 2016.

1. SOLAR-C Project

SOLAR-C is a planned project and may become Japan's fourth solar observation satellite, after Hinotori, Yohkoh, and Hinode. The plan is to realize the launch in the latter half of the 2020's. The project is intended to investigate the solar magnetic plasma activities that influence space weather and space climate around the Earth. The investigations involve the measurement of magnetic fields in the chromosphere and high-resolution imaging/spectroscopic observations that have not been achieved to date. The themes include major problems in solar research: the heating mechanism of the chromosphere/corona, the origin of solar explosive events, and the mechanism of the solar magnetic activity cycle. Since its establishment, the SOLAR-C project WG has involved many non-Japanese specialists in addition to Japanese researchers. Provisionally, Japan will be responsible for the launch vehicle and satellite; and the science instruments will be developed through the international collaborations with the U.S. and European space agencies and institutions.

2. Small-sized Project

(1) CLASP Project

The CLASP project is an observational sounding rocket experiment aiming to detect solar magnetic fields in the chromosphere and transition region through polarization observation at the far ultraviolet wavelengths. Planning and basic development started in FY 2009. The project involves an international research team with participation from Japan, the U.S., and other countries. The spectropolarimeter was prepared in Japan with components provided by the U.S. and France, and an American sounding rocket is used for the flight. The CLASP project entered the development stage fully in the latter half of FY 2012 and carried out the first flight experiment in Sep 2015. The second flight experiment is scheduled for 2019 and will change the observed spectral line from H Lyα to the chromospheric Mg II line at 280 nm.

(2) Sunrise3 Project

The Sunrise3 project is the third balloon-borne experiment in the German Sunrise program. The preparation of the plan started in FY 2015 for the flight experiment scheduled in 2020. Under the international collaboration, the Japanese team will jointly develop a high-resolution spectropolarimeter that is equivalent to the science instrument planned in SOLAR-C. The project will tackle the development demonstration of a state-of-the–art remote-sensing instrument and the challenges to front-line science studies ahead of the satellite observations.

(3) FOXSI3 Project

The FOXSI3 project is the approved third observational sounding rocket experiment in the US FOXSI program with focusing hard X-ray telescopes. One of the hard X-ray detectors is to be replaced by the high-speed CMOS camera that was developed by the Japanese team for soft X-ray coronal imaging spectroscopy. The soft X-ray energy spectrum is to be obtained at each CMOS imaging pixel by photon counting.

3. Major Activity in FY 2016

The SOLAR-C proposal, which was submitted to JAXA in Feb 2015, was not selected in the mission definition review as the candidate for the 1st JAXA Strategic Middle-class Satellite Mission. The SOLAR-C WG is refining the science objectives, investigating the possibility of reducing the diameter of the large optical telescope, and rebuilding the international collaboration framework. In terms of the international collaboration, the science objectives team for the next generation solar physics mission, which has been formed at the request of the space agencies JAXA, NASA, and ESA, has started to prioritize the potential JAXA-led solar physics missions for launch in the mid-2020's.

While publishing the first science results from the flight experiment in September 2015, the CLASP project has been preparing for the second flight experiment. The proposal for the second flight has been approved by NASA during FY 2016, and the next flight is scheduled for 2019. We are now preparing for the flight. The Sunrise3 proposal to a German funding agency has also been approved in this fiscal year, and the Japanese team has submitted funding proposals to obtain the development funds. The team has defined the Sunrise3 science cases, and the basic optical design has been carried out to satisfy the requirements. The FOXSI3 project has conducted the development of a high-speed CMOS camera and carried out the test production of a 3D printed alloyed titanium optical baffle for the stray light reduction.

4. Others

Although the SOLAR-C Project Office is reimbursed by NAOJ for its general operation and emergencies, a large part of the expenses for supporting the project preparation is funded by other sources including the Grant-in-Aid for Scientific Research, JAXA's strategic R&D fund for basic development and experiments for onboard instruments, and research grants from the private sector.

Dr. D. Song has been appointed as a Project Research Fellow since January 2017.

15. Astronomy Data Center

1. Introduction

The Astronomy Data Center (ADC), a central core of computing and archiving for astronomical data, supports scientists worldwide by providing a variety of data center services. In addition, ADC is driving forward research and development programs for future generations of service.

Our activities consist of the DB/DA Project, Network Project, JVO Project, HSC Data Analysis/Archiving Software Development Project, and open-use computer system and service.

2. DB/DA Project

The DB/DA-project conducts research and development on astronomical Data Bases and Data Analysis. It also opens various astronomical data to researchers and educators (http://dbc.nao.ac.jp/).

SMOKA (http://smoka.nao.ac.jp/) is the core of the DB/DA-project and provides archival data of Subaru Telescope, OAO 188-cm Telescope, Kiso 105-cm Schmidt Telescope (the University of Tokyo), MITSuME 50-cm Telescopes (Tokyo Institute of Technology), and KANATA 150-cm Telescope (Hiroshima University). The total amount of opened data is about 17 million frames (119 TB) as of May 2017. SMOKA contributes to many astronomical products. The total number of refereed papers using SMOKA data is 203 as of May 2017.

Continuing from the previous year, in FY 2016, we improved the system for improved operational efficiency and for the development of SMOKA's advanced retrieval functions (i.e. supernova retrieval). In addition, the first Subaru Telescope HSC SSP data release (observations up through November 19, 2015, a total of 850,000 frames) was opened to the public in March 2017.

As of May 2017, we are preparing the design of a new computer system scheduled to begin operation in March 2018 and examining the options for program and data transfer.

3. Network Project

The Network Project designs and operates NAOJ information network infrastructure for the Mitaka Headquarters and branch offices. Noteworthy topics of this fiscal year are as follows.

1) Upgrading the Wide Area Network service: We have operated the circuit service between Mizusawa and Sendai since 2015. In 2016, the service bandwidth has been upgraded from 40 Gbps to 80 Gbps. Also, we made a 100 Gbps interconnection between NAOJ and SINET operated by NII: National Institute of Informatics.
2) Use of the 100 Gbps Transpac line to the U.S.A.: NAOJ and the WIDE project are jointly operating the Transpac, the US-JAPAN Academic research and education network. The Transpac has 100 Gbps bandwidth of circuits between Tokyo and Seattle. In 2016, SINET, JGN, and Univ. of HAWAII submitted applications to use this circuit. Also through cooperation with the Univ. of HAWAII it became possible to extended the circuit from Seattle to the UH Hilo campus.
3) The Traffic analyzer system was installed: This system can mirror the inbound and outbound internet traffic based on the filter rule conditions. We can make the information and network security enforcement more cost efficient.

4. JVO Project

A new version of the JVO portal (v2), for which the usability of the user interface was greatly improved, was released. ALMA WebQL, a quick-look application for ALMA data, was updated. The feature to query to the atomic/molecular line database was implemented, which enables a user to see the line information just below the spectrum data. The features to display the spectrum data in the rest frame of the target source and to select the color map to be used for drawing an image were also implemented.

A Gaia data search service was released. In comparison to the data search service operated by the Gaia project, our system provides a more user-friendly GUI and also enables a user to search large amounts of data without a limit on the number of search result.

A test version of Subaru WebQL was developed and released. This web application enables a user to adjust the contrast of images so that they can examine the data for not only bright sources but also for dim diffuse sources.

Total number of access counts to the JVO services was 3.6 million and a total of 1 TB was downloaded in the 2016 fiscal year.

5. Project for HSC Data Analysis/Archiving Software Development

This project started in January 2009, primarily to develop the data analysis pipeline and data archiving software for Hyper Suprime-Cam (HSC). Our main effort is concentrated on the implementation of the software for effective data analysis/archiving by parallel and distributed processing, for the sake of precise photometric and astrometric calibrations, by correcting various effects originated from the camera system.

Since March 2014, the Subaru Strategic Program (SSP) with HSC has been undertaken, producing stable large data output (about 300–400 GB per night). We preformed data analysis of the SSP data, produced a database storing the processed results, and made an internal data releases in August 2016 to the SSP team collaborators. The image products involve 2.6 million files and their total size reached about 200 TB. The catalog database stores about 300 million objects in a 15 TB database volume. We have developed various user interface software for getting image or catalog products using the database through web browsers, and many of these functions have been offered to collaborators. The hardware and software for the data releases are in stable operation. In February 2017, we made the first world-wide Public Data Release (PDR) based on the data set that was distributed among the SSP collaborators in late January 2016. We have approximately 300 registered users, including individuals from various institutes in about 25 countries. No apparent major problems in the PDR have been reported to date. The PDR is expected to greatly promote scientific outcomes. Major problems in the pipeline software have been significantly reduced, although further improvements to functions are still necessary to achieve the planned accuracies for calibrations/measurements of celestial objects in the images. The on-site data analysis system being developed since 2011 has been supporting SSP and general observations by providing observing tools such as an observation log viewer, which is used to monitor the data analysis results through a web browser. This system has been contributing much to the smooth operation of the Subaru Telescope.

6. Open-use computer system and service

The new rental open-use computer system, "National Astronomical Observatory of Japan: Data analysis, archive, and service system," has been in operation since March 2013. The system plays a leading role as part of the Inter-University Research Institute. The system consists of "Multi-Wavelength data analysis subsystem", "Large data archive and service subsystem" (MASTARS, SMOKA, HSC science, ALMA, VERA, NRO, Okayama and Catalog archive service), "JVO subsystem", "Solar data archive, analysis and service subsystem", "Data analysis subsystem in Mizusawa Campus", and "Development subsystem". The total storage, memory and number of CPU cores within the system are about 6 PB, 13 TB and 2000 cores, respectively. In FY 2016, the total number of valid users was 364 (including 55 users from overseas institutes). We are working to replace the rental computer system in the current year.

In the course of the Inter-University Research we also held and supported some workshops on using software and systems. The dates and numbers of participants in FY 2016 were as follows.

1. HSC-SSP Database school, Apr 11, 2016, 21 users
2. HSC imaging analysis school, Jul 20–21, 2016, 15 users
3. IDL School for FITS data analysis, Aug 2–3, 2016, 12 users
4. SOKENDAI summer student program (Support), Aug 7–31, 2016, 4 users
5. Autumn school "Approach from theory and observation: the character and distribution of the dark matter" (Support), Nov 10–11, 2016, 10 users (analysis workshop)
6. SQL school in FY 2016, Dec 13–14, 2016, 5 users
7. N-body simulation school, Feb 8–10, 2017, 12 users
8. IDL School for the beginner, Feb 28–Mar 1, 2017, 4 users

The total number of participants of the schools in FY 2016 was 83 users.

7. Others

As part of outreach and promotions activities, 97 issues of "ADC News" were published from No. 483 to No. 579 in FY 2016. The news was distributed by E-mail to users and appeared on the ADC web pages.

16. Advanced Technology Center (ATC)

1. Organization and Summary of Activities in ATC

At the Advanced Technology Center (ATC), we are working on the development of astronomical observation equipment that is requested and to be used in the projects driven forward by the National Astronomical Observatory of Japan as "priority area development" and development research contributing to the future astronomical projects as "advanced technology development."

Furthermore, from this fiscal year, we have set up a new R&D framework called "Basic Technology Development," which does not belong to either of the categories "priority area development" or "advanced technology development." These research and development themes shall have a time limit of two years. At the same time, the Advisory Committee for ATC discusses the approach to research and development issues to be tackled at the ATC; in particular, clarifying the directives for selecting the themes for "advanced technology development" as well as how to approach them and making guidelines for organizational building and restructuring "basic technology development" projects.

For ALMA receivers (Bands 4, 8, 10), whose development we have been supporting with the highest priority, shipping was completed in FY 2013 (by March 2014), and then we reformed our organizational structure. From October 2014 we moved to the new organizational structure and carried out not only maintaining the ALMA receivers but also promoting the research, development, and future upgrades to the receivers as well as receivers to be installed on the 45-m reflector and ASTE telescope. Under this organization structure in FY 2016, we have performed ALMA receiver troubleshooting and upgraded the FOREST receiver mounted on the Nobeyama 45-m telescope. In addition, we conducted a commissioning observation with the radio camera on the ASTE telescope led by the radio camera development group that joined ATC last year.

As high priority areas of development, the observation instruments IRIS and WFOS were developed for TMT and the vibration damping, vibration isolator, mirror holders, etc. were successfully developed for the gravitational wave telescope KAGRA.

In the development of IRIS in FY 2016, we have moved forward with the basic design phase (Preliminary design phase). We specified the interface conditions of the IRIS imaging system to be handled by NAOJ/ATC, completed the basic optical and opto-mechanical design and passed through the intermediate review (Preliminary Design Review 1, PDR - 1) in November 2016. Starting in December 2016, we have been making basic designs for electrical systems and software, cost estimates, and the schedule for the final design and manufacturing phases.

We have been studying the concept of a camera system for WFOS, a wide field-of-view multi-object spectroscope, which is another TMT first generation observational instrument. We have continued the concept review of the camera system in FY 2016.

In particular, mainly led by optical engineers at ATC, we redesigned the optical system, analyzed stray light due to specification changes, pointed out the problem of vignetting in the lens system when polycrystalline fluorite was adopted, and then showed the effect on imaging performance and the necessity of measures against stray light within WFOS.

For the KAGRA auxiliary optics, we designed the optical transmission monitoring system (TMS) and made some prototypes last year. In April 2016, the test operation of the initial phase of KAGRA (iKAGRA) was completed. Since manufacturing and testing of almost all of the vibration isolators used in the room temperature part of KAGRA involved in the final design were mostly made by the ME shop at ATC, we are proud that ATC is making a big contribution to the success of KAGRA's trial operation. This fiscal year, continuing from the last fiscal year, we carried out assembly of anti-vibration filters and pre-shipment tests in collaboration with the project office. In addition, we proceeded with the design of the vibration isolation system of the wide-angle scattering baffles to be installed in the immediate vicinity of the cooling mirror.

For advanced technology development, the main themes of research and development are "CLASP, Solar-C", "Telescope Receiver Development", and "HSC".

The CLASP observation rocket experiment is a pioneering project of the solar magnetic field observation of the Sun in the far ultraviolet region. After succeeding in the first experiment carried out in September 2015, we have been preparing for the second flight experiment (planned to launch in 2019) in which the observation wavelength is to be changed. In addition, among the projects the SOLAR-C Preparation Project Office supports, there is a balloon observation project, Sunrise-3, scheduled to be implemented around 2020 after CLASP's second flight. This fiscal year we successfully completed the real optical design of the focal plane observation instrument, SCIP, for Sunrise-3 to be provided by Japan.

In "Development of Telescope Receivers," based on the technology cultivated in the development of the ALMA receivers, we have supported not only evaluation and installation of the Nobeyama FOREST receiver but also development and installation of receivers for 3 cartridge dewars to be used in the ASTE telescope.

In addition, we cooperated with Osaka Prefecture University in GLT receiver development, continued technical cooperation with Nagoya University for the NANTEN 2 telescope, and produced and shipped a three cartridge dewar for the LLAMA Project based on a consignment business contract.

We think that it is one of ATC's important missions to spread the technology and know-how accumulated in ATC to other projects and universities/research institutions to raise the overall community technologically.

Hyper Suprime-Cam (HSC) started scientific observation from March 2014, and is being used for the observations in a Subaru strategic program (SSP) and open-use observations. Although it has basically worked well up to now, we had a problem occur in the filter replacement mechanism. But we have a prospect that it can be resolved by performing preventive maintenance in a cycle shorter than assumed, because it is partly due to the loosening of the fixation of the machine parts. In order to reduce the time overhead by shortening the CCD readout time, a verification experiment in the laboratory is under consideration with the aim of increasing the CCD readout speed.

In the basic technology development, we will focus on "radio camera development" and "infrared detector development" as the themes of technology development aiming for the development of basic technologies both for future detectors and observational instruments.

At the Advisory Committee for ATC (including external committee members), discussions on not only the project promotion system at the Advanced Technology Center, but also the method of research and development contributing to future astronomy were started according to the request from the Director General. In FY 2016 discussions were held primarily about how to carry out advanced technology development contributing to the future of radio camera and infrared detector development.

2. Workshops and Development Support Facilities

(1) Mechanical Engineering Shop (ME shop)

The Mechanical Engineering (ME) shop engages in a comprehensive manufacturing process to fabricate experimental and observational instruments, from design to fabrication and verification. Three teams including design, fabrication, and measuring/ultra-precision fabrication teams cooperate to advance projects by leveraging their expertise.

The design team has mainly been working on mechanical design for the KAGRA and TMT/IRIS projects. Major contributions to the projects are as follows,

[KAGRA project]
- Mechanical design of the vibration isolation table for the Beam Reducing Telescope.
- Mechanical design of the Beam Reducing Telescope.
- Assembly of Bottom Filters for the vibration isolation system.
- Mechanical design of the suspension system for wide angle baffles.

[TMT/IRIS project]
- Design and thermal structural analysis of an optical element holder in cryogenic conditions.
- Thermal contraction analysis of the Imager structure.
- Seismic response analysis of overall IRIS structure.
- Cryogenic endurance test of mechanical components (ball bearing and ball screw) for the Imager.
- Attend preliminary design review.

The fabrication team has been working on the auxiliary optical system of KAGRA since last year, and has fabricated a five-axis lens positioner (prototype) for the Beam Reducing Telescopes. In addition, various parts of the vibration isolation system, auxiliary optical system, and transmission monitor system were delivered.

For TMT/IRIS, mechanical parts for the cryogenic endurance test were machined continuously in order to be able to supply them upon request from the design team.

In addition, we completed the fabrication of the pupil mirror array holder and the slit mirror array holder final model, which are parts for the IFU (Integral Field Unit) of the Subaru Telescope.

In collaborative development programs, we made the base plate and other prototype parts for an ultra-wide-field high-speed CMOS camera (tomo-e) under development by the University of Tokyo, Institute of Astronomy. Continuing on, we are making the final one-quarter scale model. And, we are supporting the development of a secondary mirror center cone for the TAO project.

The ultra-precision section of the fabrication team has responded to fabrication requests. Development of the wideband 37-pixel corrugated horn array has continued from the previous year. In the same way, trail fabrications for the corrugated horn for the ALMA Band 10 receiver continued and more data required for machining was obtained. Both topics will be continued. A 37-pixel Si lens array with AR coating was successfully finished as a prototype for the 109-pixel Si lens array. This was successfully installed and took data on the Nobeyama 45-m Radio Telescope. But new challenges have

Table 1: The requests in FY 2016.

From FY 2015	6	
ATC	28	
TMT/IRIS	7	
KAGRA	32	
ASTE	3	
CLASP2,SOLAR-C	5	
HSC	1	
TMT	1	
JASMINE	4	
Division of Optical and Infrared Astronomy	1	
Exoplanet Project office	7	
Public Relations Center	2	
Solar Observatory	1	
Subaru Telescope	3	
Okayama Astrophysical Observatory	3	
External Organizations		
IoA, Univ. of Tokyo	2	
Saitama University	2	
Total	102	
To FY 2016		5

arisen in the AR coating, and development will be on going.

The measurement team has responded to not just measurement requests but also supported fabrication in order to assure the high specifications. The main topic among measurement only requests was the measurement of dummy mirrors and connected parts for the KAGRA project. The main topic in fabrication support was the pupil mirror array holder.

(2) Thin Film Processing Unit

Fundamental experiments continued to design and develop the concrete processes of coating using inhomogeneous multilayers. Data were obtained with a simple in-situ monitor for thickness and refractive index during the deposition process. These data were used to try to improve the performance of an AR-multilayer, and it worked.

(3) Space Optics

Acquisition and accumulation of fundamental technologies for space observations using platforms such as balloons, sounding-rockets, and satellites are progressing through planned or ongoing project activities. In FY 2016, Space Optics primarily supported the development activities of solar observation projects that are situated as Advanced Technology Developments in ATC.

Space Optics has supported the development of the polarization calibration system of the second CLASP sounding-rocket experiment in which the target lines for the solar chromosphreric magnetic field observations at FUV wavelengths have changed. A new activity for developing the focal plane instrument of the Sunrise-3 balloon project, which aims for vector magnetic field observations of the solar photosphere and chromosphere from the altitude of the Earth's stratosphere, has started in this fiscal year.

(4) Optical Shop

Activity of the Optical Shop in 2016

1) Management

- Measuring instrument maintenance. (such as daily inspections)
- Technical consulting for users (29 cases)
- Repair and upgrade.
  - Exchange of the clean booth cover for the ZYGO
  - Installation of Keyence VH-B18
  - Upgrade of PC for FT-IR

And others

2) Common use of measurement instruments (April 2016 - March 2017)

- The number of annual user: 267
  NAOJ: 223 (including 99 form ATC)
  External organizations: 44 (including 9 from Institute of Astronomy, University of Tokyo)
- Use of LEGEX910 (large-scale 3-D measurement machine): 23
  Number of operating days: 27

(5) Optical and Infrared Detector Group

We have conducted the second round of the joint purchasing program for MESSIA6, a general purpose focal plane array controller for astronomical instruments, as part of shared use of the Advanced Technology Center. MESSIA6 was build based on the electronics developed for Hyper Suprime-Cam in cooperation with the University of Tokyo, and the High Energy Accelerator Research Organization (KEK). In this year, a total of 6 sets were purchased for 4 organizations including NAOJ divisions. We also supported the installation work of a fully-depleted CCD manufactured by Hamamatsu Photonics K.K. and MESSIA6 for the KOOLS observational instrument of Kyoto University and Okayama Astrophysical Observatory at our laboratory. We continue to provide the documentation of MESSIA6, and support the users for installing MESSIA6 and CCDs onto their instruments.

(6) Facility Management Unit

The Facility Management Unit conducts the management of ATC facilities including the buildings, electric facilities; daily maintenance of the Cold Evaporator (CE); maintenance of building equipment; oversight of construction; and management of hazardous material and laboratory equipment.

We carried out renovation work on one draft chamber used in washing work etc. in the laboratory to obtain a control wind speed satisfying the regulation value. Regarding the four draft chambers used for cleaning work etc. in the clean room, we have re-renovated three units that did not meet the regulation values.

Also, we replaced the stainless steel discharge piping with PVC in the acid-treated draft chamber with the scrubber decontamination device, as a countermeasure against corrosion of the piping. As the circulation cooling water facility and the water pipeline become polluted due to aging, inspection and cleaning work including the outdoor cooling tower was carried out to prevent deterioration of water quality.

With regard to the newly built No. 3 building (TMT building), construction of circulating cooling water facilities was considered in order to be able to use refrigerators in each laboratory, and Cold Evaporator (CE) piping connections are being considered.

There are many projects that use laboratory equipment, including ATC, GWPO/KAGRA, TMT, Division of Radio Astronomy/Chile Observatory, HSC, JASMINE, Division of Optical and Infrared Astronomy, Extrasolar Planet Detection Project Office, Subaru Telescope, Hinode Science Center, and SOLAR-C/CLASP. Projects that require high cleanliness in equipment development use clean rooms. In the 110 clean room of the No.1 building and the 101 large clean room of the No.2 building, equipment related to KAGRA was developed. In addition, the main body of the CLASP telescope, successfully launched in the United States in 2015, will return and new equipment will be developed at the 101 large clean room of the No.2 building as a new CLASP-2.

3. Prioritized Area Developments

(1) ALMA receiver maintenance of Band 4, 8, 10

For the ALMA project, the mass-production and shipment to Chile of the Band 4, 8, and 10 receiver cartridges, which were assigned to Japan, were completed in FY 2013. In Chile, most of the receivers have been installed and operated in the ALMA antennas, and many scientific results have been published. At the Advanced Technology Center (ATC), the ALMA receiver maintenance team has the responsibility of maintaining the defective receivers, and repaired four Band10 receivers during FY 2016.

Table 2: Total number of defective receivers.

Receiver	Total	Breakdown		Repaired in FY 2016	Remaining for repair
		Initial failure	Aging failure		
Band 4	6	3	3	0	0
Band 8	17	14	3	0	0
Band 10	21	6	15	4	5

Table 2 shows the total number of defective receivers broken down into “initial failure” and “aging failure.” And also shown are the number of receivers repaired in FY 2016, and the number of receivers remaining to be repaired. These remaining receivers are still inside of the antennas and will be replaced during receiver system maintenance.

All of the initial failures of Band 10 receiver were fixed in FY 2016. Thus, aging failure of electrical devices will dominate future maintenance. We have continued good collaboration with local engineers in Chile for careful maintenance such as “periodic health checks”, “preventative maintenance” and so on.

(2) TMT

We, the IRIS-Japan team at ATC, have been continuing development of the first generation Thirty Meter Telescope (TMT) instrument IRIS since 2011.

The Preliminary Design Phase is continuing in FY2016. We defined and released the design requirement document of the IRIS imager, for which NAOJ/ATC has been taking responsibility, and interface control documents between the IRIS imager and other IRIS subsystem. Also we finished the preliminary optical and opto-mechanical design of the IRIS imager. All these designs and documents were reviewed and accepted at the intermediate review (Preliminary Design Review 1) in November, 2016. After the PDR-1, we started working on the preliminary design of electronics, software, etc. and producing a management plan, cost, and schedule for the coming final design phase and fabrication phase.

In parallel, we have been continuing the prototype experiment and trial fabrication looking ahead to the coming final design phase and fabrication phase. The major issues are the durability of the ball screw under the cryogenic conditions, the cooling characteristics of the surface shape of the optical coating, and trail fabrication of the high-precision aspheric mirror.

We have been working on a conceptual study for the WFOS camera system. WFOS is another first generation instrument of TMT. In FY 2016, we figured out new optical designs that meet new requirements. It was found that the vignetting fraction was no less than 30 % as long as we employ a refractive system.

We also assessed an impact of polycrystal calcium fluoride lenses on its image quality, and found that no more than one polycrystal lens should be used in the camera. Thirdly, we conducted a stray light analysis for WFOS, and confirmed that during a full moon scattered light at the dome floor was a significant stray light source. This suggests the importance of internal baffling. An optical designer in ATC contributed to part of the optical designing work and the stray light analysis.

(3) KAGRA

We have developed KAGRA's auxiliary optics subsystem (AOS) and vibration isolation subsystem (VIS) with the Gravitational-wave Project Office (GWPO).

About AOS, we have continued the design and manufacture of some parts of the transmission monitor system (TMS). This optical system will be located at the end of each 3-km arm optical cavity of KAGRA to monitor the tilt and shift of the beam line, and make feedback signals to the control system. A prototype test of the beam reducing telescope (BRT), which is a part of the TMS, has been done, and the test results have been reflected in the design of the actual setup. The BRTs need to be isolated from vibrations as is done for the other mirrors in the KAGRA interferometer, and the design of the vibration isolation stages for BRTs has been ongoing. In addition, the design of the vibration isolation system for the wide-angle baffles, which will be installed next to the main mirrors, has been ongoing.

KAGRA-VIS is a subsystem to suspend mirrors required for the KAGRA interferometer to isolate them from seismic motions. The system consists of multi-stage isolation mechanical filters. Most of the parts of the isolation system have been brushed up, assembled, and tested by the ME shop, so the ME shop is essential for KAGRA. With these contributions, the initial phase of KAGRA (iKAGRA) finished its test run in April 2016. In this fiscal year we have continued to assemble and test several mechanical filters cooperating with the GWPO. For “standard filters,” 13 out of the required 19 pieces have been assembled, and for “bottom filters,” 2 out of 4 pieces have been assembled. Moreover, for work to upgrade KAGRA (to bKAGRA) in this fiscal year, the GWPO asked us to design a part called "bottom filter recoil mass" and propose the installation procedure. The ME shop did the work, and the designed parts have been installed in KAGRA.

As shared use of the ATC facilities, “pre-isolators” were tested by the GWPO in the large clean room. In addition, researchers from KEK and ICRR tested hydrocatalysis bonding (HCB) of sapphire parts to a sapphire dummy mirror in the ISO1 clean booth. The three-dimensional measurement system was used several times to evaluate the test results.

4. Advanced Technology Developments

(1) CLASP2/Sunrise/SOLAR-C

The CLASP sounding-rocket experiment is a pioneering project of observing the solar magnetic fields at far ultraviolet wavelengths. After succeeding in the first experiment conducted in September 2015, the development team has been preparing the new instrument to observe different chromospheric lines than those observed in the first flight. This will be used for the second flight experiment scheduled in 2019. The major activities in this fiscal year were the modified optical design and the development of the optical components in response to the change of target lines.

The Solar-C Project Office is participating in a balloon project, Sunrise-3, to be launched around 2020 after the CLASP 2nd flight. The detailed optical design of the focal plane instrument, SCIP, that the Japanese team is primarily responsible for has been carried out in this fiscal year.

(2) Telescope Receiver Developments

1) Telescope Receiver Developments

Based on the technical skills acquired through the ALMA receiver developments, the "telescope receiver development" team has responsibility for the development and support for installation of the Nobeyama FOREST receiver and the development, tests, and installation of receivers for a 3-cartridge receiver cryostat for the ASTE telescope. And also, we maintain good collaboration with other radio telescopes operated by universities, such as technical collaboration on NANTEN2 with Nagoya University, cooperative production of a receiver for the Greenland Telescope with Osaka Prefecture University, and fabrication of a 3-cartridge receiver cryostat for the LLAMA telescope through a manufacturing cooperation contract with the Universidade de São Paulo.

ATC can increase the technology standards of the community by giving feedback using the technologies and knowledge accumulated through development of specific projects, and promote the technology development of other projects, universities, and research institutions. It is also important to make the best use of the achievements of the projects.

2) Development of advanced future receivers

In the field of future developments in heterodyne receivers, we focus on two main activities. Firstly, we are involved in international collaboration for the development of the ALMA receivers in frequency bands not implemented in the array yet: Band 1, Band 2+, and Band 2+3. Secondly, we have started receiver development to support future upgrade plans for ALMA in three main directions: ultra wideband, terahertz, and multibeam receivers.

1. ALMA Band 1, 2+ and 2+3 receivers

We supported ALMA band 1 development and preparation towards production through several technical studies. We also supported studies led by NRAO and ESO for the development of Band 2+ (67–95 GHz) and 2+3 (67–116 GHz) prototype receivers, respectively. In the case of Band 2+, a corrugated horn and dielectric lens have been designed and fabricated. Preliminary tests after integration in the Band 2+ prototype receiver show good performance.

2. Ultra-Wideband receiver

In terms of RF bandwidth, we are developing SIS mixers based on high-critical-current-density junctions with the goal of covering the full ALMA Band 7+8 (275-500 GHz). So far, we have demonstrated a DSB mixer which satisfies ALMA requirements in the full 300-500 GHz band. In addition, we have designed and fabricated corrugated horns and waveguide components for Band 7+8, and are currently evaluating the performance of prototypes. In terms of IF bandwidth, we have successfully achieved the direct connection of an SIS mixer and an IF amplifier, and extended IF bandwidth to 3-18 GHz (currently, 4-8 GHz in ALMA).

3. Terahertz receiver

We have continued the development of optical components and superconducting mixers for the 1.2–1.6 THz band. In FY 2015, we demonstrated the possibility to fabricate good quality corrugated horns for these frequencies. Last year, based on them, we completed the design of ALMA compliant optics. With respect to superconducting mixers, we have worked on the design of a quasi-optical mixer in collaboration with Paris Observatory.

4. Multibeam receiver

We have worked on the concept of a multibeam receiver based on superconducting integrated circuits, and started fabrication of the first prototypes. In addition, we are collaborating with KASI in Korea towards a wideband multibeam receiver.

(3) SIS junction development

We have made steady progress in fabricating high current density (Jc) SIS junctions with the goal of providing a steady supply of high quality mixing devices to be used in receivers installed in telescopes, first and foremost ALMA, as well as future receiver development research. The devices are implemented with a Jc as high as 25–45 kA/cm^2, which is 2–4 times as high as that conventionally achievable. This breakthrough happened one year ago when found an effective way to protect the tunnel barrier from damage during counter electrode deposition by applying a 5 nm thick cap Al layer above the oxide barrier. The mixer devices fabricated in this way have enabled a single receiver to operate across an octave frequency range. With these devices, we demonstrated a receiver operating across two ALMA bands (Band 7 and Band 8) with a sensitivity meeting ALMA specification. This achievement proves the feasibility of improving ALMA observation capability by merging ALMA receivers.

In parallel with the development of high-Jc junctions, we have initialized an investigation into fabricating SIS mixers on free-standing membranes. This technique is essential for next-generation multi-pixel SIS receivers, which enable a large field of view in a radio telescope. In order to carry out this study, we have setup two sophisticated pieces of equipment in the cleanroom: a deep-reactive-ion etching system (MUC-21, Sumitomo Precision Co.) and a SUSS MA6 mask aligner that enables backside alignment. We have established a fabrication process of Si membranes from silicon-on-insulator wafers and demonstrated 6-micrometer thick free-standing Silicon membranes with a diameter of 3 mm and flat surface (the maximum bending is less than 5 micrometers). This achievement brings us a bright outlook, especially for the development of multibeam receivers with a wider field of view for ALMA.

(4) HSC

Hyper Suprime-Cam (HSC) started its science operation in March, 2014 and has been offered to the Subaru Strategic Program (SSP) and general observer's programs. During the two years so far, 137 nights were allocated for SSP and a similar number of nights were allocated for general observers. The operation has been stable over this time, but during FY 2016, we encountered mechanical problems several times in the actuators of the central unit (CU) of the filter exchanger system. An ATC engineer found several loose bolts in the CU. This suggests the importance and necessity of preventive maintenance more frequently than we had originally planned. We found the first CCD failure on April 2012 and the number of failed CCDs grew to three by May 2015. No new trouble in the CCDs was, however, reported in FY 2016. If we see more detector failure, we will have to decrease the back bias voltage to reduce the risk but this causes degradation of image resolution. Careful trade-off studies should be made based on the on-going lab experiments. After two years of SSP observations were completed, it became evident that the survey speed is about 80 % of the original plan. This is mainly because the weather was worse than our estimate of the number of clear nights. One possible solution is to reduce the CCD readout time by paying a penalty of increased readout noise. In FY 2017, we should work out optimization of the CCD clocking. This is worth spending time because even a moderate squeeze amounts to big savings of observing times over the decades of HSC operation. In fact, Suprime-Cam has been used over 19 years. We planned to install the detection efficiency monitor in FY 2016 but it was postponed due to the delay of M1 re-coating. We will set it up in October, 2017.

5. Basic Technology Development

(1) MKID camera /CMB Instruments

We are developing a wide field of view, broadband, and high sensitivity millimeter / submillimeter wave instruments. In collaboration with the University of Tsukuba and Saitama University, we have developed a superconducting MKID camera for a future Antarctica terahertz telescope. As a pathfinder, the MKID camera was installed on the Nobeyama 45 m telescope. In collaboration with KEK, ISAS, Kavli IPMU, and Riken, we are developing LiteBIRD and GroundBIRD which observe B-mode polarizations of the cosmic microwave background radiation (CMB). The LiteBIRD has been selected as one of the higher priority projects of the master plan 2017 of the Science Council of Japan. In this year, the following research results were obtained.

1) Development of broadband corrugated horn array (S. Sekiguchi et al. 2017 IEEE TST)
2) Broadband antireflection structure on Si (T. Nitta et al. 2017 IEEE TST)
3) Design of Octave-band OMT-MKID (S. Shibo et al. 2016 SPIE)
4) Confirmation of the interface between the data acquisition system of the MKID camera and the Nobeyama 45-m Radio Telescope by a test installation

(2) Near-IR Imaging Sensor Developments

In this year, we have made a trial chip of small-pixel and large-format Indium Gallium Arsenide (InGaAs) image sensors in cooperation with KEK, Hiroshima University, and Kagoshima University. The cost is expected to be lower than existing near-infrared sensors. We have successfully made fully-functional chips with a small number of bad pixels, however the readout noise slightly increased. Near infrared test observations were conducted with the manufactured chips attached to Hiroshima University's Kanata Telescope. We continue to investigate making a low noise InGaAs image sensor compatible with both small-pixels and large-format, which is suitable for a near-infrared wide field camera.

(3) Multicolor Millimeter/Submillimeter Continuum Camera

Exploring a large patch of the sky in the millimeter/submillimeter bands with a continuum camera will provide the opportunities to effectively measure the redshifts of submillimeter galaxies, the structure of the hot plasma in clusters of galaxies, and the physical properties of the dust in star-forming regions. Thus, we are developing a Transition Edge Sensor (TES) bolometer camera in collaboration with the University of Tokyo, Hokkaido University, the University of California Berkeley, and McGill University.

In FY 2016, science commissioning of the bolometer camera, capable of simultaneous observation at 1.1 mm and 0.87 mm wavelengths, on board the ASTE telescope was conducted. As a result, we have achieved the target mapping speed at the 0.87 mm wavelength, and demonstrated the effectiveness of the novel intensity calibration instrument. Our experiences are shared with the development projects such as DESHIMA and A-Pol to enhance the continuum observation capability in East Asia.

(4) Development of Terahertz Intensity Interferometry

New interferometer technology making use of intensity fluctuations in astronomical sources has been developed in the terahertz frequency region. In collaboration with the National

Institute of Advanced Industrial Science and Technology (AIST), low leakage superconducting tunnel junction detectors are being developed, and their leakage current is evaluated and fedback to the fabrication process. Compact sorption coolers were developed to cool the wide bandwidth SIS photon detectors, showing a cooling capacity of 400 uW at 0.8 K. Our proposal for imaging intensity interferometry is based on delay time measurement using photon bunches, which was demonstrated by simulation and presented in workshops. The development of SIS photon detectors is made possible by the grant-in-aid for challenging exploratory research programs from JSPS.

6. Open Use Programs, Joint Research, and Development

In FY 2016, we accepted open use programs of ATC facilities twice a year including 10 collaboration programs and 23 facility use programs. Applicant names and program titles are listed in the section “Open Use Programs etc.” Results of the programs can be found on the ATC homepage.

17. Public Relations Center

1. Overview

The Public Relations Center engages in the publication, promulgation, and promotion of scientific achievements made not only by NAOJ but also by others in the field of astronomy in general to raise public awareness; responds to reports of discoveries of new astronomical objects; and provides the ephemeris and other astronomical information directly related to people's everyday activities, such as sunrise and sunset times. In FY 2016, the Center has been comprised of 6 offices and 1 unit: the Public Relations Office, the Outreach and Education Office, the Ephemeris Computation Office, the Library Unit, the Publications Office, the IAU Office for Astronomy Outreach (OAO), and the General Affairs Office.

2. Personnel

In FY 2016, the Public Relations Center was composed of Director Toshio Fukushima and the following staff members: 2 professors, 2 associate professors, 1 assistant professor (one holds concurrent posts), 1 research engineer, 1 chief senior engineer, 1 chief engineer, 1 Chief of the Library, 5 specially appointed senior specialists, 3 research experts, 21 public outreach officials, 1 research supporter, and 2 administrative supporters.

On April 1, 2016, Associate Professor Hitoshi Yamaoka arrived and specially appointed senior specialist Hiroko Tsuzuki arrived in the Public Relations Office on September 12.

On November 30, 2016, public outreach official Diaz Rosas Elian Abril in the IAU Office of Astronomy Outreach finished her term. On March 31,2017, public outreach official Takao Ibaraki, public outreach official Kuninori Iwashiro, and public outreach official Hiroshi Futami finished their terms.

3. Public Relations Office

Through press conferences and web releases, the Public Relations Office actively developed public outreach activities focused around the results of each research project, first and foremost ALMA and Subaru Telescope, including open-use and collaborative results with other universities and research institutes. In addition, our office hosted lectures to publicize cutting-edge astronomy. In cooperation with the Outreach and Education Office, the Public Relations Office also conducted observation campaigns to promote astronomical phenomena of interest to the public, like the meteor showers. Our office organized and held independent workshops with public relation officials to improve the skills of outreach personnel.

(1) Online-Based Information Sharing

The Public Relations Office runs the NAOJ website (http://www.nao.ac.jp/en/), disseminating information via the internet. Table 1 shows the access counts for the website.

Last fiscal year, a special website "Multiwavelength Universe"English version was opened. This website won the WebAward 2016 Best Science Site.

For the NAOJ Chile Observatory, the Public Relations Office reviewed and offered advice on the proposal for the website renewal.

The office opened Twitter accounts and Facebook accounts in Japanese and English sequentially from 2010. We have been actively disseminating information on social networking services. Our office disseminates information on the status of various NAOJ projects such as public visits, regular stargazing parties at Mitaka Campus, and position openings, both in English and Japanese. As of the end of March 2017, the number of followers exceeds 80,000. From this fiscal year, we have strengthened our English version of Twitter. In the second half of the fiscal year, we started to post daily. Also, NAOJ quizzes on Twitter were started and they made the Twitter more interactive. Also, from this fiscal year, our office started to disseminate visual images on Instagram.

NAOJ e-mail newsletters No.159–171 were issued, introducing research results and NAOJ hosted events.

We continued to produce videos explaining research results, videos explaining astronomical phenomena, and videos introducing outreach activities. Including English versions, 19 original videos were produced. The videos are uploaded mainly on YouTube. As of the end of March 2017, these videos have accumulated a total of 459,139 minutes of play time and 86,005 views. This fiscal year, as a new effort, our office twice performed live stream broadcasting of heavenly bodies with the 50-cm Telescope for Public Outreach. There were about 2,000 viewers in total. In addition, we conducted live internet broadcasts including the lectures mentioned below and on Mitaka Open House Day.

Month	Access counts	Month	Access counts	Month	Access counts
April 2016	358,635	August 2016	1,237,959	December 2016	522,840
May 2016	579,476	September 2016	444,328	January 2017	620,472
June 2016	555,124	October 2016	430,131	February 2017	481,406
July 2016	463,076	November 2016	532,127	March 2017	386,173
Total: 6,611,747					

Table 1: Monthly website access statistics for the Public Relations Office website, NAOJ Public Relations Center (April 2016–March 2017).

“Keiichi Kodaira Video Clip”for the digital book	English Version
Hunting Black Holes	Japanese/English Versions
“FUREAI (Friendly) Astronomy” PR movie	Japanese Version
HSC/M31 Video Clip	
HSC/Virgo1 Video Clip	
Dr. Flaminio interview about Breakthrough Prize in Fundamental Physics	Japanese/English/Italian Versions
Dr. Barton interview about Breakthrough Prize in Fundamental Physics	Japanese/English Versions
Project PR movie “Public Relations Center”	Japanese Version
Perseid Meteor Shower (Aug.12, 2016)	Japanese Version
CfCA “Pulsar Video Clip”	
Project PR movie “Okayama Astrophysical Observatory”	Japanese Version
Project PR movie “Subaru Telescope”	Japanese Version
Project PR movie “NAOJ Chile Observatory”	Japanese Version
Cultural Properties Protection Week Movie “NAOJ Solar Tower Telescope”	Japanese/English Versions

Table 2: Summary of Produced Videos.

May 11, 2016	New Test by Deepest Galaxy Map Finds Einstein's Theory Stands True
May 25, 2016	Footprints of Baby Planets Imprinted in a Gas Disk
June 7, 2016	Japan OISTER collaboration uncovers the origin of extraordinary supernovae
July 26, 2016	Ancient Eye in the Sky
August 12, 2016	Dense molecular gas disks drive the growth of supermassive black holes—Are supernova explosions the key?
September 5, 2016	Discovery of an Extragalactic Hot Molecular Core
October 31, 2016	A joint observation by solar observing satellites Hinode and IRIS quantitatively explores the formation of the solar chromosphere
November 21, 2016	Discovery of Unexpected Supersonic Events Everywhere on the Sun - Results from 5-minute Flight of the Sounding Rocket Experiment “CLASP” -
November 22, 2016	Record-breaking Faint Satellite Galaxy of the Milky Way Discovered*
November 28, 2016	Timing the Shadow of a Potentially Habitable Extrasolar Planet Paves the Way to Search for Alien Life
December 5, 2016	ALMA measures size of seeds of planets
January 16, 2017	Tail of Stray Black Hole hiding in the Milky Way
January 24, 2017	Micro spacecraft investigates cometary water mystery
January 31, 2017	Tracing the Cosmic Web with Star-forming Galaxies in the Distant Universe
February 24, 2017	Saturn’s Rings Viewed in the Mid-infrared
February 28, 2017	First Public Data Release by the Hyper Suprime-Cam Subaru Strategic Program
March 8, 2017	Ancient Stardust Sheds Light on the First Stars — Most distant object ever observed by ALMA
March 29, 2017	Subaru Telescope Detects the Shadow of a Gas Cloud in an Ancient Proto-supercluster
January 15, 2016	Signs of Second Largest Black Hole in the Milky Way - Possible Missing Link in Black Hole Evolution
February 4, 2016	A Violent Wind Blown from the Heart of a Galaxy Tells the Tale of a Merger
February 25, 2016	Subaru-HiCIAO Spots Young Stars Surreptitiously Gluttonizing Their Birth Clouds
February 25, 2016	New Fast Radio Burst Discovery Finds ‘Missing Matter’ in the Universe
March 3, 2016	ALMA Spots Baby Star’s Growing Blanket
March 10, 2016	Deciphering Compact Galaxies in the Young Universe
March 10, 2016	Mysterious Infrared Light from Space Resolved Perfectly

Table 3: Web Releases.

June 16, 2016	ALMA Detected the Most Distant Oxygen
September 6, 2016	Avoiding “Traffic Jam” Creates Impossibly Bright “Lighthouse”*

Table 4: Press Conferences.

(2) Research Result PR

There were 20 research result announcements (compared to 27 in FY 2015 and 16 in FY 2014). For press releases aimed towards overseas audiences, we have continued to use the delivery services of American Astronomical Society, AlphaGalileo, and EurekAlert! from AAAS. We released almost all the research releases in both English and Japanese. We made videos introducing the content indicated with a * mark.

In the perennially popular Astronomy Lectures for Science Journalists program, the 23rd lecture entitled "ALMA Opens a New Astronomy" was held on December 2, 2016. Thirty people (23 companies) participated in the lecture.

(3) Activities as NAOJ's Public Relations Center

The following activities were pursued in addition to the Center's regular task of aiding research result releases.

The Public Relations Office organized lectures with research projects. On June 11, 2016, NAOJ and Riken Lecture "Origin of Materials told by the Universe;" on September 10, Hinode 10th anniversary lecture "Exploring the Universe and the Earth through Solar Observations;" and on November 26, the NAOJ lecture meeting/22nd ALMA public lecture "Exploring birth of stars and planets with ALMA" were held respectively. In addition, the office persevered in helping to organize and publicize the Subaru Telescope/ Shinshu University public lecture "From Shinshu via Hawaiʻi, a Galactic Research Journey" on November 23 and "The Subaru Telescope/Hiroshima University public lecture" on November 27.

Furthermore, since the 23rd NINS Symposium "Frontiers of Modern Astronomy: a Second Earth and the Dark Universe" was held on March 5, 2017 with NAOJ responsible for the planning and operating, the Public Relations Center was at the center of holding the event, in cooperation with the General Affairs Section, General Affairs Division.

To expand our public relation materials, our office took photographs at Mizusawa VLBI Observatory, Okayama Astrophysical Observatory, and KAGRA. For KAGRA, movies were also taken simultaneously.

Our office organized workshops with public relation officials inviting lectures from outside to improve the skills of outreach personnel. Training in photography was offered on July 25, 2016, and training in science writing was offered on January 18, 2017.

To publicize NAOJ abroad, we exhibited booths at oversea meetings for the public and events where the press gathers (New Scientist Live in London: September 2016 and AAAS meeting in Boston, February 2017). In addition, we ordered an outside film maker to make a 6 minute video for release at the American Physical Society Annual Meeting and screened it in March 2017.

(4) New Astronomical Objects

From this fiscal year, the responsibility for New Astronomical Objects moved from the Ephemeris Computation Office to the Public Relations Office. Four staff members, including one full-time and three part-time, handled reports of new astronomical objects and other communications submitted to NAOJ. In this fiscal year, there was a total of 15 reports including confirmation requests for new celestial object candidates and other reports. The contents were: 4 novae/ supernovae, 6 variable stars/transient objects, 1 comet, 1 minor planet, and 3 luminous objects. Among the many examples of reporting a variable star or known asteroid as a new object, the report of a transient object in September, was communicated via NAOJ to the IAU Central Bureau for Astronomical Telegrams and was recognized as an independent discovery of Nova Scorpii 2016 No. 2 (V1656 Sco.)

4. Outreach and Education Office

(1) Public Visits

A total of 20,522 people visited the Mitaka Campus Visitors' Area in FY 2016. In addition, the group tours in 2016, consisted of 110 general tours (4,408 guests), and 36 workplace visits by schools (362 guests), for a total of 146 tours accommodating 4,770 guests. Note that in the workplace visits, lectures by researchers, question-and-answer sessions, and visits to research facilities also took place. The office started developing the audio guide in the Visitors' Area. From October, our office began experimental operation at the 20-cm Telescope Dome, Repsold Transit Instrument Building, Gautier Meridian Circle Building, and Astronomical Instrument Museum.

Regular stargazing parties were held twice a month (the day before the 2nd Saturday and the 4th Saturday) with the 50-cm Telescope for Public Outreach. These were held regardless of cloudy or rainy weather. Advance booking (300 people for each session; a lottery system from April to September and advanced reservations until filled system from October to March) was introduced in FY 2012 for these events. A total of 23 sessions were held with 4,671 participants this year. The Regular Stargazing Parties celebrated their 20th anniversary in April 2016. More than 60,000 guests have visited in these 20 years.

	Solar info	Lunar info	Ephemeris info	Time	Solar System	Universe	Astronomy	Other	Total
April–June	167	70	43	28	330	92	147	554	1431
July–September	126	110	63	15	209	149	134	803	1609
October–December	192	233	44	4	276	121	137	649	1656
January–March	136	63	29	6	225	112	107	400	1078

Table 5: Telephone inquiries made to the Outreach and Education Office of the NAOJ Public Relations Center (April 2016–March 2017).

The Outreach and Education Office changed the regular public screenings at the 4D2U Dome Theater from three times a month to four times (1st, 2nd, 3rd Saturday, the day before the 2nd Saturday). Advanced reservations were required for these. A total of 47 screenings were held this year, with 5,432 guests participating. For five of the regular public screenings, the office held "Astronomer's Talks" where NAOJ researchers talked about the latest research and these were popular. Group screening used to only be performed on Fridays, but we changed to Wednesdays and Fridays. Therefore, the number of group tours became larger and 81 group screenings were held with 2,655 guests attending. Especially at Wednesday group screenings, teacher training sessions were held. 96 tours were organized with 1,189 attendees. In total, 224 screenings were held and a total of 9,276 guests enjoyed 4D2U's stereoscopic images.

The regular "Tangible Cultural Property Tours" ceased operation at the end of March 2016. In 2016, the NAOJ Solar Tower Telescope Special Open Days (November 3, November 5, and November 6, no reservations needed) and Tangible Cultural Heritage Tours (November 3 and March 20, advance reservations needed) were held with 624 attendees.

(2) Telephone Inquiries

The office received inquiries from the media, government offices, and the general public. The Outreach and Education Office responded to 5,774 telephone inquiries (Table 5) and 134 letters, 52 of which were official documents.

(3) Educational and Outreach Activities

For the "Fureai (Friendly) Astronomy" project, now in its 7th year, a total of 49 lecturers provided events to 80 schools out of the 86 which applied, reaching 8,017 students.

We presented the results of the questionnaire performed in Fiscal Year 2015, at the Japanese Society for Education and Popularization of Astronomy Meeting and The Astronomical Society of Japan Fall Meeting. Particularly noteworthy is that for the Astronomical Society of Japan meeting, we presented at the press conference.

"Summer Nights: Let's Count Shooing Stars, 2016" was conducted in August 2016 and we received 2,311 reports. A paper showing the possibility of obtaining observation results close to skilled observers by collecting a large number of reports from the general public was published in "Planetary and Space Science."

On August 16 (Tuesday) and August 17 (Wednesday), "Astronomy classes for kids in Summer" events were held for elementary and junior high school students. On the first day, there were lectures about the assembly and use of telescopes. In cooperation with the JASMINE Project Office, the second day was lectures about the distances of celestial bodies, three-dimensional star handcrafts of the big dipper, and an interpretation using the four-dimensional digital universe viewer, "Mitaka." Also, star gazing parties were scheduled for both days (Cancelled on the first day due to the typhoon.) The total number of attendees was 77.

The Public Relations Center participated as the secretariat for the Mitaka Open House Day, a special public event held at Mitaka Campus and organized by the steering committee.

This two-day event was held on October 21 (Friday) and October 22 (Saturday) with the theme "Gravitational Waves, a new Frontier of Astronomy." It was co-hosted by the Astrobiology Center, National Institutes of Natural Sciences; the Institute of Astronomy, the School of Science, the University of Tokyo; and the Department of Astronomical Science at the School of Physical Sciences of the Graduate University of Advanced Studies. The event flourished: 542 guests attended on pre-open day, 3,992 guests attended on open day, 4,534 guests attended in total. Each Project offered a selection of activities based on their own expertise which were suitable for a wide range of age groups. Activities included the viewing of facilities not normally open to the public, interactive panel displays, minilectures, quizzes and games that are popular among children, and a virtual reality experience.

From October 2 (Sunday) to October 4 (Tuesday), the "Workshop for Popularizing Cutting-Edge Astronomy" was held with the theme of "Gravitational Wave Astronomy" for staff members of science museums/museums, teachers, and science communicators, who are doing astronomy outreach work. Lectures were held at the University of Toyama and attendees also visited the Large-scale Cryogenic Gravitational Wave Telescope KAGRA of the Institute for Cosmic Ray Research, University of Tokyo; the Underground Neutrino Detector Super-Kamiokande; and the Kamioka Liquid Scintillator Antineutrino Detector (KamLAND, Tohoku University). 64 guests attended.

On March 2 (Thursday) and March 3 (Friday), NAOJ, the International Planetarium Society, and others, co-hosted the "Data to Dome Workshop" at the Large Seminar Room and 4D2U Dome Theater. The aims of this international hands-on workshop were to enable easy visualization and extend the possibility of science communication in planetariums. 52 guests attended including 9 invited speakers and 15 attendees from overseas (U.S.A., Canada, Taiwan, Germany, South Africa, Hong Kong, the Netherlands, and Sri Lanka.)

(4) Community Activities

The "Mitaka Picture Book House in the Astronomical Observatory Forest" welcomed 41,068 visitors in FY 2016. The Outreach and Education Office supervised the exhibition "Ephemeris Counting Life (July 2016 – June 2017)." We also cooperated with modern and traditional Tanabata events, moon viewing event, and other events. In addition, through the "Mitaka Picture Book House in the Astronomical Observatory Forest, Picture Book Original Drawings Hallway Exhibit Contest" which started from FY 2013, the Outreach and Education Office cooperated in the selection of 3 winning books.

The Outreach and Education Office conducted the 8th"Mitaka Solar System Walk" from Friday, September 23 to Sunday, October 23 in cooperation with Mitaka City and the non-profit organization (NPO) Mitaka Network University

Promotion Organization. Stamps were placed at 170 shops and 67 facilities, including NAOJ Mitaka Campus and the Mitaka City Municipal Office, for a total of 237 locations around Mitaka. Adding 19 limited stamps, 256 stamps were placed and this is a record number. Approximately 18,000 guide-maps/stamp sheets were distributed, of which 3,379 people turned theirs in for a prize. The number of participants who collected all the stamps was 387. It was a good chance to tour the Solar System while promoting commerce, industry, sightseeing and providing families with a way to enjoy Mitaka and rediscover the city's charm.

The Outreach and Education Office also provided the venue for "Astronomy Course for Apprentice Starry Sky Guides, Star Sommelier Mitaka - Let's Become Apprentice Starry Sky Guides! - " hosted by Mitaka Network University and also assisted by providing teachers and workshops.

The "Information Space of Astronomy and Science" for which Mitaka City, Mitaka Network University, and Mitaka City Planning Board co-operate celebrated the second year since its opening and 11 exhibitions were held in FY 2016. The Public Relations Center had proposed 2 of these exhibitions and helped with 3 lectures.

Also, the office offered outreach and monthly astronomical information images through large-scale information displays and "Cosmic Reading Bookstore Corner," a display of sample books available to read which changes themes (once every 2 months), and cooperated on the "M Marche Project" conducted on the 4th Sunday of every month. We welcomed 21,674 guests in the 2016 fiscal year and celebrated 20,000 visitors and 30,000 visitors since the opening. It has been acknowledged as a location in town where science can be easily accessed.

(5) Merchandizing Business

The office cooperated with merchants who organized the NAOJ original goods and aided in making 5 types of goods and 132 individual products, such as pin badges, cultural property facility post cards, and T-shirts. In addition, the office invited merchants to place vending machines dispensing capsule toys starting from August 2016. These were placed so that visitors can buy goods when the Co-op store is closed on Saturdays and Sundays. Also, the office invited booths selling goods at the Mitaka Open House Day. A total of 1,230 items of these goods were sold in the year.

5. Ephemeris Computation Office

The Ephemeris Computation Office (ECO) estimates calendrical phenomena such as the apparent positions of the Sun, Moon, and planets on the basis of international standards and publishes the "Calendar and Ephemeris" as part of the compilation of almanacs, which is one of NAOJ's raisons d'être.

(1) ECO published the 2017 edition of the Calendar and Ephemeris, the 2017 version of the calendrical section of the Rika Nenpyo (Chronological Scientific Tables), and the 2018 edition of the Reki Yoko (posted in the official gazette on February 1, 2017). The Calendar and Ephemeris webpage was updated to match what was published in the Reki Yoko.

(2) As for the website (http://eco.mtk.nao.ac.jp/koyomi/index.html.en), ECO continuously updated the contents of the Ephemeris Wiki and worked on checking the accessibility sequentially. ECO cooperated with the astronomical phenomena awareness campaigns again this year. The radiant points of the Perseid, Geminid, and Quadrantid meteor showers were published in the Astronomical Information section of the website. There were about 24 million page views for this fiscal year.

(3) The Japan Association for Calendars and Culture Promotion hosted its 6th General Meeting, and the Calendar Presentation Ceremony.

(4) ECO hosted regular exhibitions in collaboration with the Library, selecting from NAOJ's invaluable collection of historical archives written in Japanese/Chinese. The themes of the 54th and 55th permanent exhibitions were "24 Sekki and Calendar" and "Shigetomi Hazama" respectively. These exhibits can also be viewed at the Rare Materials Exhibition of the Library's website, in Japanese only (http://library.nao.ac.jp/kichou/open/index.html).

(5) New Astronomical Objects work was transferred to the Public Relations Office this fiscal year.

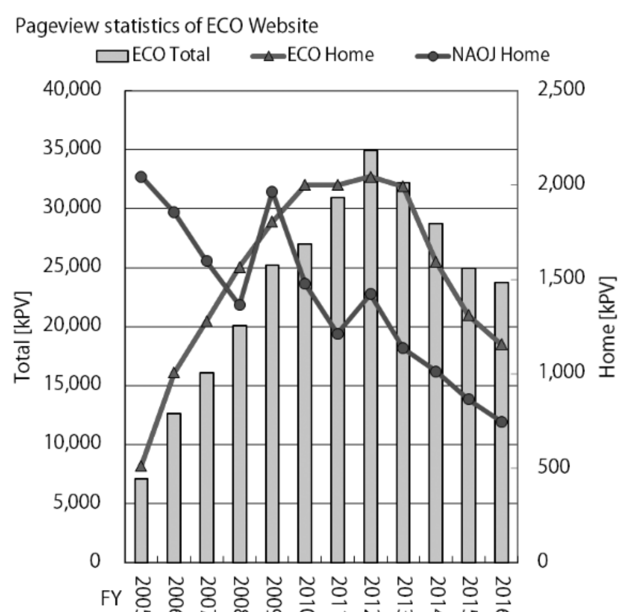


Figure 1: Pageview Statistics of ECO Website.

6. Library Unit

The Library Unit collects and sorts scientific journals and books in order to make them available for the research and study of NAOJ researchers and students. In recent years, with the continuing digitalization of scientific materials, the portion of the materials in electronic format has increased.

For non-NAOJ personnel who wish to use the Mitaka Library materials, the Library is open to the public on weekdays. In FY 2016, 249 non-NAOJ personnel came to use the Library. Also for researchers and students belonging to other organizations, we loan books or provide photocopies via the institute's library. In FY 2016, photocopies or loans were provided in a total of 96 cases.

Important documents, especially those originating from the Edo Era Tenmonkata (Shogunate Astronomer), are preserved while taking into account the environment of a specialized library. Images of some of the important documents are available to the public on the Library Unit homepage.

During the Mitaka Open House Day festivities in October, we used to open part of the Mitaka Library to the public, but in Fiscal Year 2016, we extended the subject themes. In addition to materials for general and young readers, we actually allowed visitors to take a look at many specialized books related to astronomy.

The number of books and journals owned by Mitaka Library and each observatory and the condition of continuing NAOJ publications are published in Section XI Library, Publications.

7. Publications Office

The Publications Office continued its activities in planning, editing, and printing NAOJ's original materials for PR and promotions. The following periodicals were also published this year:

- Annual Report of the National Astronomical Observatory of JAPAN Volume 28 Fiscal 2015 (Japanese)
- Annual Report of the National Astronomical Observatory of JAPAN Volume 18 Fiscal 2015 (English)
- Report of the National Astronomical Observatory of JAPAN Volume 18 (Japanese)
- NAOJ Pamphlet (Japanese)
- NAOJ Pamphlet (English)
- NAOJ News, No. 273 – No. 284 (April 2016–March 2017)
- Radio Astronomy Public Relations comic "Almar's Adventure" (#6)
- NAOJ Publicity Poster Series (#4, #5, #6)

Continuing from the previous year, in FY 2015 the Publications Office strove to strengthen its international publication ability and digital publication ability. Regarding the production of an international edition of the Rika Nenpyo (Chronological Scientific Tables), the authors performed the first check of the English translation and it is in layout. In digitalization efforts, the Office brushed up the "NAOJ-Universal Multi-Publication System (NAO-JUMPS)," which includes research highlight of the Annual Report of the NAOJ and fixed layout articles from NAOJ News. Together with this, the first book Makali'i in Hawai'i "(ISBN978-4-908895-01-2) was published using the generalized electronic book platform "NAOJ-Delivering next-generation e-books (NAOJ-Deneb)." In normal business, the Office produced and distributed the NAOJ pamphlets and the Annual Report of the National Astronomical Observatory of JAPAN. In the systematic production of special editions with the goal of developing project outreach support in NAOJ News, extra copies of each of the special editions ("The Subaru Telescope Special Edition 2016" July; "Mizusawa VLBI Observatory Special Edition" December; "Hinode Solar Observatory 10th Anniversary Special Edition" January; and "People Involved in the TMT Project Vol.01 Special Edition" March) were printed and these aided the outreach efforts of each project. The TMT Special Edition is especially noteworthy because the office conducted international interviews in California and Hawai'i. The March issue was the California issue, including 12 articles published in both Japanese and English, making a concerted effort towards content internationalization. From now on, to develop and share NAOJ News articles as a resource to be used as outreach content for each project, we plan to promote the production of overall, basic articles through close cooperation with researchers and promote international magazine compiling. Other than periodicals, the 2017 calendar "SUBARU Telescope" (the 12th since 2005) was created. The Office provided native check services to the Public Relations Office; General Affairs Division, Administration Department; and Hinode Science Center for English language publications, contributing to the expansion and enhancement of NAOJ's international information dissemination. In addition, like in other years support was also given to the publication of the "Rika Nenpyo, (Chronological Scientific Tables)."

8. International Astronomical Union Office for Astronomy Outreach (IAU/OAO)

The Office for Astronomy Outreach (OAO) of the International Astronomical Union (IAU), which is established as an office in the Public Relations Center, communicated with National Outreach Contacts (NOC's) (windows for outreach in each country) in an effort to strengthen cooperative relationships, communication, and coordination with 69 NOC's as of the end of the 2016 fiscal year. Significant progress was made between 17 NOC's this fiscal year. In relation to this, IAU OAO announced that from the next fiscal year we would begin discussing outreach systems for each country that would be more effective in achieving the objectives in the near future.

For international information provision, the office posted a total of 550 postings from OAO on IAU social media during FY 2016. The Facebook community grew by 33 % and the Twitter community by 40 %. Meanwhile, the IAU Astronomy Outreach Newsletter (e-mail news) was delivered 24 times and 300 items of information were provided to 4,500 subscribers all over the world. The newsletter has been translated and redistributed into four different languages by collaborators in the respective countries.

On May 16–20, 2016, the International Conference

CAP2016 of the IAU C2 committee was held in Medellín City, Colombia with 140 participants from 30 countries. OAO contributed to the management of the conference as one of the Executive Chairs, and many staff members participated and deepened international relations through presentations, workshops, etc. In cooperation with the Outreach and Education Office and others, the Office successfully invited the international conference CAP 2018 to Fukuoka and is proceeding on preparatory work in cooperation with the convention organizing committee members, Fukuoka City, and others.

From September 24 to September 26, NAOJ and the Japanese Society for Education and Popularization of Astronomy co-hosted "The 3rd Symposium on Universal Design for Astronomy Education" at NAOJ Mitaka Campus with 131 attendees from 15 countries.

Our office also conducted a survey on the translation network and summarized the key issues for OAO stakeholders and the astronomy outreach community in establishing translation services and language translation requests as part of OAO's activities. We held several evaluation meetings during FY 2016 and begin experimental translation network projects from FY 2017.

IAU OAO received international evaluation by IAU and NAOJ from August 31 to September 2. This is because the agreement on OAO between the IAU and NAOJ was set to expire at the end of the current fiscal year. A thorough and fruitful evaluation process was carried out. The main recommendation from the evaluators was that the scope of astronomy outreach is very wide, so OAO should focus on narrowing down its priorities, and performing projects in a systematic way. In response to the evaluation, OAO reviewed its organization and division of labor, and after having attended the Intercultural Communication Seminar, OAO is pursuing its activities under a new organization structure. In February 2017, IAU and NAOJ exchanged new agreements for 2017-2021 based on the evaluation results.

18. Division of Optical and Infrared Astronomy

1. Overview

The primary objectives of divisions in NAOJ are facilitating and invigorating projects and individual research through personnel exchanges to place researchers in environments more suitable for their individual projects. While pursuing challenging exploratory research on observation and development, the division furthers these goals by launching new projects as necessary. The division also actively engages in graduate education efforts to foster next-generation talent. These activities are based on the concept that the Division of Optical and Infrared Astronomy is a center for personnel exchange between Subaru Telescope, which engages in open use, and universities and research institutes in Japan, which focus on developmental research into new instruments and observational research. This fundamental principle has been developed since the Subaru Telescope was constructed.

The Division of Optical and Infrared Astronomy oversees OAO (Okayama Astrophysical Observatory) and Subaru Telescope (C Projects); the TMT-Japan (TMT-J) Project Office and the Gravitational Wave Project Office (B Projects); and the JASMINE Project Office and the Extrasolar Planet Detection Project Office (A Projects). The Division and the Projects carry equal weight in organizational terms. Almost all NAOJ members in optical- and infrared-related fields have positions in the Division with either the Division or one of the A, B, or C Projects as the primary appointment. At times, they may also have concurrent positions in other projects. The primary staff of the Division of Optical and Infrared Astronomy in FY 2016 consisted of two professors, and four assistant professors (including one specially appointed assistant professor).

The Division coordinates educational, research, and administrative activities for Subaru Telescope Mitaka Office and the Extrasolar Planet Detection Project Office. Since personnel transfer often occurs within the Division of Optical and Infrared Astronomy, the Division plays an increasingly important role in coordinating between Subaru Telescope and the TMT-J Project Office. The Division as a whole maintains and operates facilities which are auxiliary to research, such as mailing lists and web servers for Division of Optical and Infrared Astronomy-related projects such as Subaru Telescope, TMT-J, Extrasolar Planet Detection Project Office, Gravitational Wave Project Office, and JASMINE Project Office. The remainder of this report will focus on the research projects conducted by the primary staff of the Division of Optical and Infrared Astronomy and the activities of projects that support open use.

2. Observational Research

(1) Observational Research Using Various Types of Telescopes

Observational research utilizing the Subaru Telescope focuses on a wide variety of fields such as cosmology; galaxy formation and evolution; the formation of stars and planets; the structure and evolution of the Milky Way; stellar spectroscopy; Solar System bodies; and the search for exo-planets. A survey of high-z quasars was conducted in the survey data of Hyper Suprime-Cam (HSC) on the Subaru Telescope. A comet which was accidentally captured in a queue observation was analyzed and utilized as data about the dust trail. Comets were observed at the Kiso Observatory of the University of Tokyo. The data reduction in the search for extrasolar planets using direct imaging methods continued. Based on the infrared observations of protoplanetary disks by the Subaru Telescope, observations were proposed to ALMA, and some data were obtained successfully.

(2) International Cooperative Observational Research

The Division also engages in international collaborative studies with overseas researchers.

Planning of the observations and the collaboration with the Fessenkov Astrophysical Institute at Kazakhstan was promoted for a cooperative observations with the East Asian Core Observatories Association (EACOA) medium-size telescope and the Optical and Infrared Synergetic Telescopes for Education and Research (OISTER). In the OISTER workshop held on November 21–22, 2016 at Kyoto University, a talk was given by an attendee from the Fessenkov Astrophysical Institute. A Kazakhstan-Japan Mini Workshop was held at the Fessenkov Astrophysical Institute at Almaty, Kazakhstan during March 28–April 1.

The site survey in western Tibet continued in cooperation with the National Astronomical Observatories, Chinese Academy of Sciences (NAOC). Discussions for the site assessment and construction of a telescope were held with researchers of NAOC, the Purple Mountain Observatory, and Hiroshima University.

A study on extended ionized gas in the Leo cluster was conducted with researchers in Italy. A study on extended ultraviolet regions around galaxies continued with researchers in the USA.

(3) Research Using Archives

Researches on the verification of astronomical phenomena described in the New Testament started jointly with the National Institutes for the Humanities. Studies of astronomical phenomena based on other old ephemerides and documents continued. A statistical study on Ultra Diffuse Galaxies in the Coma Cluster was conducted using archive data from the Subaru Telescope.

The image data of the Kiso Ultraviolet-excess Galaxies (KUG) catalog and the corrections of the positions based on the images were made available on the web page of the Kiso Observatory. A paper on the update was submitted. Digitization of Kiso Schmidt plates continued.

3. Observational Instrument Development

The effect of the environment inside the dome on seeing size at the Subaru Telescope has been studied through collaboration with Chofu Aerospace Center of JAXA (Japan Aerospace Exploration Agency), Tokyo Denki University, and RIKEN. The procedure to compare the results of a fluid calculation and a water-flow experiment with the data from the Subaru Telescope environment sensors in the dome was investigated. Analysis of the ghost images of bright stars in the data of Hyper Suprime-Cam at the Subaru Telescope was conducted and a presentation was made about correction methods. Commissioning and tests of the Hosei Twin Astronomical Telescopes (HOTATE) and observations using it were supported.

4. Operational Support for Subaru Telescope

The Division of Optical and Infrared Astronomy offers support for the open use of the Subaru Telescope. This includes organizing open calls for open-use programs, program selection, administration, management of open-use-related travel expenses, and promoting PR activities for Subaru Telescope. The Division also provides support for various research conferences held at Mitaka Campus.

5. Research Environment Maintenance

The Division manages the printers and rented multi-function photocopiers; sub-networks; and data backup servers for Subaru Telescope Mitaka Office as part of its efforts to maintain the research environment. The Division maintains the web servers and their contents, and also gives assistance for setting-up computers for new administrative supporters.

6. Planning of Next-generation Large-Scale Projects

The Division is engaged in planning post-Subaru large projects in optical and infrared astronomy, such as TMT and the JASMINE series. The preparation for the assessment of new infrared detectors by the maintenance of old instruments continued.

7. PR, Outreach, and Discovery of New Astronomical Objects

The Division cooperates with the Public Relations Center in supporting matters related to the discovery of new astronomical objects and PR/outreach activities such as publications and press conferences related to Subaru Telescope research results. A Tanabata talk event at Koganei was supported. The Division actively participates in a special public event held at Mitaka Campus (Mitaka Open House Day).

8. Educational Activities

The Division of Optical and Infrared Astronomy provides postgraduate education to 23 graduate students from the Graduate University of Advanced Studies, the University of Tokyo, Tokyo Institute of Technology, Nihon University, Hosei University, and the University of Electro-Communications. Division staff members made active contributions to seminars and self-directed studies. Since April 2015 we have held a 30-minute seminar in the afternoon every day throughout the year. In December, we held the annual workshop of the Division of Optical and Infrared Astronomy so that staff members and graduate students can understand the current studies and interests of each other. The Division participated in the "Fureai (Friendly) Astronomy" project, dispatching lecturers to various schools around the country, providing pupils at elementary and junior high schools with opportunities to learn about and appreciate astronomy.

In collaboration with M-JEED, which is a project by Mongolia and Japan for a higher engineering education development promoted by the Japan International Cooperation Agency (JICA), research abilities and human training were improved through collaborations between teachers and researchers in the National University of Mongolia and NAOJ. In FY 2016, three NAOJ academic staffs visited the National University of Mongolia during September 5-10 and lectured on astronomy.

19. Division of Radio Astronomy

The Division of Radio Astronomy oversees Nobeyama Radio Observatory, Mizusawa VLBI Observatory, the RISE Lunar Exploration Project, and NAOJ Chile Observatory operating the Atacama Large Millimeter/submillimeter Array (ALMA) and Atacama Submillimeter Telescope Experiment (ASTE). The scientists and engineers of these projects are attached to the Division of Radio Astronomy, which promotes radio astronomy research to harmonize these radio astronomy projects. The research themes of the Division of Radio Astronomy are represented by keywords such as Big Bang, early Universe, galaxy formation, black holes, galactic dynamics, star formation, planetary system formation, planets and satellites, the Moon, the evolution of interstellar matter, and the origin of life in the context of the evolution of the Universe. Radio astronomy unravels mysteries and phenomena in the Universe through radio waves, which are invisible to human eyes. The detailed research results are reported in each project's section and in the research highlights. The Radio Astronomy Frequency Subcommittee has been established within the division, engaging in discussions on protection against artificial interference generated by electrical equipment, which causes major obstacles in radio astronomical observations.

1. Radio Astronomy Frequency Subcommittee

The mission of the Radio Astronomy Frequency Subcommittee is to protect the environment for radio astronomy observations. In 1932, Karl Jansky of the U.S.A. first discovered radio waves emitted by astronomical objects, albeit accidentally. Since then, dramatic advances have been made in radio observation methods, showing us new perspectives of the Universe invisible at the optical spectrum. The fact is that four Novel Prizes have been awarded to achievements made in the field of radio astronomy.

Just as light pollution from artificial light sources is an obstacle in optical observation, artificial radio interference generated by the electronic devices which surround us is a major obstacle in radio observations. Breathtaking advancement has been achieved in wireless communication technologies in recent years, and wireless commercial products such as mobile phones, wireless LANs, and automotive radars are widely used. The areas of radio applications will further expand in the future owing to their ubiquitous nature. But because of its unique capabilities, compatibility among various radio services, including both active and passive ones, will become a serious issue. Frequency is a finite resource and its sharing is an unavoidable issue. Therefore, further efforts will be necessary for maintaining the sky free from artificial interference for better radio astronomy observations.

(1) Role and Organization

The purpose of the Radio Astronomy Frequency Subcommittee is to ensure that radio astronomical observations are free from artificial interference and to raise public awareness of the importance of the protection activities. Radio astronomical observation does not emit radio waves; thus, it does not interfere with other wireless communications. A proactive approach is needed to widely raise awareness of the efforts to protect the environment for radio observations. Regular explanatory sessions are provided at the Ministry of Internal Affairs and Communications (MIC) and regional Bureaus of Telecommunications to solicit appreciation of the importance of protecting the field.

The coordination between the community of radio astronomy and commercial wireless operators is led by MIC within Japan and internationally by the International Telecommunication Union (ITU) Radiocommunication Sector (ITU-R) of the United Nations. As part of the activities for FY 2016 the Subcommittee took an active role in formulating the opinion of the Japanese radio astronomical community (on behalf of the Japanese radio astronomers) in these coordination efforts.

The Subcommittee is composed of members from NAOJ and representatives of universities and research institutes in Japan.

(2) Current Challenges

A sharing study between active radio services and radio astronomy is crucial for compatibility under the condition of limited availability of frequency resources. Some rules and regulations have been established to address the issue of interference cooperatively. The Radio Astronomy Frequency Subcommittee remains responsible for taking measures for new developments in wireless services including the following challenges:

- Significant increase in wireless activities in response to natural disasters. After the Great East Japan Earthquake in 2011, risk of radio interference has increased due to new wireless communication services prepared for natural disasters.
- Development of new radio applications. There has been a rapid increase in demand for higher frequencies. 76 GHz automobile radars have become common. Wide band radars up to 81 GHz may become more popular as they may reduce car accidents resulting in injury or death. And, transportation of high speed and high volume data, such as HDTV quality video, is becoming possible through 60 GHz radio transmission systems. Some satellite operators launched new plans for improving broad-band communication to ships and planes globally.
- Reassigning of vacant frequency bands resulting from enhanced efficiency in radio use. The digitization of television broadcasting has created vacant frequency bands, which have been reassigned for mobile phones and other applications.

The effect of interference arising from such radio applications (e.g. wireless business) varies widely depending on the frequency band used. Radio astronomy observations have been given priority in a number of frequency bands within the range between 13.36 MHz and 275 GHz under the ITU Radio

Regulations (RR). However, negotiations will be necessary between some radio services and radio astronomy if the same priority level is to be shared within a certain band or under adjacent/proximity conditions. Even faint signals, of negligible significance to general radio services, can have a chance of substantial adverse effects on radio astronomy observations.

Sources of interference that need to be addressed continue to increase and include the following devices and systems: the 23 GHz CATV wireless transmission system used in emergencies, where ammonia observations are affected; 21 GHz next-generation satellite broadcasting, where water maser observations are affected; 1.6 GHz mobile satellite phones for emergencies, where the observation of pulsars and the like are affected; a number of new UWB wireless applications used by logistics and manufacturing industries, where geodetic observations are affected; and Ka-band broad-band communication from airliners to satellites, where water maser observations are affected. 79 GHz automotive radars around Nobeyama Radio Observatory have considerable impact on the observing conditions. Although radio astronomy observations in the 60 GHz band are not common because of the high rate of absorption in the atmosphere, the 60 GHz system must be watched closely because its second harmonic can have adverse effects on CO observations in the 115 GHz band.

(3) International Activities

The ITU Radio Regulations (RR), which allocate radio frequencies to wireless applications, are revised once every three to four years in the World Radiocommunication Conference (WRC). The RR includes frequency bands in which radio astronomy observation is prioritized. Among these meetings, the Radio Astronomy Frequency Subcommittee is regularly involved in the WP7D (radio astronomy) and WP1A (frequency management) meetings. The Subcommittee also takes part in various international conferences, representing the Japanese community of radio astronomy researchers.

In FY 2016, the Subcommittee participated in the ITU-R WP7D meetings in April and October and the WP1A meetings in May and November held in Geneva; and APG19-1 meeting in July in Chengdu, China. In these meetings, the following items were discussed as major agenda items related to radio astronomy: modernization of Global Maritime Distress Safety Systems (GMDSS) utilizing 1.6 GHz satellite communication; upgrading the maritime radio communication system utilizing the 160 MHz maritime mobile-satellites, establishment of a correspondence group for compatibility studies to ensure compatibility between vehicle radars and the radio astronomy activities, identification of frequency band candidates for the new International Mobile Telecommunications (IMT2020) and so on. The WRC-19, which is scheduled for 2019, aims to identify frequency bands for IMT2020 from eleven candidate frequency bands ranging from 24 GHz to 86 GHz and to allocate active services to frequencies above 275 GHz.

(4) Activities in Japan

The three major domestic activities of the Radio Astronomy Frequency Subcommittee include: participation in various committees and working groups hosted by MIC, direct negotiations for MIC's authorization with wireless operators who generate radio interference, and promotion to raise public awareness about radio interference to radio astronomical observations. Negotiations with wireless operators to reduce interference sources represent a major part of the Subcommittee's activities in Japan.

The committees and working groups hosted by MIC are held to organize domestic tactics in preparation for international conferences, defining Japan's positions on various wireless issues. Other MIC-related meetings provide opportunities for discussing the radio application technologies related to MIC's wireless policy, and for negotiating with wireless operators on interference issues under MIC authorization. Negotiations directly affecting the protection of radio astronomy observations have been conducted concurrently to dealing with the interference problems related to societal and technological trends.

Several examples of the interference problems discussed in section (2) above are given below.

For 24 GHz automotive radars, new regulations have been prepared to make an automatic turn-off function a mandatory standard feature so that the device is disabled upon reaching certain areas around radio observatories.

In November 2015 WRC-15 resolved to allocate 77.5–78 GHz to the radiolocation service, allowing automotive vehicles to utilize the whole 76–81 GHz band for their radar, while there is a predicted increase in the use of 76 GHz and 79 GHz high resolution automobile radars. Of particular concern are the possible effects of interference from these radars on the 45-m radio telescope at Nobeyama Radio Observatory, which engages in observations of the spectral-lines of deuterated compounds and other molecules in interstellar matter. The observations with the Nobeyama 45-m Radio Telescope located in Japan will continue to carry significance in relation to the international project ALMA, which deploys 66 high-performance radio telescopes at an altitude of 5,000 m in Chile. Since automotive radars are highly relevant to human life safety, negotiations have been conducted with careful analysis in order to reach a mutually acceptable agreement.

A new radio wave application is being planned for 21 GHz next-generation satellite broadcasting with a picture resolution 16-fold higher than that of the current HDTV. This band is near the 22 GHz radio astronomy band, which is important for water maser observation. The radio signals from the satellite come from outer space. Their detrimental effects need to be alleviated with a filter at the output stage of the satellite. The NHK Science & Technology Research Laboratories developed a prototype bandpass filter to suppress spurious signals to an acceptable level. NHK plans to verify its performance further on a future satellite set to launch in December, 2017.

Radio observations in the 60 GHz band are not common because of the high atmospheric absorption rate in that frequency range. Albeit in fact, the 60 GHz system must be watched closely in terms of its proliferation in the market, since interference from it may affect CO observations in the 115 GHz band, which is within the band of the second harmonics of the 60 GHz radio system.

Following the MIC discussion for improving disaster measures, the committee discussed with Globalstar Inc. (USA) and signed the revision to the operating condition agreement to establish guard channels and radio quiet zones considering the risk of interference to the radio astronomy (OH maser observation) band from spurious emissions from the 1.6 GHz satellite uplink signal.

In a MIC working group, the Subcommittee was originally concerned that Ka-band broad-band satellite communication services may cause interference to radio astronomy observatories in Japan. However, the evaluation of both the 22 GHz downlink and airliners' 30 GHz uplink signal resulted in developing appropriate operating conditions with no risk of interference to the observatories including Nobeyama Radio Observatory. The working group plans to make a similar evaluation of operating conditions for other satellite operator systems in FY 2017.

Additionally, radio astronomy observations could be adversely affected by some of the new wireless technologies: wireless power transmission (WPT) for electric vehicle energy charging (non-beam); next generation railway radio communication systems between bullet trains and trackside; and so on. The Subcommittee continues to monitor their progress and shares this information with related radio astronomers.

Moreover, the Subcommittee has been engaged in making applications to the MIC to request frequency protection for the NAOJ telescopes as well as other telescopes owned by the Japanese community of radio astronomers on their behalf.

Collecting actual interference cases at various observatories is also important. To raise public awareness about "Interference to Radio Astronomy," these collected cases are effectively used in presentations by our community members. We are also preparing tutorial materials for the general public. As optical astronomers are actively working to protect their observation environment against artificial light, we, radio astronomers, are making the same efforts for the sake of continuing observations in radio astronomy in coming ages.

20. Division of Solar and Plasma Astrophysics

The Division of Solar and Plasma Astrophysics is mainly made of staff members from the Solar Observatory, the Hinode Science Center, and the Solar-C Project Office. It conducts research on the Sun in close coordination with these projects. An NAOJ fellow and graduate students supervised by the staff of the above-mentioned projects also belong to the Division. All of the permanent staff of these projects is affiliated with the Division.

The Division conducts both theoretical and observational research into the inner structure of the Sun and outer solar atmosphere including the photosphere, chromosphere, corona, and solar wind; and various phenomena in the magnetized plasma such as flares, sunspots, solar faculae, and prominences. The Division's theoretical research includes helioseismology studies of the internal structure of the Sun, and applications of plasma physics and magnetohydrodynamics to various phenomena on the Sun as well as on Sun-like stars. The solar group at NAOJ started observations from space in the very early stages of Japan's space program. The Division has participated in the development of the Hinode satellite, which is currently in orbit, and is playing a major role in its scientific operation. In ground based observations, the Division conducted research to introduce and utilize new technologies in the Solar Flare Telescope and has been conducting long-term monitoring observations of solar activity, and the obtained data are open to the community.

1. Research in Solar Physics

NAOJ fellow S. Toriumi published two papers in refereed journals as lead author. One is about the statistical analysis of the flare-productive active regions, while the other is on the coordinated observation of small-scale energy releasing events in a developing active region by Hinode and IRIS. He also published one refereed paper on flare statistics as a co-author. Toriumi has been promoting collaborative research with international partners; he invited Prof. R. Rutten of Lingezicht Astrophysics/University of Oslo/Utrecht University and organized a scientific meeting on the formation of the solar spectrum.

The Division has a seminar (on Friday afternoon, roughly twice a month) whose speakers are from both inside and outside of the Division. The organizer for this year was S. Toriumi.

2. Educational Activities

The teaching staff of the Division supervised three graduate students from the Graduate University for Advanced Studies (SOKENDAI). Among them, N. Kambara and M. Yoshida passed the examination for the Master's degree. The Division, in cooperation with Kyoto University and Nagoya University, supported the annual "Leading-edge Solar Research-Experience Tour" in March for undergraduate students; eight students visited solar-related research organizations and experienced the latest research in the field.

3. International Cooperation

Y. Katsukawa has been a member of the Science Working Group of the Daniel K. Inouye Solar Telescope, a 4-m telescope under construction at Haleakala, Hawai`i. Some members of the Instituto de Astrofísica de Canarias of Spain came to Japan to promote the construction of another 4-m solar telescope, which is now in the planning stage in Europe, and a meeting to discuss the collaboration was held. Several plans are also under consideration for future ground-based telescopes that would involve collaborations with East Asian countries and Peru.

21. Division of Theoretical Astronomy

1. Overview

The Division of Theoretical Astronomy (DTA) engaged in research activities for FY 2016 with the aim of achieving internationally outstanding research results both in quality and quantity to accomplish of the following four goals that were set by NAOJ:

- Advance world class cutting-edge theoretical research.
- Pursue theoretical astronomy research, particularly in areas that utilize the NAOJ supercomputers or large-scale observational instruments to give further insight into their future development.
- Encourage collaborations among researchers in Japan and strengthen domestic theoretical astronomy research.
- Invigorate postgraduate education.

The division handles a wide variety of themes in theoretical astronomy research, addressing a diversity of hierarchical structures of the Universe in terms of formation and evolution processes, dynamics, and physical state of matter, covering a span from the early Universe to galaxies, stars, planetary formation, activities of compact objects, the origins of space-time, and plasma phenomena in astronomy and astrophysics; joint research with observational astronomy using observational instruments of various frequency bands such as the Subaru Telescope, ALMA, and Nobeyama radio telescopes; and interdisciplinary research with neutrino cosmology, gravitational wave astronomy, physics of elementary particles and atomic nuclei.

The Division of Theoretical Astronomy aims to facilitate Japan's high competitiveness on the international plane through continuous production of world-leading research results and offers a superb research environment as a base for theoretical research accessible to researchers in Japan and overseas. It has accepted a wide range of both Japanese and international researchers as visiting professors, visiting project research fellows, and long-term research fellows who actively engage in various research projects in the division. In particular, the division has fostered research developments to create an influential research center for young researchers and is actively engaged in personnel exchanges with many universities and research institutes. In addition, the division actively organizes numerous cross-disciplinary international conferences, domestic meetings, and seminars for the fields of theoretical astronomy and astrophysics, observational astronomy, and experimental physics; and it leads research activities in various related fields of astronomical science. The division's full-time professors, associates, assistants, and project assistant professors, together with NAOJ postdoctoral fellows and EACOA fellows, research experts, specially appointed research staff, JSPS fellows, and research supporters conduct theoretical astronomy research and education involving postgraduate students from the Graduate University of Advanced Studies, the University of Tokyo, and the Graduate School of Japan Women's University.

2. Current Members and Transfers

In FY 2016, the dedicated faculties of the Division of Theoretical Astronomy included two professors, two associate professors, and four assistant professors in addition to one adjunct professor and one adjunct assistant professor who concurrently held primary positions at the Center for Computation Astrophysics. In addition to these research and educational members, the division was served by five project assistant professors, including one research associate, two JSPS fellow, two EACOA fellows, and in addition one administration associate who gave full support to all activities of the division. Among them Takeshi Inoue, an assistant professor, moved to Nagoya University as an associate professor from November in 2016.

3. Research Results

The research papers and presentations in international conferences carried out by the division members as author(s) or presenter(s) are listed below. Categories with fewer than 5 publications have been omitted.

- Peer-reviewed papers in English: 91
- Reports in English (talks at international conferences): 71 (invited talks: 16)
- Reports in Japanese (talks at national meetings, etc.): 42

Some of the research results are presented as the research highlights listed at the beginning of this report. The following highlights include research in which the division members took leading roles:

- Impact of New Gamow-Teller Strengths on Explosive Type Ia Supernova Nucleosynthesis (Mori, K., Kajino, T. et al.)
- New Electron Orbits in Collisionless Magnetic Reconnection (Zenitani, S. et al.)
- Kilonova Emission from Compact Binary Mergers (Tanaka, M. et al.)
- Chemodynamical Evolution of Dwarf Galaxies Deduced from r-process Elements (Hirai, Y., Kajino, T. et al.)
- H0LiCOW - Lens Mass Model of HE 0435-1223 and Blind Measurement of Its Time-delay Distance for Cosmology (Wong, K. C. et al.)
- Properties of Interstellar Dust Responsible for Steep Extinction Curves toward Type Ia Supernovae (Nozawa, T. et al.)
- Circumstellar and Explosion Properties of Type Ibn Supernovae (Moriya, T. et al.)
- Radio Transients Associated with Accretion-induced Collapse of White Dwarfs (Moriya, T.)
- Supernovae Powered by Magnetars that Transform into Black Holes (Moriya, T. et al.)
- Properties of Magnetars Mimicking 56Ni (Moriya, T. et al.)

- Formation of Spiral Arm in Galaxies by Swing Amplification (Kokubo, E. et al.)
- Planetesimal Formation by Gravitational Instability of Porous-Dust Aggregates (Kokubo, E. et al.)
- N-Body Simulation of Chariklo's Ring (Kokubo, E. et al.)
- Heavy Element Production in Type II Supernovae: Sensitivity to Nuclear Equation of States (Kajino, T. et al.)
- Relativistic Screening Effects on Big Bang Nucleosynthesis and Low-lying Resonances (Kajino, T. et al.)
- Detectability of Cosmic Dark Flow in the Type Ia Supernova Redshift-Distance Relation (Kajino, T. et al.)
- Impact of Sterile Neutrino Dark Matter on Core-collapse Supernovae (Kajino, T. et al.)
- Neutrino Antineutrino Pair Emissions in Strongly Magnetized Neutron-Star-Matter in Relativistic Quantum Approach (Kajino, T. et al.)
- Possible Measurements of Reaction Cross Sections for Explosive Nucleosynthesis using Laser -Driven γ-ray Pulses (Kajino, T. et al.)
- Isomer Production Ratio of 113Cd following Neutron-Capture Reactions to Investigate the Origin of 115Sn (Kajino, T. et al.)
- Solving the Red Supergiant and Supernova Rate Problems via Relic Supernova Neutrino Spectrum (Kajino, T. et al.)
- Non-Extensive Statistics Solution to the Cosmological Lithium Problem (Kajino, T. et al.)

The following research results are released on the division's website (http://th.nao.ac.jp/) as research highlights:

- Japan OISTER collaboration uncovers the origin of extraordinary supernovae (Tanaka, M. et al.)
- Avoiding "Traffic Jam" Creates Impossibly Bright "Lighthouse" (Kawashima, T., Ohsuga, K. et al.)
- New classes of electron orbits in magnetic reconnection (Zenitani, S. et al.)
- Cosmic lenses Bring the Universe's Expansion into Sharper Focus (Wong, K. C. et al.)
- Metallic Iron Grains Hardly Exist in the Universe (Nozawa, T. et al.)
- Mystery of Nucleosynthesis in Type Ia Supernova: Challenge from Precise Nuclear Physics (Mori, K., Kajino, T. et al.)
- Early evolutionary histories of galaxies deduced from r-process elements (Hirai, Y., Kajjino, T. et al.)
- An Elegant Solution of the Big-Bang Lithium Problem? (Kajino, T. et al.)

4. Domestic Collaborations

The Division of Theoretical Astronomy played leading roles in organizing the following domestic conferences:

- 5th TDA Symposium on "Pre-solar Grains, Evolution of Interstellar Dust, and the Origin of the Solar System", NAOJ Mitaka Campus, September 26 - 27 in 2016. (Participants; 38)
- Japan SKA Joint Science Forum on "Cosmic Magnetic Field: from Intra-Galactic Phenomena to Large Scale Structure", Yamagata Zao, October 27 - 29 in 2016. (Participants; 35)
- 6th TDA Symposium on "Role of the Magnetic Field in Stellar Formation and its Observational Evidence", NAOJ Mitaka Campus, November 24 - 25 in 2016. (Participants; 37)
- 29th RIRONKON Symposium on "Cosmic Hierarchical Structure driven by Gravity", NAOJ Mitaka Campus, December 20 – 22 in 2016. (Participants; 153)

5. International Collaborations

Toshitaka Kajino performed duties of the following posts: international referee for the National Sciences and Engineering Research Council of Canada (NSERC); international referee for Partnership for Advanced Computing in Europe (PRACE); international associate for the European Centre for Theoretical Studies in Nuclear Physics and Related Areas (ECT*); and international referee for the Swiss National Science Foundation (SNSF). Eiichiro Kokubo served on the organizing committee of Commission A4 (Celestial Mechanics and Dynamical Astronomy) of IAU.

The Division of Theoretical Astronomy played leading roles in organizing the following international conferences:

- The 4th DTA Symposium on Compact Stars and Gravitational Wave Astronomy, NAOJ Mitaka Campus, May 13 – 14 in 2016. (Participants; approx. 20)
- NIC XIV School on Nuclear Astrophysics, Niigata University, June 13 – 17 in 2016. (Participants; approx. 70)
- 14th International Symposium on Nuclei in the Cosmos (NIC XIV), Toki Messa in Niigata, June 19 – 24 in 2016. (Participants; approx. 300)
- 2nd NAOJ-ECT* International Workshop on Many Riddles About Core-Collapse Supernovae: 1 Bethe and Beyond, NAOJ Mitaka Campus, June 27 – July 1 in 2016. (Participants; 52)
- 9th Meeting on Cosmic Dust, Aobayama Campus in Tohoku University, August 15 – 19 in 2016. (Participants; 51)
- Japan-Germany Planet and Disk Workshop, Ishigaki in Okinawa, September 25 – 30 in 2016. (Participants; approx. 50)
- Quarks and Compact Stars 2017 (QCS2017), Yukawa Institute in Kyoto University, February 19 – 22 in 2017. (Participants; approx. 70)

6. Educational Activities

The lecture subjects are listed below to supplement Section III on activities of research and educational adjunct lecturer-ship at the universities and graduate schools:

· Toshitaka Kajino: Lectures on fundamentals of theoretical astronomy at the Graduate University for Advanced Studies; science of time, space, and matter, and fundamentals of physics at Gakushuin University; astrophysics and modern physics at Japan Women's University; astrophysics at Jissen Women's University; nuclear physics at Meiji University; astronomy investigation I & II, reading papers in turn I & II, and special astronomy investigation II at the Graduate School of the University of Tokyo.

· Eiichiro Kokubo: Earth and Planetary Sciences I at the University of Tokyo, Solar System and Exoplanetary Systems at the University of the Ryukyu.

· Masashi Tanaka: Introduction to observational astronomy I at the Graduate University for Advanced Studies; advanced astrophysics at Chiba University; advanced stellar physics II at Tohoku University.

· Takashi Hamana: Geology at the Tokyo University of Agriculture and Technology.

Tomoya Takiwaki and Eiichiro Kokubo also delivered SSH lectures on “Supernovae, culminating their Stellar Evolution" at Aichi prefectural high school and “Solar System and Exoplanetary Systems” at Kanazawa Izumigaoka high school, respectively, and contributed much to high school education.

7. Outreach Activities

The Division of Theoretical Astronomy actively engaged in public promotions and outreach activities by offering lectures to the general public. The following lectures were delivered this year:

· Toshitaka Kajino: “Cosmology towards the Origin of Matter and Time and Space” (International Conference NIC2017 Commemorative Lecture, Hitotsubashi Auditorium, Tokyo); “Origin of Heavy Elements” (Cosmo-Nuclear Physics Forum, RIKEN, Wako)

· Eiichiro Kokubo: “Solar System” and “Exoplanetary Systems” at Niigata Citizen University; “From Stardust to the Earth” at Osaka Prefectual University; “The Blue Planet” at Yokohama Aasahi Culture Center; “Form Stardust to the Earth and Moon” at Discovery Park Yaizu; “Exoplanet Zoo” at Ikebukuro Community College; “Introduction to Planet Formation Theory” and “Solar System and Exoplanetary Systems” at Waseda University Extension Center; “The Origin of the Earth” at Konan University

· Takiwaki Tomoya: “Science Frontier of Core-Collapse Supernovae” (Asahi Culture Center Tokyo); “Supernovae, culminating their Stellar Evolution” (Asahi Culture Center Yokohama); “Universe” (Shimadoromu General Lecture, Science and Technology Museum, Tokyo)

· Masaomi Tanaka: “The Life of a Star and Supernova Explosions” (Asahi Culture Center Shinjuku); “Following the Moment of a Supernova Explosion” (Mitaka Network University); “Science Frontier of Core-Collapse Supernova Observation” (Asahi Culture Center Shinjuku); “What is the Death of Massive Stars like – Approaching the Mysteries of Supernova Explosions” (Sundai Gakuen Sundai Astronomy Seminar); “What is the Death of Massive Stars like – Exploring the Moment of a Supernova Explosion” (Science Cafe Orion)

8. Awards

Tomoya Takiwaki was awarded the ASJ Young Astronomer Award 2016. Seiji Zenitani and Masaomi Tanaka were given the MEXT Young Scientists’ Awards. Masato Shirasaki and Masaomi Tanaka received awards from the Inoue Foundation for Science.

9. Main Visitors from Overseas

The Division of Theoretical Astronomy strives to fulfill its roles as a center of excellence in Japan for theoretical studies in astronomy and astrophysics and also as an international research institution by providing an excellent research environment. It engages in various joint research projects with visiting researchers from overseas, with the help of Grants-in-Aid for Scientific Research, government subsidies for operating expenses, the NAOJ budget for guest visitors, and others. The main international visitors of FY 2016 to the division are listed below:

Akif B. Balantekin (University of Wisconsin–Madison, US)
Carmen Adriana Martinez Barbosa (Leinden University, Netherlands)
Melina Bersten (National University of La Plata, Argentina)
Myung-Ki Cheoun, (Soongsil University, South Korea)
Emmanouil Chatzopoulos (Lousiana State University, USA)
Vivien Chen (National Taiwan University, Taiwan)
Chau Ching Chon (Academia Sinica, Taiwan)
Silvio Cherubini (Catania University, Italy)
Roland Diehl (Max Planck Institute/Technical University of Munich, Germany)
Kevin Ebinger (University of Basel, Switzerland)
Marius Eichler (University of Basel, Switzerland)
Michael A. Famiano (Western Michigan University, USA)
Morgan Fraser (University College Dublin, Ireland)
Gaston Folatelli (National University of La Plata, Argentina)
Carla Frohlich (University of North Carolina, USA)
Federico Garcia (Argentine Institute of Radio Astronomy, Argentina)
Tristan Guillot (Nice Observatory, France)
Ji-an Jiang (University of Cambridge, UK)
Oliver Just (Max Planck Institute, Germany)
Kostas Kokkotas (University of Tübingen, Germany)
Takami Kuroda (University of Basel, Switzerland)
Kyunjin Kwak, (Ulsan National Institute of Science & Technology, Korea)
Shih-Ping Lai (National Taiwan University, Taiwan)
Sheng-Jun Lin (National Taiwan University, Taiwan)
Doug Lin (University of California Santa Cruz, USA)
Andreas Lohs (University of Darmstadt, Germany)
Grant J. Mathews, (University of Notre Dame, USA)
Gail Mclaughlin (University of North Carolina, USA)
Annabella Mondino Llermanos (National University of Cordoba, Argentina)
Bernhard Mueller (The Queen's University Belfast, UK)

Quang Nygen-Luong (Korea Astronomy and Space Science Institute, Korea)
Valerio Pirronello (Catania University, Italy)
Yoshito Shimajiri (Saclay Nuclear Research Centre, France)
Benjiamin Wehmeyer (University of Basel, Switzerland)

22. Office of International Relations

The Office of International Relations strives to promote and facilitate further internationalization at NAOJ by maintaining an environment where multi-cultural researchers and students can engage cooperatively in research and educational activities. Specifically, the Office's main activities include supporting international collaborative projects; managing Security Export Control; liaising with overseas astronomical research organizations; gathering and providing information on international activities; offering support for hosting international conferences, workshops, and seminars; providing support for visiting international researchers and students; and assisting Japanese universities and research organizations for international partnerships. In FY 2016 the Office continued to work closely with the Executive Advisor to the Director General in charge of international research coordination.

1. International Collaborative Project Support

The Office of International Relations serves as a liaison point for international activities, engages in international agreements or provides support for doing so, and accumulates procedural and administrative knowledge, through consultations or investigations on individual cases to enter into and implement collaboration with overseas universities or research institutions. Other matters handled by the Office include administrative coordination in approval processes to sign agreements and memoranda for international collaborations, conducting preliminary reviews for legal documentation, supporting signing ceremonies, and managing Security Export Control for export of goods or transfer of technology. In FY 2016, nine international agreements, new and renewed, were signed including ones under the name of NINS. In the area of Security Export Control, activities included review and processing of 70 cases (121 items), and an Security Export Control briefing was held in October at Mitaka (15 attendees including 1 from Nobeyama through TV conference connection) for improving the knowledge and awareness of NAOJ staff.

2. Liaison Work for Overseas Astronomical Research Organizations

The Office of International Relations supported the organization of the East Asian Observatory (EAO) Board meeting and the JCMT Board and users' meeting, both held at Mitaka during April 13–14, 2016, and April 15–18, respectively. At the same time, the Office organized the annual directorate meeting of the East Asian Core Observatories Association (EACOA). The four institutions forming the EACOA include NAOC (China), NAOJ (Japan), KASI (South Korea), and ASIAA (Taiwan). The Office also assisted the Executive Advisor to the Director General in charge of international research coordination in coordinating with the other 3 institutions for selection of the 2017 EACOA postdoctoral fellowship program. Furthermore, the Office supported the activities of the Office for Astronomical Outreach of the IAU (IAU OAO) and the IAU Office for Astronomy Development (OAD, located in South Africa).

The Office cooperated with the IAU OAO during the review of OAO activity from the end of August to early September. The Office also supported the NAOJ Public Relations Office with its exhibit at New Scientist Live held in London during September 28–October 1. Additionally, the Office displayed an exhibit to present NAOJ's projects and research results together with recruitment information at the EAMA10 (10th East Asian Meeting on Astronomy) held September 26–30 at Seoul, South Korea.

The Office supported the organization of the JCMT TAC held in Mitaka during November 21–23, and the East Asian Astro Statistics Workshop held in Mitaka during February 27–March 2.

Pursuant to the reorganization of the Public Relations Office, it has been decided that the Public Relations Office will be responsible for overseas activities in relation to the general public, while the Office of International Relations will be in charge of activities related to overseas researchers.

3. Support for Hosting International Research Conferences, Workshops, and Seminars

The Office of International Relations offers support for the planning and implementation of international research conferences, workshops, and seminars hosted or supported by NAOJ. The work involves consultation and responses to inquiries regarding administrative issues. The Office also offers advice about which organizations or individuals to contact as appropriate, coordinates between organizations, and gathers relevant information. In FY 2016 the Office supported international research conferences and other events by preparing documentation for Japanese visa applications for 36 foreign participants in total.

4. Support for Hosting International Researchers and Students

The Office enhanced its framework for offering organizational support for research, education, and living arrangements for foreign researchers and exchange students. The Support Desk offers support services to ease difficulties for foreigners living in Japan. It supports, on-site if required, covering various matters such as administrative procedures at municipal and other governmental offices; finding and moving into an apartment and other various procedures and applications for starting up a new life; consultation on shopping, children's education, health and others; and gathering/providing useful information relating to everyday life. The Support Desk has been highly appreciated by users. The Office continued the Japanese language lessons, helping foreign members of NAOJ acquire beginner level capability, and for FY 2016, a combination of E-learning features and classroom lessons were provided, as was introduced in the previous year. The Office also provided support for visa applications, and including renewals; support was given to 48 applications: 12 for staff and family members, 18 for invited researchers, and 18 for visitor/long stay researchers.

- The Office continued its activities to support non-Japanese speaking staff, by translating various forms for applications and notices, including e-mail text and explanations of procedures (67 documents).

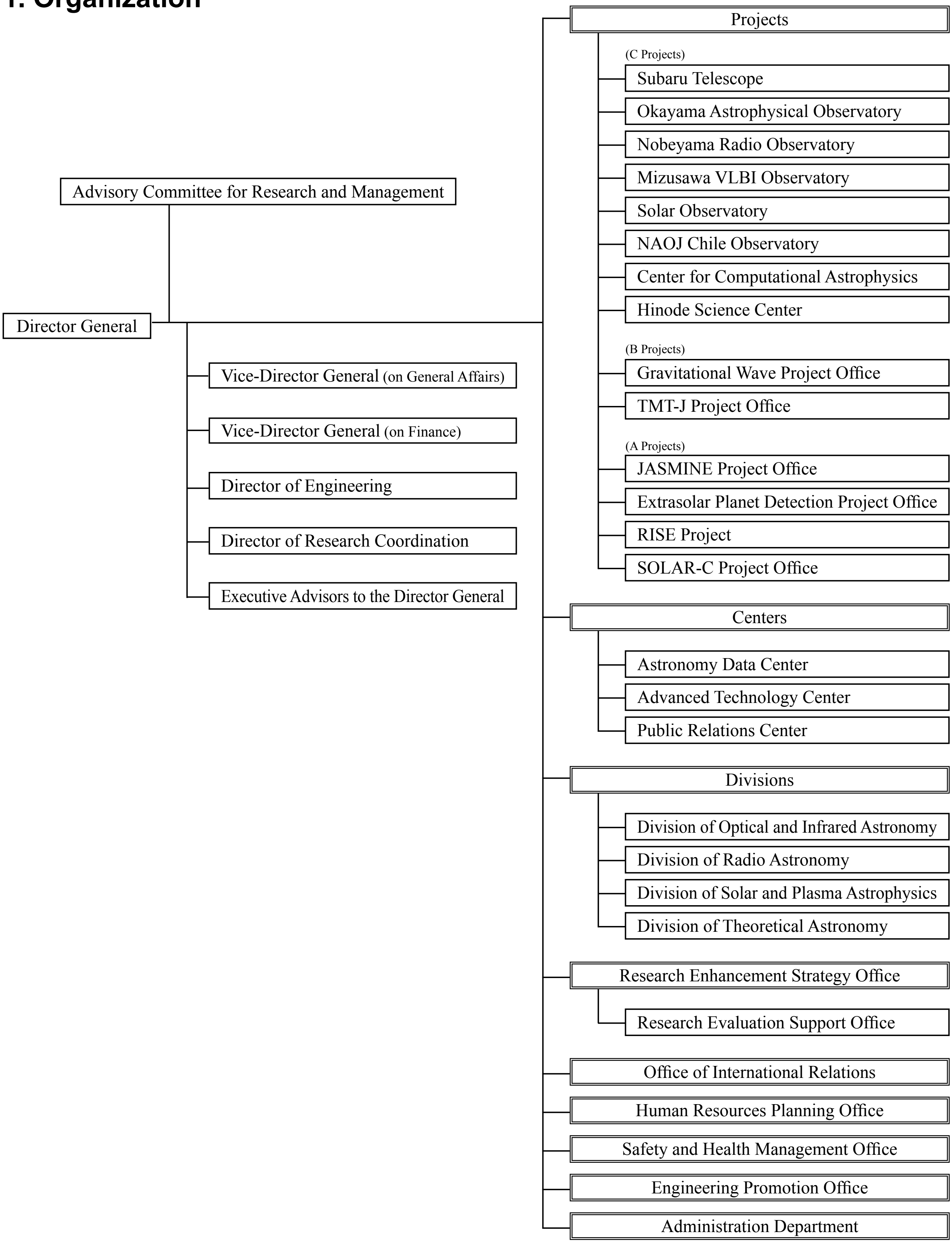
5. Assistance in International Partnerships Involving Japanese Research Organizations

The Office of International Relations assists universities and other educational and research organizations in Japan to engage in international partnerships. It also liaises with the International Strategy Headquarters and the International Cooperation Office at NINS to coordinate international collaborations. The Office oversaw the Optical and Infrared Synergetic Telescopes for Education and Research (OISTER) project conducted by Okayama Astrophysical Observatory, Ishigakijima Astronomical Observatory, and nine Japanese universities.

Although the budget for the OISTER project will be transferred to the Research Promotion Division from FY 2017 onward, the Office will continue to provide administrative support.

III Organization

1. Organization



2. Number of Staff Members

	(2017/3/31)
Regular Employees	
Director General	1
Research and Academic Staff	152
Professor	27
Executive Engineer	0
Associate Professor	39
Chief Research Engineer	11
Assistant Professor	59
Research Associate	0
Research Engineer	16
Engineering Staff	36
Administrative Staff	57
Research Administrator Staff	7
Employees on Annual Salary System	117
Fixed-term Employees	
Full-time Contract Employees	56
Part-time Contract Employees	131

3. Executives

Director General	Hayashi, Masahiko
Vice-Director General	
on General Affairs	Watanabe, Jun-ichi
on Finance	Kobayashi, Hideyuki
Director of Engineering	Takami, Hideki
Director of Research Coordination	Gouda, Naoteru
Executive Advisor to the Director General	Ogasawara, Ryusuke
Executive Advisor to the Director General	Sekiguchi, Kazuhiro

4. Research Departments

Projects

C Projects

Subaru Telescope

Director	Arimoto, Nobuo
Professor	Arimoto, Nobuo
Professor	Ohashi, Nagayoshi
Associate Professor	Hayashi, Saeko
Associate Professor	Iwata, Ikuru
Associate Professor	Kodama, Tadayuki
Associate Professor	Noumaru, Junichi
Associate Professor	Takato, Naruhisa
Associate Professor	Takeda, Yoichi
Chief Research Engineer	Iwashita, Hiroyuki
Assistant Professor	Imanishi, Masatoshi
Assistant Professor	Komiyama, Yutaka
Assistant Professor	Koyama, Yusei
Assistant Professor	Minowa, Yosuke
Assistant Professor	Okita, Hirofumi
Assistant Professor	Onodera, Masato
Assistant Professor	Pyo, Tae-soo
Specially Appointed Assistant Professor	Hayashi, Masao
Specially Appointed Assistant Professor	Tanaka, Masayuki
Research Engineer	Bando, Takamasa
Senior Engineer	Namikawa, Kazuhito
Senior Engineer	Omata, Koji
Chief Engineer	Tamura, Tomonori
Engineer	Sato, Tatsuhiro
Specially Appointed Research Staff	Niino, Yuu
Specially Appointed Research Staff	Takagi, Yuhei
Specially Appointed Research Staff	Toshikawa, Jun
Specially Appointed Senior Specialist	Hayashi, Yusuke
Specially Appointed Senior Specialist	Ikeda, Hiroyuki
Specially Appointed Senior Specialist	Oishi, Yukie
Specially Appointed Senior Specialist	Taniguchi, Akimitsu
Research Expert	Kawanomoto, Satoshi
Research Expert	Koike, Michitaro
Research Expert	Mineo, Sogo
Research Expert	Yamada, Yoshihiko
Research Expert	Yamanoi, Hitomi
Administrative Supporter	Kuwata, Hitomi
Administrative Supporter	Noguchi, Masumi
Administrative Supporter	Suehiro, Yoko
Administrative Supporter	Takamoto, Masami
Administrative Supporter	Yamada, Narumi
Administrative Supporter	Yoshida, Chie

Administration Department

Manager	Seto, Yoji
General Affairs Section	
Chief	Chiba, Satoko
Accounting Section	
Senior Staff	Sugawara, Satoshi

RCUH

RCUH	Alpiche, Dex
RCUH	Aoki, Kentaro
RCUH	Aso, Yusuke
RCUH	Balbarino, Michael
RCUH	Berghuis, Jennie
RCUH	Bulger, Joanna
RCUH	Castro, Timothy
RCUH	Clergeon, Christophe
RCUH	Currie, Thayne
RCUH	Conol, Jonah
RCUH	Cook, David
RCUH	Doi, Yoshiyuki
RCUH	Doughty, Danielle
RCUH	Elms, Brian
RCUH	Endo, Mari
RCUH	Ferreira, James
RCUH	Finet, Francois
RCUH	Formanek, Keiko
RCUH	Fujiwara, Hideaki
RCUH	Fujiyoshi, Takuya
RCUH	Gaskin, Roberta
RCUH	Gorman, William
RCUH	Guthier, Debbie
RCUH	Guyon, Olivier
RCUH	Hasegawa, Kumiko
RCUH	Hattori, Takashi
RCUH	Hopkins, James
RCUH	Inagaki, Takeshi
RCUH	Jeschke, Eric
RCUH	Jovanovic, Nemanja
RCUH	Kackley, Russell
RCUH	Kakazu, Yuko
RCUH	Kerns, Michael
RCUH	Kim, Ji Hoon
RCUH	Koshida, Shintaro
RCUH	Kudo, Tomoyuki
RCUH	Kyono, Eiji
RCUH	Lee, Chien-Hsiu
RCUH	Lemmen, Michael
RCUH	Letawsky, Michael
RCUH	Lozi, Julien
RCUH	Morris, Marita
RCUH	Murai, Rieko

RCUH	Nabeshima, Yoshitake
RCUH	Nakata, Fumiaki
RCUH	Niimi, Yuka
RCUH	Nishimura, Reid
RCUH	Nishimura, Tetsuo
RCUH	Otsuki, Noriko
RCUH	Pathak, Prashant
RCUH	Ramos, Lucio
RCUH	Roth, Noriko
RCUH	Rousselle, Julien
RCUH	Schubert, Kiaina
RCUH	Spencer, Robin
RCUH	Sur, Ryoko
RCUH	Suzuki, Yuko
RCUH	Tait, Philip
RCUH	Tajitsu, Akito
RCUH	Takiura, Koki
RCUH	Tamae, Richard
RCUH	Tanaka, Makoto
RCUH	Tanaka, Yoko
RCUH	Terai, Tsuyoshi
RCUH	Tomono, Daigo
RCUH	Toyofuku, Ralph
RCUH	Tsang, Emiko
RCUH	Weber, Mark
RCUH	Williams, Joshua
RCUH	Winegar, Tom
RCUH	Wung, Matthew
RCUH	Yoshiyama, Naomi

Okayama Astrophysical Observatory

Director	Izumiura, Hideyuki
Associate Professor	Izumiura, Hideyuki
Associate Professor	Ukita, Nobuharu
Specially Appointed Associate Professor	Kanbe, Eiji
Assistant Professor	Yanagisawa, Kenshi
Engineer	Tsutsui, Hironori
Specially Appointed Research Staff	Matsubayashi, Kazuya
Specially Appointed Senior Specialist	Fukui, Akihiko
Research Expert	Kuroda, Daisuke
Research Expert	Maehara, Hiroyuki
Research Supporter	Toda, Hiroyuki

Administration Office

Administration Section

Chief	Tanabe, Keizo
Administrative Supporter	Katayama, Kumiko
Administrative Supporter	Shibukawa, Hiroko
Administrative Supporter	Yamashita, Ayako
Administrative Maintenance Staff	Koyama, Shoji
Administrative Maintenance Staff	Watanabe, Noriaki

Nobeyama Radio Observatory

Acting Director	Kobayashi, Hideyuki
Chief Research Engineer	Kanzawa, Tomio
Assistant Professor	Ishizuki, Sumio
Assistant Professor	Minamidani, Tetsuhiro
Assistant Professor	Umemoto, Tomofumi
Specially Appointed Assistant Professor	Torii, Kazufumi
Research Engineer	Mikoshiba, Hiroshi
Senior Engineer	Handa, Kazuyuki
Senior Engineer	Miyazawa, Kazuhiko
Senior Engineer	Miyazawa, Chieko
Senior Engineer	Shinohara, Noriyuki
Chief Engineer	Kurakami, Tomio
Engineer	Nishitani, Hiroyuki
Engineer	Wada, Takuya
Specially Appointed Research Staff	Kaneko, Hiroyuki
Specially Appointed Research Staff	Miyamoto, Yusuke
Specially Appointed Senior Specialist	Oya, Masaaki
Research Expert	Kinugasa, Kenzo
Research Expert	Maekawa, Jun
Research Expert	Takahashi, Shigeru
Research Expert	Tatamitani, Yoshio
Technical Expert	Hayashi, Mitsuru
Technical Expert	Nishioka, Makiko
Administrative Supporter	Hatakeyama, Eiko
Administrative Supporter	Ide, Hidemi
Research Assistant	Fujita, Shinji
Research Assistant	Matsuo, Mitsuhiro

Administration Office

Deputy Manager	Otsuka, Tomoyoshi

General Affairs Section

Chief	Otsuka, Tomoyoshi
Administrative Supporter	Kikuchi, Kikue
Administrative Supporter	Shinkai, Hisako
Administrative Supporter	Yoda, Chizuko
Administrative Maintenance Staff	Fuji, Shigeru
Administrative Maintenance Staff	Hinata, Shigeto
Administrative Maintenance Staff	Ide, Hiroko
Administrative Maintenance Staff	Kadoshima, Junko
Administrative Maintenance Staff	Kikuchi, Michiko
Administrative Maintenance Staff	Kikuchi, Tsuyoshi
Administrative Maintenance Staff	Koike, Ikuko
Administrative Maintenance Staff	Saito, Arayo

Administrative Maintenance Staff	Tsuchiya, Junko
Administrative Maintenance Staff	Yokomori, Yasuyuki
Accounting Section	
Chief	Miyabara, Yasuhide
Senior Staff	Iijima, Kunio
Administrative Supporter	Kodaira, Toshiko
Administrative Supporter	Takasawa, Mitsue
Administrative Supporter	Takemura, Miwako
Administrative Supporter	Tokui, Chisato

Mizusawa VLBI Observatory

Director	Honma, Mareki
Professor	Honma, Mareki
Professor	Kobayashi, Hideyuki
Associate Professor	Shibata, Katsunori
Chief Research Engineer	Sato, Katsuhisa
Assistant Professor	Hada, Kazuhiro
Assistant Professor	Hirota, Tomoya
Assistant Professor	Jike, Takaaki
Assistant Professor	Kameya, Osamu
Assistant Professor	Kono, Yusuke
Assistant Professor	Sunada, Kazuyoshi
Assistant Professor	Tamura, Yoshiaki
Research Engineer	Ishikawa, Toshiaki
Research Engineer	Suzuki, Syunsaku
Chief Engineer	Ueno, Yuji
Engineer	Hirano, Ken
Specially Appointed Research Staff	Matsumoto, Naoko
Specially Appointed Research Staff	Sakai, Nobuyuki
Specially Appointed Research Staff	Tazaki, Fumie
Specially Appointed Research Staff	Wu, Yuanwei
Specially Appointed Senior Specialist	Kanaguchi, Masahiro
Specially Appointed Senior Specialist	Miura, Mitsuo
Specially Appointed Senior Specialist	Nagayama, Takumi
Specially Appointed Senior Specialist	Oyama, Tomoaki
Technical Expert	Asakura, Yu
Technical Expert	Funayama, Hiroshi
Technical Expert	Hachisuka, Kazuya
Technical Expert	Kim, Jeoung Sook
Technical Expert	Matsukawa, Yuki
Technical Expert	Nishizawa, Akihisa
Technical Expert	Sato, Kaori
Technical Expert	Takahashi, Ken
Technical Expert	Yamashita, Kazuyoshi
Technical Expert	Yoshida, Toshihiro
Research Supporter	Matsueda, Chika
Administrative Supporter	Komori, Akiyo
Administrative Supporter	Uekiyo, Hatsue
Administration Office	
Deputy Manager	Hommyo, Susumu
General Affairs Section	
Chief	Hommyo, Susumu
Staff	Iida, Naoto
Administrative Supporter	Oizumi, Yuka
Administrative Supporter	Sasaki, Mie
Administrative Supporter	Sasaki, Mie
Accounting Section	
Chief	Ito, Hiromasa
Administrative Supporter	Kikuchi, Sachiko
Administrative Supporter	Takahashi, Yumi
Ishigakijima Astronomical Observatory	
Director	Honma, Mareki
Research Expert	Hanayama, Hidekazu
Time Keeping Office	
Director	Sato, Katsuhisa

Solar Observatory

Director	Suematsu, Yoshinori
Associate Professor	Hanaoka, Yoichiro
Senior Engineer	Shinoda, Kazuya
Specially Appointed Research Staff	Joshi, Anand Diwakar
Research Expert	Hagino, Masaoki
Research Expert	Morita, Satoshi
Research Expert	Yaji, Kentaro
Administrative Supporter	Sugimoto, Junko

NAOJ Chile Observatory

Director	Sakamoto, Seiichi
Professor	Iguchi, Satoru
Professor	Kameno, Seiji
Professor	Mizuno, Norikazu
Professor	Ogasawara, Ryuusuke
Professor	Sakamoto, Seiichi
Professor	Tatematsu, Kenichi
Specially Appointed Professor	Hasegawa, Tetsuo
Associate Professor	Asaki, Yoshiharu
Associate Professor	Asayama, Shinichiro
Associate Professor	Iono, Daisuke
Associate Professor	Kiuchi, Hitoshi
Associate Professor	Kosugi, George
Associate Professor	Okuda, Takeshi
Specially Appointed Associate Professor	Muller, Erik Michael
Specially Appointed Associate Professor	Espada Fernandez, Daniel
Specially Appointed Associate Professor	Kawamura, Akiko
Specially Appointed Associate Professor	Nagai, Hiroshi

Specially Appointed Associate Professor	Nakanishi, Koichiro
Chief Research Engineer	Kikuchi, Kenichi
Chief Research Engineer	Nakamura, Kouji
Chief Research Engineer	Watanabe, Manabu
Assistant Professor	Ezawa, Hajime
Assistant Professor	Gonzalez Garcia, Alvaro
Assistant Professor	Hiramatsu, Masaaki
Assistant Professor	Hirota, Akihiko
Assistant Professor	Ishii, Shun
Assistant Professor	Kamazaki, Takeshi
Assistant Professor	Matsuda, Yuichi
Assistant Professor	Sawada, Tsuyoshi
Assistant Professor	Shimojo, Masumi
Assistant Professor	Takahashi, Satoko
Specially Appointed Assistant Professor	Akiyama, Eiji
Specially Appointed Assistant Professor	Egusa, Fumi
Specially Appointed Assistant Professor	Miura, Rie
Specially Appointed Assistant Professor	Okamoto, Joten
Specially Appointed Assistant Professor	Saigou, Kazuya
Research Engineer	Ashitagawa, Kyoko
Research Engineer	Nakazato, Takeshi
Research Engineer	Yamada, Masumi
Senior Engineer	Kato, Yoshihiro
Senior Engineer	Kobiki, Toshihiko
Senior Engineer	Nakamura, Kyoko
Chief Engineer	Ito, Tetsuya
Engineer	Shizugami, Makoto
Specially Appointed Research Staff	Ao, Yiping
Specially Appointed Research Staff	Hashimoto, Takuya
Specially Appointed Research Staff	Izumi, Natsuko
Specially Appointed Research Staff	Lu, Xing
Specially Appointed Research Staff	Kroug, Matthias Nils
Specially Appointed Research Staff	Morokuma, Kana
Specially Appointed Research Staff	Neelamkodan, Naslim
Specially Appointed Research Staff	Sanhueza Nunez, Patricio Andres
Specially Appointed Research Staff	Takahashi, Sanemichi
Specially Appointed Research Staff	Takekoshi, Tatsuya
Specially Appointed Research Staff	Tokuda, Kazuki

Specially Appointed Research Staff	Zahorecz, Sarolta
Specially Appointed Senior Specialist	Fujimoto, Yasuhiro
Specially Appointed Senior Specialist	Fukui, Hideharu
Specially Appointed Senior Specialist	Furutani, Akio
Specially Appointed Senior Specialist	Horie, Yosaku
Specially Appointed Senior Specialist	Ikeda, Emi
Specially Appointed Senior Specialist	Kawakami, Kazuyuki
Specially Appointed Senior Specialist	Kawasaki, Wataru
Specially Appointed Senior Specialist	Konuma, Mika
Specially Appointed Senior Specialist	Kuniyoshi, Masaya
Specially Appointed Senior Specialist	Matsui, Takayuki
Specially Appointed Senior Specialist	Miel, Renaud Jean Christophe
Specially Appointed Senior Specialist	Morita, Eisuke
Specially Appointed Senior Specialist	Nakamoto, Takashi
Specially Appointed Senior Specialist	Niizeki, Yasuaki
Specially Appointed Senior Specialist	Nukatani, Sorahiko
Specially Appointed Senior Specialist	Okumura, Yuji
Specially Appointed Senior Specialist	Otawara, Kazushige
Specially Appointed Senior Specialist	Saito, Motoi
Specially Appointed Senior Specialist	Shimoda, Takanobu
Specially Appointed Senior Specialist	So, Ryoken
Specially Appointed Senior Specialist	Sugimoto, Kanako
Specially Appointed Senior Specialist	Uemizu, Kazunori
Specially Appointed Senior Specialist	Yoshino, Akira
Research Expert	Sakuma, Naoko
Research Expert	Tomimuro, Hisashi
Administrative Expert	Kamada, Masako
Research Supporter	Uchida, Ayako
Research Supporter	Yamazaki, Toshitaka
Technical Supporter	Hayashi, Ritsuko
Administrative Supporter	Kono, Izumi
Administrative Supporter	Otawara, Hikaru

Administrative Supporter	Saito, Naoko

Chile Employees

Chile Employee	Aguilera, Javier
Chile Employee	Krapivka, Gabriela
Chile Employee	Toro, Lorena
Chile Employee	Zenteno, Javier

Administration Department

Manager	Okumura, Yuji
General Affairs Section	
Chief	Tsukano, Satomi
Accounting Section	
Chief	Okumura, Yuji
Staff	Hiramatsu, Naoya

Center for Computational Astrophysics

Director	Kokubo, Eiichiro
Professor	Kokubo, Eiichiro
Assistant Professor	Ohsuga, Ken
Specially Appointed Assistant Professor	Takahashi, Hiroyuki
Specially Appointed Research Staff	Asahina, Yuta
Specially Appointed Research Staff	Ohtani, Yukari
Research Expert	Kato, Tsunehiko
Research Expert	Nakayama, Hirotaka
Research Expert	Oshino, Shoichi
Research Expert	Wakita, Shigeru
Research Supporter	Fukushi, Hinako
Research Supporter	Hasegawa, Satoki
Research Supporter	Taki, Tetsuo
Research Supporter	Tanaka, Yuki
Administrative Supporter	Kimura, Yuko

Hinode Science Center

Director	Watanabe, Tetsuya
Associate Professor	Sekii, Takashi
Associate Professor	Suematsu, Yoshinori
Assistant Professor	Ishikawa, Ryoko
Assistant Professor	Katsukawa, Yukio
Assistant Professor	Kubo, Masahito
Specially Appointed Research Staff	Lee, Kyoung Sun
Technical Expert	Inoue, Naoko
Research Supporter	Ishii, Shuichi
Research Supporter	Tsuchiya, Chie
Administrative Supporter	Kano, Kaori

B Projects

Gravitational Wave Project Office

Director	Flaminio, Raffaele
Specially Appointed Professor	Flaminio, Raffaele
Associate Professor	Aso, Yoichi
Affiliated Associate Professor	Ando, Masaki
Assistant Professor	Akutsu, Tomotada
Assistant Professor	Ohishi, Naoko
Assistant Professor	Takahashi, Ryutaro
Assistant Professor	Tatsumi, Daisuke
Specially Appointed Assistant Professor	Shoda, Ayaka
Research Engineer	Ishizaki, Hideharu
Chief Engineer	Tanaka, Nobuyuki
Specially Appointed Research Staff	Barton, Mark Andrew
Specially Appointed Research Staff	Pena Arellano, Fabian Erasmo
Specially Appointed Research Staff	Zeidler, Simon
Specially Appointed Senior Specialist	Hirata, Naoatsu
Specially Appointed Senior Specialist	Tapia, San Martin Enzo Nicolas
Administrative Expert	Ohyama, Megumi
Research Supporter	Harada, Mikiko
Administrative Supporter	Sakamoto, Eri
Administrative Supporter	Yoshizumi, Mizuho
Research Assistant	Guo, Yuefan

TMT-J Project Office

Director	Usuda, Tomonori
Professor	Usuda, Tomonori
Professor	Saito, Masao
Professor	Yamashita, Takuya
Associate Professor	Aoki, Wako
Associate Professor	Kashikawa, Nobunari
Associate Professor	Sugimoto, Masahiro
Associate Professor	Terada, Hiroshi
Specially Appointed Associate Professor	Oya, Shin
Chief Research Engineer	Miyashita, Takaaki
Assistant Professor	Yasui, Chikako
Specially Appointed Research Staff	Harakawa, Hiroki
Specially Appointed Research Staff	Kubo, Mariko
Specially Appointed Research Staff	Ozaki, Shinobu
Specially Appointed Research Staff	Schramm, Malte
Specially Appointed Senior Specialist	Chapman, Junko
Specially Appointed Senior Specialist	Kozu, Akihito
Specially Appointed Senior Specialist	Kusumoto, Hiroshi
Specially Appointed Senior Specialist	Sugiyama, Motokuni
Research Expert	Ishii, Miki
Special Senior Specialist	Inatani, Junji
Research Supporter	Tajima, Toshiyuki

Administrative Supporter	Haranaka, Miyuki
Administrative Supporter	Yamaguchi, Chiyu
RCUH	Iye, Masanori

A Projects

JASMINE Project Office

Director	Gouda, Naoteru
Professor	Gouda, Naoteru
Professor	Kobayashi, Yukiyasu
Assistant Professor	Tsujimoto, Takuji
Assistant Professor	Ueda, Akitoshi
Assistant Professor	Yano, Taihei
Research Supporter	Utsunomiya, Shin
Technical Supporter	Kashima, Shingo

Extrasolar Planet Detection Project Office

Director	Tamura, Motohide
Affiliated Professor	Tamura, Motohide
Assistant Professor	Kotani, Takayuki*
Assistant Professor	Nakajima, Tadashi*
Assistant Professor	Nishikawa, Jun
Assistant Professor	Suto, Hiroshi*
Affiliated Assistant Professor	Narita, Norio
Specially Appointed Assistant Professor	Hashimoto, Jun*
Specially Appointed Assistant Professor	Hori, Yasunori*
Specially Appointed Research Staff	Konishi, Mihoko
Specially Appointed Research Staff	Omiya, Masashi
Specially Appointed Senior Specialist	Kusakabe, Nobuhiko*
Research Supporter	Kurokawa, Takashi

*concurrently appointed in NINS

RISE Project

Director	Namiki, Noriyuki
Professor	Namiki, Noriyuki
Associate Professor	Hanada, Hideo
Associate Professor	Matsumoto, Koji
Chief Research Engineer	Tsuruta, Seiitsu
Assistant Professor	Araki, Hiroshi
Assistant Professor	Noda, Hirotomo
Research Engineer	Asari, Kazuyoshi
Research Engineer	Tazawa, Seiichi
Specially Appointed Research Staff	Kawamura, Taichi
Specially Appointed Research Staff	Yamamoto, Keiko
Administrative Supporter	Sato, Sayaka

SOLAR-C Project Office

Director	Ichimoto, Kiyoshi
Professor	Ichimoto, Kiyoshi
Professor	Watanabe, Tetsuya
Associate Professor	Goto, Motoshi*
Associate Professor	Hara, Hirohisa
Associate Professor	Kano, Ryouhei
Assistant Professor	Narukage, Noriyuki
Specially Appointed Research Staff	Song, Donguk
Administrative Supporter	Fujiyoshi, Marie

*concurrently appointed in NINS

Centers

Astronomy Data Center

Director	Takata, Tadafumi
Associate Professor	Ichikawa, Shinichi
Associate Professor	Ohishi, Masatoshi
Associate Professor	Takata, Tadafumi
Assistant Professor	Furusawa, Hisanori
Assistant Professor	Ito, Takashi
Assistant Professor	Oe, Masafumi
Assistant Professor	Shirasaki, Yuji
Research Engineer	Inoue, Goki
Specially Appointed Research Staff	Homma, Hidetomo
Specially Appointed Research Staff	Sorahana, Satoko
Specially Appointed Senior Specialist	Kamegai, Kazuhisa
Specially Appointed Senior Specialist	Makiuchi, Shinichiro
Specially Appointed Senior Specialist	Ozawa, Takeaki
Specially Appointed Senior Specialist	Zapart, Christopher Andrew
Research Expert	Furusawa, Junko
Research Expert	Isogai, Mizuki
Research Expert	Tanaka, Nobuhiro
Research Supporter	Fujikawa, Makiko
Research Supporter	Noda, Sachiyo
Research Supporter	Utsumi, Motomu
Administrative Supporter	Ishii, Yuko
Research Assistant	Suzuki, Taiki

JVO Project

Director	Mizumoto, Yoshihiko

Advanced Technology Center

Director	Noguchi, Takashi
Professor	Noguchi, Takashi
Professor	Takami, Hideki
Associate Professor	Hayano, Yutaka
Associate Professor	Matsuo, Hiroshi
Associate Professor	Miyazaki, Satoshi
Associate Professor	Sekimoto, Yutaro
Associate Professor	Shan, Wenlei
Chief Research Engineer	Fujii, Yasunori

Chief Research Engineer	Okada, Norio
Assistant Professor	Kojima, Takafumi
Assistant Professor	Nakaya, Hidehiko
Assistant Professor	Oshima, Tai
Assistant Professor	Suzuki, Ryuji
Research Engineer	Fukushima, Mitsuhiro
Research Engineer	Noguchi, Motokazu
Research Engineer	Obuchi, Yoshiyuki
Research Engineer	Sato, Naohisa
Senior Engineer	Kamata, Yukiko
Senior Engineer	Kubo, Koichi
Senior Engineer	Takahashi, Toshikazu
Chief Engineer	Fukuda, Takeo
Chief Engineer	Ikenoue, Bungo
Chief Engineer	Inata, Motoko
Chief Engineer	Iwashita, Hikaru
Chief Engineer	Kaneko, Keiko
Chief Engineer	Mitsui, Kenji
Chief Engineer	Uraguchi, Fumihiro
Chief Engineer	Waseda, Koichi
Engineer	Ezaki, Shohei
Engineer	Tsuzuki, Toshihiro
Specially Appointed Research Staff	Dominjon, Agnes Micheline
Specially Appointed Research Staff	Hasebe, Takashi
Specially Appointed Research Staff	Uchiyama, Mizuho
Research Expert	Saito, Sakae
Technical Expert	Nishino, Tetsuo
Technical Expert	Suzuki, Yoshinori
Administrative Supporter	Kuroda, Kyoko
Administrative Supporter	Murakami, Hiromi
Administrative Supporter	Yoshida, Taeko
Research Assistant	Abdelouahab, Valentin Adel
Research Assistant	Gobin, Nicolas
Research Assistant	Kozuki, Yuto

Public Relations Center

Director	Fukushima, Toshio
Professor	Fukushima, Toshio
Professor	Watanabe, Jun-ichi
Associate Professor	Agata, Hidehiko
Associate Professor	Yamaoka, Hitoshi
Research Engineer	Katayama, Masato
Chief Senior Engineer	Matsuda, Ko
Chief Engineer	Nagayama, Shogo
Specially Appointed Senior Specialist	Cheung, Sze Leung
Specially Appointed Senior Specialist	Ishikawa, Naomi
Specially Appointed Senior Specialist	Lundock, Ramsey Guy
Specially Appointed Senior Specialist	Pires Canas, Lina Isabel
Specially Appointed Senior Specialist	Tsuzuki, Hiroko
Research Expert	Ono, Tomoko
Research Expert	Takata, Hiroyuki
Research Expert	Usuda, Kumiko
Research Supporter	Kume, Kaori
Public Outreach Official	Endo, Isao
Public Outreach Official	Fujita, Tokiko
Public Outreach Official	Futami, Hiroshi
Public Outreach Official	Hamura, Taiga
Public Outreach Official	Hatano, Satomi
Public Outreach Official	Ibaraki, Takao
Public Outreach Official	Ishizaki, Masaharu
Public Outreach Official	Iwashiro, Kuninori
Public Outreach Official	Koike, Akio
Public Outreach Official	Kubo, Maki
Public Outreach Official	Mikami, Naotsugu
Public Outreach Official	Naito, Seiichiro
Public Outreach Official	Natsugari, Satomi
Public Outreach Official	Nemoto, Shiomi
Public Outreach Official	Ogoe, Osamu
Public Outreach Official	Oguri, Junko
Public Outreach Official	Shibata, Yukiko
Public Outreach Official	Shioya, Yasuhisa
Public Outreach Official	Takabatake, Noriko
Public Outreach Official	Takeda, Takaaki
Administrative Supporter	Aoki, Makiko
Administrative Supporter	Noguchi, Sayumi

Public Relations Office

Director	Yamaoka, Hitoshi

Outreach and Education Office

Director	Agata, Hidehiko

Ephemeris Computation Office

Director	Katayama, Masato

Library

Chief	Todoriki, Tatsuya

Publications Office

Director	Fukushima, Toshio

The Office for Astronomy Outreach of the IAU

Director	Agata, Hidehiko

Administration Office

Director	Matsuda, Ko

Divisions

Division of Optical and Infrared Astronomy

Director	Mizumoto, Yoshihiko
Professor	Arimoto, Nobuo
Professor	Gouda, Naoteru
Professor	Kobayashi, Yukiyasu
Professor	Mizumoto, Yoshihiko
Professor	Ohashi, Nagayoshi
Professor	Saito, Masao
Professor	Sekiguchi, Kazuhiro
Professor	Usuda, Tomonori

Professor	Yamashita, Takuya
Associate Professor	Aoki, Wako
Associate Professor	Aso, Yoichi
Associate Professor	Hayashi, Saeko
Associate Professor	Iwata, Ikuru
Associate Professor	Izumiura, Hideyuki
Associate Professor	Kashikawa, Nobunari
Associate Professor	Kodama, Tadayuki
Associate Professor	Noumaru, Junichi
Associate Professor	Sugimoto, Masahiro
Associate Professor	Takato, Naruhisa
Associate Professor	Takeda, Yoichi
Associate Professor	Terada, Hiroshi
Associate Professor	Ukita, Nobuharu
Chief Research Engineer	Iwashita, Hiroyuki
Chief Research Engineer	Miyashita, Takaaki
Assistant Professor	Akutsu, Tomotada
Assistant Professor	Imanishi, Masatoshi
Assistant Professor	Komiyama, Yutaka
Assistant Professor	Koyama, Yusei
Assistant Professor	Minowa, Yosuke
Assistant Professor	Morino, Jun-ichi
Assistant Professor	Nishikawa, Jun
Assistant Professor	Ohishi, Naoko
Assistant Professor	Okita, Hirofumi
Assistant Professor	Onodera, Masato
Assistant Professor	Pyo, Tae-soo
Assistant Professor	Sôma, Mitsuru
Assistant Professor	Takahashi, Ryutaro
Assistant Professor	Tatsumi, Daisuke
Assistant Professor	Tsujimoto, Takuji
Assistant Professor	Ueda, Akitoshi
Assistant Professor	Yagi, Masafumi
Assistant Professor	Yanagisawa, Kenshi
Assistant Professor	Yano, Taihei
Assistant Professor	Yasui, Chikako
Research Engineer	Bando, Takamasa
Research Engineer	Ishizaki, Hideharu
Senior Engineer	Omata, Koji
Senior Engineer	Namikawa, Kazuhito
Chief Engineer	Tamura, Tomonori
Chief Engineer	Tanaka, Nobuyuki
Engineer	Sato, Tatsuhiro
Engineer	Tsutsui, Hironori
Administrative Supporter	Kimura, Hiroko
Research Assistant	Onoue, Masafusa
Research Assistant	Shimakawa, Rhythm
Research Assistant	Suzuki, Tomoko

Division of Radio Astronomy

Director	Iguchi, Satoru
Professor	Honma, Mareki
Professor	Iguchi, Satoru
Professor	Kameno, Seiji
Professor	Kawabe, Ryohei
Professor	Kobayashi, Hideyuki
Professor	Mizuno, Norikazu
Professor	Namiki, Noriyuki
Professor	Ogasawara, Ryusuke
Professor	Sakamoto, Seiichi
Professor	Tatematsu, Kenichi
Associate Professor	Asaki, Yoshiharu
Associate Professor	Asayama, Shinichiro
Associate Professor	Hanada, Hideo
Associate Professor	Iono, Daisuke
Associate Professor	Kiuchi, Hitoshi
Associate Professor	Kosugi, George
Associate Professor	Matsumoto, Koji
Associate Professor	Okuda, Takeshi
Associate Professor	Shibata, Katsunori
Chief Research Engineer	Kanzawa, Tomio
Chief Research Engineer	Kawashima, Susumu
Chief Research Engineer	Kikuchi, Kenichi
Chief Research Engineer	Nakamura, Kouji
Chief Research Engineer	Sato, Katsuhisa
Chief Research Engineer	Tsuruta, Seiitsu
Chief Research Engineer	Watanabe, Manabu
Assistant Professor	Araki, Hiroshi
Assistant Professor	Ezawa, Hajime
Assistant Professor	Gonzalez Garcia, Alvaro
Assistant Professor	Hada, Kazuhiro
Assistant Professor	Hiramatsu, Masaaki
Assistant Professor	Hirota, Akihiko
Assistant Professor	Hirota, Tomoya
Assistant Professor	Ishii, Shun
Assistant Professor	Ishizuki, Sumio
Assistant Professor	Jike, Takaaki
Assistant Professor	Kamazaki, Takeshi
Assistant Professor	Kameya, Osamu
Assistant Professor	Kono, Yusuke
Assistant Professor	Matsuda, Yuichi
Assistant Professor	Minamidani, Tetsuhiro
Assistant Professor	Miyoshi, Makoto
Assistant Professor	Noda, Hirotomo
Assistant Professor	Sawada, Tsuyoshi
Assistant Professor	Shimojo, Masumi
Assistant Professor	Sunada, Kazuyoshi
Assistant Professor	Takahashi, Satoko
Assistant Professor	Tamura, Yoshiaki
Assistant Professor	Umemoto, Tomofumi
Research Engineer	Asari, Kazuyoshi
Research Engineer	Ashitagawa, Kyoko
Research Engineer	Ishikawa, Toshiaki
Research Engineer	Mikoshiba, Hiroshi
Research Engineer	Nakazato, Takeshi
Research Engineer	Suzuki, Syunsaku
Research Engineer	Tazawa, Seiichi
Research Engineer	Yamada, Masumi
Senior Engineer	Handa, Kazuyuki
Senior Engineer	Kato, Yoshihiro
Senior Engineer	Kobiki, Toshihiko

Senior Engineer	Miyazawa, Chieko
Senior Engineer	Miyazawa, Kazuhiko
Senior Engineer	Nakamura, Kyoko
Senior Engineer	Shinohara, Noriyuki
Chief Engineer	Ito, Tetsuya
Chief Engineer	Kurakami, Tomio
Chief Engineer	Ueno, Yuji
Engineer	Hirano, Ken
Engineer	Nishitani, Hiroyuki
Engineer	Shizugami, Makoto
Engineer	Wada, Takuya
Specially Appointed Senior Specialist	Takebayashi, Yasuo
Research Supporter	Tsuneyama, Junko

Division of Solar and Plasma Astrophysics

Director	Hanaoka, Yoichiro
Professor	Watanabe, Tetsuya
Associate Professor	Hanaoka, Yoichiro
Associate Professor	Hara, Hirohisa
Associate Professor	Kano, Ryouhei
Associate Professor	Sekii, Takashi
Associate Professor	Suematsu, Yoshinori
Assistant Professor	Ishikawa, Ryoko
Assistant Professor	Katsukawa, Yukio
Assistant Professor	Kubo, Masahito
Assistant Professor	Narukage, Noriyuki
Specially Appointed Assistant Professor	Toriumi, Shin
Senior Engineer	Shinoda, Kazuya

Division of Theoretical Astronomy

Director	Tomisaka, Kohji
Professor	Kokubo, Eiichiro
Professor	Tomisaka, Kohji
Professor	Yoshida, Haruo
Associate Professor	Kajino, Toshitaka
Associate Professor	Nakamura, Fumitaka
Assistant Professor	Hamana, Takashi
Assistant Professor	Ohsuga, Ken
Assistant Professor	Takiwaki, Tomoya
Assistant Professor	Tanaka, Masaomi
Specially Appointed Assistant Professor	Moriya, Takashi
Specially Appointed Assistant Professor	Nozawa, Takaya
Specially Appointed Assistant Professor	Ogihara, Masahiro
Specially Appointed Assistant Professor	Sotani, Hajime
Specially Appointed Assistant Professor	Zenitani, Seiji
Specially Appointed Research Staff	Kawashima, Tomohisa
Administrative Supporter	Izumi, Shioko

5. Research Support Departments

Research Enhancement Strategy Office	
Director	Kobayashi, Hideyuki
Specially Appointed Senior Specialist	Chapman, Junko
Specially Appointed Senior Specialist	Fukui, Hideharu
Specially Appointed Senior Specialist	Hasuo, Ryuichi
Specially Appointed Senior Specialist	Hori, Kuniko
Specially Appointed Senior Specialist	Lundock, Ramsey Guy
Specially Appointed Senior Specialist	Miura, Mitsuo
Specially Appointed Senior Specialist	Yamamiya, Osamu
Research Evaluation Support Office	
Director	Watanabe, Jun-ichi
Specially Appointed Senior Specialist	Hori, Kuniko

Office of International Relations	
Director	Hasuo, Ryuichi
Specially Appointed Senior Specialist	Hasuo, Ryuichi
Specially Appointed Senior Specialist	Komiyama, Hiroko
Research Expert	Yoshida, Fumi
Support Desk	
Research Supporter	Shirato, Reiko

Human Resources Planning Office	
Director	Yamamiya, Osamu

Safety and Health Management Office	
Director	Takami, Hideki
Technical Expert	Kashiwagi, Yuji

Engineering Promotion Office	
Director	Takami, Hideki
Chief Research Engineer	Kawashima, Susumu

Administration Department	
General Manager	Sasagawa, Hikaru
General Affairs Division	
Manager	Harada, Eiichiro
Deputy Manager	Furuhata, Tomoyuki
Senior Specialist	Onishi, Tomoyuki
Specialist (Information Technology)	Chiba, Yoko
Specialist (Personnel Accounting)	Watanabe, Yukika
Specially Appointed Senior Specialist	Noguchi, Koki
Specially Appointed Senior Specialist	Yamamoto, Chieko
General Affairs Section	
Chief	Chiba, Yoko
Staff	Morita, Akitsugu
Staff	Yoshimura, Tetsuya
Vehicle Driver	Amemiya, Hidemi
Administrative Expert	Murakami, Sachiko
Administrative Expert	Noguchi, Utako
Administrative Supporter	Kobayashi, Kayo
Administrative Supporter	Seki, Kumi
Personnel Section	
Chief	Yamanouchi, Mika
Staff	Isozaki, Yuka
Staff	Sakamoto, Misato
Payroll Section	
Chief	Watanabe, Yukika
Staff	Furukawa, Shinichiro
Staff	Inoue, Miyuki
Administrative Supporter	Aiba, Narukazu
Administrative Supporter	Momma, Yoko
Employee Affairs Section	
Chief	Yamaura, Mari
Staff	Saito, Masahiro
Administrative Expert	Noguchi, Megumi
MEXT Trainee	
Staff	Matsukura, Koji
Maternity Leave	
Staff	Ouchi, Kaori
Spouse Accompaniment Leave	
Staff	Mochimaru, Shiori
Research Promotion Division	
Acting Manager	Sasagawa, Hikaru
Senior Specialist (International Relations)	Furuhata, Tomoyuki
Administrative Supporter	Torii, Makiko
Research Support Section	
Chief	Goto, Michiru
Staff	Yamafuji, Yasuto
Administrative Expert	Haruki, Mutsumi
Administrative Supporter	Hagimoto, Miya
Administrative Supporter	Komoda, Chizuru
Administrative Supporter	Urushibata, Kozue
Administrative Supporter	Yasuda, Masako
Graduate School Section	
Chief	Kikkawa, Hiroko
Administrative Expert	Inoue, Mizuho
International Academic Affairs Section	
Staff	Takada, Miyuki
Administrative Supporter	Ito, Yoshihisa

Financial Affairs Division

Manager	Nemoto, Nobuyuki
Deputy Manager	Ikeda, Hiroshi
Specialist (Audit)	Ishikawa, Junya

General Affairs Section

Chief	Yamamoto, Shinichi
Administrative Supporter	Sasaki, Sayuri

Budget Section

Chief	Akaike, Makoto
Staff	Masuda, Akio
Administrative Supporter	Ishida, Mikiko

Asset Management Section

Chief	Sato, Kanako
Staff	Takahashi, Sachiko

Purchase Validation Center

Chief	Sato, Kanako
Administrative Supporter	Hosoi, Chiho
Administrative Supporter	Nakagomi, Kimitoshi
Administrative Supporter	Tsukamoto, Satoko

Accounting Division

Manager	Tanaka, Masaru
Specialist (Contract)	Yamazaki, Go

Accounting Section

Chief	Sato, Yoko
Staff	Miyata, Yusuke
Administrative Supporter	Kobayashi, Rina
Administrative Supporter	Nagasawa, Fumi
Administrative Supporter	Suzuki, Yukiko

Procurement Section

Chief	Yamazaki, Go
Staff	Kayamori, Shinji
Staff	Sugimoto, Naomi
Staff	Takai, Tetsuya
Consultant	Hyuga, Tadayuki
Administrative Expert	Sato, Masako
Administrative Supporter	Ochiai, Nana

Facilities Division

Manager	Watanabe, Matsuo
Administrative Expert	Asada, Tsuneaki

General Affairs Section

Chief	Kawashima, Ryota
Staff	Nakagawa, Yukie
Administrative Supporter	Hasegawa, Chisato

Planning Section

Chief	Murakami, Kazuhiro
Administrative Supporter	Nagata, Yomogi

Maintenance Section

Chief	Narisawa, Hiroyuki
Senior Staff	Hayashigura, Koji

6. Personnel change

Research and Academic Staff

Date	Name	Change	New Affiliated Institute, Position	Previous Affiliated Institute, Position
2016/4/1	Yamaoka, Hitoshi	Hired	Public Relations Center, Associate Professor	(Kyushu University Graduate School of Science, Assistant Professor)
2016/4/1	Gonzalez Garcia, Alvaro	Hired	Division of Radio Astronomy (NAOJ Chile Observatory), Assistant Professor	(Advanced Technology Center, Specially Appointed Assistant Professor)
2016/4/1	Yamada, Masumi	Hired	Division of Radio Astronomy (NAOJ Chile Observatory), Research Engineer	(NAOJ Chile Observatory, Specially Appointed Senior Specialist)
2016/5/1	Yasui, Chikako	Hired	Division of Optical and Infrared Astronomy (TMT-J Project Office), Assistant Professor	
2016/7/1	Narukage, Noriyuki	Hired	Division of Solar and Plasma Astrophysics (SOLAR-C Project Office), Assistant Professor	(Advanced Technology Center, Specially Appointed Research Staff)
2016/7/1	Nakamura, Kouji	Hired	Division of Radio Astronomy (NAOJ Chile Observatory), Chief Research Engineer	(NAOJ Chile Observatory, Specially Appointed Senior Specialist)
2016/10/1	Ishii, Shun	Hired	Division of Radio Astronomy (NAOJ Chile Observatory), Assistant Professor	
2016/7/31	Espada Fernandez, Daniel	Resigned	(NAOJ Chile Observatory Specially Appointed Associate Professor)	Division of Radio Astronomy (NAOJ Chile Observatory), Associate Professor
2016/10/31	Inoue, Tsuyoshi	Resigned	(Nagoya University Graduate School of Science, Associate Professor)	Division of Theoretical Astronomy, Assistant Professor
2017/3/31	Arimoto, Nobuo	Retired		Division of Optical and Infrared Astronomy (Subaru Telescope), Professor
2017/3/31	Kobayashi, Yukiyasu	Retired		Division of Optical and Infrared Astronomy (JASMINE Project Office), Professor
2017/3/31	Mizumoto, Yoshihiko	Retired		Division of Optical and Infrared Astronomy, Professor
2017/3/31	Noguchi, Motokazu	Retired		Advanced Technology Center, Research Engineer
2017/3/1	Mizuno, Norikazu	Promoted	Division of Radio Astronomy (NAOJ Chile Observatory), Professor	Division of Radio Astronomy (NAOJ Chile Observatory), Associate Professor
2017/3/1	Saito, Masao	Promoted	Division of Optical and Infrared Astronomy (TMT-J Project Office), Professor	Division of Radio Astronomy (Nobeyama Radio Observatory), Associate Professor
2016/4/1	Nakajima, Tadashi	Reassigned	National Institutes of Natural Sciences Astrobiology Center Extrasolar Planet Detection Project Office, Assistant Professor	Division of Optical and Infrared Astronomy (Extrasolar Planet Detection Project Office), Assistant Professor

Engineering Staff

Date	Name	Change	New Affiliated Institute, Position	Previous Affiliated Institute, Position
2016/12/1	Ezaki, Shohei	Hired	Advanced Technology Center, Engineer	(NAOJ Chile Observatory, Specially Appointed Senior Specialist)
2016/6/30	Negishi, Satoru	Resigned		Division of Optical and Infrared Astronomy (Subaru Telescope), Chief Engineer

2016/4/1	Namikawa, Kazuhito	Promoted	Division of Optical and Infrared Astronomy (Subaru Telescope), Senior Engineer	Division of Optical and Infrared Astronomy (Subaru Telescope), Chief Engineer
2016/4/1	Kato, Yoshihiro	Promoted	Division of Radio Astronomy (NAOJ Chile Observatory), Senior Engineer	Division of Radio Astronomy (NAOJ Chile Observatory), Chief Engineer
2017/3/1	Omata, Koji	Promoted	Division of Optical and Infrared Astronomy (Subaru Telescope), Senior Engineer	Division of Optical and Infrared Astronomy (Subaru Telescope), Chief Engineer
2017/3/1	Kamata, Yukiko	Promoted	Advanced Technology Center, Senior Engineer	Advanced Technology Center, Chief Engineer

Administrative Staff

Date	Name	Change	New Affiliated Institute, Position	Previous Affiliated Institute, Position
2016/4/1	Sasagawa, Hikaru	Hired	General Manager	(Japan Society for the Promotion of Science)
2016/4/1	Ikeda, Hiroshi	Hired	Administration Department Financial Affairs Division, Deputy Manager	(The University of Tokyo)
2016/4/1	Yamazaki, Go	Hired	Administration Department Accounting Division Procurement Section, Chief	(Tokyo Gakugei University)
2016/4/1	Narisawa, Hiroyuki	Hired	Administration Department Facilities Division Maintenance Section, Chief	(The University of Tokyo)
2016/4/1	Tanabe, Keizo	Hired	Okayama Astrophysical Observatory Administration Office Administration Section, Chief	(Okayama University Hospital)
2016/4/1	Morita, Akitsugu	Hired	Administration Department General Affairs Division General Affairs Section, Staff	
2016/4/1	Inoue, Miyuki	Hired	Administration Department General Affairs Division Payroll Section, Staff	
2016/4/1	Takahashi, Sachiko	Hired	Administration Department Financial Affairs Division Asset Management Section, Staff	
2016/8/1	Miyabara, Yasuhide	Hired	Nobeyama Radio Observatory Administration Office Accounting Section, Chief	(Shinshu University)
2016/7/31	Shimizu, Hidetoshi	Resigned	(Shinshu University)	Nobeyama Radio Observatory Administration Office Accounting Section, Chief
2017/3/31	Nemoto, Nobuyuki	Resigned	(Ministry of Education, Culture, Sports, Science and Technology-Japan)	Administration Department Financial Affairs Division, Manager
2017/3/31	Watanabe, Yukika	Resigned	(Tokyo Gakugei University)	Administration Department General Affairs Division Payroll Section, Chief
2017/3/31	Sato, Kanako	Resigned	(Tokyo Gakugei University)	Administration Department Financial Affairs Division Asset Management Section, Chief
2017/3/31	Hayashigura, Koji	Resigned	(Tokyo National Museum)	Administration Department Facilities Division Maintenance Section, Senior Staff
2017/3/31	Yoshimura, Tetsuya	Resigned	(The University of Tokyo)	Administration Department General Affairs Division General Affairs Section, Staff
2017/3/31	Miyata, Yusuke	Resigned	(The Graduate University for Advanced Studies)	Administration Department Accounting Division Accounting Section, Staff
2017/3/31	Watanabe, Matsuo	Retired		Administration Department Facilities Division, Manager

2016/4/1	Kawashima, Ryota	Promoted	Administration Department Facilities Division General Affairs Section, Chief	Administration Department Facilities Division General Affairs Section, Senior Staff
2016/4/1	Hayashigura, Koji	Promoted	Administration Department Facilities Division Maintenance Section, Senior Staff	Administration Department Facilities Division Maintenance Section, Staff
2016/7/1	Goto, Michiru	Promoted	Administration Department General Affairs Division Research Support Section, Chief	Administration Department General Affairs Division Research Support Section, Senior Staff
2016/8/1	Furuhata, Tomoyuki	Promoted	Administration Department General Affairs Division, Deputy Manager	Subaru Telescope Administration Department Accounting Section, Chief
2016/8/1	Sugawara, Satoshi	Promoted	Subaru Telescope Administration Department Accounting Section, Senior Staff	Subaru Telescope Administration Department General Affairs Section, Staff

2016/7/1	Yokota, Banri	Reassigned	National Institutes of Natural Sciences Administrative Bureau Liaison and Planning Division Research Support Section, Staff	Administration Department Financial Affairs Division Budget Section, Staff
2016/7/1	Masuda, Akio	Reassigned	Administration Department Financial Affairs Division Budget Section, Staff	National Institutes of Natural Sciences Administrative Bureau Liaison and Planning Division Research Support Section, Staff

Employee on Annual Salary System

Date	Name	Change	New Affiliated Institute, Position	Previous Affiliated Institute, Position
2016/4/1	Hasegawa, Tetsuo	Hired	NAOJ Chile Observatory, Specially Appointed Professor (Distinguished Professor)	(Division of Radio Astronomy (NAOJ Chile Observatory), Professor)
2016/4/1	Hayashi, Masao	Hired	Subaru Telescope, Specially Appointed Assistant Professor	
2016/4/1	Okamoto, Takenori	Hired	NAOJ Chile Observatory, Specially Appointed Assistant Professor	
2016/4/1	Moriya, Takashi	Hired	Division of Theoretical Astronomy, Specially Appointed Assistant Professor	
2016/4/1	Ogihara, Masahiro	Hired	Division of Theoretical Astronomy, Specially Appointed Assistant Professor	
2016/4/1	Niino, Yuu	Hired	Subaru Telescope, Specially Appointed Research Staff	
2016/4/1	Takagi, Yuhei	Hired	Subaru Telescope, Specially Appointed Research Staff	
2016/4/1	Joshi, Anand Diwakar	Hired	Solar Observatory, Specially Appointed Research Staff	
2016/4/1	Kroug, Matthias Nils	Hired	NAOJ Chile Observatory, Specially Appointed Research Staff	
2016/4/1	Izumi, Natsuko	Hired	NAOJ Chile Observatory, Specially Appointed Research Staff	
2016/4/1	Ohtani, Yukari	Hired	Center for Computational Astrophysics, Specially Appointed Research Staff	
2016/4/1	Lee, Kyoung Sun	Hired	Hinode Science Center, Specially Appointed Research Staff	
2016/4/1	Ozaki, Shinobu	Hired	TMT-J Project Office, Specially Appointed Research Staff	
2016/4/1	Kubo, Mariko	Hired	TMT-J Project Office, Specially Appointed Research Staff	
2016/4/1	Schramm, Malte	Hired	TMT-J Project Office, Specially Appointed Research Staff	

2016/4/1	Konishi, Mihoko	Hired	Extrasolar Planet Detection Project Office, Specially Appointed Research Staff	
2016/4/1	Yamamoto, Keiko	Hired	RISE Project, Specially Appointed Research Staff	
2016/4/1	Homma, Hidetomo	Hired	Astronomy Data Center, Specially Appointed Research Staff	
2016/4/1	Hasebe, Takashi	Hired	Advanced Technology Center, Specially Appointed Research Staff	
2016/4/1	Uchiyama, Mizuho	Hired	Advanced Technology Center, Specially Appointed Research Staff	
2016/4/1	Taniguchi, Akimitsu	Hired	Subaru Telescope, Specially Appointed Senior Specialist	
2016/4/1	Oya, Masaaki	Hired	Nobeyama Radio Observatory, Specially Appointed Senior Specialist	
2016/4/1	Fujimoto, Yasuhiro	Hired	NAOJ Chile Observatory, Specially Appointed Senior Specialist	
2016/4/1	Kusumoto, Hiroshi	Hired	TMT-J Project Office, Specially Appointed Senior Specialist	
2016/4/1	Makiuchi, Shin'ichiro	Hired	Astronomy Data Center, Specially Appointed Senior Specialist	
2016/4/1	Ozawa, Takeaki	Hired	Astronomy Data Center, Specially Appointed Senior Specialist	
2016/4/1	Kamegai, Kazuhisa	Hired	Astronomy Data Center, Specially Appointed Senior Specialist	
2016/4/1	Komiyama, Hiroko	Hired	Office of International Relations, Specially Appointed Senior Specialist	
2016/5/1	Torii, Kazufumi	Hired	Nobeyama Radio Observatory, Specially Appointed Assistant Professor	
2016/7/1	Kanbe, Eiji	Hired	Okayama Astrophysical Observatory, Specially Appointed Associate Professor	
2016/7/1	Egusa, Fumi	Hired	NAOJ Chile Observatory, Specially Appointed Assistant Professor	(NAOJ Chile Observatory, Specially Appointed Research Staff)
2016/8/1	Espada Fernandez, Daniel	Hired	NAOJ Chile Observatory, Specially Appointed Associate Professor	(Division of Radio Astronomy (NAOJ Chile Observatory), Associate Professor)
2016/8/1	Lu, Xing	Hired	NAOJ Chile Observatory, Specially Appointed Research Staff	
2016/9/1	Saigou, Kazuya	Hired	NAOJ Chile Observatory, Specially Appointed Assistant Professor	
2016/9/12	Tsuzuki, Hiroko	Hired	Public Relations Center, Specially Appointed Senior Specialist	
2016/9/21	Neelamkodan, Naslim	Hired	NAOJ Chile Observatory, Specially Appointed Research Staff	
2016/10/1	Kawashima, Tomohisa	Hired	Division of Theoretical Astronomy, Specially Appointed Research Staff	
2016/10/1	Fukui, Akihiko	Hired	Okayama Astrophysical Observatory, Specially Appointed Senior Specialist	(Okayama Astrophysical Observatory, Specially Appointed Research Staff)
2016/10/25	Tapia San Martin, Enzo Nicolas	Hired	Gravitational Wave Project Office, Specially Appointed Senior Specialist	
2016/11/1	Matsubayashi, Kazuya	Hired	Okayama Astrophysical Observatory, Specially Appointed Research Staff	
2016/11/1	Kawamura, Taichi	Hired	RISE Project, Specially Appointed Research Staff	
2016/11/1	Sorahana, Satoko	Hired	Astronomy Data Center, Specially Appointed Research Staff	

2016/12/1	Zapart, Christopher Andrew	Hired	Astronomy Data Center, Specially Appointed Senior Specialist	(Astronomy Data Center, Specially Appointed Research Staff)
2017/1/16	Hashimoto, Takuya	Hired	NAOJ Chile Observatory, Specially Appointed Research Staff	
2017/1/16	Song, Donguk	Hired	SOLAR-C Project Office, Specially Appointed Research Staff	
2017/2/1	Tokuda, Kazuki	Hired	NAOJ Chile Observatory, Specially Appointed Research Staff	
2017/2/1	Zahorecz, Sarolta	Hired	NAOJ Chile Observatory, Specially Appointed Research Staff	
2017/3/1	Shoda, Ayaka	Hired	Gravitational Wave Project Office, Specially Appointed Assistant Professor	
2017/3/31	Takahashi, Sanemichi	Hired	NAOJ Chile Observatory, Specially Appointed Research Staff	

2016/4/30	Higuchi, Yuichi	Resigned		Astronomy Data Center, Specially Appointed Research Staff
2016/6/30	Egusa, Fumi	Resigned	(NAOJ Chile Observatory, Specially Appointed Assistant Professor)	NAOJ Chile Observatory, Specially Appointed Research Staff
2016/6/30	Narukage, Noriyuki	Resigned	(Division of Solar and Plasma Astrophysics SOLAR-C Project Office, Assistant Professor)	Advanced Technology Center, Specially Appointed Research Staff
2016/7/1	Nakamura, Kouji	Resigned	(Division of Radio Astronomy (NAOJ Chile Observatory), Chief Research Engineer)	NAOJ Chile Observatory, Specially Appointed Senior Specialist
2016/9/30	Motogi, Kazuhito	Resigned	(Yamaguchi University Graduate School of Sciences and Technology for Innovation, Assistant Professor)	Mizusawa VLBI Observatory, Specially Appointed Research Staff
2016/11/30	Zapart, Christopher Andrew	Resigned	(Astronomy Data Center, Specially Appointed Senior Specialist)	Astronomy Data Center, Specially Appointed Research Staff
2016/11/30	Kobayashi, Tsuyoshi	Resigned		NAOJ Chile Observatory, Specially Appointed Senior Specialist
2016/11/30	Ezaki, Shohei	Resigned	(Advanced Technology Center, Engineering Staff)	NAOJ Chile Observatory, Specially Appointed Senior Specialist
2016/12/31	Hatsukade, Bun'yo	Resigned	(The University of Tokyo Graduate School of Science Department of Astronomy, Assistant Professor)	NAOJ Chile Observatory, Specially Appointed Assistant Professor
2017/1/15	Matsuoka, Yoshiki	Resigned	(Ehime University Research Center for Space and Cosmic Evolution, Associate Professor)	Division of Optical and Infrared Astronomy, Specially Appointed Assistant Professor
2017/2/28	Karatsu, Miki	Resigned		NAOJ Chile Observatory, Specially Appointed Senior Specialist
2017/3/31	Tazaki, Fumie	Resigned	(Mizusawa VLBI Observatory, Specially Appointed Research Staff)	Mizusawa VLBI Observatory, Specially Appointed Research Staff
2017/3/31	Kanaguchi, Masahiro	Resigned		Mizusawa VLBI Observatory, Specially Appointed Senior Specialist
2017/3/31	Furutani, Akio	Resigned	(NAOJ Chile Observatory, Specially Appointed Senior Specialist)	NAOJ Chile Observatory, Specially Appointed Senior Specialist

2016/9/30	Fukui, Akihiko	Contract Expired	(Okayama Astrophysical Observatory, Specially Appointed Senior Specialist)	Okayama Astrophysical Observatory, Specially Appointed Research Staff
2016/9/30	Yamada, Ryuhei	Contract Expired		RISE Project, Specially Appointed Research Staff
2016/11/30	Kim, Jeoung Sook	Contract Expired		Mizusawa VLBI Observatory, Specially Appointed Research Staff
2017/3/31	Zenitani, Seiji	Contract Expired		Division of Theoretical Astronomy, Specially Appointed Assistant Professor

2017/3/31	Matsumoto, Naoko	Contract Expired		Mizusawa VLBI Observatory, Specially Appointed Research Staff
2017/3/31	Toshikawa, Jun	Contract Expired		Subaru Telescope, Specially Appointed Research Staff
2017/3/31	Morokuma, Kana	Contract Expired		NAOJ Chile Observatory, Specially Appointed Research Staff
2017/3/31	Takekoshi, Tatsuya	Contract Expired		NAOJ Chile Observatory, Specially Appointed Research Staff
2017/3/31	Otawara, Kazushige	Contract Expired	(NAOJ Chile Observatory, Specially Appointed Senior Specialist)	NAOJ Chile Observatory, Specially Appointed Senior Specialist

Research Administrator Staff

Date	Name	Change	New Affiliated Institute, Position	Previous Affiliated Institute, Position
2016/7/1	Hasuo, Ryuichi	Hired	Research Enhancement Strategy Office, Office of International Relations, Specially Appointed Senior Specialist	
2016/7/31	Yamaguchi, Takahiro	Resigned		Research Enhancement Strategy Office, Office of International Relations, Specially Appointed Senior Specialist
2017/1/31	Ota, Masahiko	Contract Expired		Research Enhancement Strategy Office, Safety and Health Management Office, Specially Appointed Senior Specialist

Foreign Visiting Researcher

Name	Period			Affiliated Institute
Kokkotas, Konstantinos	2016/4/26	~	2016/6/3	Eberhard Karls University of Tuebingen (Germany)
Packham, Christopher Charles	2016/5/16	~	2016/8/17	University of Texas at San Antonio (USA)
Koda, Jin	2016/4/1	~	2016/8/12	The State University of New York at Stony Brook (USA)
Overzier, Roderik Adriaan	2016/4/2	~	2016/5/1	National Observatory, Rio de Janeiro (Brazil)
Chibueze, James Okwe	2016/7/1	~	2016/9/29	University of Nigeria (Nigeria)

7. Advisory Committee for Research and Management

Members

From universities and related institutes

	Ichimoto, Kiyoshi	Hida Observatories, Graduate School of Science, Kyoto University
	Kajita, Takaaki	Institute for Cosmic Ray Research, The University of Tokyo
	Sugita, Seiji	School of Science, The University of Tokyo
	Chiba, Seiji	Graduate School of Science and Faculty of Science, Tohoku University
	Doi, Mamoru	School of Science, The University of Tokyo
	Fujisawa, Kenta	The Research Institute for Time Studies at Yamaguchi University
	Matsushita, Kyoko	Faculty of Science Division 1, Tokyo University of Science
	Mitsuda, Kazuhisa	Institute of Space and Astronautical Science
	Murakami, Izumi	National Institute for Fusion Science
○	Momose, Munetake	College of Science, Ibaraki University

From NAOJ

	Arimoto, Nobuo	Subaru Telescope
	Usuda, Tomonori	TMT-J Project Office
	Gouda, Naoteru	JASMINE Project Office
	Kokubo, Eiichiro	Center for Computational Astrophysics
	Kobayashi, Hideyuki	Mizusawa VLBI Observatory
	Sakamoto, Seiichi	NAOJ Chile Observatory
	Takami, Hideki	Advanced Technology Center
	Tomisaka, Kohji	Division of Theoretical Astronomy
	Hasegawa, Tetsuo	NAOJ Chile Observatory
	Honma, Mareki	Mizusawa VLBI Observatory
●	Watanabe, Jun-ichi	Public Relations Center

● Chairperson ○ Vise-Chairperson
Period: April 1, 2016 – March 31, 2018

8. Professors Emeriti

Professors Emeriti (NAOJ)

Kakuta, Chuichi
Hiei, Eijiro
Yamashita, Yasumasa
Nishimura, Shiro
Kozai, Yoshihide
Hirayama, Tadashi
Miyamoto, Masanori
Nariai, Kyouji
Okamoto, Isao
Nakano, Takenori
Kodaira, Keiichi
Yokoyama, Koichi
Oe, Masatsugu
Kinoshita, Hiroshi
Nishimura, Tetsuo
Kaifu, Norio
Ishiguro, Masato
Inoue, Makoto
Kawano, Nobuyuki
Andou, Hiroyasu
Karoji, Hiroshi
Chikada, Yoshihiro
Noguchi, Kunio
Fujimoto, Masakatsu
Manabe, Seiji
Miyama, Shoken
Kawaguchi, Noriyuki
Iye, Masanori
Shibasaki, Kiyoto
Sakurai, Takashi

Professors Emeriti (Tokyo Astronomical Observatory)

Moriyama, Fumio
Kozai, Yoshihide

IV Finance

Revenues and Expenses (FY2016)

(Unit: ¥1,000)

Revenues	Budget	Final Account	Budget − Final Account
Management Expenses Grants	11,443,115	11,907,321	−464,206
Facilities Maintenance Grants	828,611	718,864	109,747
Subsidy Income	48,400	48,400	0
Miscellaneous Income	45,901	59,937	−14,036
Industry-Academia Research Income and Donation Income	373,239	573,809	−200,570
Reversals of Reserves for Specific Purposes	550,000	0	550,000
Total	13,289,266	13,308,331	−19,065
Expenses	Budget	Final Account	Budget − Final Account
Management Expenses	12,039,016	11,711,869	327,147
Employee Personnel Expenses	3,700,453	3,675,932	24,521
Operating Expenses	8,338,563	8,035,937	302,626
Facilities Maintenance Expenses	828,611	718,865	109,746
Subsidy Expenses	48,400	48,400	0
Industry-Academia Research Expenses and Donation Expenses	373,239	384,672	−11,433
Total	13,289,266	12,863,806	425,460
Revenues-Expenses	Budget	Final Account	Budget − Final Account
	0	444,525	−444,525

V KAKENHI (Grants-in-Aid for Scientific Research)

1. Series of Single-year Grants for FY 2016

Research Categories	Number of Selected Projects	Budget (Unit: ¥1,000)		
		Direct Funding	Indirect Funding	Total
Scientific Research on Innovative Areas (Research in a proposed research area)	10	42,800	12,840	55,640
Scientific Research (S)	1	20,400	6,120	26,520
Scientific Research (A)	11	87,700	26,310	114,010
Scientific Research (B)	5	30,700	9,210	39,910
Young Scientists (A)	2	9,700	2,910	12,610
JSPS Research Fellows	7	8,000	2,400	10,400
JSPS International Research Fellows	1	500	0	500
Research Activity Start-up	3	3,100	930	4,030
Publication of Scientific Research Results	1	500	0	500
Total	41	203,400	60,720	264,120

2. Multi-year Fund for FY 2016

Research Categories	Number of Selected Projects	Budget (Unit: ¥1,000)		
		Direct Funding	Indirect Funding	Total
Scientific Research (C)	18	20,400	6,120	26,520
Challenging Exploratory Research	8	8,200	2,460	10,660
Young Scientists (B)	17	15,700	4,710	20,410
Total	43	44,300	13,290	57,590

3. Partial Multi-year Fund for FY 2016

Research Categories	Number of Selected Projects	Budget (Series of Single-year Grants) (Unit: ¥1,000)			Budget (Multi-year Fund) (Unit: ¥1,000)		
		Direct Funding	Indirect Funding	Total	Direct Funding	Indirect Funding	Total
Young Scientists (A)	1	0	0	0	100	30	130
Total	1	0	0	0	100	30	130

VI Research Collaboration

1. Open Use

Type	Project/Center	Category	Number of Accepted Proposal	Total Number of Researcher	Note
Open Use at Project/Center	Okayama Astrophysical Observatory	188-cm Reflector Telescope (Project Program)	2	31 (0)	2 Institutes
		188-cm Reflector Telescope (Normal Program)	30	184 (10)	16 Institutes, 5 Countries
		188-cm Reflector Telescope (Student Program)	0	0 (0)	0 Institute
		188-cm Reflector Telescope (Miscellaneous Program)	2	2 (0)	1 Institute
		188-cm Reflector Telescope (ToO Program)	2	3 (0)	2 Institutes
	Subaru Telescope		72	308 (43)	57 Institutes, 11 Countries
	Solar Observatory		*	*	*
	Nobeyama Radio Observatory	45-m Telescope (Regular Program)	23	173 (55)	48 Institutes, 11 Countries
		45-m Telescope (Short Program)	12	58 (7)	18 Institutes, 5 Countries
		45-m Telescope (Back-up Program)	1	11 (3)	5 Institutes, 2 Countries
		45-m Telescope (Large Program)	0		
		45-m Telescope (Director's Discretionary Time)	2	62 (42)	21 Institutes, 7 Countries
	Mizusawa VLBI Observatory	VERA	18	109 (68)	32 Institutes, 15 Countries
	Astronomy Data Center		364	364 (55 at foreign institutes)	34 Institutes, 17 Countries
	Center for Computational Astrophysics		225	225	50 Institutes, 11 Countries
	Hinode Science Center		94	94 (36)	39 Institutes, 11 Countries
	Advanced Technology Center	Facility Use	24	93	36 Institutes
		Joint Research and Development	10	59	21 Institutes
	NAOJ Chile Observatory	ALMA (Cycle3)	402	4,064 (3,517)	310 Institutes, 38 Countries
		ASTE	7	42 (2)	12 Institutes, 2 Countries
	Nobeyama Radio Observatory/NAOJ Chile Observatory	45-m/ASTE Joint program	4	39 (8)	15 Institutes, 2 Countries
Joint Development Research			9		7 Institutes
Joint Research			2		2 Institutes
Research Assembly			20		12 Institutes
NAOJ Symposium			1		1 Institute

The number of foreign researchers shown in brackets ( ) is included in the total.
Notes show the number of institutes and foreign countries represented by the proposal PIs. The country count does not include Japan.
The period of ALMA (Cycle3) is September, 2016 from October, 2015.
* The observation data is open to the public on the web. No application is needed to use the data.

2. Commissioned Research Fellows

Visiting Scholars (Domestic)

Period: April 1, 2016 – March 31, 2017

Name	Position at NAOJ	Affiliated Institute	Host Project/Center/Division
Uzawa,Yoshinori	Visiting Professor	Terahertz Technology Research Center, NICT	NAOJ Chile Observatory
Otsubo, Toshimichi	Visiting Professor	Hitotsubashi University	RISE Project
Onishi, Toshikazu	Visiting Professor	Osaka Prefecture University	NAOJ Chile Observatory
Oka, Tomoharu	Visiting Professor	Keio University	NAOJ Chile Observatory
Nagao, Toru	Visiting Professor	Ehime University	TMT-J Project Office
Hayashi, Yoshiyuki	Visiting Professor	Kobe University	Center for Computational Astrophysics
Momose, Munetake	Visiting Professor	Ibaraki University	NAOJ Chile Observatory
Oshima, Akitoshi	Visiting Associate Professor	Chubu University	Center for Computational Astrophysics
Kobayashi, Kaori	Visiting Associate Professor	Toyama University	NAOJ Chile Observatory
Komugi, Shinya	Visiting Associate Professor	Kogakuin University	NAOJ Chile Observatory
Sagawa, Hideo	Visiting Associate Professor	Kyoto Sangyo University	NAOJ Chile Observatory
Sekine, Yasuhito	Visiting Associate Professor	The University of Tokyo	RISE Project
Sorai, Kazuo	Visiting Associate Professor	Hokkaido University	Nobeyama Radio Observatory
Niinuma, Koutaro	Visiting Associate Professor	Yamaguchi University	Mizusawa VLBI Observatory
Hirata, Naru	Visiting Associate Professor	The University of Aizu	RISE Project
Kurayama, Tomoharu	Visiting Research Fellow	Teikyo University of Science	Mizusawa VLBI Observatory
Sakai, Takeshi	Visiting Research Fellow	The University of Electro-Communications	NAOJ Chile Observatory
Hayama, Kazuhiro	Visiting Research Fellow	Institute for Cosmic Ray Research, The University of Tokyo	Gravitational Wave Project Office
Baba, Yukie	Visiting Research Fellow	Ochanomizu University	Mizusawa VLBI Observatory

JSPS (Japan Society for the Promotion of Science) Postdoctoral Research Fellows

Name	Research Subject	Host Researcher
Arimatsu, Kou	Exploring the outer Solar System by stellar occultations observed with wide-field high-speed cameras	Watanabe, Jun-ichi
Uchiyama, Mizuho	Studying stellar evolution of forming massive young stellar objects with the mid-infrared variability observations	Yamashita, Takuya
Shouda, Ayaka	Development of the multi-messenger observation system for a gravitational-wave detector	Flaminio, Raffaele
Shirasaki, Masato	Probing Cosmic Dark Matter and Dark Energy with Higher-Order Statistics of Weak Gravitational Lensing	Hamana, Takashi
Shinnaka, Yoshiharu	Physicochemistry of the early solar nebula: Thermal history of cometary dust and isotopic fractionation of cometary volatiles	Watanabe, Jun-ichi
Yamauchi, Aya	Research in the structure of a distant region of our galaxy using a new distance measurement method with VERA	Honma, Mareki
Ichikawa, Kohei	Revealing the coevolution of black holes and galaxies through the newly discovered population of AGN	Imanishi, Masatoshi

JSPS (Japan Society for the Promotion of Science) Foreign Research Fellows

Name	Period	Host Researcher
Cataldi, Gianni	2016/11/21 ~ 2018/11/20	Ohashi, Nagayoshi
Wu, Benjamin	2016/9/27 ~ 2017/9/26	Nakamura, Fumitaka

VII Graduate Course Education

1. Department of Astronomical Science, School of Physical Sciences, SOKENDAI (The Graduate University for Advanced Studies)

SOKENDAI (The Graduate University for Advanced Studies) was established in 1988 as an independent graduate university without undergraduate courses via partnerships with inter-university research institutes for the sake of advancing graduate education.

There used to be four schools – Cultural and Social Studies, Mathematical and Physical Sciences, Life Science, and Advanced Sciences before the reorganization of the School of Mathematical and Physical Sciences into the schools of Physical Sciences, High Energy Accelerator Science, and Multidisciplinary Sciences in April 2004. Now the total of six schools are offering doctoral education and research opportunities.

NAOJ has been accepting three-year doctoral-course students since FY 1992 and five-year students since FY 2006 for the Department of Astronomical Science at the School of Physical Sciences. (The School of Mathematical and Physical Sciences was reorganized into the School of Physical Sciences in April 2004.)

(1) Objective of the Department of Astronomical Science

The Department of Astronomical Science aims to train students, through observational, theoretical, or instrument development research in astronomy or in related fields, in an environment with the most advanced observational instruments and supercomputers, as researchers who work at the forefront of world-class research; experts who carry out development of advanced technology; and specialists who endeavor in education and public outreach activities equipped with advanced and specialized knowledge.

Numbers of students to be admitted:
 Two (per year in the five-year doctoral course)
 Three (per year in the three-year doctoral course)
Degree: Doctor of Philosophy

(2) Admission Policy

The Department of Astronomical Sciences seeks students with a strong interest in astronomy and the Universe; a passion for unraveling scientific questions through theoretical, observational, and instrument development research; and students who have not only basic academic skills, but also theoretical and creative aptitude required for advanced research.

(3) Department Details (Course Offerings)

Optical and Near Infrared Astronomy
 [Educational and Research Guidance Field]
 Ground-based astronomy / Optical and infrared telescope system / Planets / Sun, stars and interstellar matter / Galaxies and cosmology

Radio Astronomy
 [Educational and Research Guidance Field]
 Ground-based astronomy / Radio telescope system / Sun, stars and interstellar matter / Galaxies

General Astronomy and Astrophysics
 [Educational and Research Guidance Field]
 High-precision astronomical measurement / Astronomy from space / Data analysis and numerical simulation / Earth and planets / Sun, stars and interstellar matter / Galaxies and cosmology

(4) Course-by-Course Education Program to Cultivate Researchers in Physical Sciences with Broad Perspectives

The School of Physical Sciences began its “Course-by-Course Education Program to Develop Student Research Capability and Aptitude” in FY 2009 as a part of MEXT’s Program for “Enhancing Systematic Education in Graduate Schools.” Since FY 2012 the School has been carrying out its succeeding program, “Course-by-Course Education Program to Cultivate Researchers in Physical Sciences with Broad Perspectives”, offering four specific courses to the students: the Basic Course, the Advanced Research Course, the Project Research Course, and the Development Research Course. In FY 2015, the Department of Astronomical Science accepted five students in the Basic Course and two students in the Advanced Research Course. The Department also offered the e-learning class “Introduction to Observational Astronomy II” as a school-wide common basic subject, as well as the “Exercise in Scientific English” class, in order to provide a good foundation for students at the graduate school.

In order to better prepare students for the international stage, the Department hosted the Asia Winter School during December 7 to 9, 2016, as well as the 2016 Summer Student programs at Mitaka, Mizusawa, Kamioka, Okayama and Chile campuses to allow undergraduate students a chance to experience research at the Department of Astronomical Science. In addition to the existing Research Assistant system, the Department also provided Associate Researcher positions for the students of the Department of Astronomical Science.

(5) Number of Affiliated Staff (2017/3/31)

Chair of the Department of Astronomical Science	1
Optical and Near Infrared Astronomy Course	
Professors	10
Associate Professors	14
Lecturer	1
Assistant Professors	16
Radio Astronomy Course	
Professors	8
Associate Professors	9
Assistant Professors	19
General Astronomy and Astrophysics Course	
Professors	6
Associate Professors	14
Assistant Professors	14
Total	112

(6) Graduate Students (33 students)

1st year (6 students)

Name	Principal Supervisor	Supervisor	Research Theme
Ishikawa, Hiroyuki	Usuda, Tomonori	Hayashi, Saeko	Detailed study of the habitable exoplanets as candidates where actual life can be found
Kawamura, Yuta	Matsuo, Hiroshi	Ezawa, Hajime	Basic development of Photon Counting Terahertz Interferometer
Tanioka, Satoshi	Aso, Yoichi	Flaminio, Raffaele	Direct measurement of the coating thermal noise using cryogenic optical cavities
Hatta, Yoshiki	Sekii, Takashi	Watanabe, Tetsuya	Helio- and asteroseismology
Hosokawa, Ko	Kotani, Takayuki	Takami, Hideki Usuda, Tomonori	Development of a new high-resolution spectrograph with a spatial resolution and study of an exoplanet characterization
Watanabe, Noriharu	Usuda, Tomonori	Takami, Hideki Aoki, Wako	Observational Studies of Orbital Evolution of Various Exoplanets System

2nd year (5 students)

Name	Principal Supervisor	Supervisor	Research Theme
Ando, Misaki	Iono, Daisuke	Saito, Masao Espada, Daniel	Observing Colliding Galaxies Using ALMA
Kambara, Nagaaki	Sekii, Takashi	Watanabe, Tetsuya	Local helioseismology
Kikuta, Satoshi	Imanishi, Masatoshi	Kodama, Tadayuki	AGN feedback to low-mass galaxy formation at high redshift
Matsuno, Tadafumi	Aoki, Wako	Arimoto, Nobuo	Observational study of metal-poor stars to reveal the history of the near-field Universe
Yoshida, Masaki	Suematsu, Yoshinori	Hara, Hirohisa	On the Structure and Heating Mechanism of Solar Chromosphere and Corona

3rd year (3 students)

Name	Principal Supervisor	Supervisor	Research Theme
Michiyama, Tomonari	Iono, Daisuke	Kodama, Tadayuki Nakanishi, Koichiro	Observing Starburst Galaxies Using ALMA
Yamamoto, Moegi	Kodama, Tadayuki	Iwata, Ikuru	Searching for distant clusters with Subaru/HSC
Kim, Jungha	Honma, Mareki	Shibata, Katsunori	Understanding the circumstellar structure of high-mass young stellar objects based on KaVA observations

4th year (6 students)

Name	Principal Supervisor	Supervisor	Research Theme
Okutomi, Koki	Aso, Yoichi	Flaminio, Raffaele	Development of laser interferometer module torwards DECIGO
Onoue, Masafusa	Kashikawa, Nobunari	Miyazaki, Satoshi	Studies on High-z quasars by wide-field imaging observation
Baba, Haruka	Aoki, Wako	Usuda, Tomonori	Development of infrared instruments and observational research for exploring Earth-like exoplanets
Ryu, Tsuguru	Hayashi, Saeko	Usuda, Tomonori	High-Contrast Imaging for Intermediate-Mass Giants with Long-Term Radial Velocity Trends
Uchiyama, Hisakazu	Kashikawa, Nobunari	Matsuda, Yuichi	The study of large-scale structures based on wide-imaging observations of Subaru telescope
Taniguchi, Kotomi	Saito, Masao	Ohishi, Masatoshi	Chemical evolution and mechanisms of carbon-chain molecules in star-forming regions

5th year (13 students)

Name	Principal Supervisor	Supervisor	Research Theme
Yang, Yi	Hayashi, Saeko	Usuda, Tomonori	Direct Imaging of Circumstellar Disks and Planets in Binary Systems
Ishikawa, Shogo	Kashikawa, Nobunari	Kodama, Tadayuki	Measurement of dark halo mass by clustering analysis of star-forming galaxies
Onishi, Kyoko	Iguchi, Satoru	Iono, Daisuke	Observational study towards black-hole mass: resolving the coevolution process of black hole and galaxy
Onitsuka, Masahiro	Usuda, Tomonori	Takato, Naruhisa	Observational Studies of the Structure and Evolution of Exoplantes
Sakurai, Junya	Miyazaki, Satoshi	Kobayashi, Yukiyasu	Study of large scale structures in the universe through wide field imaging
Shimakawa, Rhythm	Kodama, Tadayuki	Arimoto, Nobuo	Environmental and mass dependence of galaxy properties at the cosmic noon
Suzuki, Taiki	Ohishi, Masatoshi	Saito, Masao	Research on Organic Molecules in the Universe
Min, Cheul Hong	Honma, Mareki	Shibata, Katsunori	Research for a symbiotic star using VERA
Pathak, Prashant	Takami, Hideki	Minowa, Yosuke	Chromaticity effects on high resolution imaging
Kobayashi, Hiroshi	Ohsuga, Ken	Tomisaka, Kohji	Radiation Hydrodynamics Simulations of Clumpy Outflows from Black-hole Accretion disks
Suzuki, Tomoko	Kodama, Tadayuki	Iono, Daisuke	Galaxy formation beyond the peak epoch probed by [OIII] emitters
Shino, Nagisa	Honma, Mareki	Shibata, Katsunori	Testing the massive-star formation scenario via methanol maser observations
Sukom, Amnart	Tomisaka, Kohji	Hayashi, Saeko	Study of star and planetary formation process and the exoplanets based on infrared observations

2. Education and Research Collaboration with Graduate Schools

Name	Affiliated Institute	Supervisor	Thesis
Inooka, Kota	The University of Tokyo	Yamashita, Takuya	Observational research of exoplanets
Choi, Insa	The University of Tokyo	Ohashi, Nagayoshi	A study on Star Formation using radio interferometer
Shimizu, Takayuki	The University of Tokyo	Sekimoto, Yutaro	Development of the instruments for the cosmic microwave background observation.
Mori, Kanji	The University of Tokyo	Kajino, Toshitaka	Impact of New GT Strengths on Explosive SN Ia Nucleosynthesis
Yamaguchi, Masayuki	The University of Tokyo	Kawabe, Ryohei	mm/sub-mm Study of Planet and Star Formation
Kurose, Ippei	The University of Tokyo	Ohashi, Nagayoshi	Observational Study of Star Forming Regions
Sakai, Iori	The University of Tokyo	Kobayashi, Yukiyasu	The performance evoluation of Nano-JASMINE's CCD with radial rays
Sasaki, Hirokazu	The University of Tokyo	Kajino, Toshitaka	Collective neutrino oscillations and application to nucleosynthesis in core-collapse supernovae
Fujii, Yoshinori	The University of Tokyo	Flaminio, Raffaele	Development of the vibration isolation system for the KAmioka GRavitational-wave Antenna
Fujita, Ayato	The University of Tokyo	Gouda, Naoteru	Dynamical Structure and its Evolution of the Milky Way
Tatsuuma, Misako	The University of Tokyo	Kokubo, Eiichiro	Planetary System Formation
Luo, Yudong	The University of Tokyo	Kajino, Toshitaka	Field Theory and Cosmology
Shu, Shibo	The University of Tokyo	Sekimoto, Yutaro	Development of superconducting MKID camera for CMB B-mode polarization
Kuramochi, Kazuki	The University of Tokyo	Kobayashi, Hideyuki	Observational demonstration of RIAF with sub-mm VLBI using Sparse Modeling
Lee, Minju	The University of Tokyo	Kawabe, Ryohei	Environmental effect on galaxy evolution using dense gas tracer
Kato, Yuta	The University of Tokyo	Sakamoto, Seiichi	Star forming activity in the z=2-3 proto-clusters with Infrared Space telescope
Sakai, Daisuke	The University of Tokyo	Kobayashi, Hideyuki	Dynamical study of molecular clouds in the Galactic center with radio observations
Hirai, Yutaka	The University of Tokyo	Kajino, Toshitaka	Exploring galactic chemo-dynamical evolution through r-process elements
Marchio, Manuel	The University of Tokyo	Flaminio, Raffaele	Development, characterization and improvement of the mirrors for the KAGRA gravitational wave detector
Aso, Yusuke	The University of Tokyo	Ohashi, Nagayoshi	A study on Star Formation using radio interferometer
Ohashi, Satoshi	The University of Tokyo	Sakamoto, Seiichi	Chemical evolution of the star-forming cores in the giant molecular clouds
Saito, Toshiki	The University of Tokyo	Kawabe, Ryohei	Star Formation and Super Massive Black Hole in Merging Galaxies through Dense Molecular Gas Observations
Shibagaki, Shota	The University of Tokyo	Kajino, Toshitaka	Revealing the origin of r-process elements with astrophysical simulations
Shibata, Takashi	The University of Tokyo	Kokubo, Eiichiro	Terrestrial Planet Formation
Sekiguchi, Shigeyuki	The University of Tokyo	Sekimoto, Yutaro	Development of broadband dual polarimetry MKID camera for observation of CMB B-mode polarization
Tagawa, Hiromichi	The University of Tokyo	Gouda, Naoteru	Early cosmic merger of multiple black holes
Koyamatsu, Shin	The University of Tokyo	Ohashi, Nagayoshi	Formation and Evolution of Protoplanetary Disks

3. Commissioned Graduate Students

Doctoral Course	Affiliated Institute	Period	Supervisor	Thesis
Kozuki, Yuto	Osaka Prefecture University	2016/4/1 ~ 2017/3/31	Noguchi, Takashi	100 GHz SIS Mixer with wide RF and IF bandwidth
Silva, Andrea	Tufts University	2016/4/1 ~ 2017/3/31	Iono, Daisuke	ALMA Observations of Starburst Galaxies
Fujita, Shinji	University of Tsukuba	2016/4/1 ~ 2017/3/31	Saito, Masao	Studying of processes of clump formation in GMCs
Matsuo, Mitsuhiro	Kagoshima University	2016/4/1 ~ 2017/3/31	Saito, Masao	Observations of molecular clouds in the outer galaxy with a wideband digital spectrometer

Master's Course	Affiliated Institute	Period	Supervisor	Thesis
Kokubo, Tsukasa	Tokyo University of Agriculture and Technology	2016/4/1 ~ 2017/3/31	Watanabe, Jun-ichi	Optical processing and evaluation for exoplanet exploration system
Ito, Ayaka	Hosei University	2016/4/1 ~ 2017/3/31	Usuda, Tomonori	Observational Studies of Exoplanets
Takumi, Asami	The Open University of Japan	2016/4/1 ~ 2017/3/31	Watanabe, Jun-ichi	Observational researches on Small Solar System Bodies
Tani, Ryo	The University of Electro-Communications	2016/10/1 ~ 2017/3/31	Kashikawa, Nobunari	Circum galactic medium probed by Lyman-alpha intensity mapping
Morozumi, Tatsuhiko	The University of Tokyo	2016/10/1 ~ 2017/3/31	Aso, Yoichi	Development of Beam Reducing Telescope
Oyamada, Shuri	Japan Women's University	2016/10/1 ~ 2017/3/31	Nakamura, Fumitaka	Observational Study of Orion Molecular Cloud with a dense gas tracer
Komeda, Satoshi	Kyushu University	2016/10/1 ~ 2017/3/31	Fukushima, Toshio	Research of X-ray objects using archive data from X-ray satellites

4. Degrees Achieved with NAOJ Facilities

Name	Degree	Thesis
Saito, Yuriko	Doctor of Philosophy, SOKENDAI	Investigation of the Coevolution between Supermassive Blackholes and Galaxies at Redshift 3 through Subaru Near-Infrared Observations
Matsuzawa, Ayumu	Doctor of Philosophy, SOKENDAI	Study on the Verification Method of Pointing Performance of Submillimeter Wavelength Antenna through the ALMA
Ishikawa, Shogo	Doctor of Philosophy, SOKENDAI	The Galaxy–Halo Connection Across Cosmic History
Onishi, Kyoko	Doctor of Philosophy, SOKENDAI	Black-Hole Mass Measurements in Nearby Galaxies Using Molecular Gas Dynamics
Onitsuka, Masahiro	Doctor of Philosophy, SOKENDAI	A Study of the Transit-Like Phenomena around a T-Tauri Star
Shimakawa, Rhythm	Doctor of Philosophy, SOKENDAI	The Forming Galaxy Clusters at the Cosmic Noon
Suzuki, Taiki	Doctor of Philosophy, SOKENDAI	A Study on Evolution of N-bearing Complex Organic Molecules towards Glycine
Suzuki, Tomoko	Doctor of Philosophy, SOKENDAI	Accelerated Star-Forming Activity before the Peak Epoch as Revealed by Galaxies Emitting Strong Lines of Doubly Ionized Oxygen
Min, Cheulhong	Doctor of Philosophy, SOKENDAI	VERA Observations of 43GHz SiO Masers toward a Symbiotic Star R Aquarii

VIII Public Access to Facilities

1. Mitaka Campus

[Open year-round]

Dates: April to March, 10:00–17:00
Every day except for the New Year's season (December 28–January 4)
Visitors: 20,413
Open Facilities: Observatory History Museum (65-cm Telescope Dome), 20-cm Telescope Dome, Solar Tower Telescope, Exhibit Room, Repsold Transit Instrument Building (Transit Instrument Museum), Astronomical Instruments Museum, Gautier Meridian Circle Building, Old Library

[Regular Star Gazing Parties]

Dates: Friday before second Saturday; fourth Saturday
Visitors: 4,671 (23 events)
Open Facility: 50-cm Telescope for Public Outreach

[4D2U Theater Showings]

Dates: Friday before second Saturday; first, second, and third Saturdays
Visitors: 5,432 (47 events)
Open Facility: 4D2U Dome Theater

[Special Open-House Event] Mitaka Open House Day

Dates: October 21 (Fri.), 2016, 14:00–19:00
October 22 (Sat.), 2016, 10:00–19:00
Topic: Gravitational Waves, a new Frontier of Astronomy
Visitors: 4,534

This event is jointly sponsored by NAOJ, the University of Tokyo School of Science Institute of Astronomy, the SOKENDAI Department of Astronomical Science, and the NINS Astrobiology Center. It has been held for 2 days each year, starting from 2010. The perennially popular lectures related to this year's theme were hosted by the Institute of Astronomy, University of Tokyo ("The Universe Observed in Kiso's Sky by Tomo-e Gozen" Shigeyuki Sakoh, Assistant Professor) and NAOJ ("Listening to the Universe with Gravitational Waves" Raffaele Flaminio, NAOJ Specially Appointed Professor; and "Seeing Gravitational Waves with Electromagnetic Waves? Pursuing the true Nature of Gravitational Wave Sources through Electromagnetic Follow-up Observations" Michitoshi Yoshida, Professor, Hiroshima University).

* Guided tours corresponding to group tours (Dantai Kengaku) and cultural property events were also held. In addition the "Information Space of Astronomy and Science" was opened in 2015 near the south entrance of Mitaka Station to distribute information.

2. Mizusawa Campus

[Open year-round]

Dates: April to March (except for New Year's season), 9:00–17:00 daily
Visitors: 18,100
Open Facilities: Kimura Hisashi Memorial Museum, VERA 20-m antenna, 10-m VLBI antenna

The open house event is held at the campus with the cooperation of the Oshu Space and Astronomy Museum (OSAM: Yugakukan) located in the campus.

[Special Open Day] Held as part of Iwate Galaxy Festival 2016 (Hours: 10:00-20:30)

Date: August 20 (Sat.), 2016, 10:00–20:30
Visitors: Approximately 2,500

Same as last year, the Open Day was co-hosted with Ihatov Space Action Center / the Oshu Space and Astronomy Museum (OSAM: Yugakukan) and the city of Oshu. The event was opened with a performance by a marching band from a local elementary school. NAOJ offered such attractions as exhibits about the research results of VERA, RISE, and CfCA; tours of the 20-m parabolic antenna; commemorative photo booth; plastic bottle rocket launch; a quiz game; tours of the supercomputer "Aterui;" and a special guided tour of the Array Operations Center (AOC) and the VLBI correlator.

Special lectures about black holes were given by Ms. Arisa Kuroda of TV fame, Masaki Ando, Associate Professor of University of Tokyo, Mareki Honma, Director of the Mizusawa VLBI Observatory and Ken Osuga, Assistant Professor of the Center for Computational Astrophysics, and were enormously well received.

OSAM (Yugakukan) offered various experiments in the science stalls, workshops, etc., which were carried out by the student interns. The Open Day was a great success with close ties to the local people.

Iriki: VERA Iriki Station

[Open year-round]

Dates: April to March (except for New Year's season)
Visitors: 5,949

[Special Open Day]

Date: August 7 (Sun.), 2016, 12:00–20:00
Visitors: Approximately 4,500

This special open event was held in conjunction with "Yaeyama Highland Star Festival 2016" hosted by the executive committee primarily formed by members of Satsuma-Sendai city hall and Kagoshima University.

At the NAOJ VERA 20-m radio telescope and the Kagoshima University 1-m optical/infrared telescope facilities, guided tours of telescopes and observation buildings were held. NAOJ offered such attractions as parent-child science experiments, plastic bottle rocket launching, 4D2U (4-Dimentional Digital Universe screening), and a stargazing party at night. This time JAXA supported a chance to try on a spacesuit, which was well received.

The special lecture of the year was given by Takumi Nagayama, Specially Appointed Senior Specialist from Mizusawa VLBI Observatory. All visitors had fun and were satisfied with scientific programs offered in this festival.

Ogasawara: VERA Ogasawara Station

[Open year-round]

Dates: April to March (except for New Year's season)

Visitors: 9,930

[Special Open Day]

Date: February 12 (Sun.), 2017, 10:00–16:30

Visitors: 227

A special open house event was held this year again under the name "Star Island 16". Same as last year, the free shuttle buses were appreciated by the visitors. The number of visitors was 227, which was more than last year. Because the number of the resident in the island is about 2,000, more than 10 % of the islanders visited this event.

NAOJ offered such attractions as exhibits about the research results of VERA and RISE, 20-m parabolic antenna driving experience, quiz games, a commemorative photo booth, and short lectures.

On the night before the special open house, Space Lectures were given at the Ogasawara Visitor Center by Director General Masahiko Hayashi and Kazuhiro Hada, Assistant Professor at Mizusawa VLBI Observatory, and were attended by 46.

A stargazing party was held by the local Ogasawara astronomy club on the day following the special open house, February 13, and NAOJ members also assisted. Thanks to good weather, the stargazing party was well received and the number of visitors was 50.

Ishigakijima: VERA Ishigakijima Station

[Open year-round]

Dates: April to March (except for the New Year's season); premises are open to the public 24 hours/day, and the observation rooms are open during the hours of 10:00–16:30.

Visitors: 2,442

[Special Open day] The Special Open Day was held as a part of the Star Festival of the Southern Island.

Dates: August 7 (Sun.), 2016, 10:00–17:00

Visitors: 194 (252 during the Star Festival of the Southern Island)

Same as previous years, attractions like antenna tours, a commemorative photo booth, merchandise, commemorative lectures, and exhibits were offered.

Ishigakijima: Ishigakijima Astronomical Observatory

[Open year-round]

Dates: April to March

Open Hours: Wednesdays through Sundays (Except for the New Year's season; when Monday / Tuesday is a national holiday, it is open and then closes on the next day.), 10:00–17:00

Stargazing Sessions: Evenings on Saturdays, Sundays, Holidays, and Star Festival weekdays (19:00–22:00), two 30-minute sessions per evening, with support of NPO Yaeyama Star Club

4D2U Screening: from 15:00 to 15:30 every day when the observatory is open

Visitors: 15,061 (903 during the Star Festival of the Southern Island)

Open Facilities: Murikabushi 105-cm optical/infrared telescope, Starry Sky Study Room (featuring the 4D2U "4-Dimensional Digital Universe"), interior of observation dome (including exhibits of astronomical images)

The Starry Sky Study Room, constructed adjacent to the observatory in 2013 by the Ishigaki city, was very popular, welcoming 6,186 guests.

[Star Festival of the Southern Island 2016]

Dates: August 6 (Sat.) to August 14 (Sun.), 2016

Visitors: Approximately 11,000

This year is the 15th anniversary of both the completion of VERA Ishigakijima Station and the Star Festival of the Southern Island. Approximately 11,000 visitors attended the dimmed-light stargazing event blessed with better weather than ever before. The annual planetarium screening was attended by 623.

The activities at Ishigakijima Astronomical Observatory boost regional development like school education, lifelong learning, and sightseeing. The cooperation agreement between NAOJ and the Ishigaki-city tourism exchange association has been finalized. And it is widely recognized that the starry sky can be used as a tourism resource. Considering this situation, we will continue to strengthen our ties with other associations.

3. Nobeyama Campus

[Regular Open]

Open Time: 8:30–17:00 (every day except during New Year's Season (Dec. 29 to Jan. 3), open until 18:00 during the summer (Jul. 20 to Aug. 31))

Visitors: 44,961

Open Facilities: 45-m Radio Telescope, Nobeyama Millimeter Array, Nobeyama Radioheliograph, etc. (just viewing) and NINS Nobeyama exhibition room (just July to September)

[Open House Day]

Date: August 27 (Sat.), 2016, 9:30–16:00

Visitors: 1,675

The theme of the 2016 Open House Day was "Let's go on a journey to look for a Black Hole". We have two lectures on the theme, which attract large audiences every year. This year one was "Pursuing Objects Emitting Gravitational Waves" by Dr. Tanaka, Masaomi (NAOJ). The other was "Objects lurking in the Galactic Center" by Prof. Oka, Tomoharu (Keio University). However, we had only 1,675 visitors due to stormy weather on that day. Several events, such as the chance to touch the main reflector panel of the 45-m Radio Telescope, had to be canceled. It was severe conditions for visitors and staff members. In spite of the bad weather, we had some established hands-on events such as the antenna handicrafts, radio detector handicrafts, and the antenna origami. At the NINS exhibition room, the presentation of the 4D theater, exhibits of other institutes, and the Mitaka VR system operated by the CfCA team were offered. In addition, the ALMA team offered the ALMA VR system and some short lectures. Moreover, we had balloons for children presented by the NRO character, Dr. Nobeyama, and the NRO original panel for taking commemorative pictures. We had unfortunate weather, but felt some hope because we were supported by many people from other projects of NAOJ as well as other institutes of NINS.

[Jimoto Kansha Day] (Thanks Day for the locals)

Date: February 11 (Sat.), 2017, 13:30–16:00

Visitors: 45

It is difficult for the local people to join the Open House Day during the farming season. They do not know so much what we, not only NRO but also Tsukuba and Shinshu Universities, study in Nobeyama. In response to these comments, we established this event in cooperation with Shinshu University, Faculty of Agriculture, Education and Research Center of Alpine Field Science and Tsukuba University, Agricultural and Forestry Research Center, Yatsugatake Forest. At the Vegetaball With hosted by Shinshu University, we also had an exhibition on the "scarlet runner bean" project, which is studied by Shinshu University in cooperation with Minamimaki Village. The exhibitions by elementary school students and a "scarlet runner bean" sampling party were held out. Also, we had three lectures, "Nagano is Astro-Prefecture" by NAOJ, "Talk about various plants in the local area" by Tsukuba University and "Introduction to the scarlet runner bean project" by Shinshu University.

It appeared to be a local-based event.

4. Okayama Campus

Okayama Astrophysical Observatory

[Open year-round]

Dates: 9:00–16:30 daily
Visitors: 10,102
Open Facilities: Window view of Okayama 188-cm Reflector Telescope

[Special Stargazing Party]

Date: April 2 (Sat.), 2016, 18:30–22:25
Visitors: 79
133 applications for 348 applicants were received. Pollux of Gemini and Jupiter were viewed.

Date: July 30 (Sat.), 2016, 18:30–22:25
Visitors: 81
124 applications for 359 applicants were received. Mars and Saturn were viewed.

5. Subaru Telescope

[Summit Facility Tour]

- Dates open for public tour: 55 (these dates are listed in the public tour program page at the Subaru Telescope's web site, only 1 day was canceled due to the hurricane; no tours scheduled during the winter months of December to March, the weather was particularly bad in December, January and March)
- Public tour visitors: 456
- Special tour visitors: 127 groups, 592 visitors

[Base Facility Tour]

- Special tour visitors: 40 groups, 398 visitors

[Public information]

- Primary means of disseminating public information is posting at the official website http://subarutelescope.org
  - ○ Science results from the Subaru Telescope – 9 Japanese and 10 English articles
  - ○ Depicting special activities or announcing Calls for Proposals, recruitment – 46 Japanese and 30 English articles. Japanese topics include 22 articles in a series introducing the Subaru Telescope.
- Web postings are supplemented by social media via official accounts
  - ○ Twitter accounts – SubaruTelescope (for Japanese), SubaruTel_Eng (for English)
  - ○ Facebook pages – 国立天文台 (for Japanese), National Astronomical Observatory of Japan (for English, started February 2015)
  - ○ YouTube channels – Subaru Telescope NAOJ (for Japanese), Subaru Telescope NAOJe (for English)

[Outreach]

1. Lectures at the Subaru Telescope's base facility in Hilo: 18 cases, reached 281 people

2. Remote presentations, mainly to Japan: 11 cases, reached 1,349 people

3. Lectures, demonstrations, workshops etc. in the vicinity: 16 cases, reached 482 people

4. Lectures in Japan: 13 cases, reached 4,933 people

5. Others - Exhibits etc.: 8 cases, reached approximately 1,905 people

6. Media coverage
   23 Japanese media visits. No English media visits.

IX Overseas Travel

Research and Academic Staff Overseas Travel

(Including employees on annual salary system)

category / country/area	Business Trip	Training	Total
South Korea	43	0	43
China	37	0	37
Thailand	5	0	5
Taiwan	29	0	29
Hong Kong	1	0	1
Singapore	1	0	1
Indonesia	1	0	1
Philippines	0	0	0
Other areas in Asia	23	0	23
Hawai`i	68	0	68
U.S.A.	94	0	94
Australia	6	0	6
Italy	26	0	26
U.K.	33	0	33
France	13	0	13
Canada	5	0	5
Guam, Saipan	0	0	0
Germany	37	0	37
Other areas in Europe and Oceania	50	0	50
Mexico	2	0	2
Brazil	0	0	0
Africa	4	0	4
Other areas in South and Central America *	46	0	46
Total	524	0	524

* Most travelers to South and Central America went to Chile.

X Award Winners

Award Recipients	Affiliated Division	Job Title	Award	Date
Onishi, Kyoko	SOKENDAI	Student	The 2nd SOKENDAI Future Scientist Award	2016/4/4
Saito, Masao; Mizuno, Norikazu; Iguchi, Satoru; et al.	Nobeyama Radio Observatory/NAOJ Chile Observatory/NAOJ Chile Observatory/et al.	Associate Professor/Associate Professor/ Professor/et al.	FY2016 The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology, Prizes for Science and Technology (Development Category)	2016/4/12
Zenitani, Seiji	Division of Theoretical Astronomy	Assistant Professor	FY2016 The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology, The Young Scientists' Prize	2016/4/21
Tanaka, Masaomi	Division of Theoretical Astronomy	Assistant Professor	FY2016 The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology, The Young Scientists' Prize	2016/4/21
Flaminio, Raffaele; Barton, Mark; et al.	Gravitational Wave Project Office		Special Breakthrough Prize In Fundamental Physics	2016/5/2
Akutsu, Tomotada	Gravitational Wave Project Office	Assistant Professor	Spotlight on Optics (from the Optical Society, OSA)	2016/5/26
Fukagawa, Misato	NAOJ Chile Observatory	Specially Appointed Associate Professor	The 5th NINS Young Researcher's Prize	2016/6/5
Flaminio, Raffaele; et al.	Gravitational Wave Project Office		2016 Gruber Cosmology Prize	2016/7/12
Public Relations Center Web Team	Public Relations Center		WebAward 2016 Best Science Website	2016/9/12
Hara, Hirohisa; Watanabe, Tetsuya; Toriumi, Shin	SOLAR-C Project Office/ Hinode Science Center/ Division of Solar and Plasma Astrophysics	Associate Professor/ Professor/Specially Appointed Assistant Professor	Daiwa Adrian Prize 2016	2016/11/15
Iye, Masanori	TMT-J Project Office	RCUH/Professor emeritus	SPIE FELLOW	2017/1/31
Tanaka, Masaomi	Division of Theoretical Astronomy	Assistant Professor	The 9th Inoue Science Research Award	2017/2/3
CLASP Project Team	SOLAR-C Project Office/ Hinode Science Center		2016 NAOJ Director General Prize	2017/3/7
Nobeyama 45m-Telescope Improvement Team	Nobeyama Radio Observatory/Advanced Technology Center		2016 NAOJ Director General Prize	2017/3/7
Okamoto, Joten	NAOJ Chile Observatory	Specially Appointed Assistant Professor	The 9th SPSS Award	2017/3/9
Nakamura, Koji	Gravitational Wave Project Office	Research Affiliate	Particle Physics Scholarships 11th Seitaro Nakamura Prize	2017/3/17
Hada, Kazuhiro	Mizusawa VLBI Observatory	Assistant Professor	ASJ Young Astronomer Awards 2016	2017/3/17
Takiwaki, Tomoya	Division of Theoretical Astronomy	Assistant Professor	ASJ Young Astronomer Awards 2016	2017/3/17

XI Library, Publications

1. Library

Number of books in each library (2017/3/31)

	Japanese Books	Foreign Books	Total
Mitaka	17,462	45,823	63,285
Okayama	222	3,363	3,585
Nobeyama	1,225	6,294	7,519
Mizusawa	4,972	18,083	23,055
Hawai`i	1,605	4,534	6,139
Total	25,486	78,097	103,583

Number of journal titles in each library (2017/3/31)

	Japanese Journals	Foreign Journals	Total
Mitaka	638	775	1,413
Okayama	4	18	22
Nobeyama	16	82	98
Mizusawa	659	828	1,487
Hawai`i	17	17	34
Total	1,334	1,720	3,054

2. Publication

Here we list continuing publications produced by NAOJ in FY 2016.

Mitaka

01) Report of the National Astronomical Observatory of Japan, Vol. 18: 1 issue
02) Annual Report of the National Astronomical Observatory of Japan (in Japanese), no. 28, Fiscal Year 2015: 1 issue
03) Annual Report of the National Astronomical Observatory of Japan (in English), vol. 18 Fiscal Year 2015: 1 issue
04) National Astronomical Observatory Reprint, No. 2749–2885; 137 issues
05) Calendar and Ephemeris, 2017; 1 issue
06) NAOJ News, No. 273–284; 12 issues
07) Guide to the National Astronomical Observatory of Japan pamphlet (Japanese); 1 issue
08) Guide to the National Astronomical Observatory of Japan pamphlet (English); 1 issue
09) Rikanenpyo (Chronological Scientific Tables), 2017; 1 issue

XII Important Dates

April 1, 2016 – March 31, 2017

2016	
April 2	Spring 2016 Special Stargazing Party held at Okayama Astrophysical Observatory, with 79 visitors in attendance (out of 348 applicants).
April 12	Japanese ALMA Antenna Development Team won Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology (Prizes for Science and Technology, Development Category).
April 17	Seventh Open Observatory event held at the Ibaraki University Center for Astronomy and the NAOJ Mizusawa VLBI Observatory Ibaraki Station, with 348 visitors in attendance.
April 21	The ALMA Observatory issued the ALMA Cycle 4 call for proposals for early scientific observations which starts from October 2016 and received by the deadline a total of 1610 observation proposals from astronomers around the world.
May 7	Subaru Telescope staff interacted with the public during the AstroDay event in a shopping mall in Hilo.
May 17	The Japan-Chile Chamber of Commerce and Industry held its monthly meeting and invited NAOJ Chile Observatory Director Seiichi Sakamoto as a speaker to give a lecture.
May 20	A NAOJ Chile Observatory staff member gave a lecture at the Japanese School of Buenos Aires, Argentina.
May 28	“Starry Sky Photo Session in NAOJ Nobeyama” was held in Nobeyama Radio Observatory. There were 31 participants from many places in Japan.
June 6~ June 10	Observation training of Radio Astronomy at Nobeyama Radio Observatory for Undergraduate Students was performed; there were 12 participants.
June 11	NAOJ and Riken Lecture “Origin of Materials told by the Universe” held at Hitotsubashi Hall with 325 guests in attendance.
Early July	Subaru Telescope staff’s visual work was part of the exhibit at the Tokyo train station during the star festival program.
July 7	A NAOJ Chile Observatory staff member gave a lecture as a Tanabata event at the Japanese School in Santiago.
July 15~ September 18	An exhibit “The Sun” held at the Information Space of Astronomy and Science.
July 17	Star Festival held using the 6-m antenna at the NAOJ Mizusawa VLBI Observatory Kagoshima station in Kagoshima City Kinko Bay Park, co-hosted with Kagoshima City and Kagoshima University, with approximately 200 visitors in attendance.
July 25~July 29	Facility Guide Week for Educational Organization was carried out at Nobeyama Radio Observatory.
July 30	Summer 2016 Special Stargazing Party held at Okayama Astrophysical Observatory, with 81 visitors in attendance (out of 359 applicants).
August 3~ August 5	Chura-boshi Research Team workshop for high school students held at VERA Ishigakijima Station and Ishigakijima Astronomical Observatory, with 15 participants from Ishigakijima,one participant from the main island of Okinawa and one participant from Hyogo Prefecture in attendance. The team using radio-waves couldn't discover anything but the second team using visible light observations with the Murikabushi Telescope discovered 3 candidates.
August 6~ August 14	The Star Festival of the Southern Island 2016 held together with a special open house event at the VERA Ishigakijima Station and Ishigakijima Astronomical Observatory with approximately 11,000 visitors to the whole Star Festival. Events including an astronomical observation party at Ishigakijima Astronomical Observatory, attended by 338 visitors; and a special public opening of the VERA Station attended by 252 visitors.
August 7	Special open house of VERA Iriki station held jointly with the Yaeyama Highland Star Festival 2016, with approximately 4,500 visitors in attendance.
August 8~ August 10	Tenth Z-star Research Team event held for high school students in the six Tohoku prefectures, with 15 participants attending. The participants were divided into two groups, made a astronomical obsevation, and analyzed data using the VERA Mizusawa 20-m radio telescope. However, neither team could find any maser celestial objects.
August 10~ September 6	As a part of the summer student program held by NAOJ and the Department of Astronomical Science of the Graduate University for Advanced Studies (SOKENDAI), two undergraduate students from Kyoto Sangyo University stayed at the Chile Observatory and conducted research with ALMA data.
August 16~ August 17	“Astronomy classes for kids in Summer 2016” held in Mitaka Campus.

August 20	Iwate Galaxy Festival 2016, a special open house day of Mizusawa Campus, held with approximately 2,500 visitors in attendance.
August 20	A lecture “What is the Sun?” held at the Information Space of Astronomy and Science.
August 27	Open House day of Nobeyama Radio Observatory. There were 1,675 visitors for this event.
September 10	Hinode 10th anniversary lecture “Exploring the Universe and the Earth through Solar Observations” held at Nagoya University with 228 guests in attendance.
September 12~ September 17	8 undergraduate students participated in the observation experience program at the Subaru Telescope.
September 15	Mr.Toshiei Mizuochi, State Minister for Ministry of Education, Culture, Sports, Science and Technology visited the Santiago Central Office of the Joint ALMA Observatory.
September 23~ November 6	An exhibit “Mitaka Solar System Walk - Let’s Realize the Size and Distance of Each Planet -” opened at the Information Space of Astronomy and Science.
September 24~ September 26	NAOJ, International Astronomical Union Office for Astronomy Outreach, and Japanese Society for Education and Popularization of Astronomy co-hosted “The 3rd Symposium on Universal Design for Astronomy Education” with 131 guests (including 25 handicapped persons and 15 foreigners).
October 2~ October 4	The 12th Workshop for Popularizing Cutting Edge Astronomy held with the theme of “Gravitational Wave Astronomy” at University of Toyama and the Institute for Cosmic Ray Research, University of Tokyo.
October 12~ November 6	An exhibit “Solar Tower Telescope” opened at the Information Space of Astronomy and Science.
October 21~ October 22	Mitaka Open House Day held, with 4,534 visitors in attendance.
November 17	The Management Agreement Concerning Operations of ALMA was signed by the National Astronomical Observatory of Japan, the Associated Universities Inc., and the European Southern Observatory in the Santiago Central Office of the Joint ALMA Observatory.
November 21	A ceremony for FY 2016 continuous service recognition was held. 10 NAOJ staff members were recognized: Hitoshi Yamaoka, George Kosugi, Satoshi Miyazaki, Fumitaka Nakamura, Tadafumi Takata, Hiroshi Araki, Tomofumi Umemoto, Yoji Seto, Hiroyuki Narisawa, and Tatsuya Todoriki.
November 23	The first “Nagano is Astro-Prefecture” meeting was held in Matsumoto Campus of Shinshu University by the executive committee consisting of staff members of Nobeyama Radio Observatory, Kiso Observatory in the University of Tokyo, Shinshu University, and so on.There were about 100 participants.
November 23	The Subaru Telescope/Shinshu University public lecture “From Shinshu via Hawai`i, a galactic Research Journey” held at Shinshu University with 350 guests in attendance.
November 26	NAOJ lecture meeting/22nd ALMA public lecture “The Birth of Stars and Planets Explored by ALMA” held at Nagoya City Science Museum with 225 guests in attendance.
November 27	“The Subaru Telescope/Hiroshima University public lecture” held at Hiroshima Children's Museum.

2017

January 6~ January 10	Graduate students from the Department of Astronomical Science, SOKENDAI (Graduate University for Advanced Studies) and astronomy major students from the University of Hawai‘i at Hilo worked together to observe with the Subaru Telescope.
January 14	Honorable Hirokazu Matsuno, the minister of the Ministry of Education, Culture, Sports, Science and Technology - Japan, visited the Subaru Telescope’s facilities at Hilo and Maunakea.
January 26	NAOJ Chile Observatory staff members visited a summer camp held by Santiago Japanese School to give a lecture.
January 28	Staff of the Subaru Telescope held science workshops and put on an interactive booth at the annual Onizuka Science Day at the University of Hawai‘i at Hilo.
February 11	“Jimoto kansha Day (Thanks Day for the locals)” was held at the Vegetaball With hosted by Shinshu University. It was carried out by 3 Nobeyama Institutes (Tsukuba and Shinshu Universities and Nobeyama Radio Observatory). There were 45 participants.
February 12	Star Island 16 open house event of VERA Ogasawara Station held, with 227 visitors in attendance (more than the average year).
March 2~ March 3	NAOJ/The International Planetarium Society (IPS) and others co-hosted the “Data to Dome Workshop” with 52 guests from 8 oversea countries in attendance.
March 5	The 23rd NINS Symposium “Frontiers of Modern Astronomy: a Second Earth and the Dark Universe” held at Tokyo International Exchange Center (TIEC) with 273 guests in attendance.
March 13~ March 17	Staff of the Subaru Telescope and TMT-J Project Office visited classes in the public schools in Hilo and vicinity during the Journey through the Universe program.

March 31	A ceremony for FY 2016 continuous service recognition for retiring staff members was held. 5 staff members were recognized: Yoshihiko Mizumoto, Nobuo Arimoto, Yukiyasu Kobayashi, Motokazu Noguchi, and Matsuo Watanabe.
Throughout the year	NAOJ staff participated in the “Fureai (Friendly) Astronomy” program by visiting schools to talk about their work and the telescope. This outreach program started seven years ago and was spearheaded by Dr. Nobuo Arimoto, the Director of the Subaru Telescope.

XIII Publications, Presentations

1. Refereed Publications

Abbott, B. P., et al. including **Tanaka, M.**, **Yanagisawa, K.**: 2016, Localization and Broadband Follow-up of the Gravitational-wave Transient GW150914, *ApJL*, **826**, L13.

Abbott, B. P., et al. including **Tanaka, M.**, **Yanagisawa, K.**: 2016, Supplement: "Localization and Broadband Follow-up of the Gravitational-wave Transient GW150914" (2016, ApJL, 826, L13), *ApJS*, **225**, 8.

Abbott, B. P., et al. including **Flaminio, R.**: 2016, Upper Limits On The Rates of Binary Neutron Star and Neutron Star-black Hole Mergers from Advanced Ligo's First Observing Run, *ApJL*, **832**, L21.

Abbott, B. P., et al. including **Flaminio, R.**: 2016, Supplement: "The Rate of Binary Black Hole Mergers Inferred from Advanced Ligo Observations Surrounding GW150914" (2016, ApJL, 833, L1), *ApJS*, **227**, 14.

Abbott, B. P., et al. including **Flaminio, R.**: 2016, Characterization of Transient Noise in Advanced LIGO Relevant to Gravitational Wave Signal GW150914, *Classical Quant. Grav.*, **33**, 134001.

Abbott, B. P., et al. including **Flaminio, R.**: 2016, GW150914: First Results from the Search for Binary Black Hole Coalescence with Advanced LIGO, *Phys. Rev. D*, **93**, 122003.

Abbott, B. P., et al. including **Flaminio, R.**: 2016, Observing Gravitational-Wave Transient GW150914 with Minimal Assumptions, *Phys. Rev. D*, **93**, 122004.

Abbott, B. P., et al. including **Flaminio, R.**: 2016, Search for Transient Gravitational Waves in Coincidence with Short-duration Radio Transients during 2007-2013, *Phys. Rev. D*, **93**, 122008.

Abbott, B. P., et al. including **Flaminio, R.**: 2016, High-energy Neutrino Follow-up Search of Gravitational Wave Event GW150914 with ANTARES and IceCube, *Phys. Rev. D*, **93**, 122010.

Abbott, B. P., et al. including **Flaminio, R.**: 2016, Comprehensive All-sky Search for Periodic Gravitational Waves in the Sixth Science Run LIGO Data, *Phys. Rev. D*, **94**, 042002.

Abbott, B. P., et al. including **Flaminio, R.**: 2016, Directly Comparing GW150914 with Numerical Solutions of Einstein's Equations for Binary Black Hole Coalescence, *Phys. Rev. D*, **94**, 064035.

Abbott, B. P., et al. including **Flaminio, R.**: 2016, First Targeted Search for Gravitational-wave Bursts from Core-collapse Supernovae in Data of First-generation Laser Interferometer Detectors, *Phys. Rev. D*, **94**, 102001.

Abbott, B. P., et al. including **Flaminio, R.**: 2016, Properties of the Binary Black Hole Merger GW150914, *Phys. Rev. Let.*, **116**, 241102.

Abbott, B. P., et al. including **Flaminio, R.**: 2016, GW151226: Observation of Gravitational Waves from a 22-Solar-Mass Binary Black Hole Coalescence, *Phys. Rev. Let.*, **116**, 241103.

Abbott, B. P., et al. including **Flaminio, R.**: 2016, Tests of General Relativity with GW150914, *Phys. Rev. Let.*, **116**, 221101.

Abbott, B. P., et al. including **Flaminio, R.**: 2016, Binary Black Hole Mergers in the First Advanced LIGO Observing Run, *Phys. Rev. X*, **6**, 041015.

Abbott, B. P., et al. including **Flaminio, R.**: 2016, Improved Analysis of GW150914 Using a Fully Spin-Precessing Waveform Model, *Phys. Rev. X*, **6**, 041014.

Abbott, B. P., et al. including **Flaminio, R.**: 2017, The Basic Physics of the Binary Black Hole Merger GW150914, *Ann. Phys.-Berlin*, **529**, 1600209.

Abbott, B. P., et al. including **Flaminio, R.**: 2017, All-sky Search for Short Gravitational-wave Bursts in the First Advanced LIGO Run, *Phys. Rev. D*, **95**, 042003.

Abbott, B. P., et al. including **Flaminio, R.**: 2017, Upper Limits on the Stochastic Gravitational-Wave Background from Advanced LIGO's First Observing Run, *Phys. Rev. Let.*, **118**, 121101.

Abbott, B. P., et al. including **Flaminio, R.**: 2017, Directional Limits on Persistent Gravitational Waves from Advanced LIGO's First Observing Run, *Phys. Rev. Let.*, **118**, 121102.

Akiyama, E., et al. including **Hashimoto, J.**, **Hasegawa, Y.**, **Kudo, T.**, **Kusakabe, N.**, **Kuzuhara, M.**, **Ohashi, N.**, **Egner, S.**, **Guyon, O.**, **Hayano, Y.**, **Hayashi, M.**, **Hayashi, S. S.**, **Ishii, M.**, **Iye, M.**, **Kandori, R.**, **Morino, J.**, **Nishimura, T.**, **Pyo, T.**, **Suenaga, T.**, **Suto, H.**, **Suzuki, R.**, **Takahashi, Y. H.**, **Takato, N.**, **Terada, H.**, **Tomono, D.**, **Takami, H.**, **Usuda, T.**, **Tamura, M.**: 2016, Spiral Structure and Differential Dust Size Distribution in the LKHα 330 Disk, *AJ*, **152**, 222.

Akiyama, K., **Kuramochi, K.**, **Ikeda, S.**, Fish, V. L., **Tazaki, F.**, **Honma, M.**, Doeleman, S. S., Broderick, A. E., Dexter, J., Mościbrodzka, M., Bouman, K. L., Chael, A. A., Zaizen, M.: 2017, Imaging the Schwarzschild-radius-scale Structure of M87 with the Event Horizon Telescope Using Sparse Modeling, *ApJ*, **838**, 1.

Akiyama, K., Stawarz, L., Tanaka, Y. T., **Nagai, H.**, Giroletti, M., **Honma, M.**: 2016, EVN Observations of HESS J1943+213: Evidence for an Extreme TeV BL Lac Object, *ApJL*, **823**, L26.

Akutsu, T., Saito, Y., Sakakibara, Y., Sato, Y., **Niwa, Y.**, Kimura, N., Suzuki, T., Yamamoto, K., Tokoku, C., Koike, S., Chen, D., **Zeidler, S.**, Ikeyama, K., Ariyama, Y.: 2016, Vacuum and Cryogenic Compatible Black Surface for Large Optical Baffles in Advanced Gravitational-wave Telescopes, *Opt. Mater. Exp.*, **6**, 1613

Alexander, D. M., et al. including **Matsuda, Y.**: 2016, ALMA Observations of a $z \approx 3.1$ Protocluster: Star Formation from Active Galactic Nuclei and Lyman-alpha Blobs in an Overdense Environment, *MNRAS*, **461**, 2944–2952.

Alonso-Herrero, A., et al. including **Packham, C.**, **Ichikawa, K.**, **Imanishi, M.**: 2016, The Complex Evolutionary Paths of Local Infrared Bright Galaxies: A High-angular Resolution Mid-infrared View, *MNRAS*, **463**, 2405–2424.

Arai, A., Kawakita, H., **Shinnaka, Y.**, **Tajitsu, A.**: 2016, Origins of Absorption Systems of Classical Nova V2659 CYG (NOVA CYG 2014), *ApJ*, **830**, 30.

Arai, H., et al. including **Fujita, S.**, **Yamauchi, A.**, **Kaneko, H.**, **Miyamoto, Y.**: 2016, A Multi-Line Ammonia Survey of the Galactic Center Region with the Tsukuba 32 m Telescope. I. Observations and Data, *PASJ*, **68**, 76.

Araki, H., **Kashima, S.**, **Noda, H.**, Kunimori, H., Chiba, K., Mashiko, H., Kato, H., Otsubo, T., Matsumoto, Y., **Tsuruta, S.**, **Asari, K.**, **Hanada, H.**, Yasuda, S., **Utsunomiya S.**, Takino, H.: 2016, Thermo-optical

Simulation and Experiment for the Assessment of Single, Hollow, and Large Aperture Retroreflector for lunar Laser Ranging, *Earth Planets Space*, **68**, 101.

Asahina, Y., **Kawashima, T.**, Furukawa, N., Enokiya, R., Yamamoto, H., Fukui, Y., Matsumoto, R.: 2017, Magnetohydrodynamic Simulations of the Formation of Molecular Clouds toward the Stellar Cluster Westerlund 2: Interaction of a Jet with a Clumpy Interstellar Medium, *ApJ*, **836**, 213.

Asensio-Torres, R., et al. including **Currie, T.**, **Kudo, T.**, **Akiyama, E.**, **Egner, S.**, **Guyon, O.**, **Hayano, Y.**, **Hayashi, M.**, **Hayashi, S. S.**, **Ishii, M.**, **Iye, M.**, **Kandori, R.**, **Morino, J.-I.**, **Nishimura, T.**, **Pyo, T.-S.**, **Serabyn, E.**, **Suto, H.**, **Suzuki, R.**, **Takahashi, Y.**, **Takato, N.**, **Terada, H.**, **Takami, H.**, **Usuda, T.**, **Tamura, M.**: 2016, Polarimetry and Flux Distribution in the Debris Disk around HD 32297, *A&A*, **593**, A73.

Baba, J., **Morokuma-Matsui, K.**, **Miyamoto, Y.**, **Egusa, F.**, Kuno, N.: 2016, Gas Velocity Patterns in Simulated Galaxies: Observational Diagnostics of Spiral Structure Theories, *MNRAS*, **460**, 2472–2481.

Baba, J., **Morokuma-Matsui, K.**, Saitoh, T. R.: 2017, Eventful Evolution of Giant Molecular Clouds in Dynamically Evolving Spiral Arms, *MNRAS*, **464**, 246–263.

Barnes, P. J., Hernandez, A. K., O'Dougherty, S. N., Schap, W. J., III, **Muller, E.**: 2016, The Galactic Census of High- and Medium-mass Protostars. III. ^{12}CO Maps and Physical Properties of Dense Clump Envelopes and Their Embedding GMCs, *ApJ*, **831**, 67.

Beaulieu, J.-P., et al. including **Fukui, A.**: 2016, Revisiting the Microlensing Event OGLE 2012-BLG-0026: A Solar Mass Star with Two Cold Giant Planets, *ApJ*, **824**, 83.

Bekki, K., **Tsujimoto, T.**: 2016, Formation of Anomalous Globular Clusters with Metallicity Spreads: A Unified Picture, *ApJ*, **831**, 70.

Beltran, M. T., Cesaroni, R., Moscadelli, L., Sanchez-Monge, A., **Hirota, T.**, Kumar, M. S. N.: 2016, Binary System and Jet Precession and Expansion in G35.20-0.74N, *A&A*, **593**, A49.

Bennett, D. P., et al. including **Fukui, A.**: 2016, The First Circumbinary Planet Found by Microlensing: OGLE-2007-BLG-349L(AB)c, *AJ*, **152**, 125.

Bertulani, C. A., **Kajino, T.**: 2016, Frontiers in Nuclear Astrophysics, *Prog. Part. Nucl. Phys.*, **89**, 56–100.

Beuther, H., et al. including **Nguyen-Luong, Q.**: 2016, The HI/OH/Recombination Line Survey of the Inner Milky Way (THOR) Survey Overview and Data Release 1, *A&A*, **595**, A32.

Bhattacharya, A., et al. including **Fukui, A.**: 2016, Discovery of a Gas Giant Planet in Microlensing Event OGLE-2014-BLG-1760, *AJ*, **152**, 140.

Boissier, S., Boselli, A., Ferrarese, L., Cote, P., Roehlly, Y., Gwyn, S. D. J., Cuillandre, J. C., Roediger, J., **Koda, J.**, Mateos, J. C. M., de Paz, A. G., Madore, B. F.: 2016, The Properties of the Malin 1 Galaxy Giant Disk A Panchromatic View from the NGVS and GUViCS Surveys, *A&A*, **593**, A126.

Bonvin, V., et al. including **Wong, K. C.**: 2017, H0LiCOW - V. New COSMOGRAIL Time Delays of HE 0435-1223: H0to 3.8 per cent Precision from Strong Lensing in a Flat ΛCDM Model, *MNRAS*, **465**, 4914-4930.

Bourrier, V., Lecavelier des Etangs, A., Ehrenreich, D., **Tanaka, Y. A.**, Vidotto, A. A.: 2016, An Evaporating Planet in the Wind: Stellar Wind Interactions with the Radiatively Braked Exosphere of GJ436 b, *A&A*, **591**, A121.

Brammer, G. B., et al. including **Tanaka, M.**, **Ferré-Mateu, A.**, **Kodama, T.**: 2016, Ultra-deep Ks-band Imaging of the Hubble Frontier Fields, *ApJS*, **226**, 6.

Broderick, J. W., et al. including **Kuniyoshi, M.**: 2016, Low-radio-frequency Eclipses of the Redback Pulsar J2215+5135 Observed in the Image Plane with LOFAR, *MNRAS*, **459**, 2681–2689.

Burns, R. A., Handa, T., **Nagayama, T.**, **Sunada, K.**, Omodaka, T.: 2016, H_2O Masers in a Jet-driven Bow Shock: Episodic Ejection from a Massive Young Stellar Object, *MNRAS*, **460**, 283–290.

Cabezas, D. P., Martinez, L. M., Buleje, Y. J., Ishitsuka, M., Ishitsuka, J. K., **Morita, S.**, Asai, A., UeNo, S., Ishii, T. T., Kitai, R., Takasao, S., Yoshinaga, Y., Otsuji, K., Shibata, K.: 2017, Dandelion Filament Eruption and Coronal Waves Associated with a Solar Flare on 2011 February 16, *ApJ*, **836**, 33.

Cai, Z., Fan, X., Yang, Y., Bian, F., Prochaska, J. X., Zabludoff, A., McGreer, I., Zheng, Z.-Y., Green, R., Cantalupo, S., Frye, B., Hamden, E., Jiang, L., **Kashikawa, N.**, Wang, R.: 2017, Discovery of an Enormous Lyα Nebula in a Massive Galaxy Overdensity at $z = 2.3$, *ApJ*, **837**, 71.

Capocasa, E., Barsuglia, M., Degallaix, J., Pinard, L., Straniero, N., Schnabel, R., Somiya, K., **Aso, Y.**, **Tatsumi, D.**, **Flaminio, R.**: 2016, Estimation of Losses in a 300 m Filter Cavity and Quantum Noise Reduction in the KAGRA Gravitational-wave Detector, *Phys. Rev. D*, **93**, 082004.

Chaikovska, I., et al. including **Flaminio, R.**: 2016, High Flux Circularly Polarized Gamma Beam Factory: Coupling a Fabry-Perot Optical Cavity with an Electron Storage Ring, *Sci. Rep.*, **6**, 36569.

Chan, J. H. H., Suyu, S. H., More, A., Oguri, M., Chiueh, T., Coupon, J., Hsieh, B.-C., **Komiyama, Y.**, **Miyazaki, S.**, Murayama, H., Nishizawa, A. J., Price, P., **Tait, P. J.**, **Terai, T.**, Utsumi, Y., Wang, S.-Y.: 2016, Galaxy-scale Gravitational Lens Candidates from the Hyper Suprime-Cam Imaging Survey and the Galaxy And Mass Assembly Spectroscopic Survey, *ApJ*, **832**, 135.

Chen, G. C. F., Suyu, S. H., **Wong, K. C.**, Fassnacht, C. D., Chiueh, T., Halkola, A., Hu, I. S., Auger, M. W., Koopmans, L. V. E., Lagattuta, D. J., McKean, J. P., Vegetti, S.: 2016, SHARP - III. First Use of Adaptive-optics Imaging to Constrain Cosmology with Gravitational Lens Time Delays, *MNRAS*, **462**, 3457–3475.

Chen, K.-J., Woosley, S., Skubold, T.: 2016, Magnetar-Powered Supernovae in Two Dimensions. I. Superluminous Supernovae, *ApJ*, **832**, 73.

Chen, Z. W., Zhang, S. B., Zhang, M. M., Jiang, Z. B., **Tamura, M.**, Kwon, J.: 2016, Coeval Intermediate-mass Star Formation in N4W, *ApJ*, **822**, 114.

Chibueze, J. O., Csengeri, T., **Tatematsu, K.**, **Hasegawa, T.**, **Iguchi, S.**, Alhassan, J. A., Higuchi, A. E., Bontemps, S., Menten, K. M.: 2017, Class II 6.7 GHz Methanol Maser Association with Young Massive Cores Revealed by ALMA, *ApJ*, **836**, 59.

Chibueze, J. O., Kamezaki, T., Omodaka, T., Handa, T., **Nagayama, T.**, Baba, T., **Sunada, K.**, **Shizugami, M.**, Burns, R. A., **Honma, M.**, Ubachukwu, A. A., Chukwude, A. E., Alhassan, J. A.: 2016, Astrometry and Expanding Bubble of a Deeply Embedded Young Stellar Object in M17, *MNRAS*, **460**, 1839–1845.

Currie, T., et al. including **Guyon, O.**, **Tamura, M.**, **Kudo, T.**, **Jovanovic, N.**, **Lozi, J.**, **Kuzuhara, M.**, **Akiyama, E.**, **Hayashi, S. S.**, **Yang, Y.**: 2017, Subaru/SCExAO First-light Direct Imaging of a Young Debris Disk around HD 36546, *ApJL*, **836**, L15.

Dai, F., et al. including **Narita, N.**: 2016, Doppler Monitoring of Five K2 Transiting Planetary Systems, *ApJ*, **823**, 115.

Darnley, M. J., et al. including **Maehara, H.**: 2016, M31N 2008-12a - The Remarkable Recurrent Nova in M31: Panchromatic Observations of the 2015 Eruption, *ApJ*, **833**, 149.

De Looze, I., Baes, M., Cormier, D., **Kaneko, H.**, Kuno, N., Young, L., Bendo, G. J., Boquien, M., Fritz, J., Gentile, G., Kennicutt, R. C., Madden, S. C., Smith, M. W. L., and Wilson, C. D.: 2017, The Interstellar Medium in Andromeda's Dwarf Spheroidal Galaxies: II. Multi-Phase Gas Content and ISM Conditions, *NMRAS*, **465**, 3741–3758.

Ding, X., et al. including **Wong, K. C.**: 2017, H0LiCOW. VI. Testing the Fidelity of Lensed Quasar Host Galaxy Reconstruction, *MNRAS*, **465**, 4634–4649.

Doi, A., **Oyama, T.**, **Kono, Y.**, **Yamauchi, A.**, **Suzuki, S.**, **Matsumoto, N.**, **Tazaki, F.**: 2016, A radio detection survey of narrow-line Seyfert 1 galaxies using very long baseline interferometry at 22 GHz, *PASJ*, **68**, 73.

Dong, R., et al. including **Hashimoto, J.**, **Akiyama, E.**, **Kudo, T.**, **Tamura, M.**: 2017, The Sizes and Depletions of the Dust and Gas Cavities in the Transitional Disk J160421.7-213028, *ApJ*, **836**, 201.

Draper, Z. H., et al. including **Bulger, J.**: 2016, The Peculiar Debris Disk of Hd 111520 as Resolved by the Gemini Planet Imager, *ApJ*, **826**, 147.

Egusa, F., Mentuch Cooper, E., **Koda, J.**, Baba, J.: 2017, Gas and Stellar Spiral Aarms and Their Offsets in the Grand-Design Spiral Galaxy M51, *MNRAS*, **465**, 460–471.

Egusa, F., Usui, F., Murata, K., Yamashita, T., Yamamura, I., Onaka, T.: 2016, Revised Calibration for Near- and Mid-infrared Images from ~4000 Pointed Observations with AKARI/IRC, *PASJ*, **68**, 19.

Ezawa, H., **Matsuo, H.**, Ukibe, M., Fujii, G., Shiki, S.: 2016, SIS Detectors for Terahertz Photon Counting System, *J. Low Temp. Phys.*, **184**, 244–249.

Fagioli, M., Carollo, C. M., Renzini, A., Lilly, S. J., **Onodera, M.**, Tacchella, S.: 2016, Minor Mergers or Progenitor Bias? The Stellar Ages of Small and Large Quenched Galaxies, *ApJ*, **831**, 173.

Faisst, A. L., Capak, P. L., Davidzon, I., Salvato, M., Laigle, C., Ilbert, O., Onodera, M., Hasinger, G., **Kakazu, Y.**, Masters, D., McCracken, H. J., Mobasher, B., Sanders, D., Silverman, J. D., Yan, L., Scoville, N. Z.: 2016, Rest-UV Absorption Lines as Metallicity Estimator: The Metal Content of Star-forming Galaxies at $z \sim 5$, *ApJ*, **822**, 29.

Famiano, M. A., Balantekin, A. B., **Kajino, T.**: 2016, Low-lying Resonances and Relativistic Screening in Big Bang Nucleosynthesis, *Phys. Rev. C*, **93**, 045804.

Famiano, M. A., **Kajino, T.**, **Aoki, W.**, Suda, T.: 2016, Dependence of the Sr-to-Ba and Sr-to-Eu Ratio on the Nuclear Equation of State in Metal-Poor Halo Stars, *ApJ*, **830**, 61.

Finet, F., Surdej, J.: 2016, Multiply Imaged Quasi-stellar Objects in the Gaia Survey, *A&A*, **590**, A42.

Fissel, L. M., et al. including **Nakamura, F.**: 2016, Balloon-Borne Submillimeter Polarimetry of the Vela C Molecular Cloud: Systematic Dependence of Polarization Fraction on Column Density and Local Polarization-Angle Dispersion, *ApJ*, **824**, 134.

Fujii, Y., **Kojima, T.**, **Gonzalez, A.**, **Asayama, S.**, **Kroug, M.**, **Kaneko, K.**, Ogawa, H., **Uzawa, Y.**: 2016, Low-Noise Integrated Balanced SIS Mixer for 787–950 GHz, *Supercond. Sci. Technol.*, **30**, 024001.

Fujinaga, Y., Niinuma, K., Kimura, A., **Fujisawa, K.**, **Oyama, T.**, **Mizuno, S.**, **Kono, Y.**, Takemura, S., Sawada-Satoh, S., Akutagawa, K., Sugiyama, K., **Motogi, K.**, Fukuzaki, Y.: 2016, The Discovery of New AGN Candidates within the Field of Fermi Unassociated γ-ray Sources, *PASJ*, **68**, 70.

Fujita, Y., **Nagai, H.**: 2017, Discovery of a New Subparsec Counterjet in NGC 1275: The Inclination Angle and the Environment, *MNRAS Lett.*, **465**, L94–L98.

Fujiwara, H., Morishima, R., **Fujiyoshi, T.**, **Yamashita, T.**: 2017, Seasonal Variation of the Radial Brightness Contrast of Saturn's Rings Viewed in Mid-infrared by Subaru/COMICS, *A&A*, **599**, A29.

Fukui, A., Livingston, J., **Narita, N.**, Hirano, T., **Onitsuka, M.**, **Ryu, T.**, **Kusakabe, N.**: 2016, Ground-based Transit Observation of the Habitable-zone Super-Earth K2-3d, *AJ*, **152**, 171.

Fukushima, T.: 2016, Zonal Toroidal Harmonic Expansions Of External Gravitational Fields For Ring-Like Objects, *AJ*, **152**, 35.

Fukushima, T.: 2016, Rectangular Rotation of Spherical Harmonic Expansion of Arbitrary High Degree and Order, *J. Geodesy*, **91**, 995–1011.

Fukushima, T.: 2016, Mosaic Tile Model to Compute Gravitational Field for Infinitely Thin Non-axisymmetric Objects and Its Application to Preliminary Analysis of Gravitational Field of M74, *MNRAS*, **459**, 3825–3860.

Fukushima, T.: 2016, Numerical Computation of Gravitational Field for General Axisymmetric Objects, *MNRAS*, **462**, 2138–2176.

Fukushima, T.: 2016, Numerical Integration of Gravitational Field for General Three-dimensional Objects and its Application to Gravitational Study of Grand Design Spiral Arm Structure, *MNRAS*, **463**, 1500–1517.

Fuller, L., Lopez-Rodriguez, E., **Packham, C.**, Ramos-Almeida, C., Alonso-Herrero, A., Levenson, N. A., Radomski, J., **Ichikawa, K.**, García-Bernete, I., González-Martín, O., Díaz-Santos, T., Martínez-Paredes, M.: 2016, Investigating the Dusty Torus of Seyfert Galaxies Using SOFIA/FORCAST Photometry, *MNRAS*, **462**, 2618–2630.

Furusawa, H., **Kashikawa, N.**, Kobayashi, M. A. R., Dunlop, J. S., Shimasaku, K., **Takata, T.**, **Sekiguchi, K.**, Naito, Y., **Furusawa, J.**, Ouchi, M., **Nakata, F.**, Yasuda, N., Okura, Y., Taniguchi, Y., Yamada, T., Kajisawa, M., Fynbo, J. P. U., Le Fèvre, O.: 2016, A New Constraint on the Lyα Fraction of UV Very Bright Galaxies at Redshift 7, *ApJ*, **822**, 46.

Gaidos, E., Mann, A. W., Rizzuto, A., Nofi, L., Mace, G., Vanderburg, A., Feiden, G., **Narita, N.**, **Takeda, Y.**, Esposito, T. M., De Rosa, R. J., Ansdell, M., Hirano, T., Graham, J. R., Kraus, A., Jaffe, D.: 2017, Zodiacal exoplanets in time (ZEIT) - II. A 'super-Earth' Orbiting a Young K Dwarf in the Pleiades Neighbourhood, *MNRAS*, **464**, 850–862.

Gandilo, N. N., et al. including **Nakamura, F.**: 2016, Submillimeter Polarization Spectrum in the Vela C Molecular Cloud, *ApJ*, **824**, 84.

Garcia, E. V., et al. including **Currie, T.**, **Guyon, O.**, **Jovanovic, N.**, **Lozi, J.**, **Kudo, T.**, **Kuzuhara, M.**, **Hashimoto, J.**, **Kusakabe, N.**, **Hayano, Y.**, **Hayashi, M.**, **Hayashi, S. S.**, **Ishii, M.**, **Iye, M.**, **Kandori, R.**, **Morino, J.-I.**, **Nishimura, T.**, **Pyo, T.-S.**, **Suenaga, T.**, **Suto, H.**, **Suzuki, R.**, **Takahashi, Y. H.**, **Takami, H.**, **Takato, N.**, **Terada, H.**, **Usuda, T.**, **Tamura, M.**: 2017, SCExAO and GPI Y JHBand Photometry and Integral Field Spectroscopy of the Young Brown Dwarf Companion to HD 1160, *ApJ*, **834**, 162.

García-Bernete, I., Ramos Almeida, C., Acosta-Pulido, J. A., Alonso-Herrero, A., González-Martín, O., Hernán-Caballero, A., Pereira-Santaella, M., Levenson, N. A., **Packham, C.**, Perlman, E. S., **Ichikawa, K.**, Esquej, P., Díaz-Santos, T.: 2016, The Nuclear and Extended Mid-infrared Emission of Seyfert Galaxies, *MNRAS*, **463**, 3531–3555.

García-González, J., Alonso-Herrero, A., Hernán-Caballero, A., Pereira-Santaella, M., Ramos-Almeida, C., Acosta-Pulido, J. A., Díaz-Santos, T., Esquej, P., González-Martín, O., **Ichikawa, K.**, López-Rodríguez, E., Povic, M., Roche, P. F., Sánchez-Portal, M.: 2016, The Nuclear and Integrated Far-infrared Emission of Nearby Seyfert Galaxies, *MNRAS*, **458**, 4512–4529.

Geach, J. E., et al. including **Matsuda, Y.**, **Ao, Y.**, **Kubo, M.**: 2016, ALMA Observations of Ly*α* Blob 1: Halo Substructure Illuminated from Within, *ApJ*, **832**, 37.

Giannini, E., et al. including **Finet, F.**: 2017, MiNDSTEp Differential Photometry of the Gravitationally Lensed Quasars WFI 2033-4723 and HE 0047-1756: Microlensing and a New Time Delay, *A&A*, **597**, A49.

Giono, G., et al. including **Ishikawa, R.**, **Narukage, N.**, **Kano, R.**, **Katsukawa, Y.**, **Kubo, M.**, **Bando, T.**, **Hara, H.**, **Suematsu, Y.**: 2017, Polarization Calibration of the Chromospheric Lyman-Alpha SpectroPolarimeter for a 0.1 % Polarization Sensitivity in the VUV Range. Part II: In-Flight Calibration, *Sol. Phys.*, **292**, 57.

Giono, G., **Ishikawa, R.**, **Narukage, N.**, **Kano, R.**, **Katsukawa, Y.**, **Kubo, M.**, Ishikawa, S., **Bando, T.**, **Hara, H.**, **Suematsu, Y.**, Winebarger, A., Kobayashi, K., Auchere, F., Bueno, J. T.: 2016, Polarization Calibration of the Chromospheric Lyman-Alpha SpectroPolarimeter for a 0.1 % Polarization Sensitivity in the VUV Range. Part I: Pre-flight Calibration, *Sol. Phys.*, **291**, 3831.

Giroletti, M., Marcote, B., Garrett, M. A., Paragi, Z., Yang, J., **Hada, K.**, Muxlow, T. W. B., Cheung, C. C.: 2016, FRB 150418: Clues to Its Nature from European VLBI Network and e-MERLIN Observations, *A&A*, **593**, L16.

Gobat, R., Daddi, E., Strazzullo, V., Garilli, B., Mignoli, M., Ma, Z., Jin, S., Maraston, C., Magdis, G., Béthermin, M., Cappellari, M., Carollo, M., Cimatti, A., Feruglio, C., Moresco, M., **Onodera, M.**, Pozzetti, L., **Renzini, A.**, Sargent, M., Valentino, F., Zanella, A.: 2017, In and Out Star Formation in $z \sim 1.5$ Quiescent Galaxies from Rest-frame UV Spectroscopy and the Far-infrared, *A&A*, **599**, A95.

Gonzalez, A., **Kaneko, K.**, **Kojima, T.**, **Asayama, S.**, **Uzawa, Y.**: 2017, Terahertz Corrugated Horns (1.25–1.57 THz): Design, Gaussian Modeling, and Measurements, *IEEE Trans. Terahertz Science and Technology*, **7**, 42–52.

Gonzalez, A.: 2016, Probe Characterization in Terahertz Near-Field Beam Measurement Systems, *IEEE Trans. Terahertz Science and Technology*, **6**, 824–831.

Gordon, K. D., et al. includiong **Kawamura, A.**: 2017, Dust and Gas in the Magellanic Clouds from the HERITAGE Herschel Key Project. I. Dust Properties and Insights into the Origin of the Submm Excess Emission, *ApJ*, **837**, 98.

Gozaliasl, G., Finoguenov, A., Khosroshahi, H. G., Mirkazemi, M., Erfanianfar, G., **Tanaka, M.**: 2016, Brightest Group Galaxies: Stellar Mass and Star Formation Rate (paper I), *MNRAS*, **458**, 2762–2775.

Gratier, P., Majumdar, L., **Ohishi, M.**, Roueff, E., Loison, J. C., Hickson, K. M., Wakelam, V.: 2016, A New Reference Chemical Composition for TMC-1, *ApJS*, **225**, 25.

Gu, L., Wen, Z., Gandhi, P., Inada, N., Kawaharada, M., **Kodama, T.**, Konami, S., Nakazawa, K., Xu, H., Makishima, K.: 2016, Galaxy Infall by Interacting with Its Environment: A Comprehensive Study of 340 Galaxy Clusters, *ApJ*, **826**, 72.

Hada, K.: 2017, The Structure and Propagation of the Misaligned Jet M87, *Galaxies*, **5**, 2.

Hagiwara, Y., Horiuchi, S., Doi, A., **Miyoshi, M.**, Edwards, P. G.: 2016, A Search for Submillimeter H_2O Masers in Active Galaxies:. The Detection of 321 GHz H_2O Maser Emission in NGC 4945, *ApJ*, **827**, 69.

Harada, Y., Goossens, S., **Matsumoto, K.**, Yan, J., Ping, J., **Noda, H.**, Haruyama, J.: 2016, The Deep Lunar Interior with a Low-viscosity Zone: Revised Constraints from Recent Geodetic Parameters on the Tidal Response of the Moon, *Icarus*, **276**, 96–101.

Harikane, Y., Ouchi, M., Ono, Y., More, S., Saito, S., Lin, Y.-T., Coupon, J., Shimasaku, K., Shibuya, T., Price, P. A., Lin, L., Hsieh, B.-C., Ishigaki, M., **Komiyama, Y.**, Silverman, J., **Takata, T.**, Tamazawa, H., **Toshikawa, J.**: 2016, Evolution of Stellar-to-Halo Mass Ratio at z = 0–7 Identified by Clustering Analysis with the Hubble Legacy Imaging and Early Subaru/Hyper Suprime-Cam Survey Data, *ApJ*, **821**, 123.

Harra, L. K., Schrijver, C. J., Janvier, M., Toriumi, S., Hudson, H., Matthews, S., Woods, M. M., **Hara, H.**, Guedel, G., Kowalski, A., Osten, R., Kusano, K., Lueftinger, T.: 2016, The Characteristics of Solar X-Class Flares and CMEs: A Paradigm for Stellar Superflares and Eruptions?, *Sol. Phys.*, **291**, 1761–1782.

Hasegawa, H., et al. including **Zenitani, S.**: 2016, Decay of Mesoscale Flux Transfer Events during Quasi-continuous Spatially-extended Reconnection at the Magnetopause, *Geophys. Res. Lett.*, **43**, 4375–4763.

Hasegawa, Y., Harada, R., **Tokuda, K.**, Kimura, K., Ogawa, H., Onishi, T., Nishimura, A., Han, J., Inoue, M.: 2017, A New Approach to Suppress the Effect of Machining Error for Waveguide Septum Circular Polarizer at 230 GHz Band in Radio Astronomy, *J. Infrared, Millimeter, and Terahertz Waves*, **38**, 638–652.

Hatsukade, B., Kohno, K., Umehata, H., Aretxaga, I., Caputi, K., Dunlop, J., Ikarashi, S., **Iono, D.**, Ivison, R., **Lee, M.**, Makiya, R., **Matsuda, Y.**, Motohara, K., **Nakanishi, K.**, Ohta, K., Tadaki, K., Tamura, Y., Wang, W.-H., Wilson, G., Yamaguchi, Y., Yun, M.: 2016, SXDF-ALMA 2-arcmin2 Deep Survey: 1.1-mm Number Counts, *PASJ*, **68**, 36.

Hayakawa, T., Nakamura, T., Kotaki, H., Kando, M., **Kajino, T.**: 2017, Explosive Nucleosynthesis Study Using Laser Driven g-ray Pulses, *Quantum Beam Science*, **1**, 3.

Hayakawa, T., Toh, Y., Huang, M., Shizuma, T., Kimura, A., Nakamura, S., Harada, H., Iwamoto, N., Chiba, S., **Kajino, T.**: 2016, Measurement of the Isomer Production Ratio for the Cd-112(n,gamma)Cd-113 Reaction Using Neutron Beams at J-PARC, *Phys. Rev. C*, **94**, 055803.

Hayama, K., Kuroda, T., Nakamura, K., Yamada, S.: 2016, Circular Polarizations of Gravitational Waves from Core-Collapse Supernovae: A Clear Indication of Rapid Rotation, *Phys. Rev. Lett.*, **116**, 151102.

Hayashi, M., **Kodama, T.**, **Tanaka, I.**, **Shimakawa, R.**, **Koyama, Y.**, Tadaki, K.-i., **Suzuki, T. L.**, **Yamamoto, M.**: 2016, Enhanced Star Formation of Less Massive Galaxies in a Protocluster at z = 2.5, *ApJL*, **826**, L28.

Hébrard, G., et al. including **Jovanovic, N.**, **Lozi, J.**: 2016, The SOPHIE Search for Northern Extrasolar Planets. X. Detection and Characterization of Giant Planets by the Dozen, *A&A*, **588**, A145.

Helminiak, K. G., et al. including **Kuzuhara, M.**, **Kandori, R.**, **Suenaga, T.**, **Kusakabe, N.**, **Narita, N.**, **Currie, T.**, **Kudo, T.**, **Akiyama, E.**, **Guyon, O.**, **Hayano, Y.**, **Hayashi, M.**, **Hayashi, S. S.**, **Ishii, M.**, **Iye, M.**, **Morino, J.**, **Nishimura, T.**, **Ryu, T.**, **Pyo, T.**, **Suto, H.**, **Suzuki, R.**, **Takahashi, Y. H.**, **Takato, N.**, **Terada, H.**, **Takami, H.**, **Usuda, T., Tamura, M.**: 2016, SEEDS Direct Imaging of the RV-detected

Companion to V450 Andromedae, and Characterization of the System, *ApJ*, **832**, 33.

Hełminiak, K. G., **Ukita, N.**, **Kambe, E.**, Kozłowski, S. K., Sybilski, P., Ratajczak, M., **Maehara, H.**, Konacki, M.: 2016, HIDES Spectroscopy of Bright Detached Eclipsing Binaries from the Kepler Field - I. Single-lined Objects, *MNRAS*, **461**, 2896–2913.

Henderson, C. B., et al. including **Fukui, A.**, **Lee, C. H.**, **Tamura, M.**: 2016, Campaign 9 of the K2 Mission: Observational Parameters, Scientific Drivers, and Community Involvement for a Simultaneous Space- and Ground-based Microlensing Survey, *PASP*, **128**, 124401.

Herczeg, G. J., et al. including **Maehara, H.**: 2016, The Eruption of the Candidate Young Star ASASSN-15QI, *ApJ*, **831**, 133.

Hidaka, J., **Kajino, T.**, Mathews, G. J.: 2016, Red-Supergiant and Supernova Rate Problems: Implication for the Relic Supernova Neutrino Spectrum, *ApJ*, **827**, 85.

Higuchi, Y., **Shirasaki, M.**: 2016, The Imprint of $f(R)$ Gravity on Weak Gravitational Lensing - I. Connection between Observables and Large-scale Structure, *MNRAS*, **459**, 2762–2776.

Hine, N. K., Geach, J. E., **Matsuda, Y.**, Lehmer, B. D., Michałowski, M. J., Farrah, D., Spaans, M., Oliver, S. J., Smith, D. J. B., Chapman, S. C., Jenness, T., Alexander, D. M., Robson, I., van der Werf, P.: 2016, The average submillimetre properties of Lyman α blobs at z = 3, *MNRAS*, **460**, 4075–4085.

Hirano, T., Nowak, G., **Kuzuhara, M.**, Palle, E., Dai, F., Yu, L., Van Eylen, V., **Takeda, Y.**, Brandt, T. D., **Narita, N.**, Velasco, S., Prieto Arranz, J., Sanchis-Ojeda, R., Winn, J. N., **Kudo, T.**, **Kusakabe, N.**, **Fukui, A.**, Sato, B., Albrecht, S., Ribas, I., **Ryu, T.**, **Tamura, M.**: 2016, The K2-ESPRINT Project IV. A Hot Jupiter in a Prograde Orbit with a Possible Stellar Companion, *ApJ*, **825**, 53.

Hirao, Y., et al. including **Fukui, A.**: 2016, OGLE-2012-BLG-0724Lb: A Saturn-mass Planet around an M Dwarf, *ApJ*, **824**, 139.

Hirashita, H., **Nozawa, T.**, Asano, R. S., Typhoon, L.: 2016, Revisiting the Lifetime Estimate of Large Presolar Grains in the Interstellar Medium, *Planet. Space. Sci.*, **133**, 17–22.

Hirota, T., Machida, M. N., Matsushita, Y., **Motogi, K.**, **Matsumoto, N.**, Kim, M. K., Burns, R. A., **Honma, M.**: 2016, ALMA Band 8 Continuum Emission from Orion Source I, *ApJ*, **833**, 238.

Homma, D., Chiba, M., Okamoto, S., **Komiyama, Y.**, **Tanaka, M.**, Tanaka, M., Ishigaki, M. N., Akiyama, M., **Arimoto, N.**, Garmilla, J. A., Lupton, R. H., Strauss, M. A., **Furusawa, H.**, **Miyazaki, S.**, Murayama, H., Nishizawa, A. J., Takada, M., **Usuda, T.**, Wang, S.-Y.: 2016, A New Milky Way Satellite Discovered in the Subaru/Hyper Suprime-Cam Survey, *ApJ*, **832**, 21.

Hotokezaka, K., Wanajo, S., **Tanaka, M.**, Bamba, A., Terada, Y., Piran, T.: 2016, Radioactive Decay Products in Neutron Star Merger Ejecta: Heating Efficiency and Gamma-ray Emission, *MNRAS*, **459**, 35–43.

Hou, S. Q., He, J. J., Parikh, A., Kahl, D., Bertulani, C. A., **Kajino, T.**, Mathews, G. J., Zhao, G.: 2017, Non-extensive Statistics to the Cosmological Lithium Problem, *ApJ*, **834**, 165.

Hsieh, P.-Y., Ho, P. T. P., Hwang, C.-Y., **Shimajiri, Y.**, Matsushita, S., Koch, P. M., **Iono, D.**: 2016, The Fossil Nuclear Outflow in the Central 30 pc of the Galactic Center, *ApJ*, **831**, 72.

Hu, B., Menten, K. M., **Wu, Y.**, Bartkiewicz, A., Rygl, K., Reid, M. J., Urquhart, J. S., Zheng, X.: 2016, On the Relationship of UC HII Regions and Class II Methanol Masers. I. Source Catalogs, *ApJ*, **833**, 18.

Huang, K., et al. including **Takahashi, S.**: 2017, ALMA and RATIR observations of GRB 131030A, *PASJ*, **69**, 8.

Ichikawa, K., Ricci, C., Ueda, Y., Matsuoka, K., Toba, Y., Kawamuro, T., Trakhtenbrot, B., Koss, M. J.: 2017, The Complete Infrared View of Active Galactic Nuclei from the 70 Month Swift/BAT Catalog, *ApJ*, **835**, 74.

Ikarashi, S., et al. including **Nakanishi, K.**, **Hatsukade, B.**, **Iono, D.**, **Kawabe, R.**: 2017, Extremely Red Submillimeter Galaxies: New $z \geq$ 4-6 Candidates Discovered using ALMA and Jansky VLA, *ApJ*, **835**, 286.

Ikeda, S., **Tazaki, F.**, **Akiyama, K.**, **Hada, K.**, **Honma, M.**: 2016, PRECL: A New Method for Interferometry Imaging from Closure Phase, *PASJ*, **68**, 45.

Ikeya, M., **Noguchi, T.**, **Kojima, T.**, **Sakai, T.**: 2017, Low Leakage Current Nb-Based Tunnel Junctions with an Extra Top Al Layer, *IEICE Transaction on Electronics*, **E100-C**, 291–297.

Imai, M., Sakai, N., Oya, Y., Lopez-Sepulcre, A., Watanabe, Y., Ceccarelli, C., Lefloch, B., Caux, E., Vastel, C., Kahane, C., Sakai, T., **Hirota, T.**, Aikawa, Y., Yamamoto, S.: 2016, Discovery of a Hot Corino in the Bok Globule B335, *ApJL*, **830**, L37.

Imanishi, M., **Nakanishi, K.**, Izumi, T.: 2016, ALMA HCN and HCO^+ J =3–2 Observations of Optical Seyfert and Luminous Infrared Galaxies: Confirmation of Elevated HCN-to-HCO^+ Flux Ratios in AGNs, *AJ*, **152**, 218.

Imanishi, M., **Nakanishi, K.**, Izumi, T.: 2016, ALMA Investigation of Vibrationally Excited HCN/HCO^+/HNC Emission Lines in the AGN-Hosting Ultraluminous Infrared Galaxy IRAS 20551-4250, *ApJ*, **825**, 44.

Imanishi, M., **Nakanishi, K.**, Izumi, T.: 2016, ALMA 0.1–0.2 arcsec Resolution Imaging of the NGC 1068 Nucleus: Compact Dense Molecular Gas Emission at the Putative AGN Location, *ApJL*, **822**, L10.

Inoue, A. K., Tamura, Y., **Matsuo, H.**, Mawatari, K., Shimizu, I., Shibuya, T., Ota, K., Yoshida, N., Zackrisson, E., **Kashikawa, N.**, Kohno, K., Umehata, H., **Hatsukade, B.**, **Iye, M.**, **Matsuda, Y.**, Okamoto, T., Yamaguchi, Y.: 2016, Detection of an Oxygen Emission Line from a High-redshift Galaxy in the Reionization Epoch, *Science*, **352**, 1559–1562.

Iono, D., Yun, M., Aretxaga, I., **Hatsukade, B.**, Hughes, D., Ikarashi, S., Izumi, T., **Kawabe, R.**, Kohno, K., **Lee, M.**, **Matsuda, Y.**, **Nakanishi, K.**, **Saito, T.**, Tamura, Y., Ueda, J., Umehata, H., Wilson, G., **Michiyama, T.**, **Ando, M.**: 2016, Clumpy and Extended Starbursts in the Brightest Unlensed Submillimeter Galaxies, *ApJL*, **829**, L10.

Iovino, A., et al. including **Tanaka, M.**: 2016, A High Definition View of the COSMOS Wall at $z \sim 0.73$, *A&A*, **592**, A78.

Ishiguro, M., et al. including **Kuroda, D.**, **Hanayama, H.**, **Yanagisawa, K.**, **Miyaji, T.**, **Fukushima, H.**, **Watanabe, J.**: 2016, 2014–2015 Multiple Outbursts of 15P/Finlay, *AJ*, **152**, 169.

Ishikawa, S., **Kashikawa, N.**, **Hamana, T.**, **Toshikawa, J.**, **Onoue, M.**: 2016, The Very Wide-field gzK Galaxy Survey - II. The Relationship between Star-forming Galaxies at z ~ 2 and Their Host Haloes Based upon HOD Modelling, *MNRAS*, **458**, 747–758.

Ito, T.: 2016, High-order Analytic Expansion of Disturbing Function for Doubly Averaged Circular Restricted Three-body Problem, *Adv. Astron.*, **2016**, 8945090.

Iwai, A., Itoh, Y., **Terai, T.**, Gupta, R., Sen, A., Takahashi, J.: 2017, Optical Spectroscopy and Photometry of Main-belt Asteroids with a High Orbital Inclination, *Res. Astron. Astrophys.*, **17**, 17.

Iwai, K., **Shimojo, M.**, **Asayama, S.**, **Minamidani, T.**, White, S.,

Bastian, T., **Saito, M.**: 2017, The Brightness Temperature of the Quiet Solar Chromosphere at 2.6 mm, *Sol. Phys.*, **292**, 22.
Izumi, T., **Nakanishi, K.**, **Imanishi, M.**, Kohno, K.: 2016, ALMA Observations of the Submillimetre Hydrogen Recombination Line from the Type 2 Active Nucleus of NGC 1068, *MNRAS*, **459**, 3629–3634.
Jackson, N., et al. including **Kuniyoshi, M.**: 2016, LBCS: The LOFAR Long-Baseline Calibrator Survey, *A&A*, **595**, A86.
Jeffery, C. S., Baran, A. S., Behara, N. T., Kvammen, A., Martin, P., **Naslim, N.**, Østensen, R. H., Preece, H. P., Reed, M. D., Telting, J. H., Woolf, V. M.: 2017, Discovery of a Variable Lead-rich Hot Subdwarf: UVO 0825+15, *MNRAS*, **465**, 3101–3124.
Jin, Z. P., Hotokezaka, K., Li, X., **Tanaka, M.**, D'Avanzo, P., Fan, Y. Z., Covino, S., Wei, D. M., Piran, T.: 2016, The 050709 Macronova and the GRB/macronova Connection, *Nature Communications*, **7**, 12898.
Jogo, K., Nakamura, T., Ito, M., **Wakita, S.**, Zolotov, M. T., Messenger, S. R.: 2017, Mn-Cr Ages and Formation Conditions of Fayalite in CV3 Carbonaceous Chondrites: Constraints on the Accretion Ages of Chondritic Asteroids, *Geochim. Cosmochim. Ac.*, **199**, 58.
Johnson, H. L., Harrison, C. M., Swinbank, A. M., Bower, R. G., Smail, I., **Koyama, Y.**, Geach, J. E.: 2016, The Spatially Resolved Dynamics of Dusty Starburst Galaxies in a $z \sim 0.4$ Cluster: Beginning the Transition from Spirals to S0s, *MNRAS*, **460**, 1059–1076.
Johnston, S., Keane, E. F., Bhandari, S., Macquart, J.-P., Tingay, S. J., Barr, E., Bassa, C. G., Beswick, R., Burgay, M., Chandra, P., **Honma, M.**, Kramer, M., Petroff, E., Possenti, A., Stappers, B. W., Sugai, H.: 2017, Radio Light Curve of the Galaxy Possibly Associated with FRB 150418, *MNRAS*, **465**, 2143–2150.
Joshi, A. D., **Hanaoka, Y.**, **Suematsu, Y.**, **Morita, S.**, Yurchyshyn, V., Cho, K. S.: 2016, Pre-Eruption Oscillations in Thin and Long Features in a Quiescent Filament, *ApJ*, **833**, 243.
Jovanovic, N., Schwab, C., Cvetojevic, N., **Guyon, O.**, Martinache, F.: 2016, Enhancing Stellar Spectroscopy with Extreme Adaptive Optics and Photonics, *PASP*, **128**, 121001.
Jung, Y. K., et al. including **Fukui, A.**: 2017, Binary Source Microlensing Event OGLE-2016-BLG-0733: Interpretation of a Long-term Asymmetric Perturbation, *AJ*, **153**, 129.
Kamata, S., Kimura, J., **Matsumoto, K.**, Nimmo, F., Kuramoto, K., **Namiki, N.**: 2016, Tidal deformation of Ganymede: Sensitivity of Love numbers on the interior structure, *J. Geophys. Res. Planets*, **121**, 1362–1375.
Kamezaki, T., Nakagawa, A., Omodaka, T., Handa, T., Inoue, K., Kurayama, T., **Kobayashi, H.**, **Nagayama, T.**, **Ueno, Y.**: 2016, Annual parallax measurements of a Mira variable star, U Lyncis, *PASJ*, **68**, 71.
Kamezaki, T., Nakagawa, A., Omodaka, T., Inoue, K., Chibueze, J., O., **Nagayama, T.**, **Ueno, Y.**, **Matsunaga, N.**: 2016, Annual Parallax and a Dimming Event of a Mira Variable Star, FV Bootis, *PASJ*, **68**, 75.
Kashino, D., et al. including **Arimoto, N.**, **Onodera, M.**: 2017, The FMOS-COSMOS Survey of Star-forming Galaxies at $z \approx 1.6$. IV. Excitation State and Chemical Enrichment of the Interstellar Medium, *ApJ*, **835**, 88.
Kashino, D., **Renzini, A.**, Silverman, J. D., Daddi, E.: 2016, Hide-and-seek with the Fundamental Metallicity Relation, *ApJL*, **823**, L24.
Kashiwagi, K., **Kurokawa, T.**, Okuyama, Y., Mori, T., Tanaka, Y., Yamamoto, Y., Hirano, M.: 2016, Direct Generation of 12.5-GHz-Spaced Optical Frequency Comb with Ultrabroad Coverage in Near-infrared Region by Cascaded Fiber Configuration, *Opt. Express*, **24**, 8120.
Kashiwagi, K., Seki, S., Tsuda, H., Takenouchi, H., **Kurokawa, T.**: 2017, Differential Processing for Frequency Chirp Measurement Using Optical Pulse Synthesizer, *Opt. Commu.*, **387**, 135–140.
Kataoka, A., Tsukagoshi, T., Momose, M., **Nagai, H.**, Muto, T., **Dullemond, C. P.**, **Pohl, A.**, Fukagawa, M., Shibai, H., Hanawa, T., Murakawa, K.: 2016, Submillimeter Polarization Observation of the Protoplanetary Disk around HD 142527, *ApJL*, **831**, L12.
Kato, Y., **Matsuda, Y.**, Smail, I., Swinbank, A. M., **Hatsukade, B.**, Umehata, H., **Tanaka, I.**, **Saito, T.**, **Iono, D.**, Tamura, Y., Kohno, K., Erb, D. K., Lehmer, B. D., Geach, J. E., Steidel, C. C., Alexander, D. M., Yamada, T., Hayashino, T.: 2016, Herschel Protocluster Survey: a Search for Dusty Star-forming Galaxies in Protoclusters at $z = 2$–3, *MNRAS*, **460**, 3861–3872.
Katsuda, S., **Tanaka, M.**, Morokuma, T., Fesen, R., Milisavljevic, D.: 2016, Constraining the Age and Distance of the Galactic Supernova Remnant G156.2+5.7 by H-alpha Expansion Measurements, *ApJ*, **826**, 108.
Kawaguchi, K., Kyutoku, K., Shibata, M., **Tanaka, M.**: 2016, Models of Kilonova/macronova Emission from Black Hole-neutron Star Mergers, *ApJ*, **825**, 52.
Kawakita, H., Ootsubo, T., Arai, A., **Shinnaka, Y.**, Nagashima, M.: 2017, Mid-infrared Spectroscopic Observations of the Dust-forming Classical Nova V2676 OPH, *AJ*, **153**, 74.
Kawamuro, T., Ueda, Y., **Tazaki, F.**, Ricci, C., Terashima, Y.: 2016, Suzaku Observations of Moderately Obscured (Compton-thin) Active Galactic Nuclei Selected by Swift/BAT Hard X-ray Survey, *ApJS*, **225**, 14.
Kawamuro, T., Ueda, Y., **Tazaki, F.**, Terashima, Y., Mushotzky, R.: 2016, Study of Swift/Bat Selected Low-luminosity Active Galactic Nuclei Observed with Suzaku, *ApJ*, **831**, 37.
Kawashima, T., Mineshige, S., **Ohsuga, K.**, Ogawa, T.: 2016, A Radiation-hydrodynamics Model of Accretion Columns for Ultra-luminous X-ray Pulsars, *PASJ*, **68**, 83.
Kawate, T., Ishii, T. T., Nakatani, Y., **Ichimoto, K.**, Asai, A., **Morita, S.**, Masuda, S.: 2016, Temporal Evolution and Spatial Distribution of White-light Flare Kernels in a Solar Flare, *ApJ*, **833**, 50.
Kim, J., Jeong, W.-S., Pyo, J., Pak, S., Park, W.-K., Kwon, J., **Tamura, M.**: 2017, Near-infrared Polarimetric Study of the N159/N160 Star-forming Complex in the Large Magellanic Cloud, *AJ*, **153**, 126.
Kim, J.-W., et al. including **Kim, J. H.**: 2016, Discovery of a Supercluster at $z \sim 0.91$ and Testing the ΛCDM Cosmological Model, *ApJL*, **821**, L10.
Kimura, Y., Tanaka, K. K., **Nozawa, T.**, Takeuchi, S., Inatomi, Y.: 2017, Pure Iron Grains Are Rare in the Universe, *Science Advances*, **3**, e1601992.
Kitayama, T., Ueda, S., Takakuwa, S., Tsutsumi, T., Komatsu, E., Akahori, T., **Iono, D.**, Izumi, T., **Kawabe, R.**, Kohno, K., **Matsuo, H.**, Ota, N., Suto, Y., Takizawa, M., Yoshikawa, K.: 2016, The Sunyaev-Zel'dovich Effect at 5″: RX J1347.5-1145 Imaged by ALMA, *PASJ*, **68**, 88.
Kiuchi, H., Kawanishi, T., Kanno, A.: 2017, Wide Frequency Range Optical Synthesizer with High-frequency Resolution, *IEEE Photonics Technol. Lett.*, **29**, 78–81.
Kiuchi, H.: 2017, Postprocessing Phase Stabilizer for Wide Frequency Range Photonic-microwave Signal Distribution, *IEEE Trans. Terahertz Science and Technology*, **7**, 177–183.
Kojima, T., **Gonzalez, A.**, **Asayama, S.**, **Uzawa, Y.**: 2017, Design and

Development of a Hybrid-Coupled Waveguide Multiplexer for a Multiband Receiver, *IEEE Trans. Terahertz Science and Technology*, **7**, 10–19.

Kojima, T., **Kroug, M.**, Sato, K., **Sakai, T.**, **Uzawa, Y.**: 2017, On-Wafer Capacitance Measurement of Nb-Based SIS Junctions With a 4-K Probe Station, *IEEE Tran. Appl. Supercond.*, **27**, 9000704.

Kong, S., Tan, J. C., Caselli, P., Fontani, F., Pillai, T., Butler, M. J., Shimajiri, Y., **Nakamura, F.**, Sakai, T.: 2016, The Deuterium Fraction in Massive Starless Cores and Dynamical Implications, *ApJ*, **821**, 94.

Konishi, M., et al. including **Kudo, T.**, **Akiyama, E.**, **Guyon, O.**, **Hayano, Y.**, **Hayashi, M.**, **Hayashi, S. S.**, **Ishii, M.**, **Iye, M.**, **Kandori, R.**, **Morino, J.-I.**, **Nishimura, T.**, **Oh, D.**, **Pyo, T.-S.**, **Serabyn, E.**, **Suenaga, T.**, **Suto, H.**, **Suzuki, R.**, **Takahashi, Y. H.**, **Takato, N.**, **Terada, H.**, **Takami, H.**, **Usuda, T.**, **Tamura, M.**: 2016, A Substellar Companion to Pleiades HII 3441, *PASJ*, **68**, 92.

Kooistra, R., et al. including **Kudo, T.**, **Kusakabe, N.**, **Hashimoto, J.**, **Egner, S. E.**, **Guyon, O.**, **Hayano, Y.**, **Hayashi, M.**, **Hayashi, S. S.**, **Ishii, M.**, **Iye, M.**, **Kandori, R.**, **Kuzuhara, M.**, **Morino, J. I.**, **Nishimura, T.**, **Pyo, T. S.**, **Suenaga, T.**, **Suto, H.**, **Suzuki, R.**, **Takahashi, Y. H.**, **Takato, N.**, **Terada, H.**, **Tomono, D.**, **Takami, H.**, **Usuda, T.**, **Tamura, M.**, **Currie, T.**, **Akiyama, E.**: 2017, Radial Decoupling of Small and Large Dust Grains in the Transitional Disk RX J1615.3-3255, *A&A*, **597**, A132.

Koprowski, M. P., Coppin, K. E. K., Geach, J. E., Hine, N. K., Bremer, M., Chapman, S., Davies, L. J. M., Hayashino, T., Knudsen, K. K., **Kubo, M.**, Lehmer, B. D., **Matsuda, Y.**, Smith, D. J. B., van der Werf, P. P., Violino, G., Yamada, T.: 2016, A Resolved Map of the Infrared Excess in a Lyman Break Galaxy at $z = 3$, *ApJ*, **828**, L21.

Koshimoto, N., et al. including **Fukui, A.**: 2017, OGLE-2012-BLG-0950Lb: The First Planet Mass Measurement from Only Microlens Parallax and Lens Flux, *AJ*, **153**, 1.

Kubo, M., et al. including **Katsukawa, Y.**, **Suematsu, Y.**, **Kano, R.**, **Bando, T.**, **Narukage, N.**, **Ishikawa, R.**, **Hara, H.**, **Giono, G.**, **Ichimoto, K.**, **Goto, M.**: 2016, Discovery of Ubiquitous Fast-propagating Intensity Disturbances by the Chromospheric Lyman Alpha Spectropolarimeter (CLASP), *ApJ*, **832**, 141.

Kuroda, T., Kotake, K., **Takiwaki, T.**: 2016, A New Gravitational-wave Signature from Standing Accretion Shock Instability in Supernovae, *ApJL*, **829**, L14.

Kusune, T., Sugitani, K., **Nakamura, F.**, Watanabe, M., **Tamura, M.**, Kwon, J., Sato, S.: 2016, Magnetic Field of the Vela C Molecular Cloud, *ApJL*, **830**, L23.

Kuwahara, Y., **Shoda, A.**, Eda, K., **Ando, M.**: 2016, Search for a Stochastic Gravitational Wave Background at 1–5 Hz with a Torsion-bar Antenna, *Phys. Rev. D*, **94**, 042003.

Kwon, J., **Tamura, M.**, Hough, J. H., Nagata, T., **Kusakabe, N.**: 2016, Near-infrared Circular and Linear Polarimetry of Monoceros R2, *AJ*, **152**, 67.

Kwon, J., **Tamura, M.**, Hough, J. H., Nagata, T., **Kusakabe, N.**: 2016, Near-infrared Imaging Polarimetry of GGD 27: Circular Polarization and Magnetic Field Structures, *ApJ*, **824**, 95.

Lee, C.-H., Lin, C.-C.: 2017, Double-lined M Dwarf Eclipsing Binaries from Catalina Sky Survey and LAMOST, *Res. Astron. Astrophys.*, **17**, 15.

Lee, C.-H.: 2016, A Closer Look at the Canarias Einstein Ring, *MNRAS*, **462**, 3006–3010.

Lee, C.-H.: 2016, AGB stars in Leo P and Their Use as Metallicity Probes, *MNRAS Lett.*, **461**, L37–L40.

Lee, C.-H.: 2017, A Double-line M-dwarf Eclipsing Binary from CSS x SDSS, *AJ*, **153**, 118.

Lee, C.-H.: 2017, A Computer Vision Approach to Identify Einstein Rings and Arcs, *PASA*, **34**, e014.

Lee, J. O., Moon, Y. J., Lee, J. Y., **Lee, K. S.**, Kim, R. S.: 2016, Coronal Electron Density Distributions Estimated from CMEs, DH Type II Radio Bursts, and Polarized Brightness Measurements, *J. Geophys. Res. A: SP*, **121**, 2853.

Lee, K. S., Imada, S., Watanabe, K., Bamba, Y., Brooks, D. H.: 2017, IRIS, Hinode, SDO, and RHESSI Observations of a White Light Flare Produced Directly by Non-thermal Electrons, *ApJ*, **836**, 150.

Lee, M. Y., et al. including **Kawamura, A.**, **Muller, E.**: 2016, Radiative and Mechanical Feedback into the Molecular Gas in the Large Magellanic Cloud I. N159W, *A&A*, **596**, A85.

Li, F. C., Xu, Y., **Wu, Y. W.**, Yang, J., Lu, D. R., Menten, K. M., Henkel, C.: 2016, Ammonia and CO Outflow around 6.7 GHz Methanol Masers, *AJ*, **152**, 92.

Li, W. X., Yang, Y., Tu, B. S., Xiao, J., Grumer, J., Brage, T., **Watanabe, T.**, Hutton, R., Zou, Y. M.: 2016, Atomic-level Pseudo-degeneracy of Atomic Levels Giving Transitions Induced by Magnetic Fields, of Importance for Determining the Field Strengths in the Solar Corona, *ApJ*, **826**, 219.

Lin, S.-J., Shimajiri, Y., Hara, C., Lai, S.-P., **Nakamura, F.**, Sugitani, K., **Kawabe, R.**, Kitamura, Y., Yoshida, A., Tatei, H., Akashi, T., Higuchi, A. E., Tsukagoshi, T.: 2016, The Intrinsic Abundance Ratio and X-factor of CO Isotopologues in L1551 Shielded from FUV Photodissociation, *ApJ*, **826**, 193.

Liu, H. B., Lai, S. P., **Hasegawa, Y.**, Hirano, N., Rao, R., Li, I. H., **Fukagawa, M.**, Girart, J. M., Carrasco-Gonzalez, C., Rodriguez, L. F.: 2016, Detection of Linearly Polarized 6.9 mm Continuum Emission from the Class 0 Young Stellar Object NGC 1333 IRAS4A, *ApJ*, **821**, 41.

Liu, T., et al. including **Tatematsu, K.**: 2016, Star Formation Laws in Both Galactic Massive Clumps and External Galaxies: Extensive Study with Dust Coninuum, HCN (4–3), and CS (7–6), *ApJ*, **829**, 59.

Liu, T., Zhang, Q. Z., Kim, K. T., Wu, Y. F., Lee, C. W., Goldsmith, P. F., Li, D., Liu, S. Y., Chen, H. R., **Tatematsu, K.**, Wang, K., Lee, J. E., Qin, S. L., Mardones, D., Cho, S. H.: 2016, Discovery of an Extremely Wide-angle Bipolar Outflow in AFGl 5142, *ApJ*, **824**, 31.

Liu, X., Cassou, K., Chiche, R., Dupraz, K., Favier, P., **Flaminio, R.**, Honda, Y., Huang, W. H., Martens, A., Michel, C., Pinard, L., Sassolas, B., Soskov, V., Tang, C. X., Zomer, F.: 2016, Laser Frequency Stabilization Using Folded Cavity and Mirror Reflectivity Tuning, *Opt. Commu.*, **369**, 84–88.

Lomax, J. R., et al. including **Kudo, T.**, **Kusakabe, N.**, **Currie, T. M.**, **Egner, S.**, **Guyon, O.**, **Hayano, Y.**, **Hayashi, M.**, **Hayashi, S. S.**, **Ishii, M.**, **Iye, M.**, **Kandori, R.**, **Morino, J.**, **Nishimura, T.**, **Pyo, T.**, **Suenaga, T.**, **Suto, H.**, **Suzuki, R.**, **Takahashi, Y. H.**, **Takato, N.**, **Terada, H.**, **Tomono, D.**, **Takami, H.**, **Tamura, M.**: 2016, Constraining the Movement of the Spiral Features and the Locations of Planetary Bodies within the AB Aur System, *ApJ*, **828**, 2.

Long, Z. C., Fernandes, R. B., Sitko, M., Wagner, K., Muto, T., Hashimoto, J., Follette, K., Grady, C. A., Fukagawa, M., Hasegawa, Y. Kluska, J., Kraus, S., Mayama, S., McElwain, M. W., **Oh, D.**,

Tamura, M., Uyama, T., Wisniewski, J. P., **Yang, Y.**: 2017, The Shadow Knows: Using Shadows to Investigate the Structure of the Pretransitional Disk of HD 100453, *ApJ*, **838**, 62.

Lopez-Rodriguez, E., **Packham, C.**, Jones, T. J., Siebenmorgen, R., Roche, P. F., Levenson, N. A., Alonso-Herrero, A., Perlman, E., **Ichikawa, K.**, Ramos Almeida, C., González-Martín, O., Nikutta, R., Martinez-Paredez, M., Shenoy, D., Gordon, M. S., Telesco, C. M.: 2017, Infrared Polarimetry of Mrk 231: Scattering Off Hot Dust Grains in the Central Core, *MNRAS*, **464**, 1762–1770.

Louvet, F., Motte, F., Gusdorf, A., **Lu'o'Ng, Q. N.**, Lesaffre, P., Duarte-Cabral, A., Maury, A., Schneider, N., Hill, T., Schilke, P., Gueth, F.: 2016, Tracing Extended Low-velocity Shocks through SiO Emission Case Study of the W43-MM1 Ridge, *A&A*, **595**, A122.

Lunnan, R., et al. including **Yagi, M.**: 2017, Two New Calcium-rich Gap Transients in Group and Cluster Environments, *ApJ*, **836**, 60.

Ly, C., Malhotra, S., Malkan, M. A., Rigby, J. R., **Kashikawa, N.**, de los Reyes, M. A., Rhoads, J. E.: 2016, The Metal Abundances across Cosmic Time (MACT) Survey. I. Optical Spectroscopy in the Subaru Deep Field, *ApJS*, **226**, 5.

Lykawka, P. S., **Ito, T.**: 2017, Terrestrial Planet Formation: Constraining the Formation of Mercury, *ApJ*, **838**, 106.

Makise, K., Terai, H., **Uzawa, Y.**: 2016, NbN/AlN/NbN/TiN Tunnel Junctions on Si (100) Substrate for Superconducting Devices, *IEEE Tran. Appl. Supercond.*, **26**, 1100403.

Marchant, P., Langer, N., Podsiadlowski, Ph., Tauris, T. M., **Moriya, T. J.**: 2016, A New Route towards Merging Massive Black Holes, *A&A*, **588**, A50.

Martinache, F., **Jovanovic, N.**, **Guyon, O.**: 2016, Closed-loop Focal Plane Wavefront Control with the SCExAO Instrument, *A&A*, **593**, A33.

Maruyama, T., Cheoun, M. K., **Kajino, T.**, Mathews, G. J.: 2016, Pion Production via Proton Synchrotron Radiation in Strong Magnetic Fields in Relativistic Field Theory: Scaling Relations and Angular Distributions, *Phys. Lett. B*, **757**, 125–129.

Massol, H., Hamano, K., Tian, F., Ikoma, M., Abe, Y., Chassefiere, E., Davaille, A., Genda, H., Gudel, M., **Hori, Y.**, Leblanc, F., Marcq, E., Sarda, P., Shematovich, V., Stokl, A., Lammer, H.: 2016, Formation and Evolution of Protoatmospheres, *Space Sci. Rev.*, **205**, 153–211.

Mathews, G. J., Rose, B. M., Garnavich, P. M., Yamazaki, D. G., **Kajino, T.**: 2016, Detectability of Cosmic Dark Flow in the Type Ia Supernova Redshift-distance Relation, *ApJ*, **827**, 60.

Matsubayashi, K., Sugai, H., Shimono, A., Akita, A., **Hattori, T.**, **Hayano, Y.**, **Minowa, Y.**, Takeyama, N.: 2016, Adaptive Optics at Optical Wavelengths: Test Observations of Kyoto 3DII Connected to Subaru Telescope AO188, *PASP*, **128**, 095003.

Matsui, H., et al. including **Hayashi, Y.-Y.**: 2016, Performance Benchmarks for a Next Generation Numerical Dynamo Model, *Geochem. Geophy. Geosy.*, **17**, 1586–1607.

Matsumoto, N., Komori, K., Ito, S., Michimura, Y., **Aso, Y.**: 2016, Direct Measurement of Optical-trap-induced Decoherence, *Phys. Rev. A*, **94**, 033822.

Matsumoto, Y., **Oshino, S.**, Hasegawa, Y., **Wakita, S.**: 2017, Chondrule Accretion with a Growing Protoplanet, *ApJ*, **837**, 103.

Matsuno, T., **Aoki, W.**, Suda, T., Li, H.-N.: 2017, Lithium in CEMP-No Stars: A new Constraint on the Lithium Depletion Mechanism in the Early Universe, *PASJ*, **69**, 24.

Matsuo, H., **Ezawa, H.**: 2016, Advantages of Photon Counting Detectors for Terahertz Astronomy, *J. Low. Temp. Phys.*, **184**, 718–723.

Matsuoka, Y., et al. including **Onoue, M.**, **Kashikawa, N.**, **Imanishi, M.**, **Furusawa, H.**, **Ikeda, H.**, **Kikuta, S.**, **Komiyama, Y.**, **Miyazaki, S.**, **Tait, P. J.**, **Takata, T.**, **Tanaka, M.**: 2016, Subaru High-*z* Exploration of Low-luminosity Quasars (SHELLQs). I. Discovery of 15 Quasars and Bright Galaxies at $5.7 < z < 6.9$, *ApJ*, **828**, 26.

Matsushita, S., **Asaki, Y.**, Fomalont, E. B., **Morita, K. I.**, Barkats, D., Hills, R. E., **Kawabe, R.**, Maud, L. T., Nikolic, B., Tilanus, R. P. J., Vlahakis, C., Whyborn, N. D.: 2017, ALMA Long Baseline Campaigns: Phase Characteristics of Atmosphere at Long Baselines in the Millimeter and Submillimeter Wavelengths, *PASP*, **129**, 035004.

Maxted, N. I., de Wilt, P., Rowell, G. P., Nicholas, B. P., Burton, M. G., Walsh, A., Fukui, Y., **Kawamura, A.**: 2016, Ammonia Excitation Imaging of Shocked Gas towards the W28 Gamma-ray Source HESS J1801-233, *MNRAS*, **462**, 532–546.

McCully, C., et al. including **Wong, K. C.**: 2017, Quantifying Environmental and Line-of-sight Effects in Models of Strong Gravitational Lens Systems, *ApJ*, **836**, 141.

McKean, J. P., et al. including **Kuniyoshi, M.**: 2016, LOFAR Imaging of Cygnus A - Direct Detection of a Turnover in the Hotspot Radio Spectra, *MNRAS*, **463**, 3143–3150.

Micheva, G., **Iwata, I.**, Inoue, A. K., **Matsuda, Y.**, Yamada, T., Hayashino, T.: 2017, Searching for Candidates of Lyman Continuum Sources - Revisiting the SSA22 Field, *MNRAS*, **465**, 316–336.

Micheva, G., **Iwata, I.**, Inoue, A. K.: 2017, Lyman Continuum Leaking AGN in the SSA22 Field, *MNRAS*, **465**, 302–315.

Michikoshi, S., **Kokubo, E.**: 2016, Galactic Spiral Arms by Swing Amplification, *ApJ*, **821**, 35.

Michikoshi, S., **Kokubo, E.**: 2016, Swing Amplification of Galactic Spiral Arms: Phase Synchronization of Stellar Epicycle Motion, *ApJ*, **823**, 121.

Michikoshi, S., **Kokubo, E.**: 2016, Planetesimal Formation by Gravitational Instability of a Porous Dust Disk, *ApJL*, **825**, L28.

Michikoshi, S., **Kokubo, E.**: 2017, Simulating the Smallest Ring World of Chariklo, *ApJL*, **837**, L13.

Michiyama, T., **Iono, D.**, **Nakanishi, K.**, Ueda, J., **Saito, T.**, **Ando, M.**, **Kaneko, H.**, Yamashita, T., **Matsuda, Y.**, **Hatsukade, B.**, **Kikuchi, K.**, Komugi, S., Muto, T.: 2017, Investigating the Relation between CO (3-2) and Far-infrared Luminosities for Nearby Merging Galaxies Using ASTE, *PASJ*, **68**, 96.

Mizuki, T., et al. including **Nishikawa, J.**, **Kudo, T.**, **Kuzuhara, M.**, **Kudo, T.**, **Kusakabe, N.**, **Hashimoto, J.**, **Egner, S.**, **Guyon, O.**, **Hayano, Y.**, **Hayashi, M.**, **Hayashi, S. S.**, **Ishii, M.**, **Iye, M.**, **Kandori, R.**, **Kwon, J.**, **Morino, J.**, **Nishimura, T.**, **Pyo, T.**, **Suenaga, T.**, **Suto, H.**, **Suzuki, R.**, **Takahashi, Y. H.**, **Takato, N.**, **Terada, H.**, **Takami, H.**, **Usuda, T.**, **Tamura, M.**: 2016, High-contrast Imaging of Epsilon Eridani with Ground-based Instruments, *A&A*, **595**, A79.

Mohanty., P. K., et al. including **Oshima, A.**: 2016, Transient Weakening of Earth's Magnetic Shield Probed by a Cosmic Ray Burst, *Phys. Rev. Lett.*, **117**, 171101.

Momose, R., Ouchi, M., Nakajima, K., Ono, Y., Shibuya, T., Shimasaku, K., Yuma, S., Mori, M., Umemura, M.: 2016, Statistical properties of diffuse Lyα haloes around star-forming galaxies at $z \sim 2$, *MNRAS*, **457**, 2318–2330.

More, A., **Lee, C.-H.**, Oguri, M., Ono, Y., Suyu, S. H., Chan, J. H. H., Silverman, J. D., More, S., Schulze, A., **Komiyama, Y.**, **Matsuoka,**

Y., **Miyazaki, S.**, Nagao, T., Ouchi, M., **Tait, P. J.**, Tanaka, M. M., **Tanaka, M.**, **Usuda, T.**, Yasuda, N.: 2017, A New Quadruple Gravitational Lens from the Hyper Suprime-Cam Survey: The Puzzle of HSC J115252+004733, *MNRAS*, **465**, 2411–2419.

More, A., Suyu, S. H., Oguri, M., More, S., **Lee, C.-H.**: 2017, Interpreting the Strongly Lensed Supernova iPTF16geu: Time Delay Predictions, Microlensing, and Lensing Rates, *ApJL*, **835**, L25.

Mori, K., Famiano, M. A., **Kajino, T.**, Suzuki, T., Hidaka, J., Honma, M., Iwamoto, K., Nomoto, K., Otsuka, T.: 2016, Impact of New Gamow-Teller Strengths on Explosive Type Ia Supernova Nucleosynthesis, *ApJ*, **833**, 179.

Morii, M., Ikeda, S., Tominaga, N., **Tanaka, M.**, Morokuma, T., Ishiguro, K., Yamato, J., Ueda, N., Suzuki, N., Yasuda, N., Yoshida, N.: 2016, Machine-learning Selection of Optical Transients in Subaru/Hyper Suprime-Cam Survey, *PASJ*, **68**, 104.

Morii, M., **Yamaoka, H.**, Mihara, T., Matsuoka, M., Kawai, N.: 2016, Search for Soft X-ray Flashes at the Fireball Phase of Classical/recurrent Novae Using MAXI/GSC Data, *PASJ*, **68**, S11.

Moriya, T. J., Chen, T.-W., Langer, N.: 2017, Properties of Magnetars Mimicking ^{56}Ni-powered Light Curves in Type IC Superluminous Supernovae, *ApJ*, **835**, 177.

Moriya, T. J., Eldridge, J. J.: 2016, Rapidly Evolving Faint Transients from Stripped-envelope Electron-capture Supernovae, *MNRAS*, **461**, 2155–2161.

Moriya, T. J., Maeda, K.: 2016, Circumstellar and Explosion Properties of Type Ibn Supernovae, *ApJ*, **824**, 100.

Moriya, T. J., Metzger, B. D., Blinnikov, S. I.: 2016, Supernovae Powered by Magnetars that Transform into Black Holes, *ApJ*, **833**, 64.

Moriya, T. J., Tauris, T. M.: 2016, Constraining the Ellipticity of Strongly Magnetized Neutron Stars Powering Superluminous Supernovae, *MNRAS Lett.*, **460**, L55–L58.

Moriya, T. J.: 2016, Radio Transients from Accretion-induced Collapse of White Dwarfs, *ApJL*, **830**, L38.

Morokuma, T., et al. including **Tanaka, M.**, **Kuroda, D.**, **Yanagisawa, K.**: 2016, J-GEM Follow-up Observations to Search for an Optical Counterpart of the First Gravitational Wave Source GW150914, *PASJ*, **68**, L9.

Morokuma, T., Tominaga, N., **Tanaka, M.**, Yasuda, N., **Furusawa, H.**, Taniguchi, Y., Kato, T., Jiang, J., Nagao, T., Kuncarayakti, H., **Morokuma-Matsui, K.**, **Ikeda, H.**, Blinnikov, S., Nomoto, K., Kokubo, M., Doi, M.: 2016, An Effective Selection Method for Low-mass Active Black Holes and First Spectroscopic Identification, *PASJ*, **68**, 40.

Morokuma-Matsui, K., Muraoka, K.: 2017, Kennicutt-Schmidt Relation Variety and Star-forming Cloud Fraction, *ApJ*, **837**, 137.

Morselli, L., **Renzini, A.**, Popesso, P., Erfanianfar, G.: 2016, The Effect of Disc Inclination on the Main Sequence of Star-forming Galaxies, *MNRAS*, **462**, 2355–2365.

Mosleh, M., Tacchella, S., Renzini, A., Carollo, C. M., Molaeinezhad, A., **Onodera, M.**, Khosroshahi, H. G., Lilly, S.: 2017, Connection between Stellar Mass Distributions within Galaxies and Quenching Since $z = 2$, *ApJ*, **837**, 2.

Motogi, K., Sorai, K., **Honma, M.**, **Hirota, T.**, **Hachisuka, K.**, Niinuma, K., Sugiyama, K., **Yonekura, Y.**, **Fujisawa, K.**: 2016, Accelerating a Water Maser Face-on Jet from a High Mass Young Stellar Object, *PASJ*, **68**, 69.

Mukae, S., Ouchi, M., Kakiichi, K., Suzuki, N., Ono, Y., Cai, Z., Inoue, A. K., Chiang, Y., Shibuya, T., **Matsuda, Y.**: 2017, Cosmic Galaxy-IGM HI Relation at $z \sim 2$–3 Probed in the COSMOS/UltraVISTA 1.6 Deg^2 Field, *ApJ*, **835**, 281.

Müller, T. G., et al including **Kuroda, D.**: 2017, Hayabusa-2 Mission Target Asteroid 162173 Ryugu (1999 JU_3): Searching for the Object's Spin-axis Orientation, *A&A*, **599**, A103.

Murakami, G., Yoshioka, K., Yamazaki, A., Tsuchiya, F., Kimura, T., Tao, C., Kita, H., Kagitani, M., Sakanoi, T., **Uemizu, K.**, Kasaba, Y., Yoshikawa, I., Fujimoto, M.: 2016, Response of Jupiter's Inner Magnetosphere to the Solar Wind Derived from Extreme Ultraviolet Monitoring of the Io Plasma Torus, *Geophys. Res. Lett.*, **43**, 12308–12316.

Muraoka, K., Sorai, K., Kuno, N., Nakai, N., Nakanishi, H., Takeda, M., Yanagitani, K., **Kaneko, H.**, **Miyamoto, Y.**, Kishida, N., Hatakeyama, T., Umei, M., Tanaka, T., Tomiyasu, Y., Saita, C., Ueno, S., **Matsumoto, N.**, Salak, D., **Morokuma-Matsui, K.**: 2016, CO Multi-line Imaging of Nearby Galaxies (COMING). I. Physical Properties of Molecular Gas in the Barred Spiral Galaxy NGC 2903, *PASJ*, **68**, 89.

Muraoka, K., Takeda, M., Yanagitani, K., **Kaneko, H.**, **Nakanishi, K.**, Kuno, N., Sorai, K., Tosaki, T., Kohno, K.: 2016, CO($J = 3$–2) on-the-fly Mapping of the Nearby Spiral Galaxies NGC628 and NGC7793: Spatially Resolved CO($J = 3$–2) Star-formation Law, *PASJ*, **68**, 18.

Nagai, H., **Nakanishi, K.**, Paladino, R., Hull, C. L. H., Cortes, P., Moellenbrock, G., Fomalont, E., Asada, K., **Hada, K.**: 2016, ALMA Science Verification Data: Millimeter Continuum Polarimetry of the Bright Radio Quasar 3C 286, *ApJ*, **824**, 132.

Nagao, T., Maeda, K., **Nozawa, T.**: 2016, Extinction Laws toward Stellar Sources within a Dusty Circumstellar Medium and Implications for Type Ia Supernovae, *ApJ*, **823**, 104.

Nagashima, K., **Sekii, T.**, Gizon, L., Birch, A. C.: 2016, Statistics of the Two-point Cross-covariance Function of Solar Oscillations, *A&A*, **593**, A41.

Nakagawa, A., Kurayama, T., Matsui, M., Omodaka, T., **Honma, M.**, **Shibata, K. M.**, **Sato, K.**, **Jike, T.**: 2016, Parallax of a Mira Variable R Ursae Majoris Studied with Astrometric VLBI, *PASJ*, **68**, 78.

Nakajima, K., Ellis, R. S., **Iwata, I.**, Inoue, A. K., Kusakabe, H., Ouchi, M., Robertson, B. E.: 2016, A Hard Ionizing Spectrum in $z = 3$–4 Lyα Emitters with Intense [O III] Emission: Analogs of Galaxies in the Reionization Era?, *ApJL*, **831**, L9.

Nakajima, T., Sorahana, S.: 2016, Carbon-to-oxygen Ratios in M Dwarfs and Solar-type Stars, *ApJ*, **830**, 159.

Nakamura, F., Dobashi, K., Shimoikura, T., Tanaka, T., Onishi, T.: 2017, Wide-Field ^{12}CO ($J = 2-1$) and ^{13}CO ($J = 2$–1) Observations toward the Aquila Rift and Serpens Molecular Cloud Complexes. I. Molecular Clouds and Their Physical Properties, *ApJ*, **837**, 154.

Nakamura, K., Horiuchi, S., Tanaka, M., Hayama, K., **Takiwaki, T.**, Kotake, K.: 2016, Multi-messenger Signals of Long-term Core-collapse Supernova Simulations: Synergetic Observation Strategies, *MNRAS*, **461**, 3296–3313.

Nakamura, T., **Ando, M.**, Kinugawa, T., Nakano, H., Eda, K., Sato, S., Musha, M., **Akutsu, T.**, Tanaka, T., Seto, N., Kanda, N., Itoh, Y.: 2016, Pre-DECIGO Can Get the Smoking Gun to Decide the Astrophysical or Cosmological Origin of GW150914-like Binary Black Holes, *Prog. Theor. Eep. Phys.*, 093E01.

Nakano, M., Soejima, T., Chibueze, J. O., **Nagayama, T.**, Omodaka, T., Handa, T., **Sunada, K.**, Kamezaki, T., Burns, R. A.: 2017, Interaction between the H II Region and AFGL 333-Ridge: Implications for the Star Formation Scenario, *PASJ*, **69**, 16.

Nakazato, K.-i., **Niino, Y.**, Sago, N.: 2016, Gravitational Wave Background from Binary Mergers and Metallicity Evolution of Galaxies, *ApJ*, **832**, 146.

Narita, N., Hirano, T., **Fukui, A.**, **Hori, Y.**, Dai, F., Yu, L., Livingston, J., **Ryu, T.**, Nowak, G., **Kuzuhara, M.**, Sato, B., **Takeda, Y.**, Albrecht, S., **Kudo, Y.**, **Kusakabe, N.**, Palle, E., Ribas, I., **Tamura, M.**, Van Eylen, V., Winn, J. N.: 2017, The K2-ESPRINT project. VI. K2-105 b, a Hot Neptune around a Metal-rich G-dwarf, *PASJ*, **69**, 29.

Narukage, N., **Kubo, M.**, **Ishikawa, R.**, Ishikawa, S., **Katsukawa, Y.**, **Kobiki, T.**, **Giono, G.**, **Kano, R.**, **Bando, T.**, Tsuneta, S., Auchere, F., Kobayashi, K., Winebarger, A., McCandless, J., Chen, J. R., Choi, J.: 2017, High-Reflectivity Coatings for a Vacuum Ultraviolet Spectropolarimeter, *Sol. Phys.*, **292**, 40.

Newman, K., Conway, J., Belikov, R., **Guyon, O.**: 2016, Focal Plane Phase Masks for PIAA: Design and Manufacturing, *PASP*, **128**, 055003.

Niida, M., Nagao, T., **Ikeda, H.**, Matsuoka, K., Kobayashi, M. A. R., Toba, Y., Taniguchi, Y.: 2016, Revisiting the Completeness and Luminosity Function in High-redshift Low-luminosity Quasar Surveys, *ApJ*, **832**, 208.

Niino, Y., **Aoki, K.**, Hashimoto, T., **Hattori, T.**, **Ishikawa, S.**, **Kashikawa, N.**, **Kosugi, G.**, **Onoue, M.**, **Toshikawa, J.**, Yabe, K.: 2017, The Redshift-selected Sample of Long Gamma-ray Burst Host Galaxies: The Overall Metallicity Distribution at $z < 0.4$, *PASJ*, **69**, 27.

Nishimura, Y., Shimonishi, T., Watanabe, Y., Sakai, N., Aikawa, Y., **Kawamura, A.**, Yamamoto, S.: 2016, Spectral Line Survey toward a Molecular Cloud in IC10, *ApJ*, **829**, 94.

Nishimura, N., Sawai, H., **Takiwaki, T.**, Yamada, S., Thielemann, F.-K.: 2017, The Intermediate r-process in Core-collapse Supernovae Driven by the Magneto-rotational Instability, *ApJL*, **836**, L21.

Nishiyama, S., Schodel, R., Yoshikawa, T., Nagata, T., **Minowa, Y.**, **Tamura, M.**: 2016, Spectroscopically Identified Intermediate Age Stars at 0.5–3 pc Distance from Sagittarius A*, *A&A*, **588**, A49.

Nishizawa, S., Odaka, M., Takahashi, Y. O., Sugiyama, K., Nakajima, K., Ishiwatari, M., Takehiro, S., Yashiro, H., Sato, Y., Tomita, H., **Hayashi, Y.-Y.**: 2016, Martian Dust Devil Statistics from High-resolution Large-eddy Simulations, *Geophys. Res. Lett.*, **43**, 4180–4188.

Nitta, S., Wada, T., Fuchida, T., Kondoh, K.: 2016, Critical Differences of Asymmetric Magnetic Reconnection from Standard Models, *ApJ*, **828**, 63.

Nitta, T., **Sekimoto, Y.**, Noda, K., Sekiguchi, S., Shu, S., **Matsuo, H.**, **Dominjon, A.**, Naruse, M., Kuno, N., Nakai, N.: 2017, Broadband Pillar-Type Antireflective Subwavelength Structures for Silicon and Alumina, *IEEE Trans. Terahertz Sci. Technol.*, **7**, 295–301.

Noda, C. Q., Shimizu, T., Cobo, B. R., **Suematsu, Y.**, **Katsukawa, Y.**, **Ichimoto, K.**: 2016, Analysis of a Spatially Deconvolved Solar Pore, *MNRAS*, **460**, 1476–1485.

Noda, C. Q., Shimizu, T., Katsukawa, Y., Rodriguez, J. D., Carlsson, M., Anan, T., Oba, T., **Ichimoto, K.**, **Suematsu, Y.**: 2017, Chromospheric Polarimetry through Multiline Observations of the 850-nm Spectral Region, *MNRAS*, **464**, 4534–4543.

Noda, C. Q., Shimizu, T., Rodriguez, J. D., **Katsukawa, Y.**, **Ichimoto, K.**, Anan, T., **Suematsu, Y.**: 2016, Spectropolarimetric Capabilities of Ca II 8542 Angstrom Line, *MNRAS*, **459**, 3363–3376.

Noda, C. Q., Shimizu, T., **Suematsu, Y.**: 2016, Analysis of horizontal flows in the solar granulation, *MNRAS*, **457**, 1703–1710.

Noda, C. Q., **Suematsu, Y.**, Cobo, B. R., Shimizu, T., Ramos, A. A.: 2016, Analysis of Spatially Deconvolved Polar Faculae, *MNRAS*, **460**, 956–965.

Noda, H., Kunimori, H., Mizuno, T., Senshu, H., Ogawa, N., Takeuchi, H., Moore, C., Pollard, A., Yamaguchi, T., **Namiki, N.**, Kase, T., Saiki, T., Tsuda, Y.: 2017, Laser Link Experiment with the Hayabusa2 Laser Altimeter for In-flight Alignment Measurement, *Earth Planets Space*, **69**, 2.

Noda, S., Ishiwatari, M., Nakajima, K., Takahashi, Y. O., Takehiro, S., Onishi, M., Hashimoto, G. L., Kuramoto, K., **Hayashi, Y.-Y.**: 2017, The Circulation Pattern and Day-night Heat Transport in the Atmosphere of a Synchronously Rotating Aquaplanet: Dependence on Planetary Rotation Rate, *Icarus*, **282**, 1–18.

Noguchi, T., Naruse, M., Sekine, M., Karatsu, K., Sekimoto, Y.: 2016, Effect of Quasiparticles in the Intragap States on the Superconducting Surface Resistance, *IEEE Tran. Appl. Supercond.*, **26**, 1500804.

Nomura, M., **Ohsuga, K.**: 2017, Line-driven Disc Wind Model for Ultrafast Outflows in Active Galactic Nuclei - Scaling with Luminosity, *MNRAS*, **465**, 2873–2879.

Notsu, S., Nomura, H., Ishimoto, D., Walsh, C., Honda, M., **Hirota, T.**, Millar, T. J.: 2016, Candidate Water Vapor Lines to Locate the H_2O Snowline through High-dispersion Spectroscopic Observations. I. The Case of a T Tauri Star, *ApJ*, **827**, 113.

Notsu, S., Nomura, H., Ishimoto, D., Walsh, C., Honda, M., **Hirota, T.**, Millar, T. J.: 2017, Candidate Water Vapor Lines to Locate the H_2O Snowline through High-dispersion Spectroscopic Observations. II. The Case of a Herbig Ae Star, *ApJ*, **836**, 118.

Notsu, Y., Honda, S., **Maehara, H.**, Notsu, S., Namekata, K., Nogami, D., Shibata, K.: 2017, Spectroscopic Observations of Active Solar-analog Stars with High X-ray Luminosity, as a Proxy of Superflare Stars, *PASJ*, **69**, 12.

Nowak, G., et al. including **Fukui, A.**, **Kuzuhara, M.**, **Narita, N.**: 2017, EPIC 219388192b—An Inhabitant of the Brown Dwarf Desert in the Ruprecht 147 Open Cluster, *AJ*, **153**, 131.

Nozawa, T.: 2016, Properties of Interstellar Dust Responsible for Extinction Laws with Unusually Low Total-to-selective Extinction Ratios of Rv = 1–2, *Planet. Space. Sci.*, **133**, 36–46.

Oda, S., Tanimoto, A., Ueda, Y., **Imanishi, M.**, Terashima, Y., Ricci, C.: 2017, Shedding Light on the Compton-thick Active Galactic Nucleus in the Ultraluminous Infrared Galaxy UGC 5101 with Broadband X-Ray Spectroscopy, *ApJ*, **835**, 179.

Ogawa, T., Mineshige, S., **Kawashima, T.**, **Ohsuga, K.**, Hashizume, K.: 2017, Radiation Hydrodynamic Simulations of a Super-Eddington Accretor as a Model for Ultra-luminous Sources, *PASJ*, **69**, 33.

Oh, D., et al. including **Hashimoto, J.**, **Tamura, M.**, **Akiyama, E.**, **Currie, T.**, **Kudo, T.**, **Kusakabe, N.**, **Egner, S.**, **Guyon, O.**, **Hayano, Y.**, **Hayashi, M.**, **Hayashi, S. S.**, **Ishii, M.**, **Iye, M.**, **Kandori, R.**, **Kuzuhara, M.**, **Morino, J. I.**, **Nishimura, T.**, **Pyo, T. S.**, **Suenaga, T.**, **Suto, H.**, **Suzuki, R.**, **Takahashi, Y. H.**, **Takato, N.**, **Terada, H.**, **Takami, H.**, **Usuda, T.**: 2016, Near-infrared Imaging Polarimetry of LkCa 15: A Possible Warped Inner Disk, *PASJ*, **68**, L3.

Oh, D., et al. including **Hashimoto, J.**, **Yang, Y.**, **Kudo, T.**, **Kusakabe, N.**, **Akiyama, E.**, **Currie, T.**, **Guyon, O.**, **Hayano, Y.**, **Hayashi,**

M., **Hayashi, S. S.**, **Ishii, M.**, **Iye, M.**, **Kandori, R.**, **Morino, J. I.**, **Nishimura, T.**, **Pyo, T. S.**, **Suenaga, T.**, **Suto, H.**, **Suzuki, R.**, **Takahashi, Y. H.**, **Takato, N.**, **Terada, H.**, **Takami, H.**, **Usuda, T.**, **Tamura, M.**: 2016, Resolved Near-infrared Image of the Inner Cavity in the GM Aur Transitional Disk, *ApJL*, **831**, L7.

Oh, H., et al. including **Pyo, T.-S.**: 2016, Three-dimensional Shock Structure of the Orion KL Outflow with IGRINS, *ApJ*, **833**, 275.

Ohashi, S., **Sanhueza, P.**, Chen, H. V., Zhang, Q., Busquet, G., **Nakamura, F.**, Palau, A., **Tatematsu, K.**: 2016, Dense Core Properties in the Infrared Dark Cloud G14.225-0.506 Revealed by ALMA, *ApJ*, **833**, 209.

Ohashi, S., **Tatematsu, K.**, **Sanhueza, P.**, **Hirota, T.**, Choi, M., **Mizuno, N.**: 2016, Detection of a Turbulent Gas Component Associated with a Starless Core with Subthermal Turbulence in the Orion A Cloud, *MNRAS*, **459**, 4130–4135.

Ohta, Y., et al. including **Fukagawa, M.**, **Hashimoto, J.**, **Kudo, T.**, **Kusakabe, N.**, **Kotani, T.**, **Currie, T.**, **Akiyama, E.**, **Egner, S. E.**, **Guyon, O.**, **Hayashi, M.**, **Hayashi, S. S.**, **Ishii, M.**, **Iye, M.**, **Kandori, R.**, **Morino, J.**, **Nishimura, T.**, **Pyo, T.**, **Suto, H.**, **Suzuki, R.**, **Takami, H.**, **Takato, N.**, **Usuda, T.**, **Tamura, M.**: 2016, Extreme Asymmetry in the Polarized Disk of V1247 Orionis, *PASJ*, **68**, 53.

Okada, H., Totani, T., Tonegawa, M., Akiyama, M., Dalton, G., Glazebrook, K., Iwamuro, F., Ohta, K., **Takato, N.**, Tamura, N., **Yabe, K.**, Bunker, A. J., Goto, T., Hikage, C., Ishikawa, T., Okumura, T., Shimizu, I.: 2016, The Subaru FMOS Galaxy Redshift Survey (FastSound). II. The Emission Line Catalog and Properties of Emission Line Galaxies, *PASJ*, **68**, 47.

Okamoto, T. J., Liu, W., Tsuneta, S.: 2016, Helical Motions of Fine-structure Prominence Threads Observed by Hinode and IRIS, *ApJ*, **831**, 126.

Okumura, T., et al. including **Takato, N.**: 2016, The Subaru FMOS Galaxy Redshift Survey (FastSound). IV. New Constraint on Gravity Theory from Redshift Space Distortions at $z \sim 1.4$, *PASJ*, **68**, 38.

Onitsuka, M., **Fukui, A.**, **Narita, N.**, Hirano, T., **Kusakabe, N.**, **Ryu, T.**, **Tamura, M.**: 2017, Multi-color Simultaneous Photometry of the T-Tauri Star with Planetary Candidate, CVSO 30, *PASJ*, **69**, L2

Onodera, M., Carollo, C. M., Lilly, S., Renzini, A., **Arimoto, N.**, Capak, P., Daddi, E., Scoville, N., Tacchella, S., **Tatehora, S.**, Zamorani, G.: 2016, ISM Excitation and Metallicity of Star-forming Galaxies at $z \simeq 3.3$ from Near-IR Spectroscopy, *ApJ*, **822**, 42.

Ootsubo, T., Doi, Y., Takita, S., Nakagawa, T., Kawada, M., Kitamura, Y., Matsuura, S., Usui, F., **Arimatsu, K.**: 2016, AKARI Far-infrared Maps of the Zodiacal Dust Bands, *PASJ*, **68**, 35.

Orosz, G., Imai, H., Dodson, R., Rioja, M. J., Frey, S., Burns, R. A., Etoka, S., Nakagawa, A., Nakanishi, H., **Asaki, Y.**, Goldman, S. R., Tafoya, D.: 2017, Astrometry of OH/IR Stars Using 1612 MHz Hydroxyl Masers. I. Annual Parallaxes of WX Psc and OH138.0+7.2, *AJ*, **153**, 119.

Osato, K., Sekiguchi, T., **Shirasaki, M.**, Kamada A., Yoshida, N.: 2016, Cosmological Constraint on the Light Gravitino Mass from CMB Lensing and Cosmic Shear, *J. Cosmol. Astropart. Phys.*, **06**, 004.

Otsubo, T., Matsuo, K., Aoyama, Y., **Yamamoto, K.**, Hobiger, T., Kubo-oka, T., Sekido, M.: 2016, Effective Expansion of Satellite Laser Ranging Network to Improve Global Geodetic Parameters, *Earth Planets Space*, **68**, 65.

Oya, Y., Sakai, N., Watanabe, Y., Higuchi, A. E., **Hirota, T.**, López-Sepulcre, A., Sakai, T., Aikawa, Y., Ceccarelli, C., Lefloch, B., Caux, E., Vastel, C., Kahane, C., Yamamoto, S.: 2017, L483: Warm Carbon-chain Chemistry Source Harboring Hot Corino Activity, *ApJ*, **837**, 174.

Oyama, T., **Kono, Y.**, **Suzuki, S.**, **Kanaguchi, M.**, **Nishikawa, T.**, **Kawaguchi, N.**, **Hirota, T.**, **Nagayama, T.**, **Kobayashi, H.**, Imai, H., Kuwahara, S., Kano, A., Oyadomari, M., Chong, S. N.: 2016, The First Simultaneous Mapping of Four 7 mm SiO Maser Lines Using the OCTAVE System, *PASJ*, **68**, 105.

Pathak, P., **Guyon, O.**, **Jovanovic, N.**, **Lozi, J.**, Martinache, F., **Minowa, Y.**, **Kudo, T.**, **Takami, H.**, **Hayano, Y.**, **Narita, N.**: 2016, A High-precision Technique to Correct for Residual Atmospheric Dispersion in High-contrast Imaging Systems, *PASP*, **128**, 124404.

Perley, D. A., **Niino, Y.**, Tanvir, N. R., Vergani, S. D., Fynbo, J. P. U.: 2016, Long-Duration Gamma-Ray Burst Host Galaxies in Emission and Absorption, *Space Sci. Rev.*, **202**, 111–142.

Perna, D., Barucci, M. A., Ishiguro, M., Alvarez-Candal, A., **Kuroda, D.**, Yoshikawa, M., Kim, M.-J., Fornasier, S., Hasegawa, S., Roh, D.-G., Müller, T. G., Kim, Y.: 2017, Spectral and Rotational Properties of Near-Earth Asteroid (162173) Ryugu, Target of the Hayabusa2 Sample Return Mission, *A&A*, **599**, L1.

Pierre, M., et al. including **Finet, F.**: 2016, The XXL Survey. I. Scientific Motivations - XMM-Newton Observing Plan - Follow-up Observations and Simulation Programme, *A&A*, **592**, A1.

Pinard, L., Michel, C., Sassolas, B., Balzarini, L., Degallaix, J., Dolique, V., **Flaminio, R.**, Forest, D., Granata, M., Lagrange, B., Straniero, N., Teillon, J., Cagnoli, G.: 2017, Mirrors Used in the LIGO Interferometers for First Detection of Gravitational Waves, *Appl. Opt.*, **56**, C11–C15.

Prieto, M. A., Fernandez-Ontiveros, J. A., Markoff, S., **Espada, D.**, Gonzalez-Martin, O.: 2016, The Central Parsecs of M87: Jet Emission and an Elusive Accretion Disc, *MNRAS*, **457**, 3801–3816.

Quang, N. L., Nguyen, H. V. V., Motte, F., Schneider, N., **Fujii, M.**, Louvet, F., Hill, T., **Sanhueza, P.**, Chibueze, J. O., Didelon, P.: 2016, The Scaling Relations and Star Formation Laws of Mini-starburst Complexes, *ApJ*, **833**, 23.

Raouafi, N. E., et al. including **Shimojo, M.**: 2016, Solar Coronal Jets: Observations, Theory, and Modeling, *Space Sci. Rev.*, **201**, 1–53.

Rathborne, J. M., Whitaker, J. S., Jackson, J. M., Foster, J. B., Contreras, Y., Stephens, I. W., Guzman, A. E., Longmore, S. N., **Sanhueza, P.**, Schuller, F., Wyrowski, F., Urquhart, J. S.: 2016, Molecular Line Emission Towards High-Mass Clumps: The MALT90 Catalogue, *PASA*, **33**, e030.

Renzini, A.: 2016, The Dominance of Quenching through Cosmic Times, *MNRAS Lett.*, **460**, L45–L49.

Rich, E. A., **Currie, T.**, Wisniewski, J. P., **Hashimoto, J.**, Brandt, T. D., Carson, J. C., **Kuzuhara, M.**, Uyama, T.: 2016, Thermal Infrared Imaging and Atmospheric Modeling of VHS J125601.92-125723.9 B: Evidence for Moderately Thick Clouds and Equilibrium Carbon Chemistry in a Hierarchical Triple System, *ApJ*, **830**, 114.

Rusu, C. E., Oguri, M., **Minowa, Y.**, **Iye, M.**, **Inada, N.**, **Oya, S.**, Kayo, I., **Hayano, Y.**, **Hattori, M.**, **Saito, Y.**, **Ito, M.**, **Pyo, T.**, **Terada, H.**, **Takami, H.**, Watanabe, M.: 2016, Subaru Telescope Adaptive Optics Observations of Gravitationally Lensed Quasars in the Sloan Digital Sky Survey, *MNRAS*, **458**, 2–55.

Rutten, R. J.: 2017, Solar H-alpha Features with Hot Onsets III. Long Fibrils in Lyman-alpha and with ALMA, *A&A*, **598**, A89.

Ryu, T., et al., including **Narita, N.**, **Kudo, T.**, **Omiya, M.**, **Harakawa, H.**,

Ando, H., **Currie, T.**, **Egner, S.**, **Guyon, O.**, **Hayano, Y.**, **Hayashi, M.**, **Hayashi, S. S.**, **Hełminiak, K. G.**, **Ishii, M.**, **Iye, M.**, **Izumiura, H.**, **Kambe, E.**, **Kandori, R.**, **Kokubo, E.**, **Mayama, S.**, **Morino, J.**, **Nishimura, T.**, **Pyo, T.-S.**, **Suenaga, T.**, **Suto, H.**, **Suzuki, R.**, **Takato, N.**, **Takeda, Y.**, **Terada, H.**, **Takami, H.**, **Usuda, T.**, **Tamura, M.**: 2016, High-contrast Imaging of Intermediate-mass Giants with Long-term Radial Velocity Trends, *ApJ*, **825**, 127.

Saigo, K., Onishi, T., Nayak, O., Meixner, M., Tokuda, K., **Harada, R.**, Morioka, Y., Sewiło, M., **Indebetouw, R.**, Torii, K., **Kawamura, A.**, Ohama, A., Hattori, Y., Yamamoto, H., Tachihara, K., **Minamidani, T.**, **Inoue, T.**, Madden, S., Galametz, M., Lebouteiller, V., Chen, C. R., **Mizuno, N.**, Fukui, Y.: 2017, Kinematic Structure of Molecular Gas around High-mass YSO, Papillon Nebula, in N159 East in the Large Magellanic Cloud: A New Perspective with ALMA, *ApJ*, **835**, 108.

Saito, T., **Iono, D.**, Xu, C. K., Sliwa, K., Ueda, J., **Espada, D.**, **Kaneko, H.**, König, S., **Nakanishi, K.**, **Lee, M.**, Yun, M. S., Aalto, S., Hibbard, J. E., Yamashita, T., Motohara, K., **Kawabe, R.**: 2017, Spatially resolved CO SLED of the Luminous Merger Remnant NGC 1614 with ALMA, *ApJ*, **835**, 174.

Saito, T., **Iono, D.**, Xu, C., **Ueda, J.**, **Nakanishi, K.**, Yun, M. S., **Kaneko, H.**, Yamashita, T., Lee, M., Espada, D., Motohara, K., **Kawabe, R.**: 2016, Spatially Resolved Radio-to-Far-infrared SED of the Luminous Merger Remnant NGC 1614 with ALMA and VLA, *PASJ*, **68**, 20.

Saito, T., **Iono, D.**, **Espada, D.**, **Nakanishi, K.**, Ueda, J., Sugai, H., Takano, S., Yun, M., **Imanishi, M.**, **Ohashi, S.**, **Lee, M.**, Hagiwara, Y., Motohara, K., **Kawabe, R.**: 2017, Merger-induced Shocks in the Nearby LIRG VV 114 through Methanol Observations with ALMA, *ApJ*, **834**, 6.

Sakurai, T.: 2017, Heating Mechanisms of the Solar Corona, *Proc. Japan Academy, Ser. B*, **93**, 87–97.

Salak, D., Nakai, N., Hatakeyama, T., **Miyamoto, Y.**: 2016, Gas Dynamics and Outflow in the Barred Starburst Galaxy NGC 1808 Revealed with ALMA, *ApJ*, **823**, 68.

Santos, F. P., et al. including **Fumitaka N.**: 2017, Comparing Submillimeter Polarized Emission with Near-infrared Polarization of Background Stars for the Vela C Molecular Cloud, *ApJ*, **837**, 161.

Satoh, T., Nakamura, M., Ueno, M., **Uemizu, K.**, Suzuki, M., Imamura, T., Kasaba, Y., Yoshida, S., Kimata, M.: 2016, Development and In-flight Calibration of IR2: 2-μm Camera Onboard Japan's Venus Orbiter, Akatsuki, *Earth Planets Space*, **68**, 74.

Sawada-Satoh, S., Roh, D. G., Oh, S. J., Lee, S. S., Byun, D. Y., **Kameno, S.**, Yeom, J. H., Jung, D. K., Kim, H. R., Hwang, J. Y.: 2016, Spatially Resolved HCN Absorption Features in the Circumnuclear Region of NGC 1052, *ApJL*, **830**, L3.

Schneider, G., Grady, C. A., Stark, C. C., Gaspar, A., Carson, J., Debes, J. H., Henning, T., Hines, D. C., Jang-Condell, H., Kuchner, M. J., Perrin, M., Rodigas, T. J., **Tamura, M.**, Wisniewski, J. P.: 2016, Deep HST/STIS Visible-light Imaging of Debris Systems around Solar Analog Hosts, *AJ*, **152**, 64.

Scoville, N., et al. including **Morokuma-Matsui, K.**: 2017, Evolution of Interstellar Medium, Star Formation, and Accretion at High Redshift, *ApJ*, **837**, 150.

Scullion, E., van der Voort, L. R., **Antolin, P.**, Wedemeyer, S., Vissers, G., Kontar, E. P., Gallagher, P. T., 2016, Observing the Formation of Flare-driven Coronal Rain, *ApJ*, **833**, 184.

Sekiguchi, S., Sugimoto, M., Shu, S., **Sekimoto, Y.**, **Mitsui, K.**, **Nishino, T.**, **Okada, N.**, **Kubo, K.**, **Takahashi, T.**, Nitta, T.: 2017, Broadband Corrugated Horn Array with Direct Machined Fabrication, *IEEE Trans. Terahertz Sci. Technol.*, **7**, 36–41.

Seko, A., Ohta, K., Yabe, K., **Hatsukade, B.**, Akiyama, M., Tamura, N., Iwamuro, F., Dalton, G.: 2016, Constraint on the Inflow/Outflow Rates in Star-forming Galaxies at z Similar to 1.4 from Molecular Gas Observations, *ApJ*, **833**, 53.

Seko, A., Ohta, K., Yabe, K., **Hatsukade, B.**, Aono, Y., **Iono, D.**: 2016, Gas-to-Dust Ratios in Massive Star-Forming Galaxies at $z \sim 1.4$, *PASJ*, **68**, 62.

Shan, W., **Sekimoto, Y.**, **Noguchi, T.**: 2016, Parametric Amplification in a Superconducting Microstrip Transmission Line, *IEEE Tran. Appl. Supercond.*, **26**, 1801209.

Shi, S.-C., Paine, S., Yao, Q.-J., Lin, Z.-H., Li, X.-X., Duan, W.-Y., **Matsuo, H.**, Zhang, Q., Yang, J., Ashley, M. C. B., Shang, Z., Hu, Z.-W.: 2016, Terahertz and Far-infrared Windows Opened at Dome A in Antarctica, *Nature Astronomy*, **1**, 0001.

Shimoikura, T., Dobashi, K., Matsumoto, T., **Nakamura, F.**: 2016, Discovery of Infalling Motion with Rotation of the Cluster-Forming Clump S235AB ant its Implication of the Clump Structures, *ApJ*, **832**, 205.

Shimonishi, T., Onaka, T., **Kawamura, A.**, Aikawa, Y.: 2016, The Detection of a Hot Molecular Core in the Large Magellanic Cloud with ALMA, *ApJ*, **827**, 72.

Shin, J. W., Cheoun, M. K., Park, T. S., **Kajino, T.**: 2016, New Neutrino Source for the Study of Solar Neutrino Physics in the Vacuum-matter Transition Region, *Phys. Rev. C*, **94**, 045804.

Shinnaka, H., Kawakita, H.: 2016, Nitrogen Isotopic Ratio of Cometary Ammonia from High-resolution Optical Spectroscopic Observations of C/2014 Q2 (LOVEJOY), *AJ*, **152**, 145.

Shinnaka, Y., Fougere, N., Kawakita, H., Kameda, S., Combi, M. R., Ikezawa, S., Seki, A., Kuwabara, M., Sato, M., Taguchi, M., Yoshikawa, I.: 2017, Imaging Observations of the Hydrogen Coma of COMET 67P/CHURYUMOV-GERASIMENKO in 2015 September by the PROCYON/LAICA, *AJ*, **153**, 76.

Shinnaka, Y., Kawakita, H., Jehin, E., Decock, A., Hutsemékers, D., Manfroid, J., Arai, A.: 2016, Nitrogen Isotopic Ratios of NH_2 in Comets: Implication for ^{15}N-fractionation in Cometary Ammonia, *MNRAS*, **462**, S195–S209.

Shinnaka, Y., Kawakita, H., Jehin, E., Decock, A., Hutsemékers, D., Manfroid, J.: 2016, Ortho-to-para Abundance Ratios of NH_2 in 26 Comets: Implications for the Real Meaning of OPRs, *MNRAS*, **462**, S124–S131.

Shirasaki, M., Macias, O., Horiuchi, S., Shirai, S., Yoshida, N.: 2016, Cosmological Constraints on Dark Matter Annihilation and Decay: Cross-correlation Analysis of the Extragalactic γ-ray Background and Cosmic Shear, *Phys. Rev. D*, **94**, 063522.

Shirasaki, M., Nagai, D., Lau, T. E.: 2016, Covariance in the Thermal SZ-Weak Lensing Mass Scaling Relation of Galaxy Clusters, *MNRAS*, **460**, 3913–3924.

Shirasaki, M.: 2017, Statistical Connection of Peak Counts to Power Spectrum and Moments in Weak Lensing Field, *MNRAS*, **465**, 1974–1983.

Shirasaki, Y., Komiya, Y., **Ohishi, M.**, **Mizumoto, Y.**: 2016, Properties of Galaxies around AGNs with the Most Massive Supermassive Black Holes Revealed By Clustering Analysis, *PASJ*, **68**, 23.

Shvartzvald, Y., et al. including **Fukui, A.**: 2016, The First Simultaneous Microlensing Observations by Two Space Telescopes: Spitzer and Swift Reveal a Brown Dwarf in Event OGLE-2015-BLG-1319, *ApJ*, **831**, 183.

Shvartzvald, Y., et al. including **Fukui, A.**: 2016, The Frequency of Snowline-region Planets from Four Years of OGLE-MOA-Wise Second-generation Microlensing, *MNRAS*, **457**, 4089–4113.

Silva, H. O., **Sotani, H.**, Berti, E.: 2016, Low-mass Neutron Stars: Universal Relations, the Nuclear Symmetry Energy and Gravitational Radiation, *MNRAS*, **459**, 4378–4388.

Sirbu, D., Thomas, S. J., Belikov, R., **Lozi, J.**, Bendek, E., Pluzhnik, E., Lynch, D. H., Hix, T., Zell, P., **Guyon, O.**, Schneider, G.: 2016, Demonstration of Broadband Contrast at 1.2λ/D and Greater for the EXCEDE Starlight Suppression System, *J. Astron. Telesc. Instrum.*, **2**, 025002.

Smith, A. M. S., et al. including **Narita, N.**: 2017, K2-99: a Subgiant Hosting a Transiting Warm Jupiter in an Eccentric Orbit and a Long-period Companion, *MNRAS*, **464**, 2708–2716.

Sobral, D., Stroe, A., **Koyama, Y.**, Darvish, B., Calhau, J., Afonso, A., **Kodama, T.**, **Nakata, F.**: 2016, The Nature of Hα Star-forming Galaxies at z ~ 0.4 in and around Cl 0939+4713: The Environment Matters, *MNRAS*, **458**, 3443–3454.

Soma, M., **Tanikawa, K.**: 2016, Earth Rotation Derived from Occultation Records, *PASJ*, **68**, 29.

Song, Q. W., **Nakajima, H.**, Huang, G. L., Tan, B. L., Huang, Y., Wu, Z.: 2016, Turnover Frequency in Solar Microwave Bursts with an Extremely Flat Optically Thin Spectrum, *Sol. Phys.*, **291**, 3619–3635.

Sotani, H., Iida, K., Oyamatsu, K.: 2017, Probing Nuclear Bubble Structure via Neutron Star Asteroseismology, *MNRAS*, **464**, 3101–3107.

Sotani, H., **Kokkotas, K. D.**: 2017, Maximum Mass Limit of Neutron Stars in Scalar-tensor Gravity, *Phys. Rev. D*, **95**, 044032.

Sotani, H., **Takiwaki, T.**: 2016, Gravitational Wave Asteroseismology with Protoneutron Stars, *Phys. Rev. D*, **94**, 044043.

Sotani, H.: 2017, Effect of Nuclear Saturation Parameters on a Possible Maximum Mass of Neutron Stars, *Phys. Rev. C*, **95**, 025802.

Srianand, R., Hussain, T., Noterdaeme, P., Petitjean, P., Krühler, T., Japelj, J., Pâris, I., **Kashikawa, N.**: 2016, Detection of Emission Lines from z ~ 3 DLAs towards the QSO J2358+0149, *MNRAS*, **460**, 634–649.

Stephens, I. W., Gouliermis, D., Looney, L. W., Gruendl, R. A., Chu, Y. H., Weisz, D. R., Seale, J. P., Chen, C. H. R., Wong, T., Hughes, A., Pineda, J. L., Ott, J., **Muller, E.**: 2017, Stellar Clusterings around “Isolated” Massive YSOS in the LMC, *ApJ*, **834**, 94.

Stephens, I. W., Jackson, J. M., Whitaker, J. S., Contreras, Y., Guzman, A. E., **Sanhueza, P.**, Foster, J. B., Rathborne, J. M.: 2016, Linking Dense Gas from the Milky Way to External Galaxies, *ApJ*, **824**, 29.

Strazzullo, V., Daddi, E., Gobat, R., Valentino, F., Pannella, M., Dickinson, M., Renzini, A., Brammer, G., **Onodera, M.**, Finoguenov, A., Cimatti, A., Carollo, C. M., **Arimoto, N.**: 2016, The Red Sequence at Birth in the Galaxy Cluster Cl J1449+0856 at z = 2, *ApJL*, **833**, L20.

Sugiyama, K., et al. including **Fujisawa, K.**, **Hachisuka, K.**, **Yonekura, Y.**, **Motogi, K.**, **Matsumoto, N.**, **Kobayashi, H.**, **Kawaguchi, N.**, **Shibata, K. M.**, **Honma, M.**, **Hirota, T.**: 2016, Observations of 6.7 GHz Methanol Masers with East-Asian VLBI Network. II. Internal Proper Motion Measurement in G006.79-00.25, *PASJ*, **68**, 72.

Sumi, T., et al. including **Fukui, A.**: 2016, The First Neptune Analog or Super-Earth with a Neptune-like Orbit: MOA-2013-BLG-605Lb, *ApJ*, **825**, 112.

Suzuki, D., et al. including **Fukui, A.**: 2016, The Exoplanet Mass-ratio Function from the MOA-II Survey: Discovery of a Break and Likely Peak at a Neptune Mass, *ApJ*, **833**, 145.

Suzuki, T. L., **Kodama, T.**, Sobral, D., Khostovan, A. A., **Hayashi, M.**, **Shimakawa, R.**, **Koyama, Y.**, Tadaki, K., **Tanaka, I.**, **Minowa, Y.**, **Yamamoto, M.**, Smail, I., Best, P. N.: 2016, [OIII] Emission Line as a Tracer of Star-forming Galaxies at High Redshifts: Comparison between Hα and [OIII] Emitters at z=2.23 in HiZELS, *MNRAS*, **462**, 181–189.

Suzuki, T., **Ogihara, M.**, Morbidelli, A., Crida, A., Guillot, T.: 2016, Evolution of Protoplanetary Discs with Magnetically Driven Disc Winds, *A&A*, **596**, A74.

Suzuki, T., **Ohishi, M.**, **Hirota, T.**, **Saito, M.**, Majumdar, L., Wakelam, V.: 2016, Survey Observations of a Possible Glycine Precursor, Methanimine (CH_2NH), *ApJ*, **825**, 79.

Suzuki, T., **Ohishi, M.**, **Hirota, T.**, **Saito, M.**, Majumdar, L., Wakelam, V.: 2016, Erratum: Survey Observations of a Possible Glycine Precursor, Methanimine (CH_2NH), *ApJ*, **831**, 114.

Tadaki, K., Genzel, R., **Kodama, T.**, Wuyts, S., Wisnioski, E., Förster S., Natascha M., Burkert, A., Lang, P., Tacconi, L. J., Lutz, D., Belli, S., Davies, R. I., **Hatsukade, B.**, **Hayashi, M.**, Herrera-Camus, R., Ikarashi, S., Inoue, S., Kohno, K., **Koyama, Y.**, Mendel, J. T., **Nakanishi, K.**, Shimakawa, R., **Suzuki, T. L.**, Tamura, Y., **Tanaka, I.**, Übler, H. Wilman, D. J.: 2017, Bulge-forming Galaxies with an Extended Rotating Disk at z ~ 2, *ApJ*, **834**, 135.

Tagawa, H., **Gouda, N.**, **Yano, T.**, Hara, T.: 2016, The Validation of Made-to-measure Method for Reconstruction of Phase-space Distribution Functions, *MNRAS*, **463**, 927–951.

Tagawa, H., Umemura, M., **Gouda, N.**: 2016, Mergers of Accreting Stellar-mass Black Holes, *MNRAS*, **462**, 3812–3822 .

Takahashi, H. R., **Ohsuga, K.**, **Kawashima, T.**, **Sekiguchi, Y.**: 2016, Formation of Overheated Regions and Truncated Disks around Black Holes: Three-dimensional General Relativistic Radiation-magnetohydrodynamics Simulations, *ApJ*, **826**, 23.

Takakuwa, S., **Saigo, K.**, Matsumoto, T., **Saito, M.**, Lim, J., Hanawa, T., Yen, H. W., Ho, P. T. P.: 2017, Spiral Arms, Infall, and Misalignment of the Circumbinary Disk from the Circumstellar Disks in the Protostellar Binary System L1551 NE, *ApJ*, **837**, 86.

Takeda, Y., Hashimoto, O., Honda, S.: 2017, Photospheric Carbon and Oxygen Abundances of F-G Type Stars in the Pleiades Cluster, *PASJ*, **69**, 1.

Takeda, Y., Honda, S.: 2016, Oxygen Abundance Determination of B-type Stars with the O I 7771-5 Å lines*, *PASJ*, **68**, 32.

Takeda, Y., **Omiya, M.**, **Harakawa, H.**, Sato, B.: 2016, Sulfur and Zinc Abundances of Red Giant Stars, *PASJ*, **68**, 81.

Takeda, Y., **Tajitsu, A.**, Sato, B., Liu, Y.-J., Chen, Y.-Q., Zhao, G.: 2016, Fundamental Stellar Parameters and Age-metallicity Relation of Kepler Red Giants in Comparison with Theoretical Evolutionary Tracks, *MNRAS*, **457**, 4454–4469.

Takekoshi, T., **Minamidani, T.**, **Komugi, S.**, Kohno, K., Tosaki, T., Sorai, K., **Muller, E.**, **Mizuno, N.**, **Kawamura, A.**, Onishi, T., Fukui, Y., **Ezawa, H.**, **Oshima, T.**, Scott, K. S., Austermann, J. E., **Matsuo, H.**, Aretxaga, I., Hughes, D. H., **Kawabe, R.**, Wilson, G. W., Yun, M. S.: 2017, The 1.1 mm Continuum Survey of the Small Magellanic Cloud: Physical Properties and Evolution of the Dust-selected Clouds, *ApJ*, **835**, 55.

Taki, T., Fujimoto, M., Shigeru, I.: 2016, Dust and Gas Density Evolution at a Radial Pressure Bump in Protoplanetary Disks, *A&A*, **591**, A86.

Takiwaki, T., Kotake, K., Suwa, Y.: 2016, Three-dimensional Simulations of Rapidly Rotating Core-collapse Supernovae: Finding a Neutrino-powered Explosion Aided by Non-axisymmetric Flows, *MNRAS Lett.*, **461**, L112–L116.

Tan, K., Shi, J., Takada-Hidai, M., **Takeda, Y.**, Zhao, G.: 2016, A Non-LTE Study of Silicon Abundances in Giant Stars from the Si I Infrared Lines in the zJ-Band, *ApJ*, **823**, 36.

Tanaka, M., Maeda, K., Mazzali, P. A., Kawabata, K. S., Nomoto, K.: 2017, Three-Dimensional Explosion Geometry of Stripped-Envelope Core-Collapse Supernovae. II. Modelling of Polarization, *ApJ*, **837**, 105.

Tanaka, M., **Wong, K. C.**, More, A., Dezuka, A., Egami, E., Oguri, M., Suyu, S. H., Sonnenfeld, A., Higuchi, R., **Komiyama, Y.**, **Miyazaki, S.**, **Onoue, M.**, Oyamada, S., Utsumi, Y.: 2016, A Spectroscopically Confirmed Double Source Plane Lens System in the Hyper Suprime-Cam Subaru Strategic Program, *ApJL*, **826**, L19.

Tanaka, M.: 2016, Kilonova/Macronova Emission from Compact Binary Mergers, *Adv. Astron.*, **2016**, 6341974.

Tanaka, Y. T., et al. including **Takagi, Y.**, **Kuroda, D.**, **Sekiguchi, K.**: 2016, No Evidence of Intrinsic Optical/Near-infrared Linear Polarization for V404 Cygni during Its Bright Outburst in 2015: Broadband Modeling and Constraint on Jet Parameters, *ApJ*, **823**, 35.

Taniguchi, K., **Saito, M.**, Ozeki, H.: 2016, ^{13}C Isotopic Fractionation of HC_3N in Star-Forming Regions: Low-Mass Star Forming Region L1527 and High-Mass Star-Forming Region G28.28-0.36, *ApJ*, **830**, 106.

Tapia, V., **Gonzalez, A.**, Finger, R., Mena, F. P., Monasterio, D., Reyes, N., Sanchez, M., Bronfman, L.: 2017, High Efficiency Wideband Refractive Optics for ALMA Band-1 (35–52 GHz), *J. Infrared, Millimeter, and Terahertz Waves*, **38**, 261–275.

Tatematsu, K., et al. including **Ohashi, S.**, **Sanhueza, P.**, **Luong, Q. N.**, **Hirota, T.**, **Saito, M.**, **Kim, J.**: 2017, Astrochemical Properties of Planck Cold Clumps, *ApJS*, **228**, 12.

Tatematsu, K., Ohashi, S., **Sanhueza, P.**, **Luong, Q. N.**, **Umemoto, T.**, **Mizuno, N.**: 2016, Angular Momentum of the N_2H^+ Cores in the Orion A Cloud, *PASJ*, **68**, 24.

Terada, H., Tokunaga, A. T.: 2017, Multi-epoch Detections of Water Ice Absorption in Edge-on Disks around Herbig Ae Stars: PDS 114N and PDS 453, *ApJ*, **834**, 115.

Terai, T., Itoh, Y., Oasa, Y., **Furusho, R.**, **Watanabe, J.**: 2016, Photometric Measurements of H_2O Ice Crystallinity on Trans-Neptunian Objects, *ApJ*, **827**, 65.

Terao, K., Nagao, T., Hashimoto, T., **Yanagisawa, K.**, Matsuoka, K., Toba, Y., **Ikeda, H.**, Taniguchi, Y.: 2016, Near-infrared Spectroscopy of Nearby Seyfert Galaxies: Is There Evidence for Shock Excitation in Narrow-line Regions?, *ApJ*, **833**, 190.

Tian, H., Young, P. R., Reeves, K. K., Wang, T. J., **Antolin, P.**, Chen, B., He, J. S.: 2016, Global Sausage Oscillation of Solar Flare Loops Detected by the Interface Region Imaging Spectrograph, *ApJL*, **823**, L16.

Toba, Y., Nagao, T., Kajisawa, M., Oogi, T., Akiyama, M., **Ikeda, H.**, Coupon, J., Strauss, M. A., Wang, W.-H., **Tanaka, M.**, Niida, M., **Imanishi, M.**, **Lee, C.-H.**, Matsuhara, H., **Matsuoka, Y.**, **Onoue, M.**, Terashima, Y., Ueda, Y., Harikane, Y., **Komiyama, Y.**, **Miyazaki, S.**, Noboriguchi, A., **Usuda, T.**: 2017, Clustering of Infrared-bright Dust-obscured Galaxies Revealed by the Hyper Suprime-Cam and WISE, *ApJ*, **835**, 36.

Tokuda, K., Onishi, T., Matsumoto, T., **Saigo, K.**, **Kawamura, A.**, Fukui, Y., Inutsuka, S.-i., Machida, M. N., Tomida, K., Tachihara, K., André, P.: 2016, Revealing a Detailed Mass Distribution of a High-density Core MC27/L1521F in Taurus with ALMA, *ApJ*, **826**, 26.

Torii, K., Hattori, Y., Hasegawa, K., Ohama, A., Haworth, T. J., Shima, K., Habe, A., Tachihara, K., **Mizuno, N.**, Onishi, T., Mizuno, A., Fukui, Y.: 2017, Triggered O Star Formation in M20 via Cloud–Cloud Collision: Comparisons between High-resolution CO Observations and Simulations, *ApJ*, **835**, 142.

Toriumi, S., **Katsukawa, Y.**, **Cheung, M. C. M.**: 2017, Various Local Heating Events in the Earliest Phase of Flux Emergence, *ApJ*, **836**, 63.

Toriumi, S., Schrijver, C. J., Harra, L. K., Hudson, H., Nagashima, K.: 2017, Magnetic Properties of Solar Active Regions that Govern Large Solar Flares and Eruptions, *ApJ*, **834**, 56.

Tosaki, T., Kohno, K., Harada, N., Tanaka, K., **Egusa, F.**, Izumi, T., Takano, S., Nakajima, T., Taniguchi, A., Tamura, Y.: 2017, A Statistical Study of Giant Molecular Clouds Traced by ^{13}CO, C^{18}O, CS, and CH_3OH in the Disk of NGC 1068 Based on ALMA Observations, *PASJ*, **69**, 18.

Toshikawa, J., **Kashikawa, N.**, Overzier, R., Malkan, M. A., **Furusawa, H.**, **Ishikawa, S.**, **Onoue, M.**, Ota, K., **Tanaka, M.**, **Niino, Y.**, **Uchiyama, H.**: 2016, A Systematic Survey of Protoclusters at $z \sim 3$-6 in the CFHTLS Deep Fields, *ApJ*, **826**, 114.

Trakhtenbrot, B., Civano, F., Urry, C. M., Schawinski, K., Marchesi, S., Elvis, M., Rosario, D. J., Suh, H., Mejia-Restrepo, J. E., Simmons, B. D., Faisst, A. L., **Onodera, M.**: 2016, Faint COSMOS AGNs at $z \sim 3.3$. I. Black Hole Properties and Constraints on Early Black Hole Growth, *ApJ*, **825**, 4.

Tsuboi, M., Kitamura, Y., **Miyoshi, M.**, Uehara, K., Tsutsumi, T., **Miyazaki, A.**: 2016, Galactic Center Mini-spiral by ALMA: Possible Origin of the Central Cluster, *PASJ*, **68**, L7.

Tsujimoto, T., Yokoyama, T., Bekki, K.: 2017, Chemical Evolution of ^{244}Pu in the Solar Vicinity and Its Implications for the Properties of *r*-process Production, *ApJL*, **835**, L3.

Tsukagoshi, T., Nomura, H., Muto, T., **Kawabe, R.**, Ishimoto, D., Kanagawa, K. D., Okuzumi, S., Ida, S., Walsh, C., Millar, T. J.: 2016, A Gap with a Deficit of Large Grains in the Protoplanetary Disk around TW Hya, *ApJ*, **829**, L35.

Ueda, J., Watanabe, Y., **Iono, D.**, Wilner, D. J., Fazio, G. G., **Ohashi, S.**, **Kawabe, R.**, **Saito, T.**, Komugi, S.: 2017, ALMA Observations of the Dense and Shocked Gas in the Nuclear Region of NGC 4038 (Antennae Galaxies), *PASJ*, **69**, 6.

Ueta, T., Tomasino, R. L., Takita, S., **Izumiura, H.**, Shirahata, M., Fullard, A., Yamamura, I., Matsuura, S.: 2017, Surface Brightness Correction for Compact Extended Sources Observed by the AKARI Far-Infrared Surveyor in the Slow-scan Mode, *PASJ*, **69**, 11.

Umehata, H., et al. including **Matsuda, Y.**, **Ao, Y.**, **Kawabe, R.**, **Hatsukade, B.**, **Kubo, M.**, **Nakanishi, K.**: 2017, ALMA Reveals Strong [CII] Emission in a Galaxy Embedded in a Giant Lyα Blob at $z = 3.1$, *ApJ*, **834**, L16.

Umehata, H., Tamura, Y., Kohno, K., Ivison, R., Smail, I., **Hatsukade, B.**, **Nakanishi, K.**, Kato, Y., Ikarashi, S., **Matsuda, Y.**, Fujimoto, S., **Iono, D.**, **Lee, M.**, Steidel, C., Saito, T., Alexander, D., Yun, M., Kubo, M.: 2017, ALMA Deep Field in SSA22: Source Catalog and Number Counts, *ApJ*, **835**, 98.

Utsumi, Y., Geller, M. J., Dell'Antonio, I. P., **Kamata, Y.**, **Kawanomoto, S.**, **Koike, M.**, **Komiyama, Y.**, **Koshida, S.**, **Mineo, S.**, **Miyazaki, S.**, **Sakurai, J.**, **Tait, P. J.**, **Terai, T.**, **Tomono, D.**, **Usuda, T.**, **Yamada, Y.**, Zahid, H. J.: 2016, A Weak Lensing View of the Downsizing of Star-forming Galaxies, *ApJ*, **833**, 156.

Uyama, T., et al. including **Akiyama, E.**, **Currie, T.**, **Kudo, T.**, **Egner, S.**, **Guyon, O.**, **Hayano, Y.**, **Hayashi, M.**, **Hayashi, S. S.**, **Ishii, M.**, **Iye, M.**, **Kandori, R.**, **Morino, J.-I.**, **Nishimura, T.**, **Pyo, T.-S.**, **Serabyn, E.**, **Suenaga, T.**, **Suto, H.**, **Suzuki, R.**, **Takahashi, Y. H.**, **Takato, N.**, **Terada, H.**, **Watanabe, M.**, **Takami, H.**, **Usuda, T.**, **Tamura, M.**: 2017, The SEEDS High-Contrast Imaging Survey of Exoplanets Around Young Stellar Objects, *AJ*, **153**, 106.

Uzawa, Y., **Kroug, M.**, **Kojima, T.**, Makise, K., **Gonzalez, A.**, Saito, S., **Fujii, Y.**, **Kaneko, K.**, Terai, H., Wang, Z.: 2017, Design of Terahertz SIS Mixers Using Nb/AlN/Nb Junctions Integrated with All-NbTiN Tuning Circuits, *IEEE Tran. Appl. Supercond.*, **27**, 1500705.

Valentino, F., et al. including **Onodera, M.**, **Arimoto, N.**: 2016, A Giant Lyα Nebula in the Core of an X-Ray Cluster at Z = 1.99: Implications for Early Energy Injection, *ApJ*, **829**, 53.

Van Eylen, V., et al. including **Narita, N.**, **Ryu, T.**, **Takeda, Y.**: 2016, The K2-ESPRINT Project V: A Short-period Giant Planet Orbiting a Subgiant Star*, *AJ*, **152**, 143.

Veneziani, M., et al. including **Mizuno, N.**: 2017, An Analysis of Star Formation with Herschel in the Hi-GAL Survey II. The Tips of the Galactic Bar, *A&A*, **599**, A7.

Wakita, S., Matsumoto, Y., **Oshino, S.**, Hasegawa, Y.: 2017, Planetesimal Collisions as a Chondrule Forming Event, *ApJ*, **834**, 125.

Wakita, S., **Nozawa, T.**, Hasegawa, Y.: 2017, Diffusion of Oxygen Isotopes in Thermally Evolving Planetesimals and Size Ranges of Presolar Silicate Grains, *ApJ*, **836**, 106.

Wang, W.-H., et al. including **Hatsukade, B.**, **Iono, D.**, **Lee, M.**, **Matsuda, Y.**, **Nakanish, K.**, **Kodama, T.**: 2016, The SXDF-ALMA 2-arcmin2 Deep Survey: Stacking Rest-frame Near-infrared Selected Objects, *ApJ*, **833**, 195.

Warren, M. L., Mathews, G. J., Meixner, M., Hidaka, J., **Kajino, T.**: 2016, Impact of Sterile Neutrino Dark Matter on Core-collapse Supernovae, *Int. J. Modern Phys. A*, **31(25)**, 1650137.

Wedemeyer, S., et al. including **Shimojo, M.**: 2016, Solar Science with the Atacama Large Millimeter/Submillimeter Array—A New View of Our Sun, *Space Sci. Rev.*, **200**, 1–73.

Wong, G. F., Horiuchi, S., Green, J. A., Tothill, N. F. H., **Sugimoto, K.**, Filipovic, M. D.: 2016, Implementation of Tidbinbilla 70-m on-the-fly Mapping and Hydrogen Radio Recombination Line Early Results, *MNRAS*, **458**, 151–157.

Wong, K. C., et al.: 2017, H0LiCOW - IV. Lens Mass Model of HE 0435-1223 and Blind Measurement of Its Time-delay Distance for Cosmology, *MNRAS*, **465**, 4895–4913.

Wu, B., Tan, J. C., **Nakamura, F.**, Van L. S., Christie, D., Collins, D.: 2017, GMC Collisions as Triggers of Star Formation. II. 3D Turbulent, Magnetized Simulations, *ApJ*, **835**, 137.

Xu, H., Zhang, H., Kuzanyan, K., **Sakurai, T.**: 2016, On the Origin of Differences in Helicity Parameters Derived from Data of Two Solar Magnetographs, *Sol. Phys.*, **291**, 2253–2267.

Yagi, M., **Koda, J.**, **Komiyama, Y.**, **Yamanoi, H.**: 2016, Catalog of Ultra-diffuse Galaxies in the Coma Clusters from Subaru Imaging Data, *ApJS*, **225**, 11.

Yamagishi, M., Kaneda, H., Ishihara, D., Oyabu, S., Suzuki, T., Onaka, T., Nagayama, T., **Umemoto, T.**, **Minamidani, T.**, Nishimura, A., Matsuo, M., Fujita, S., Tsuda, Y., Kohno, M., Ohashi, S.: 2016, Spatial Variations of PAH Properties in M17SW Revealed by Spitzer/IRS Spectral Mapping, *ApJ*, **833**, 163.

Yamaguchi, Y., et al. including **Hatsukade, B.**, **Kawabe, R.**, **Kodama, T.**, **Matsuda, Y.**, **Nakanishi, K.**: 2016, SXDF-ALMA 2 $arcmin^2$ Deep Survey: Resolving and Characterizing the Infrared Extragalactic Background Light Down to 0.5 mJy, *PASJ*, **68**, 82.

Yamamoto, T., **Hayama, K.**, Mano, S., Itoh, Y., Kanda, N.: 2016, Characterization of Non-Gaussianity in Gravitational Wave Detector Noise, *Phys. Rev. D*, **93**, 082005.

Yamanaka, M., et al. including **Tanaka, M.**, **Hanayama, H.**, **Kinugasa, K.**, **Nagayama, T.**, **Kuroda, D.**, **Sekiguchi, K.**: 2017, Broad-lined Supernova 2016coi with a Helium Envelope, *ApJ*, **837**, 1.

Yamanaka, M., et al. including **Tanaka, M.**, **Nagayama, T.**, **Isogai, M.**, **Hanayama, H.**, **Kuroda, D.**, **Ukita, N.**, **Yanagisawa, K.**, **Izumiura, H.**, **Sekiguchi, K.**: 2016, OISTER Optical and Near-infrared Observations of the Super-Chandrasekhar Supernova Candidate SN 2012dn: Dust Emission from the Circumstellar Shell, *PASJ*, **68**, 68.

Yamashita, T., Odaka, M., Sugiyama, K., Nakajima, K., Ishiwatari, M., Nishizawa, S., Takahashi, Y. O., **Hayashi, Y.-Y.**: 2016, A Numerical Study of Convection in a Condensing CO_2 Atmosphere under Early Mars, *J. Atmos. Sciences*, **73**, 4151–4169.

Yamauchi, A., **Yamashita, K.**, **Honma, M.**, **Sunada, K.**, Nakagawa, A., **Ueno, Y.**: 2016, The Far Distance to G7.47+0.06 from Proper Motion Measurement of H_2O Masers, *PASJ*, **68**, 60.

Yang, Y., et al. including **Hayashi, S. S.**, **Tamura, M.**, **Mayama, S.**, **Akiyama, E.**, **Oh, D.**, **Kudo, T.**, **Egner, S.**, **Guyon, O.**, **Hayano, Y.**, **Hayashi, M.**, **Ishii, M.**, **Iye, M.**, **Kandori, R.**, **Morino, J.**, **Nishimura, T.**, **Pyo, T.**, **Serabyn, E.**, **Suenaga, T.**, **Suto, H.**, **Suzuki, R.**, **Takahashi, Y. H.**, **Takato, N.**, **Terada, H.**, **Takami, H.**, **Usuda, T.**: 2017, Near-infrared Imaging Polarimetry of Inner Region of GG Tau A Disk, *AJ*, **153**, 7.

Yasui, C., Kobayashi, N., **Saito, M.**, Izumi, N.: 2016, Low-Metallicity Young Clusters in the Outer Galaxy. II. Sh 2-208, *AJ*, **151**, 115.

Yen, H. W., Koch, P. M., Takakuwa, S., Krasnopolsky, R., **Ohashi, N.**, Aso, Y.: 2017, Signs of Early-stage Disk Growth Revealed with ALMA, *ApJ*, **834**, 178.

Yonekura, Y., et al. including **Fujisawa, K.**, **Ohyama, T.**, **Kono, Y.**, **Kobayashi, H.**, **Kawaguchi, N.**, **Honma, M.**, **Shibata, K. M.**, **Sato, K.**, **Ueno, Y.**, **Jike, T.**, **Tamura, Y.**, **Hirota, T.**, **Miyazaki, A.**, **Hachisuka, K.**: 2016, The Hitachi and Takahagi 32 m Radio Telescopes: Upgrade of the Antennas from Satellite Communication to Radio Astronomy, *PASJ*, **68**, 74.

Yoshida, F., **Ito, T.**, Dermawan, B., Nakamura, T., **Takahashi, S.**, Ibrahimov, M. A., Malhotra, R., Ip, W., Chen, W., Sawabe, Y., Haji, M., Saito, R., Hirai, M.: 2016, Lightcurves of the Karin Family Asteroids, *Icarus*, **269**, 15–22.

Yoshida, M., et al. including **Morokuma, T.**, **Tanaka, M.**, **Matsubayashi, K.**, **Furusawa, H.**, **Koshida, S.**, **Kuroda, D.**, **Nakata, F.**, **Terai, T.**, **Yanagisawa, K.**: 2017, J-GEM Follow-up Observations of the Gravitational Wave Source GW151226*, *PASJ*, **69**, 9.

Yoshikawa, I., Yoshioka, K., Murakami, G., Suzuki, F., Hikida, R., Yamazaki, A., Kimura, T., Tsuchiya, F., Kagitani, M., Sakanoi, T., **Uemizu, K.**, Tao, C., Nozawa, H., Kasaba, Y., Fujimoto, M.: 2016, Properties of Hot Electrons in the Jovian Inner Magnetosphere Deduced from Extended Observations of the Io Plasma Torus, *Geophys. Res. Lett.*, **43**, 11552–11557.

You, C., Zabludoff, A., Smith, P., Yang, Y., Kim, E., Jannuzi, B., Prescott, M. K. M., **Matsuda, Y.**, Lee, M. G.: 2017, Mapping the Polarization of the Radio-Loud Lyα Nebula B3 J2330+3927, *ApJ*, **834**, 182.

Yun, Y., et al. including **Matsumoto, N.**, **Min, C. H.**, **Hirota, T.**, **Honma, M.**, **Hwang, J.-W.**, **Jike, T.**, **Kanaguchi, M.**, **Kawaguchi, N.**, **Kobayashi, H.**, **Kono, Y.**, **Oyama, T.**, **Shibata, K. M.**, **Tamura, Y.**: 2016, SiO Masers around WX Psc Mapped with the KVN and VERA Array (KaVA), *ApJ*, **822**, 3.

Yuzurihara, H., **Hayama, K.**, Mano, S., Verkindt, D., Kanda, N.: 2016, Unveiling Linearly and Nonlinearly Correlated Signals between Gravitational Wave Detectors and Environmental Monitors, *Phys. Rev. D*, **94**, 042004.

Zeegers, S. T., Costantini, E., de Vries, C. P., Tielens, A. G. G. M., Chihara, H., de Groot, F., Mutschke, H., Waters, L. B. F. M., **Zeidler, S.**: 2017, Absorption and Scattering by Interstellar Dust in the Silicon K-edge of GX 5-1, *A&A*, **599**, A117.

Zeidler, S., **Akutsu, T.**, **Torii, Y.**, Hirose, E., **Aso, Y.**, **Flaminio, R.**: 2017, Calculation Method for Light Scattering Caused by Multilayer Coated Mirrors in Gravitational Wave Detectors, *Opt. Express*, **25**, 4741.

Zenitani, S., **Nagai, T.**: 2016, Particle Dynamics in the Electron Current Layer in Collisionless Magnetic Reconnection, *Phys. Plasmas*, **23**, 102102.

Zhao, B., Caselli, P., Li, Z.-Y., Krasnopolsky, R., Shang, H., **Nakamura, F.**: 2016, Protostellar Disc Formation Enabled by Removal of Small Dust Grains, *MNRAS*, **460**, 2050–2076.

2. Publications of the National Astronomical Observatory of Japan

Not Published.

3. Report of the National Astronomical Observatory of Japan (in Japanese)

Sôma, M.: 2016, Estimating the Year and Place of Observations for the Celestial Map in the Kitora Tumulus, *Rep. Nat. Astron. Obs. Japan*, **18**, 1-12.

4. Conference Proceedings

Abe, S., Kero, J., Nakamura, T., Fujiwara, Y., Kastinen, D., **Watanabe, J.**, Hashiguchi, H.: 2016, Asteroidal Meteors Detected by MU Radar Head-echo Observations, Proc. Int. Meteor Conf., Egmond, the Netherlands, 2-5 June 2016, Eds. A. Roggemans, P. Roggemans, 18.

Ammons, S. M., Garcia, E. V., Salama, M., Neichel, B., Lu, J., Marois, C., Macintosh, B., Savransky, D., Bendek, E., **Guyon, O.**, Marin, E., Garrel, V., Sivo, G.: 2016, Precision Astrometry with Adaptive Optics: Constraints on the Mutual Orbit of Luhman 16AB from GeMS, Proc. SPIE 9909, Eds. E. Marchetti, L. M. Close, J.-P. Véran, 99095T.

Aoki, W., Beers, T. C., Suda, T., Lee, Y. S.: 2016, Very Low-Mass Stars with Extremely Low Metallicity in the Milky Way's Halo, Proc. IAU Symp. 317, Eds. A. Bragaglia, M. Arnaboldi, M. Rejkuba, D. Romano, 45-50.

Aoki, W.: 2017, Spectroscopic Approach to Galactic Archaeology with Subaru, Proc. 14th Int. Symp. on Nuclei in the Cosmos (NIC2016), Eds. S. Kubono, et al., 010602.

Bento, J., Feger, T., Ireland, M., Rains, A., **Jovanovic, N.**, Coutts, D., Schwab, C., Arriola, A., Gross, S., 2016, Performance and Future Developments of the RHEA Singlemode Spectrograph, Proc. SPIE 9908, Eds. C. J. Evans, L. Simard, H. Takami, 99086K.

Bono, G., et al. including **Tsujimoto, T.**: 2016, Classical Cepheids and RR Lyrae Stars: Similar, but not Too Much, *Memorie Della Societa Astronomica Italiana*, **87**, 358–381.

Canas, L., **Shibata, Y.**: 2017, Making Tactile Planetarium from Low-cost Materials, *Japanese Society for Education and Popularization of Astronomy*, **29**, 85–86.

Chavan, A. M., et al. including **Akiyama, E.**: 2016, ALMA Quality Assurance: Concepts, Procedures, and Tools, Proc. SPIE 9910, Eds. A. B. Peck, R. L. Seaman, C. R. Benn, 99101H.

Cheoun, M. K., Ha, E., Yang, G. S., Kim, K. S., **Kajino, T.**: 2016, Neutrino-induced Reactions and Neutrino Scattering with Nuclei in Low and High Neutrino Energy, CETUP* 2015 – Workshop on Dark Matter, Neutrino Physics and Astrophysics & PPC 2015 – IXth International Conference on Interconnections between Particle Physics and Cosmology, AIP Conf. Proc. 1743, Eds. B. Szczerbinska, R. Allahverdi, K. Babu, B. Balantekin, B. Dutta, T. Kamon, J. Kumar, F. Queiroz, L. Strigari, R. Surman, 040002.

Cheung, S.-l.: 2016, OAD Task Force 3 Discussions, Proc. IAU, 11, T29A (Transactions IAU), Ed. T. Montmerle, 403–404.

Chiba, M., Tanaka, M., **Komiyama, Y.**: 2016, Subaru Hyper Suprime Cam Survey of the Andromeda Halo, Proc. IAU Symp. 317, Eds. A. Bragaglia, M. Arnaboldi, M. Rejkuba, D. Romano, 278–279.

Christensen, L. L., Russo, P., Fienberg, R. T., **Cheung, S.-l.**, Robson I., Odman-Govender, C., Arcand, K. K., **Sekiguchi, K.**, Zhu, J., Wheeler, P.: 2016, Division C Commission 55: Communicating Astronomy with the Public, Proc. IAU, 11, T29A (Transactions IAU), Ed. T. Montmerle, 209–218.

Das, M., **Saito, T.**, **Iono, D.**, Honey, M., Ramya, S.: 2016, Molecular Gas and Star Formation in Void Galaxies, Proc. IAU Symp. 308, Eds. R. van de Weygaert, S. Shandarin, E. Saar, J. Einasto, 610–613.

Dennison, K., Ammons, S. M., Garrel, V., Marin, E., Sivo, G., Bendek, E., **Guyon, O.**: 2016, An Engineered Design of a Diffractive Mask for High Precision Astrometry, Proc. SPIE 9909, Eds. E. Marchetti, L. M. Close, J.-P. Véran, 99094E.

Ebizuka, N., Okamoto, T., Hosobata, T., Yamagata, Y., Sasaki, M., Uomoto, M., Shimatsu, T., Sato, S., Hashimoto, N., **Tanaka, I.**, **Hattori, T.**, **Ozaki, S.**, **Aoki, W.**: 2016, Novel diffraction gratings for next generation spectrographs with high spectral dispersion, Proc. SPIE 9912, Eds. R. Navarro, J. H. Burge, 99122Z.

Ezaki, Y., Kato, A., Hattori, T., Saruta, Sofuku, S., Nakaoji, T., Kawaguchi, N., Takaki, J., Horiuchi, Y., Haruna, M., Tabata, M., Hosokawa, Y., **Kusumoto, H.**, **Usuda, T.**: 2016, Overview of Key Technologies for TMT Telescope Structure, Proc. SPIE 9906, Eds. H. J. Hall, R. Gilmozzi, H. K. Marshall, 99060Y.

Fabricius, M., **Walawender, J.**, **Arimoto, N.**, **Cook, D.**, **Elms, B.**, Hashiba, Y., **Hattori, T.**, Hu, Y.-S., **Iwata, I.**, **Nishimura, T.**, **Omata, K.**, **Tait, P.**, **Takato, N.**, **Tanaka, I.**, Wang, S.-Y., **Weber, M.**, **Wung, M.**: 2016, Detector Upgrade of Subaru's Multi-object Infrared Camera and Spectrograph (MOIRCS), Proc. SPIE 9908, Eds. C. J. Evans, L. Simard, H. Takami, 990828.

Farinato, J., et al. including **Guyon, O.**: 2016, SHARK-NIR: from K-band to a key Instrument, a Status Update, Proc. SPIE 9909, Eds. E. Marchetti, L. M. Close, J.-P. Véran, 990931.

Feinberg, L., Rioux, N., Bolcar, M., Liu, A., **Guyon, O.**, Stark, C., Arenberg, J.: 2016, End-to-end Assessment of a Large Aperture Segmented Ultraviolet Optical Infrared (UVOIR) Telescope Architecture, Proc. SPIE 9904, Eds. H. A. MacEwen, G. G. Fazio, M. Lystrup, 99040H.

Flaminio, R.: 2016, The Cryogenic Challenge: Status of the KAGRA Project, *J. Phys.: Conf. Ser.*, **716**, 012034.

Fujii, Y., **Sekiguchi, T.**, **Takahashi, R.**, **Aso, Y.**, **Barton, M.**, **Erasmo, F.**, **Arellano, P.**, **Shoda, A.**, **Akutsu, T.**, Miyakawa, O., Kamiizumi, M., **Ishizaki, H.**, **Tatsumi, D.**, **Hirata, N.**, **Hayama, K.**, **Okutomi, K.**, Miyamoto, T., Ishizuka, H., DeSalvo, R., **Flaminio, R.**: 2016, Active Damping Performance of the KAGRA Seismic Attenuation System Prototype, *J. Phys.: Conf. Ser.*, **716**, 012022.

Fujikawa, S., et al. including **Sôma, M.**: 2016, V1656 SCORPII = PNV J17225112-3158349, IAU Circ. 9283, Ed. D. W. E. Green.

Gee, W. T., **Guyon, O.**, Walawender, J., **Jovanovic, N.**, Boucher, L.: 2016, Project PANOPTES: a Citizen-scientist Exoplanet Transit Survey Using Commercial Digital Cameras, Proc. SPIE 9908, Eds. C. J. Evans, L. Simard, H. Takami, 99085V.

Giono, G., **Katsukawa, Y.**, **Ishikawa, R.**, **Narukage, N.**, **Kano, R.**, **Kubo, M.**, Ishikawa, S., **Bando, T.**, **Hara, H.**, **Suematsu, Y.**, Winebarger, A., Kobayashi, K., Auchere, F., Trujillo Bueno, J.: 2016, Optical Alignment of the Chromospheric Lyman-Alpha SpectroPolarimeter Using Sophisticated Methods to Minimize Activities Under Vacuum, Proc. SPIE 9905, Eds. J.-W. A. den Herder, T. Takahashi, M. Bautz, 99053D.

Goebel, S. B., **Guyon, O.**, Hall, D. N. B., **Jovanovic, N.**, Atkinson, D. E.: 2016, Evolutionary Timescales of AO-produced Speckles at NIR Wavelengths, Proc. SPIE 9909, Eds. E. Marchetti, L. M. Close, J.-P. Véran, 990918.

Green, R., et al. including **Cheung, S.-l.**: 2016, Cosmic Light, Proc. IAU, 11, T29A (Transactions IAU), Ed. T. Montmerle, 549.

Groff, T., Chilcote, J., Kasdin, J., Galvin, M., Loomis, C., Carr, M., Brandt, T., Knapp, G., Limbach, M., **Guyon, O.**, **Jovanovic, N.**, McElwain, M., **Takato, N.**, **Hayashi, M.**: 2016, Laboratory Testing and Performance Verification of the CHARIS Integral Field Spectrograph, Proc. SPIE 9908, Eds. C. J. Evans, L. Simard, H. Takami, 99080O.

Hagino, M., Ichimoto, K., Ueno, S., Kimura, G., Otsuji, K., Kitai, R., Zhong, L., Xu, Z., Shinoda, K., **Hara, H.**, **Suematsu, Y.**, Shimizu, T.: 2016, Development of the Universal Tunable Filter and High-resolution Imaging Observation with the Fuxian Solar Observatory, ASP Conf. Ser. 504, Eds. I. Dorotovic, C. E. Fischer, M. Temmer, 103–106.

Hanada, H., **Tsuruta, S.**, **Asari, K.**, **Araki, H.**, **Noda, H.**, **Kashima, S.**, Funazaki, K., Satoh, A., Taniguchi, H., Kato, H., Kikuchi, M., Sasaki, H., Hasegawa, T., Gusev, A.: 2016, Expected Accuracy of a Small Telescope Like PZT for Observations of Vertical Gravity Gradient and Lunar Rotation, 4th IAG Symposium on Terrestrial Gravimetry: Static And Mobile Measurements, Ed. V. G. Peshekhonov, 220–227.

Hanaoka, Y., **Solar Observatory of NAOJ**: 2016, Past and Present of the Synoptic Observations of the Sun at the National Astronomical Observatory of Japan, ASP Conf. Ser. 504, Eds. I. Dorotovic, C. E. Fischer, M. Temmer, 313–315.

Hirai, Y., Ishimaru, Y., Saitoh, T. R., Fujii, M. S., Hidaka, J., **Kajino, T.**: 2016, Chemo-dynamical Evolution Model: Enrichment of r-process Elements in the Local Group Dwarf Galaxies, Proc. IAU Symp. 317, Eds. A. Bragaglia, M. Arnaboldi, M. Rejkuba, D. Romano, 308–309.

Hirai, Y., Ishimaru, Y., Saitoh, T. R., Fujii, M. S., Hidaka, J., **Kajino, T.**: 2017, Chemo-Dynamical Evolution of r-process Elements in the Local Group Galaxies, JPS Conf. Proc. 14 (NIC2016), Eds. S. Kubono, et al., 020204.

Hirano, T., Sato, B., Masuda, K., Benomar, O. M., **Takeda, Y.**, **Omiya, M.**, **Harakawa, H.**: 2016, Search for Close-in Planets around Evolved Stars with Phase-curve variations and Radial Velocity Measurements, Proc. IAU, 11, T29A (Transactions IAU), Ed. T. Montmerle, 63–64.

Honda, S., Notsu, Y., **Maehara, H.**, Notsu, S., Shibayama, T., Nogami, D., Shibata, K.: 2017, Lithium Abundance of the Solar-Type Superflare Stars, JPS Conf. Proc. 14 (NIC2016), Eds. S. Kubono, et al., 020303.

Huang, Y., et al. including **Iguchi, S.**, **Asayama, S.**, **Iono, D.**, **Gonzalez, A.**: 2016, The Atacama Large Millimeter/sub-millimeter Array band-1 receiver, Proc. SPIE 9911, Eds. G. Z. Angeli, P. Dierickx, 99111V.

Iguchi, S., **Saito, M.**: 2016, Large Aperture Millimeter/Submillimeter Telescope: Which is More Cost-Effective, Aperture Synthesis Telescope Versus Large Single Dish Telescope?, Proc. SPIE 9906, Eds. H. J. Hall, R. Gilmozzi, H. K. Marshall, 99062T.

Ishigaki, M. N., **Tsujimoto, T.**, Shigeyama, T., **Aoki, W.**: 2016, Chemical Evolution of r-process Elements in the Draco Dwarf Spheroidal Galaxy, Proc. IAU Symp. 317, Eds. A. Bragaglia, M. Arnaboldi, M. Rejkuba, D. Romano, 310–311.

Ishikawa, S., Shimizu, T., **Kano, R.**, **Bando, T.**, **Ishikawa, R.**, **Giono, G.**, Beabout, D. L., Beabout, B. L., Nakayama, S., Tajima, T.: 2016, In-Flight Performance of the Polarization Modulator in the CLASP Rocket Experiment, Proc. SPIE 9905, Eds. J.-W. A. den Herder, T. Takahashi, M. Bautz, 99052U

Ishino, H., et al. including **Hasebe, T.**, **Noguchi, T.**, **Sekimoto, Y.**: 2016, LiteBIRD: Lite Satellite for the Study of B-mode Polarization and Inflation from Cosmic Microwave Background Radiation Detection, Proc. SPIE 9904, Eds. H. A. MacEwen, G. G. Fazio, M. Lystrup, 99040X.

Ishizuka, M., **Kotani, T.**, **Nishikawa, J.**, **Tamura, M.**, **Kurokawa, T.**, Mori, T., **Kokubo, T.**: 2016, Fiber Mode Scrambler Experiments for the Subaru Infrared Doppler Instrument (IRD), Proc. SPIE 9912, Eds.

R. Navarro, J. H. Burge, 99121Q.

Izumi, N., Kobayashi, N., **Yasui, C.**, Tokunaga, A. T., **Saito, M.**, Hamano, S.: 2017, Star-Formation Efficiency in the outer Galaxy, Proc. IAU Symp. 321, Eds. A. Gil de Paz, J. H. Knapen, J. C. Lee, 31–33.

Jenniskens, P, Borovicka, J., **Watanabe, J.**, Jopek, T., Abe, S., Consolmagno, Guy J., Ishiguro, M., Janches, D., Ryabova, Galina O., Vaubaillon, J., Zhu, J.: 2016, Division F Commission 22: Meteors, Meteorites, and Interplanetary Dust, Proc. IAU, 11, T29A (Transactions IAU), Ed. T. Montmerle, 365–379.

Jike, T.: 2016, VERA Geodetic VLBI with a Newly Developed High-speed Sampler and Recorder, IVS 2016 General Meeting Proceedings, Eds. D. Behrend, K. D. Baver, K. L. Armstrong, 159–162.

Jovanovic, N., Cvetojevic, N., Schwab, C., Norris, B., **Lozi, J.**, Gross, S., Betters, C., Singh, G., **Guyon, O.**, Martinache, F., **Doughty, D.**, Tuthill, P.: 2016, Efficiently Feeding Single-mode Fiber Photonic Spectrographs with an Extreme Adaptive Optics System: On-sky Characterization and Preliminary Spectroscopy, Proc. SPIE 9908, Eds. C. J. Evans, L. Simard, H. Takami, 99080R.

Jovanovic, N., et al. inluding **Guyon, O.**, **Lozi, J.**, **Currie, T.**, **Pathak, P.**, **Doughty, D.**, **Goebel, S.**, **Kudo, T.**, **Kotani, T.**, **Minowa, Y.**, **Takato, N.**, **Tamura, M.**, **Takami, H.**, **Hayashi, M.**: 2016, The SCExAO High Contrast Imager: Transitioning from Commissioning to Science, Proc. SPIE 9909, Eds. E. Marchetti, L. M. Close, J.-P. Véran, 99090W.

Jovanovic, N., **Guyon, O.**, **Kawahara, H.**, **Kotani, T.**: 2017, Application of Multicore Optical Fibers in Astronomy, Optical Fiber Communications conference 2017, W3H.3.

Kakiuchi, K., Suzuki, T. K., Fukui, Y., **Torii, K.**, Machida, M., Matsumoto, R.: 2017, Vertical Flows and Structures Excited by Magnetic Activity in the Galactic Center Region, Proc. IAU Symp. 322, Eds. R. M. Crocker, S. N. Longmore, G. V. Bicknell, 220–221.

Katsukawa, Y., **Kamata, Y.**, Anan, T., **Hara, H.**, **Suematsu, Y.**, **Bando, T.**, Ichimoto, K., Shimizu, T.: 2016, Development of a Near-Infrared Detector and a Fiber-optic Integral Field Unit for a Space Solar Observatory SOLAR-C, Proc. SPIE 9904, Eds. H. A. MacEwen, G. G. Fazio, M. Lystrup, 99045I.

Kawabe, R., **Kohno, K.**, **Tamura, Y.**, **Takekoshi, T.**, **Oshima, T.**, **Ishii, S.**: 2016, New 50-m-class Single-dish Telescope: Large Submillimeter Telescope (LST), Proc. SPIE 9906, Eds. H. J. Hall, R. Gilmozzi, H. K. Marshall, 990626.

Kitagawa, Y., Yamagata, Y., Morita, S., Motohara, K., **Ozaki, S.**, Takahashi, H., Konishi, M., Kato, N. M., Kobayakawa, Y., Terao, Y., Ohashi, H.: 2016, Fabrication of a Wide-field NIR Integral Field Unit for SWIMS Using Ultra-precision cutting, Proc. SPIE 9912, Eds. R. Navarro, J. H. Burge, 991225.

Kiuchi, H., Hills, R., Whyborn, N. D., **Asayama, S.**, **Sakamoto, S.**, **Iguchi, S.**, Corder, S. A.: 2016, Artificial Calibration Source for ALMA Radio Interferometer, Proc. SPIE 9914, Eds. W. S. Holland, J. Zmuidzinas, 99142O.

Kokubo, T., Mori, T., **Kurokawa, T.**, Kashiwagi, K., Tanaka, Y., **Kotani, T.**, **Nishikawa, J.**, **Tamura, M.**: 2016, 12.5-GHz-spaced Laser Frequency Comb Covering Y, J, and H Bands for Infrared Doppler Instrument, Proc. SPIE 9912, Eds. R. Navarro, J. H. Burge, 99121R.

Komiyama, Y., **Nakaya, H.**, **Kashikawa, N.**, Uchida, T.: 2016, Conceptual Design of Wide-field Focal Plane with InGaAs Image Sensors, Proc. SPIE 9908, Eds. C. J. Evans, L. Simard, H. Takami, 99085X.

Kuroda, D., **Hanayama, H.**, **Miyaji, T.**, **Watanabe, J.**, **Yanagisawa, K.**, **Nagayama, S.**, Yoshida, M., Ohta, K., Kawai, N.: 2016, GRB 160624A: MITSuME Ishigakijima Upper Limits, GRB Coordinates Network, Circular Service, 19571, 1.

Kuroda, D., **Hanayama, H.**, **Miyaji, T.**, **Watanabe, J.**, **Yanagisawa, K.**, **Nagayama, S.**, Yoshida, M., Ohta, K., Kawai, N.: 2016, GRB 160623A: MITSuME Ishigakijima Optical Observation, GRB Coordinates Network, Circular Service, 19572, 1.

Kuroda, D., **Hanayama, H.**, **Miyaji, T.**, **Watanabe, J.**, **Yanagisawa, K.**, **Nagayama, S.**, Yoshida, M., Ohta, K., Kawai, N.: 2016, GRB 160625B: MITSuME Ishigakijima Optical Observation, GRB Coordinates Network, Circular Service, 19599, 1.

Kuroda, D., **Hanayama, H.**, **Miyaji, T.**, **Watanabe, J.**, **Yanagisawa, K.**, **Nagayama, S.**, Yoshida, M., Ohta, K., Kawai, N.: 2016, GRB 160703A: MITSuME Ishigakijima Optical Observation, GRB Coordinates Network, Circular Service, 19653, 1.

Labadie, L., Berger, J.-P., Cvetojevic, N., Haynes, R., Harris, R., **Jovanovic, N.**, Lacour, S., Martin, G., Minardi, S., Perrin, G., Roth, M., Thomson, R. R.: 2016, Astronomical Photonics in the Context of Infrared Interferometry and High-resolution Spectroscopy, Proc. SPIE 9907, Eds. F. Malbet, M. J. Creech-Eakman, P. G. Tuthill, 990718.

Li, H.-N., **Aoki, W.**, Honda, S., Zhao, G., Suda, T., Christlieb, N.: 2017, Exploring the Early Chemical Evolution of the Milky Way with LAMOST and Subaru, JPS Conf. Proc. 14 (NIC2016), Eds. S. Kubono, et al., 010201.

Lozi, J., **Guyon, O.**, **Jovanovic, N.**, Singh, G., **Goebel, S.**, Norris, B., **Okita, H.**: 2016, Characterizing and Mitigating Vibrations for SCExAO, Proc. SPIE 9909, Eds. E. Marchetti, L. M. Close, J.-P. Véran, 99090J.

Males, J., et al. including **Guyon, O.**, **Jovanovic, N.**, **Lozi, J.**: 2016, The Path to Visible Extreme Adaptive Optics with MagAO-2K and MagAO-X, Proc. SPIE 9909, Eds. E. Marchetti, L. M. Close, J.-P. Véran, 990952.

Martinache, F., **Jovanovic, N.**, **Guyon, O.**: 2016, Subaru Coronagraphic eXtreme Adaptive Optics: On-sky Performance of the Asymmetric Pupil Fourier Wavefront Sensor, Proc. SPIE 9909, Eds. E. Marchetti, L. M. Close, J.-P. Véran, 990954.

Matsuo, M., **Minamidani, T.**, **Umemoto, T.**, Nishimura, A., Nakahishi, H., Kuno, N., **Fujita, S.**, Tosaki, T., Tsuda, Y., Yamagishi, M., Kohno, M., FUGIN team: 2017, A Survey of Molecular Clouds in the Outer Galaxy with the Highest Spatial Resolution, Proc. IAU Symp. 321, Eds. A. Gil de Paz, J. H. Knapen, J. C. Lee, 44–44.

Mawet, D., et al. including **Guyon, O.**: 2016, Keck Planet Imager and Characterizer: Concept and Phased Implementation, Proc. SPIE 9909, Eds. E. Marchetti, L. M. Close, J.-P. Véran, 99090D.

Mennesson, B., et al. including **Guyon, O.**, **Tamura, M.**: 2016, The Habitable Exoplanet (HabEx) Imaging Mission: preliminary science drivers and technical requirements, Proc. SPIE 9904, Eds. H. A. MacEwen, G. G. Fazio, M. Lystrup, 99040L.

Miller, K., **Guyon, O.**: 2016, Linear Dark Field Control: Simulation for Implementation and Testing on the UA Wavefront Control Testbed, Proc. SPIE 9909, Eds. E. Marchetti, L. M. Close, J.-P. Véran, 99094G.

Minamidani, T., **Nishimura, A.**, **Miyamoto, Y.**, **Kaneko, H.**, **Iwashita, H.**, **Miyazawa, C.**, **Nishitani, H.**, **Wada, T.**, **Fujii, Y.**, **Takahashi, T.**, **Iizuka, Y.**, Ogawa, H., Kimura, K., **Kozuki, Y.**, Hasegawa, Y., **Matsuo, M.**, **Fujita, S.**, **Ohashi, S.**, **Morokuma-Matsui, K.**, **Maekawa, J.**, Muraoka, K., Nakajima, T., **Umemoto, T.**, Sorai, K., **Nakamura, F.**, Kuno, N., **Saito, M.**: 2016, Development of the New Multi-Beam 100 GHz Band SIS Receiver FOREST for the Nobeyama 45-m Telescope, Proc. SPIE 9914, Eds. W. S. Holland, J. Zmuidzinas, 99141Z.

Minamidani, T., **Umemoto, T.**, **Nishimura, A.**, **Matsuo, M.**, Tsuda, Y., **Ohashi, S.**, Tosaki, T., Kuno, N.: 2016, Nobeyama CO Galactic Plane Survey: New Chapter of the Nobeyama 45-m Telescope, EAS Publ. Ser., **75–76**, 193–194.

Minowa, Y., **Takato, N.**, **Iwata, I.**, **Hattori, T.**: 2016, An Overview of Current and Future Instrumentation at the Subaru Telescope, Proc. SPIE 9908, Eds. C. J. Evans, L. Simard, H. Takami, 990806.

Mitsuda, K., Hashiba, Y., **Minowa, Y.**, **Hayano, Y.**, **Sugai, H.**, Shimono, A., Matsubayashi, K., Hattori, T., Kamata, Y., Ozaki, S., Doi, M., Sako, S.: 2016, CCD System Upgrading of the Kyoto3DII and Integral Field Spectroscopic Observation with the New System, Proc. SPIE 9908, Eds. C. J. Evans, L. Simard, H. Takami, 99082M.

Miura, N., Oh-ishi, A., Kuwamura, S., Baba, N., **Hanaoka, Y.**, Ueno, S., Nakatani, Y., **Ichimoto, K.**: 2016, Status of Hida Solar Adaptive Optics System and Experiment of Tomographic Wavefront Sensing, Proc. SPIE 9909, Eds. E. Marchetti, L. M. Close, J.-P. Véran, 99092N.

Miyamoto, Y., Nakai, N., Seta, M., Salak, D., Nagai, M., Ishii, S., **Yamauchi, A.**: 2016, Hot Gas in the Center of the Seyfert Galaxy NGC 3079, Proc. IAU Symp. 315, Eds. P. Jablonka, Ph. Andre, F. van der Tak, E55.

Montmerle T., et al. including **Cheung, S.-l.**: 2016, Executive Committee Working Group: Public Naming of Planets and Planetary Satellites, Proc. IAU, 11, T29A (Transactions IAU), Ed. T. Montmerle, 539–548.

Morokuma-Matsui, K., Koda, J., **Takekoshi, T.**, **Saito, M.**, Nakanishi, H., Boissier, S., Madore, B. F., Boselli, A., Gil de Paz, A., Thilker, D., Yagi, M., Sorai, K., Kuno, N.: 2017, Search for Molecular Gas in XUV Disk of M83, Proc. IAU Symp. 321, Eds. A. Gil de Paz, J. H. Knapen, J. C. Lee, 268–268.

Motohara, K., et al. including **Koshida, S.**, **Uchiyama, M.**: 2016, NIR Camera and Spectrograph SWIMS for TAO 6.5 m Telescope: Overview and Development Status, Proc. SPIE 9908, Eds. C. J. Evans, L. Simard, H. Takami, 99083U.

Murakami, N., **Nishikawa, J.**, Akaiwa, N., Komuro, Y., Baba, N., **Tamura, M.**: 2016, Fiber Mode Scrambler Experiments for the Subaru Infrared Doppler Instrument (IRD), Proc. SPIE 9912, Eds. R. Navarro, J. H. Burge, 99121Q.

Murakami, N., **Nishikawa, J.**, Akaiwa, N., Komuro, Y., Baba, N., **Tamura, M.**: 2016, A Three-layer Eight-octant Phase Mask towards Broadband High-contrast Observations, Proc. SPIE 9912, Eds. R. Navarro, J. H. Burge, 99126G.

Murthy, J., Witt, A., Baggaley, W. J., Dwek, E., Levasseur-Regourd, A.-C., Mann, I., Mattila, K., **Watanabe, J.**: 2016, Division G Commission 21: Galactic and Extragalactic Backgrounds Radiation, Proc. IAU, 11, T29A (Transactions IAU), Ed. T. Montmerle, 522–524.

Naito, H., Watanabe, F., Sano, Y., Kuramoto, K., Itagaki, K., Kiyota, S., Arai, A., Matsumoto, K., Kojiguchi, N., Sugiura, Y., **Maehara, H.**, Nishiyama, K., Kabashima, F., Henze, M., Darnley, M. J., Shafter, A. W., Kato, M.: 2016, Optical Photometric Observations of M31N 2008-12a: Pre- and Post-maximum of the 2016 Eruption, The Astronomer's Telegram, 9891.

Nakai, Y., Baba, N., Murakami, N., Miura, N., **Tamura, M.**: 2016, Image restoration for a hypertelescope, Proc. SPIE 9907, Eds. F. Malbet, M. J. Creech-Eakman, P. G. Tuthill, 99073F.

Nakaya, H., **Komiyama, Y.**, **Kashikawa, N.**, Uchida, T., Nagayama, T., Yoshida, M.: 2016, Low Temperature Performance of a Commercially Available InGaAs Image Sensor, Proc. SPIE 9915, Eds. A. D. Holland, J. Beletic, 99151O.

Narukage, N., et al. including **Ishikawa, R.**, **Kubo, M.**, **Kano, R.**, **Suematsu, Y.**, **Yoshida, M.**: 2016, Chromospheric LAyer SpectroPolarimeter (CLASP2), Proc. SPIE 9905, Eds. J.-W. A. den Herder, T. Takahashi, M. Bautz, 990508.

Newman, K., Sirbu, D., Belikov, R., **Guyon, O.**: 2016, Development of PIAA Complex Mask Coronagraphs for Large Aperture Ground-based Telescopes, Proc. SPIE 9912, Eds. R. Navarro, J. H. Burge, 99126L.

Nishikawa, J., Oya, M., Murakami, N., **Tamura, M.**, **Kurokawa, T.**, Tanaka, Y., **Kotani, T.**: 2016, Contrast Improvement with Imperfect Pre-coronagraph and Dark-hole, Proc. IAU, 11, T29A (Transactions IAU), Ed. T. Montmerle, 213.

Nishikawa, J., Oya, M., Murakami, N., **Tamura, M.**, **Kurokawa, T.**, Tanaka, Y., **Kotani, T.**: 2016, Contrast Improvement with Imperfect Pre-coronagraph and Dark-hole, Proc. SPIE 9904, Eds. H. A. MacEwen, G. G. Fazio, M. Lystrup, 99043E.

Nishimura, A., **Umemoto, T.**, **Minamidani, T.**, Kuno, N., Tosaki, T., Fujita, S., Matsuo, M., Tsuda, Y., Ohashi, S., NRO-GPS team: 2016, Nobeyama 45 m CO Galactic Plane Survey: Filament Properties and Star Formation in M17, Proc. IAU Symp. 315, Eds. P. Jablonka, Ph. Andre, F. van der Tak, E58.

Ohishi, M.: 2016, Search for Complex Organic Molecules in Space, *J. Phys.: Conf. Ser.*, **728**, 052002.

Ohsawa, R., et al. including **Watanabe, J.**: 2016, Development of a Real-time Data Processing System for a Prototype of the Tomo-e Gozen Wide Field CMOS Camera, Proc. SPIE 9913, Eds. G. Chiozzi, J. C. Guzman, 991339.

Oka, T., Mizuno, R., Miura, K., Takekawa, S.: 2017, Signature of an Intermediate-Mass Black Hole in the Central Molecular Zone of Our Galaxy, Proc. IAU Symp. 322, Eds. R. M. Crocker, S. N. Longmore, G. V. Bicknell, 119–122.

Oka, T., Mizuno, R., Miura, K., Takekawa, S.: 2017, Posiible Detection of Quasi-Periodic Oscillations from Sgr A* at 43 GHz, Proc. IAU Symp. 322, Eds. R. M. Crocker, S. N. Longmore, G. V. Bicknell, 50–51.

Onishi, T., **Nishimura, A.**, Tokuda, K., Harada, R., Dobashi, K., Shimoikura, T., Kimura, K., Ogawa, H.: 2016, Large-Scale Molecular Gas Survey in ^{12}CO, ^{13}CO and C^{18}O (J = 2–1) with the Osaka 1.85 m mm-submm Telescope, Proc. IAU Symp. 315, Eds. P. Jablonka, Ph. Andre, F. van der Tak, E62.

Ozaki, S., **Miyazaki, S.**, **Tsuzuki, T.**, **Tanaka, Y.**: 2016, Polishing Test of a Poly-crystal Calcium Fluoride Lens: toward the Development of TMT WFOS, Proc. SPIE 9908, Eds. C. J. Evans, L. Simard, H. Takami, 99089N.

Pathak, P., **Guyon, O.**, **Jovanovic, N.**, **Lozi, J.**, Martinache, F., **Minowa, Y.**, **Kudo, T.**, **Takami, H.**, **Hayano, Y.**, **Narita, N.**: 2016, First On-sky Closed Loop Measurement and Correction of Atmospheric Dispersion, Proc. SPIE 9909, Eds. E. Marchetti, L. M. Close, J.-P. Véran, 990956.

Pehlivan, Y., Subasi, A. L., Birol, S., Ghazanfari, N., Yuksel, H., Balantekin, A. B., **Kajino, T.**: 2016, Can We Scan the Supernova Model Space for Collective Oscillations?, CETUP* 2015 – Workshop on Dark Matter, Neutrino Physics and Astrophysics & PPC 2015 –

IXth International Conference on Interconnections between Particle Physics and Cosmology, AIP Conf. Proc. 1743, Eds. B. Szczerbinska, R. Allahverdi, K. Babu, B. Balantekin, B. Dutta, T. Kamon, J. Kumar, F. Queiroz, L. Strigari, R. Surman, 040007.

Rains, A., Ireland, M., **Jovanovic, N.**, Feger, T., Bento, J., Schwab, C., Coutts, D., Guyon, O., Arriola, A., Gross, S.: 2016, Precision Single Mode Fibre Integral Field Spectroscopy with the RHEA Spectrograph, Proc. SPIE 9908, Eds. C. J. Evans, L. Simard, H. Takami, 990876.

Rezaei, M., Park, M.-S., Wheaton, S., Tan, C. L., Fathipour, V., **Guyon, O.**, Ulmer, M. P., Mohseni, H.: 2016, New Progress in Electron-injection Detectors for NIR Imagers with Low Noise and High Frame Rates, Proc. SPIE 9915, Eds. A. D. Holland, J. Beletic, 99150P.

Saito, T., **Iono, D.**, **Ueda, J.**, Yun, M. S., **Nakanishi, K.**, Sugai, H., **Imanishi, M.**, Hagiwara, Y., **Kaneko, H.**, Motohara, K., Espada, D., Yamashita, T., **Lee, M.**, **Michiyama, T.**, **Kawabe, R.**: 2016, Molecular Gas Excitation and Chemistry in VV 114 and NGC 1614 with ALMA, Proc. IAU Symp. 315, Eds. P. Jablonka, Ph. Andre, F. van der Tak, E71.

Sako, S., et al. including **Watanabe, J.**: 2016, Development of a Prototype of the Tomo-e Gozen Wide-field CMOS Camera, Proc. SPIE 9908, Eds. C. J. Evans, L. Simard, H. Takami, 99083P.

Salak, D., Nakai, N., **Miyamoto, Y.**: 2016, Evolution of Molecular Clouds in the Starburst Galaxy NGC 1808 Revealed with ALMA, *EAS Publ. Ser.*, **75–76**, 69–70.

Schwab, C., **Jovanovic, N.**, Feger, T., Bakovic, M., Gurevich, Y. V., Stürmer, J., Apodaca, R., Vanzi, L., Rukdee, S., Lawrence, J. S., Coutts, D. W., Cvetojevic, N., Mahadevan, S., Stefánsson, G. K., Halverson, S. P., **Guyon, O.**: 2016, Adaptive Optics Fed Single-mode Spectrograph for High-precision Doppler Measurements in the Near-infrared, Proc. SPIE 9912, Eds. R. Navarro, J. H. Burge, 991274.

Sekimoto, Y., Sekiguchi, S., Shu, S., Sekine, M., Nitta, T., Naruse, M., **Dominjon, A.**, **Hasebe, T.**, **Shan, W.**, **Noguchi, T.**, **Miyachi, A.**, Mita, M., Kawasaki, S.: 2016, Design of Corrugated-horn-coupled MKID Focal Plane for CMB B-mode Polarization, Proc. SPIE 9914, Eds. W. S. Holland, J. Zmuidzinas, 99142A.

Shu, S., Sekiguchi, S., Sekine, M., **Sekimoto, Y.**, Nitta, T., **Dominjon, A.**, **Noguchi, T.**, Naruse, M., **Shan, W.**: 2016, Development of Octave-band Planar Ortho-mode Transducer with Kinetic Inductance Detector for LiteBIRD, Proc. SPIE 9914, Eds. W. S. Holland, J. Zmuidzinas, 99142C.

Singh, G., **Lozi, J.**, Choquet, E., Serabyn, E., **Guyon, O.**: 2016, PSF Calibration Using the Lyot-based Low Order Wavefront Sensor Telemetry: First Simulations, Proc. SPIE 9909, Eds. E. Marchetti, L. M. Close, J.-P. Véran, 99097K.

Sôma, M., et al.: 2016, NOVA SCORPII 2016 No. 2 = PNV J17225112-3158349, CBET 4320, Ed. D. W. E. Green.,

Stoehr, F., Manning, A., Moins, C., Jenkins, D., Lacy, M., Leon, S., **Muller, E.**, **Nakanishi, K.**, Matthews, B., Gaudet, S., Murphy, E., **Ashitagawa, K.**, **Kawamura, A.**: 2017, The ALMA Science Archive, *The Messenger*, **167**, 2–6.

Suematsu, Y., Saito, K., Koyama, M., Enokida, Y., Okura, Y., Nakayasu, T., Sukegawa, T.: 2016, Development of Compact Metal-mirror Image Slicer Unit for Optical Telescope of the SOLAR-C Mission, Proc. SPIE 9904, Eds. H. A. MacEwen, G. G. Fazio, M. Lystrup, N. Batalha, N. Siegler, E. C. Tong, 990411.

Suematsu, Y., Solar-C Working Group: 2016, The SOLAR-C Mission: Science Objectives and Current Status, ASP Conf. Ser. 504, Eds. I. Dorotovic, C. E. Fischer, M. Temmer, 299–308.

Sugai, H., Kashima, S., Kimura, K., Matsumura, T., Inoue, M., Ito, M., Nishibori, T., **Sekimoto, Y.**, Ishino, H., Sakurai, Y., Imada, H., Fujii, T.: 2016, Optical Designing of LiteBIRD, Proc. SPIE 9904, Eds. H. A. MacEwen, G. G. Fazio, M. Lystrup, 99044H.

Suzuki, T. K., Fukui, Y., **Torii, K.**, Machida, M., Matsumoto, R., Kakiuchi, K.: 2017, Investigating Magnetic Activity in the Galactic Centre by Global MHD Simulation, Proc. IAU Symp. 322, Eds. R. M. Crocker, S. N. Longmore, G. V. Bicknell, 137–140.

Takakuwa, S., Phashi, N., Yen, H.-W., Chou, T.-L., Saigo, K., **Saito, M.**, **Aso, Y.**, Aikawa, Y., **Koyamatsu, S.**, Machida, M. N., Takahashi, S. Z., Tomida, K., **Tomisaka, K.**: 2016, SMA and ALMA Studies of Protoplanetary Disk Formation around Low-Mass Protostars, Proc. IAU Symp. 315, Eds. P. Jablonka, Ph. Andre, F. van der Tak, 126–129.

Takekawa, S., **Oka, T.**, Tanak, K.: 2017, Physical Contact between the +20 $km\,s^{-1}$ Cloud and the Galactic Circumnuclear Disk, Proc. IAU Symp. 322, Eds. R. M. Crocker, S. N. Longmore, G. V. Bicknell, 145–146.

Tanaka, M., Chiba, M., **Komiyama, Y.**, Tanaka, M., Okamoto, S., Okamoto, T.: 2017, The Missing Satellite Problem Outside of the Local Group, Proc. IAU Symp. 321, Eds, A. Gil de Paz, J. H. Knapen, J. C. Lee, 196–198.

Tanaka, M., Chiba, M., **Komiyama, Y.**: 2016, Discovery of New Dwarf Galaxies around NGC4631 with Subaru/Hyper Suprime-Cam, Proc. IAU Symp. 317, Eds. A. Bragaglia, M. Arnaboldi, M. Rejkuba, D. Romano, 350–351.

Tokuyama, S., **Oka, T.**, Takekawa, S., Yamada, M., Iwata, Y., Tsujimoto, S.: 2017, Statistical Study of High-Velocity Compact Clouds Based on the Complete CO Imagings of the Central Molecular Zone, Proc. IAU Symp. 322, Eds. R. M. Crocker, S. N. Longmore, G. V. Bicknell, 154–155.

Walawender, J., **Wung, M.**, **Fabricius, M.**, **Tanaka, I.**, **Arimoto, N.**, **Cook, D.**, **Elms, B.**, Hashiba, Y., Hu, Y.-S., **Iwata, I.**, **Nishimura, T.**, **Omata, K.**, **Takato, N.**, Wang, S.-Y., **Weber, M.**: 2016, The nuMOIRCS Project: Detector Upgrade Overview and Early Commissioning Results, Proc. SPIE 9908, Eds. C. J. Evans, L. Simard, H. Takami, 99082G.

Wizinowich, P., Chun, M., Mawet, D., Agapito, G., Dekany, R., Esposito, S., Fusco, T., **Guyon, O.**, Hall, D., Plantet, C., Rigaut, F.: 2016, Near-infrared wavefront sensing, Proc. SPIE 9909, Eds. E. Marchetti, L. M. Close, J.-P. Véran, 990915.

Yamada, M., **Oka, T.**, Tanaka, K., Nomura, M., Takekawa, S., Iwata, Y., Tokuyama, S., Tanabe, K., Tsujimoto, S., Furusawa, M.: 2017, Kinematics of the Ultra-High-Velocity Gas in the Expanding Molecular Shell Adjacent to the W44 Supernova Remnant, Proc. IAU Symp. 322, Eds. R. M. Crocker, S. N. Longmore, G. V. Bicknell, 151–153.

Yamanaka, M., Nakaoka, T., Kawabata, M., Kawabata, K. S., **Tanaka, M.**, Tominaga, N., Maeda, K., Hashimoto, O., **Kinugasa, K.**, Takayama, M., Morihana, K., Oister Collaboration: 2016, Spectroscopic Follow-Up Observations of AT 2016coi (ASASSN-16fp) : Possible Detection of Helium, The Astronomer's Telegram, 9124.

Yamaoka, H., Green, D. W. E., Samus, N. N., Aksnes, K., Gilmore, A. C., Nakano, S., Sphar, T., Tichá, J., Williams, G. V.: 2016, Division B Commission 6: Astronomical Telegrams, Proc. IAU, 11, T29A (Transactions IAU), Ed. T. Montmerle, 90–98.

Yasui, C., **Izumi, N.**, **Saito, M.**, Kobayashi, N.: 2017, A Spatially-Resolved Study of Initial Mass Function in the Outer Galaxy, Proc. IAU Symp. 321, Eds. A. Gil de Paz, J. H. Knapen, J. C. Lee, 34–36.

Yatsu, Y., Kawai, N., Fujiwara, T., Tachibana, Y., Yoshii, T., Harita, S., Muraki, Y., Ohuchi, H., **Kuroda, D.**, **Yanagisawa, K.**, **Hanayama, H.**: 2016, Recent progress of the Robotic Telescope System "MITSuME", IV Workshop on Robotic Autonomous Observatories, Revista Mexicana de Astronomía y Astrofísica (Serie de Conferencias) Vol. 48, Eds. M. D. Caballero-García, S. B. Pandey, D. Hiriart, A. J. Castro-Tirado, 24–26.

Yilmaz, M., Selam, S. O., Sato, B., Bikmaev, I., **Izumiura, H.**, Keskin, V., **Kambe, E.**: 2016, The Line Bisectors of G Type Giant Star HD199719, The 19th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun, Ed. G. A. Freiden, 69.

Yoneta, K., Murakami, N., **Kotani, T.**, **Kawahara, H.**, Matsuo, T., Baba, N., **Tamura, M.**: 2016, Development of Speckle Nulling Technique for the Savart-plate Lateral-shearing Interferometric Nuller for Exoplanets (SPLINE), Proc. SPIE 9912, Eds. R. Navarro, J. H. Burge, 99126I.

Yoshii, Y., et al. including **Koshida, S.**: 2016, The University of Tokyo Atacama Observatory 6.5 m Telescope: Project Overview and Current Status, Proc. SPIE 9906, Eds. H. J. Hall, R. Gilmozzi, H. K. Marshall, 99060R.

Zacharias, N., Brown, A., Evans, D., Chen, L., **Gouda, N.**, Makarov, V., Shulga, A., Souchay, J., Teixeira, R., Unwin, S.: 2016, Division a Commission 8: Astrometry, Proc. IAU, 11, T29A (Transactions IAU), Ed. T. Montmerle, 46–59.

5. Publications in English

Kubono, S., **Kajino, T.**, Nishimura, S., Isobe, T., Nagataki, S., Shima, T., **Takeda, Y.** (Ed.): 2017, Proceedings of 14th International Symposium on Nuclei in the Cosmos (NIC2016), JPS, Japan.

Valtonen, M., Anosova, J., Kholshevnikov, K., Mylläri, A., Orlov, V., **Tanikawa, K.**: 2016, The Three-body Problem from Pythagoras to Hawking, Springer International Publishing, Switzerland.

Yamada, M., Yoo, J., **Zenitani, S.**: 2016, Magnetic Reconnection: Energy Conversion and Inventory of a Prototypical Magnetic Reconnection layer (Astrophysics and Space Science Library book series 427), Springer International Publishing, Switzerland.

6. Conference Presentations

Agata, H., **Canas, L.**, Karino, S.: 2016, Astronomy Education Standard Curriculum, CAP2016, (Medellín, Colombia, May 16–20, 2016).

Agata, H., **Canas, L.**, Karino, S.: 2016, Astronomy Education Standard Curriculum, Global Hands-On Universe (GHOU) Conference 2016 with Galileo Teacher Training Program (GTTP) International Workshop 2016, (Stord, Norway, Aug. 22–28, 2016).

Agata, H., **Canas, L.**, **Usuda-Sato, K.**, **Kato, T.**: 2016, Workshop: Mitaka Software - from Your Classroom to the Universe, Global Hands-On Universe (GHOU) Conference 2016 with Galileo Teacher Training Program (GTTP) International Workshop 2016, (Stord, Norway, Aug. 22–28, 2016).

Agata, H.: 2016, Astronomy Education in Mongolia, International Educational Workshop on Space Science in Mongolia 2016, (Selenge, Mongolia, Sep. 8, 2016).

Agata, H.: 2016, Activity of IAU Outreach (OAO) and NAOJ - Astronomy for Everyone!, International Educational Workshop on Space Science in Mongolia 2016, (Ulaanbaatar, Mongolia, Sep. 6, 2016).

Agata, H.: 2016, Exploring the Universe with Mitaka software & Outreach strategy NAOJ, Global Hands-On Universe (GHOU) Conference 2016 with Galileo Teacher Training Program (GTTP) International Workshop 2016, (Stord, Norway, Aug. 22–28, 2016).

Akiyama, E., Hashimoto, J., Liu, H. B., Li, I. J., Motohide, T.: 2016, Differential Grain Growth in the Spiral Structure of the LkHα 330 Disc, Star Formation 2016, (Exeter, UK, Aug. 21–26, 2016).

Akiyama, E., Sitko, M., Liu, H. B., Grady, C., Hashimoto, J., Muto, T.: 2017, Disk Structure in a Large Hole of a Pre-transitional Disk around Sun-like PDS 70 Young Star, East-Asian ALMA Science Workshop 2016, (Hsinchu, Taiwan, Mar. 10–12, 2017).

Antolin, P., **Okamoto, J.**, De Pontieu, B., Van Doorsselaere, T., Yokoyama, T., De Moortel, I.: 2016, Alfvénic Waves in Prominences and Associated Instabilities and Heating, AOGS 2016, (Beijing, China, Jul. 31–Aug. 5, 2016).

Antolin, P., **Okamoto, J.**, De Pontieu, B., Van Doorsselaere, T., Yokoyama, T., De Moortel, I.: 2016, Resonant Absorption as Feeding Mechanism for Alfvenic Turbulence - Observable Signatures in a Solar Prominence, IRIS-6: The Chromosphere, (Stockholm, Sweden, Jun. 20–23, 2016).

Aoki, W.: 2016, Spectroscopic approach to Galactic Archaeology with Subaru, Panoramas of the Evolving Cosmos, The 6th Subaru Int. Conf., (Hiroshima, Japan, Nov. 28–Dec. 2, 2016).

Aoki, W.: 2016, Observational Constraints on the Astrophysical Site of the r-Process, 14th Int. Symp. on Nuclei in the Cosmos (NIC2016), (Niigata, Japan, Jun. 19-24, 2016).

Aso, Y., KAGRA collaboration: 2016, R&D for the gravitational wave detector KAGRA, 21st Int. Conf. on General Relativity and Gravitation (GR21), (New York, USA, Jul. 10–25, 2016).

Aso, Y., KAGRA collaboration: 2017, Status of the KAGRA project, LVC Meeting in Pasadena, (Pasadena, CA, USA, Mar. 13–16, 2017).

Aso, Y.: 2017, Room Temperature Vibration Isolation Systems of KAGRA, 5th ELiTES Meeting, (Toyama, Japan, Feb. 8–10, 2017).

Bento, J., Feger, T., Ireland, M., Rains, A., **Jovanovic, N.**, Coutts, D., Schwab, C., Arriola, A., Gross, S.: 2016, Performance and Future Developments of the RHEA Singlemode Spectrograph, SPIE Ground-based and Airborne Instrumentation for Astronomy VI, (Edinburgh, UK, Jun. 26–30, 2016).

Canas, L., **Cheung, S.-l.**, **Shibata, Y.**: 2016, National Outreach Contacts (NOC): IAU's Outreach Network Program Case Study, Communicating Astronomy with the Public 2016, (Medellin, Colombia, May 16–20, 2016).

Canas, L., **Cheung, S.-l.**, **Shibata, Y.**: 2016, IAU Outreach (OAO) - bringing together formal education and outreach, Global Hands-On Universe (GHOU) Conference 2016 with Galileo Teacher Training Program (GTTP) International Workshop 2016, (Stord, Norway, Aug. 22–28, 2016).

Canas, L., Perez, A., Gil, A., Carcia, B., Merced, W., **Usuda-Sato, K.**: 2016, Astronomy for Inclusion: Network and Hands-on Workshop, Communicating Astronomy with the Public 2016, (Medellin, Colombia, May 16–20, 2016).

Canas, L., **Shibata, Y.**: 2016, Making tactile planetarium from low-sost materials, 3rd Symposium on Universal Design for Astronomy Education, (Tokyo, Japan, Sep. 24–26, 2016).

Canas, L., Simmons, M., McMonigal, C., Doran, R.: 2016, Big & Global4Local: Micro-Crowdfunding Local Astronomy Outreach and Education Projects, Communicating Astronomy with the Public 2016, (Medellin, Colombia, May 16–20, 2016).

Canas, L., **Usuda-Sato, K.**, Perez, A., Gil, A., Garcia, B., Merced, W.: 2016, Workshop: Accessible Astronomy - Take an Inclusion Program to Your Country, Global Hands-On Universe (GHOU) Conference 2016 with Galileo Teacher Training Program (GTTP) International Workshop 2016, (Stord, Norway, Aug. 22–28, 2016).

Canas, L.: 2016, IAU Office for Astronomy Outreach: Astronomy for Everyone, Southeast Asia Astronomical Network (SEAAN) 2016, (Hanoi, Viet Nam, Dec. 12–13, 2016).

Cheung, S.-l.: 2016, The IAU Office for Astronomy Outreach — its mission and the beyond NameExoWorlds and Cosmic Light, Communicating Astronomy with the Public 2016, (Medellin, Colombia, May 16–20, 2016).

Cheung, S.-l.: 2016, IAU Office for Astronomy Outreach, Latin America IAU Regional Meeting 2016, (Cartagena de Indias, Colombia, Oct. 2–7, 2016).

Currie, T. M., **Guyon, O.**, **Jovanovic, N.**, **Lozi, J.**, **Tamura, M.**, **Kudo, T.**, **Uyama, T.**, Garcia, E.: 2017, SEEDS: Direct Imaging of Exoplanets and Their Forming Disks with the Subaru Telescope, AAS Meeting #229, (Grapevine, TX, USA, Jan. 3–7, 2017).

Ebizuka, N., Okamoto, T., Hosobata, T., Yamagata, Y., Sasaki, M., Uomoto, M., Shimatsu, T., Sato, S., Hashimoto, Kirino, O., N., **Tanaka, I.**, **Hattori, T.**, **Ozaki, S.**, **Aoki, W.**: 2017, Current Status of Novel Gratings for Next Generation Astronomical Instruments IV, Subaru Users' Meeting FY2016, (Tokyo, Japan, Jan. 10–12, 2017).

Ebizuka, N., Okamoto, T., Hosobata, T., Yamagata, Y., Sasaki, M., Uomoto, M., Shimatsu, T., Sato, S., Hashimoto, N., **Tanaka, I.**, **Hattori, T.**, **Ozaki, S.**, **Aoki, W.**: 2016, Novel Diffraction Gratings for Next Generation Spectrographs with High Spectral Dispersion, SPIE Advances in Optical and Mechanical Technologies for Telescopes and Instrumentation II, (Edinburgh, UK, Jun. 26–Jul. 1, 2016).

Egusa, F., Mentuch Cooper, E., Koda, J., Baba, J.: 2016, Offsets between Gas and Stellar Spiral Arms in M51, Discs in Galaxies, (Garching, Germany, Jul. 11–15, 2016).

Egusa, F.: 2016, Gas Disk Dynamics, Extensitve CO Survey of Nearby Galaxies, (Mitaka, Japan, Dec. 7–9, 2016).

Egusa, F.: 2016, Extensive CO Survey of Nearby Galaxies with ACA, ALMA/45m/ASTE Users Meeting 2016, (Mitaka, Japan, Dec. 19–20, 2016).

Ezawa, H., **Matsuo, H.**, Ukibe, M., Fujii, G., Shiki, S.: 2016, Developments towards the terahertz intensity interferometry, SPIE Astronomical Telescopes + Instrumentatio, (Edinburgh, UK, Jun. 26–Jul. 1, 2016).

Flaminio, R.: 2016, Observation of Gravitational Waves from a Binary Black Hole Merger: results and perspectives, 4th DTA Symp., (Mitaka, Japan, May 13–14, 2016).

Flaminio, R.: 2016, Observation of Gravitational Waves: Latest Results and Perspectives, Ultimate Subaru Science Workshop 2016, (Tokyo, Japan, Jun. 16–17, 2016).

Flaminio, R.: 2016, Gravitational Wave Astronomy: Status and Perspectives, 2nd NAOJ-ECT Workshop on Many Riddles About Core-Collapse Supernovae: Bethe and Beyond, (Mitaka, Japan, Jun. 27–Jul. 1, 2016).

Flaminio, R.: 2016, Gravitational Wave Detectors: Status of the Art and Perspectives, Irago Conferecne 2016, (Tokyo, Japan, Nov. 1–2, 2016).

Flaminio, R.: 2016, Status of KAGRA, The 2nd International Meeting on KAGRA, (Beijing, China, Nov. 10–12, 2016).

Fujii, Y., Adams, T., Marion, F., **Flaminio, R.**: 2016, Localization of Coalescing Binaries with a Hierarchical Network of Gravitational Wave Detectors, Gravitational-Wave Astrophysics in the High Event Rate Regime, (Tokyo, Japan, Dec. 5–6, 2016).

Fujita, C., Ozeki, H., **Kobayashi, K.**: 2016, The Microwave Spectroscopy of Aminoacetonitrile in the Vibrational Excited States 2, 71st International Symposium on Molecular Spectroscopy, (Urbana-Champagne, IL, USA, Jun. 20–24, 2016).

Fujiwara, H., Morishima, R., **Fujiyoshi, T.**, **Yamashita, T.**: 2017, Seasonal Variation of the Radial Brightness Contrast of Saturn's Rings Viewed in Mid-infrared by Subaru/COMICS, Ice in the Solar System, (Madrid, Spain, Jan. 23–26, 2017).

Fujiwara, H.: 2016, Dust in Warm Debris Disks, Seach for Life: From Early Earth to Exoplanets, (Quy Nhon, Vietnam, Dec. 11–16, 2016).

Fujiwara, H.: 2016, Introduction to Research with Subaru Telescope, Tropical School in Undergraduate Astronomy: Astronomical Observations, (Quy Nhon, Vietnam, Dec. 11, 2016).

Fujiwara, H.: 2017, Dust in Warm Debris Disks, NARIT Friday Seminar, (Chiang Mai, Thailand, Feb. 17, 2017).

Fukui, A.: 2016, Characterizations of Transiting Exoplanets with Multi-band Camera MuSCAT, Japan-Germany Planet and Disk Workshop, (Ishigaki, Japan, Sep. 25–30, 2016).

Fukui, A.: 2016, MuSCAT & MuSCAT2: New Multiband Imagers for Precise Photometry, 21st Int. Microlensing Conf. Ushering in the New Age of Microlensing from Space, (Pasadena, CA, USA, Feb. 1–3, 2017).

Fukushima, K., **Kobayashi, K.**, **Hirota, T.**: 2016, Methanol Maser Survey Observation with the Nobeyama 45 m Telescope, Workshop for Interstellar Matter 2016, (Sapporo, Japan Oct. 19–21, 2016).

Gee, W. T., **Guyon, O.**, Walawender, J., **Jovanovic, N.**, Boucher, L.: 2016, Project PANOPTES: a Citizen-scientist Exoplanet Transit Survey Using Commercial Digital Cameras, SPIE Ground-based and Airborne Instrumentation for Astronomy VI, (Edinburgh, UK, Jun. 26–30, 2016).

Giono, G., **Katsukawa, Y.**, **Ishikawa, R.**, **Narukage, N.**, **Kano, R.**, **Kubo, M.**, Ishikawa, S., **Bando, T.**, **Hara, H.**, **Suematsu, Y.**, Winebarger, A., Kobayashi, K., Auchere, F., Trujillo Bueno, J.: 2016, Optical Alignment of the Chromospheric Lyman-Alpha SpectroPolarimeter Using Sophisticated Methods to Minimize Activities Under Vacuum, SPIE Astronomical Telescopes + Instrumentatio, (Edinburgh, UK, Jun. 26–Jul. 1, 2016).

Goebel, S. B., **Guyon, O.**, Hall, D. N. B., **Jovanovic, N.**, Atkinson, D. E.: 2016, Evolutionary Timescales of AO-produced Speckles at NIR Wavelengths, SPIE Adaptive Optics Systems V, (Edinburgh, UK, Jun. 26, 2016).

Gonzalez, A., **Asayama, S.**, Tapia, V., Finger, R., Monasterio, D., Reyes, N.: 2016, Effects of Cryostat Infrared Filters on the Performance of ALMA band 1 (35–52 GHz) Receiver Optics, IEEE Antenna and Propagation Symposium/ USNC URSI 2016, (Fajardo, Puerto Rico, Jun. 26–Jul. 1, 2016).

Gonzalez, A., **Kaneko, K.**, **Asayama, S.**: 2017, Recent Work on (sub-) mm-wave Ultra WideBand Corrugated Horns for Radio Astronomy, 11th European Conf. on Antennas and Propagation (EuCAP 2017), (Paris, France, Mar. 19–24, 2017).

Gonzalez, A., **Kaneko, K.**, **Kojima, T.**, **Asayama, S.**, **Uzawa, Y.**: 2016, Corrugated Horns for ALMA band 11 (1.25–1.57 THz), 27th Int. Symp. on Space Terahertz Technology, (Nanjing, China, Apr. 12–15, 2016).

Gonzalez, A., **Kojima, T.**, **Fujii, Y.**, **Asayama, S.**: 2016, Reconfigurable Beam Measurement System and Use for ALMA band 11 (1.25–1.57 THz), 27th Int. Symp. on Space Terahertz Technology, (Nanjing, China, Apr. 12–15, 2016).

Gonzalez, A., **Kojima, T.**, **Kaneko, K.**, **Asayama, S.**: 2017, Development of a wideband waveguide diplexer to provide LO power in the 275–500 GHz band, 28th Int. Symp. on Space Terahertz Technology, (Cologne, Germany, Mar. 13–15, 2017)

Gonzalez, A., Tapia, V., Reyes, N., Mena, F. P., Nesti, R., Villa, F., Cuttaia, F., de Rosa, A., di Giorgio, A. M., Morbidini, A., Yagoubov, P.: 2016, ALMA Band 2+3 (67–116 GHz) optics design and first measurements, IEEE Antenna and Propagation Symposium/ USNC URSI 2016, (Fajardo, Puerto Rico, Jun. 26–Jul. 1, 2016).

Gonzalez, A.: 2016, Optics work for the band 2 and 2+3 receivers at NAOJ, ALMA bands 2/2+3 Workshop, (Gothenburg, Sweden, May 23–24, 2016).

Gonzalez, A.: 2016, Optics Research for Future Receivers at NAOJ, ALMA Developer's workshop, (Gothenburg, Sweden, May 25–27, 2016).

Gouda, N.: 2016, Small-JASMINE, Gaia-JASMINE joint meeting, (Mitaka, Japan, Dec. 6–9, 2016).

Groff, T., Chilcote, J., Kasdin, J., Brandt, T., Galvin, M., Loomis, C., Carr, M., Knapp, G., **Guyon, O.**, **Jovanovic, N.**, **Lozi, J.**, **Takato, N.**, **Hayashi, M.**: 2017, On-Sky Performance Verification of the CHARIS IFS, AAS Meeting #229, (Grapevine, TX, USA, Jan. 3–7, 2017).

Groff, T., Chilcote, J., Kasdin, J., Galvin, M., Loomis, C., Carr, M., Brandt, T., Knapp, G., Limbach, M., **Guyon, O.**, **Jovanovic, N.**, McElwain, M., **Takato, N.**, **Hayashi, M.**: 2016, Laboratory Testing and Performance Verification of the CHARIS Integral Field Spectrograph, SPIE Ground-based and Airborne Instrumentation for Astronomy VI, (Edinburgh, UK, Jun. 26–30, 2016).

Gusev, A., **Hanada, H.**, Kosov, A., Meng, Z., Ping, J.: 2016, Dynamics and Interior of the Inner Solid and Outer Liquid Cores of the Moon for ChangE-4/5/6, Luna-25/26/27, ILOM Projects, AOGS 2016, (Beijing, China, Jul. 31–Aug. 5, 2016).

Gusev, A., **Hanada, H.**, Meng, Zh., Ping, J.: 2016, Tidal-librational

Dissipative Dynamics of the Multi-layers Moon, AstroKazan 2016, (Kazan, Russia, Aug. 25–29, 2016).

Guyon, O.: 2016, Where are our Closest Neighbours? Looking for Life on Nearby Exoplanets, Conf. on Lasers and Electro-Optics 2016, (San Jose, USA, Jun. 5–10, 2016).

Guyon, O.: 2016, Imaging and Characterization of Rocky Planets in the Habitable Zones of Nearby Stars with ELTs, Fourth Annual GMT Community Science Meeting, (Asilomar, CA, USA, Sept. 26–28, 2016).

Hada, K.: 2016, Report on EAVN Imaging Test Observations and Future Prospects, East Asia VLBI Workshop 2016, (Guiyang, Guizhou, China, Nov. 7–11, 2016).

Hada, K.: 2016, Millimeter VLBI with ALMA and Its User Support, ALMA/45m/ASTE/Mopra Users Meeting 2016, (Mitaka, Japan, Dec. 19–20, 2016).

Hada, K.: 2016, M87 Jet Imaged at Highest Sensitivity: An Improved View of the Transverse Structure, M87 Workshop, (Taipei, Taiwan, May 23–27, 2016).

Hada, K.: 2016, The Structure and Propagation of the Misaligned Jet M87, Blazars Through Sharp Multi-wavelength eyes, (Malaga, Spain, May 30–Jun. 3, 2016).

Hada, K.: 2016, Radio Imaging of M87 at Low Frequencies, EHT Collaboration Meeting 2016, (Boston, MA, USA, Nov. 29–Dec. 3, 2016).

Hada, K.: 2017, The East Asian VLBI Network, Black Hole Astrophysics with VLBI - Past, Present and Future, (Mitaka, Japan, Mar. 27–29, 2017).

Hada, K.: 2017, An Improved View of the M87 Jet: Radio Imaging of the Spine-sheath Structure, Challenges of AGN Jets, (Mitaka, Japan, Jan. 17–20, 2017).

Hanada, H., **Araki H.**, **Tsuruta, S.**, **Asari, K.**, **Noda, H.**, **Kashima, S.**, Funazaki, K., Satoh, A., Taniguchi, H., Kato, H., Kikuchi, M., Sasaki, H., Hasegawa, T., Gusev, A.: 2016, Results of Ground Experiments Using a Small Telescope Like PZT for Observation of Lunar Rotation and a New Proposal for Miniaturization, AOGS 2016, (Beijing, China, Jul. 31–Aug. 5, 2016).

Hanada, H., **Araki H.**, **Tsuruta, S.**, **Asari, K.**, **Noda, H.**, **Kashima, S.**, Funazaki, K., Satoh, A., Taniguchi, H., Kato, H., Kikuchi, M., Sasaki, H., Hasegawa, T., Gusev, A.: 2016, Expected Accuracy of a Small Telescope Like PZT for Observations of Vertical Gravity Gradient and Lunar Rotation, 4th IAG Symposium on Terrestrial Gravimetry: Static And Mobile Measurements, (Saint Petersburg, Russia, Apr. 12–15, 2016).

Hanada, H., **Tsuruta, S.**, **Asari, K.**, **Araki, H.**, **Noda, H.**, **Kashima, S.**, Funazaki, K., Satoh, A., Taniguchi, H., Kato, H., Kikuchi, M., Sasaki, H., Hasegawa, T., Gusev, A.: 2016, Evaluation of Accuracy of a Small Telescope Like PZT for Observation of Lunar Rotation and a New Proposal for Future Missions, AstroKazan 2016, (Kazan, Russia, Aug. 25–29, 2016).

Hanaoka, Y., **Sakurai, T.**, **IRMag Group**: 2016, Statistical Study of the Magnetic Field in Solar Filaments, 8th Solar Polarization Workshop, (Firenze, Italy, Sep. 12–16, 2016).

Hanaoka, Y.: 2016, NAOJ's Synoptic Solar Observations, Theoretical and Observational Approaches to the Solar Magnetic Field, (Tokyo, Japan, May 27, 2016).

Hanaoka, Y.: 2017, Direct Observations of the Magnetic Field in Solar Filaments, 2nd PSTEP International Symposium, (Kyoto, Japan, Mar. 23–24, 2017).

Hanayama, H.: 2016, Ishigaki Observatory ~Ishigakijima Astronomical Observatory and Murikabushi 105 cm Telescope~, JOVIAL Kick-off Meeting, (Nice, France, Apr. 18–20, 2016).

Hara, H.: 2016, Hinode EUV Imaging Spectroscopy at the Site of Magnetic Reconnection in Solar Flares, 10th Hinode Science Meeting, (Nagoya, Japan, Sep. 5–8, 2016).

Hara, H.: 2016, Solar Corona: Recent Progress from Space Observations, International Congress on Plasma Physics (ICPP)-2016, (Kaohsiung, Taiwan, Jun. 27–Jul. 1, 2016).

Hara, H.: 2017, Hinode EUV Imaging Spectroscopy at the Site of Magnetic Reconnection in Solar Flares, Magnetic Reconenction 2017, (Matsuyama, Japan, Mar. 19–22, 2017).

Harada, Y., Goossens, S., **Matsumoto, K.**, Yan, J., Ping, J., **Noda, H.**, Haruyama, J.: 2016, The Deep Lunar Interior with a Low-Viscosity Zone: Revised Constraints from Recent Geodetic Parameters on the Tidal Response of the Moon, AOGS 2016, (Beijing, China, Jul. 31–Aug. 5, 2016).

Harada, Y., Goossens, S., **Matsumoto, K.**, Yan, J., Ping, J., **Noda, H.**, Haruyama, J.: 2016, The Deep Lunar Interior with a Low-viscosity Zone: Revised constraints from Recent Geodetic Parameters on the Tidal Response of the Moon, Japan Geoscience Union Meeting 2016, (Chiba, Japan, May 22–26, 2016).

Harada, Y., Goossens, S., **Matsumoto, K.**, Yan, J., Ping, J., **Noda, H.**, Haruyama, J.: 2016, The Deep Lunar Interior with a Low-Viscosity Zone: Revised Constraints from Recent Geodetic Parameters on the Tidal Response of the Moon, ISLPS2016, (Wuhan, China, Jun. 9–10, 2016).

Hayakawa, T., Toh, Y., Shizuma, T., Kimura, A., Nakamura, S., Harada, H., Iwamoto, N., **Kajino, T.**, Chiba, S.: 2016, Neutron Capture Reaction on ^{112}Cd to Study of the s-process Origin of ^{115}Sn, 14th Int. Symp. on Nuclei in the Cosmos (NIC2016), (Niigata, Japan, Jun. 19–24, 2016).

Hayashi, M.: 2016, Physical Conditions of the Interstellar Medium in Star-forming Galaxies at z~1.5, The Changing Face of Galaxies: uncovering transformational physics, (Hobart, Tasmania, Australia, Sep. 19–23, 2016).

Hayashi, M.: 2016, Probing Star Forming Galaxies at z<1.5 with Wide-field HSC-SSP Narrowband Data, Panoramas of the Evolving Cosmos, The 6th Subaru Int. Conf., (Hiroshima, Japan, Nov. 28–Dec. 2, 2016).

Hidaka, J., **Kajino, T.**, Mathews, G. J.: 2016, Study of Red Supergiant and Supernova Rate Problems via Relic Supernova Neutrino Spectrum, 14th Int. Symp. on Nuclei in the Cosmos (NIC2016), (Niigata, Japan, Jun. 19–24, 2016).

Hirai, Y., Ishimaru, Y., Saitoh, T. R., Fujii, M. S., Hidaka, J., **Kajino, T.**: 2016, Chemo-dynamical Evolution of r-process Elements in the Local Group Galaxies, 14th Int. Symp. on Nuclei in the Cosmos (NIC2016), (Niigata, Japan, Jun. 19–24, 2016).

Hiramatsu, M., **Shirasaki, Y.**: 2017, Japanese Virtual Observatory's ALMA FITS Data Archive, Data to Dome Workshop, (Tokyo, Japan, Mar. 2–3, 2017).

Hirota, T., **Motogi, K.**, **Honma, M.**, Machida, M. N., Matsushita, Y.: 2016, High Resolution Imaging of disk/outflow System in Orion Source I, Half a Decade of ALMA: Cosmic Dawns Transformed, (Indian Wells, CA, USA, Sep. 20–23, 2016).

Hirota, T.: 2016, Interstellar and Circumstellar Maser Observations with KaVA, TVN, and beyond, TVN2016: Thai VLBI Network (TVN) Collaborative Workshop, (Krabi, Thailand, Sep. 5-9, 2016).

Hirota, T.: 2016, Hot Water Disk around Orion Source I, Water in the Universe: From Clouds to Oceans, (Noordwijk, Netherland, Apr. 12–15, 2016).

Hirota, T.: 2016, A Survey of the Vibrationally Excited H_2O lines in Nearby Massive YSOs, JCMT Users Meeting, (Mitaka, Tokyo, Japan, Apr. 17–19, 2016).

Hirota, T.: 2016, KaVA Large Program for Star-Formation, East Asia VLBI Workshop 2016, (Guiyang, Guizhou, China, Nov. 7–11, 2016).

Hirota, T.: 2016, CASA Users Committee Report, ALMA/45m/ASTE/Mopra Users Meeting 2016, (Mitaka, Japan, Dec. 19–20, 2016).

Hirota, T.: 2016, Hot water molecule around Orion source I, Workshop for Interstellar Matter 2016, (Sapporo, Japan Oct. 19–21, 2016).

Hirota, T.: 2017, Maser Sciences with ALMA Band 1, ALMA Band 1 Science Workshop, (Taipei, Taiwan, Jan. 16–20, 2017).

Hirota, T.: 2017, High Resolution Observational Studies of Star-formation, NARIT-CMU Mini-Colloquia on Masers & Star-formation, (Chiang Mai, Thailand, Feb. 15, 2017).

Hirota, T.: 2017, VERA and ALMA Observations of Orion KL, NARIT Friday Seminar, (Chiang Mai, Thailand, Feb. 17, 2017).

Honma, M.: 2016, Astrometry with VERA and Future of EAVN, TVN2016: Thai VLBI Network (TVN) Collaborative Workshop, (Krabi, Thailand, Sep. 5–9, 2016).

Honma, M.: 2016, Discussion: Future Possible Collaboration of KaVA and EAVN Science Working Group in East-Asian Region, East Asia VLBI Workshop 2016, (Guiyang, Guizhou, China, Nov. 7–11, 2016).

Honma, M.: 2016, Status Report from Mizusawa VLBI, East Asia VLBI Workshop 2016, (Guiyang, Guizhou, China, Nov. 7–11, 2016).

Honma, M.: 2016, Imaging the Event-horizon-scale Structure of Sgr A* with Sparse Modeling, M87 Workshop, (Taipei, Taiwan, May 23–27, 2016).

Honma, M.: 2017, Imaging Black Hole Shadow with Sparse Modeling, Black Hole Astrophysics with VLBI - Past, Present and Future, (Mitaka, Japan, Mar. 27–29, 2017).

Hori, Y., Iwasawa, M., **Oshino, S.**, Fujii, M. S.: 2016, Towards High-resoultion N-body Simulations for Planet Formation, Japan-Germany Planet and Disk Workshop, (Ishigaki, Japan, Sep. 25–30, 2016).

Hori, Y., Liu, S.-F., Lin, D. N. C.: 2016, Impact of Giant Impacts on Planetary Interiors, New Directions in Planet Formation, (Leiden, The Netherlands, Jul. 11–15, 2016).

Hori, Y.: 2017, The Primordoal Atmosphere on a Terrestrial Planet in a Habitable Zone, Astrobiology Center Internatioal Workshop, (Hiroshima, Japan, Mar. 22–24, 2017).

Huang, Y.-D., et al. including **Iguchi, S.**, **Asayama, S.**, **Iono, D.**, **Gonzalez, A.**: 2016, The Atacama Large Millimeter/sub-millimeter Array (ALMA) band-1 receiver, SPIE conference on Astronomical Telescopes + Instrumentation 2016, (Edinburgh, UK, Jun. 10–15, 2016).

Hwang, Y.-J., et al. including **Gonzalez, A.**: 2016, Band 1 Receiver Front-end Cartridges for Atacama Large Millimeter/submillimeter Array (ALMA): Design and Development toward Production, SPIE conference on Astronomical Telescopes + Instrumentation 2016, (Edinburgh, UK, Jun. 10–15, 2016).

Ichikawa, K.: 2016, Discovery of a Dead AGN in Arp 187, East Asia AGN workshop 2016, (Seoul, Korea, Sep. 22, 2016).

Ichikawa, K.: 2016, 3–500 μm Infrared Properties of 70-month Swift/BAT AGN Catalog, Hidden Monsters: Obscured AGN and Connections to Galaxy Evolution, (Hanover, NH, USA, Aug. 8–12 2016).

Ichikawa, K.: 2016, Science Case of MICHI from AGN/BH Physics Group, TMT/MICHI science workshop, (Kyoto, Jpaan, May 23, 2016).

Ichikawa, K.: 2016, Key AGN Science Cases with MICHI, TMT Science Forum 2016, (Kyoto, Japan, May 24–26, 2016).

Imanishi, M.: 2016, ALMA Molecular Gas Observations of Luminous Infrared Galaxies as a Tool to Scrutinize Elusive Deeply-Buried AGNs, Molecular Gas in Galactic Environments, (Charlottesville, USA, Apr. 4–7, 2016).

Imanishi, M.: 2016, ALMA Molecular Gas Observations of Luminous Infrared Galaxies as a Tool to Scrutinize Elusive Deeply Buried AGNs, Hidden Monsters: Obscured AGN and Connections to Galaxy Evolution, (Hanover, NH, USA, Aug. 8–12 2016).

Imanishi, M.: 2016, ALMA Molecular Line Observations of the Ultraluminous Infrared Galaxies and Optical Seyfert Galaxies, Half a Decade of ALMA: Cosmic Dawns Transformed, (Indian Wells, CA, USA, Sep. 20–23, 2016).

Ishihara, Y., Hareyama, M., Honda, C., **Hirata, N.**, Morota, T., Ohtake, M.: 2017, Highland Crust of the Orientale Basin Region Based on Unsupervised Classification of Absroption Specrtra of the Moon, 48th Lunar and Planetary Science Conference, (the Woodlands TX, USA, Mar. 20–24, 2017).

Ishihara, Y., Kawamura T., **Yamada, R.**, Ogawa, K., Takeuchi, N., Araya, A,. Lognonné, P., Shirai, K., Tsuji, T.,Kobayashi, T., Nishikawa, Y., Drilleau, M., Tanaka, S.: 2016, Investigation and Development of Seismic Observation Package for Asteroid and Small Body Explorations, Japan Geoscience Union Meeting 2016, (Chiba, Japan, May 22–26, 2016).

Ishikawa, R., **Kano, R.**, **Kubo, M.**, **Narukage, N.**, **Katsukawa, Y.**, **Giono, G.**, **Bando, T.**, **Hara, H.**, **Suematsu, Y.**, Ishikawa, S., Tsuneta, S., Trujillo Bueno, J., Stepan, J., Uitenbroek, H., Winebarger, A., Kobayashi, K., Auchere, F.: 2016, Comparison of the scattering polarization observed by CLASP; Possible indication of the Hanle effect, 8th Solar Polarization Workshop, (Firenze, Italy, Sep. 12–16, 2016).

Ishikawa, R., **Kano, R.**, Winebarger, A., Auchere, F., Trujillo Bueno, J., **Narukage, N.**, Kobayashi, K., **Bando, T.**, **Katsukawa, Y.**, **Kubo, M.**, Ishikawa, S., **Giono, G.**, **Hara, H.**, **Suematsu, Y.**, Shimizu, T., Sakao, T., Tsuneta, S., Ichimoto, K., Goto, M., Cirtain, J., De Pontieu, B., Casini, R., Manso Sainz, R., Asensio Ramos, A., Stepan, J., Belluzzi, L., Carlsson, M.: 2016, The Chromosphere and Transition Region as Seen with CLASP, IRIS-6: The Chromosphere, (Stockholm, Sweden, Jun. 20–23, 2016).

Ishikawa, S., **Kajino, T.**, Shibagaki, S., Balantekin, B. A., Famiano, M. A.: 2016, Three-Body Model Calculation of ^{9}Be Formation Rate and Application to Supernova Nucleosynthesis, 14th Int. Symp. on Nuclei in the Cosmos (NIC2016), (Niigata, Japan, Jun. 19–24, 2016).

Ishikawa, S., **Kubo, M.**, **Katsukawa, Y.**, **Kano, R.**, **Narukage, N.**, **Ishikawa, R.**, Winebarger, A., Kobayashi, K., Trujillo Bueno, J., **Bando, T.**, Auchere, F.: 2016, CLASP/SJ Observation of Time Variations of Lyman-alpha Emissions in a Solar Active Region (poster), 10th Hinode Science Meeting, (Nagoya, Japan, Sep. 5–8, 2016).

Ishikawa, S., Shimizu, T., **Kano, R.**, **Bando, T.**, **Ishikawa, R.**, Giono, G., Beabout, D. L., Beabout, B. L., Nakayama, S., Tajima, T.: 2016, In-flight Performance of the Polarization Modulator in the CLASP Rocket Experiment, SPIE Astronomical Telescopes + Instrumentatio, (Edinburgh, UK, Jun. 26–Jul. 1, 2016).

Izumiura, H.: 2016, The Situation That the Observatories and Telescopes at Okayama are Placed in, Software and Observational Strategy for Precise Radial Velocity Work with Medium Size Telescopes, (Munchen, Germany, Dec. 1–3, 2016).

Izumiura, H.: 2016, Robotic RV Explorer and Possible Collaborations, Software and Observational Strategy for Precise Radial Velocity Work with Medium Size Telescopes, (Munchen, Germany, Dec. 1–3, 2016).

Izumiura, H.: 2017, A Census of Mass-losing Long Period Variables Showing SiO Masers in the Direction of the Galactic Nuclear Star Cluster with ALMA Band 1, ALMA Band 1 Science Workshop, (Taipei, Taiwan, Jan. 16–20, 2017).

Joshi, A. D., Forbes, T. G., Park S.-H., Cho, K.-S.: 2016, Poster - A Trio of Confined Flares in AR 11087, 10th Hinode Science Meeting, (Nagoya, Japan, Sep. 5–8, 2016).

Jovanovic, N., Cvetojevic, N., Schwab, C., Norris, B., **Lozi, J.**, Gross, S., Betters, C., Singh, G., **Guyon, O.**, Martinache, F., **Doughty, D.**, Tuthill, P.: 2016, Efficiently feeding single-mode Fiber Photonic Spectrographs with an Extreme Adaptive Optics System: On-sky Characterization and Preliminary Spectroscopy, SPIE Astronomical Telescopes + Instrumentatio, (Edinburgh, UK, Jun. 26–Jul. 1, 2016).

Jovanovic, N., et al. including **Guyon, O.**, **Lozi, J.**, **Currie, T.**, **Pathak, P.**, **Doughty, D.**, **Goebel, S.**, **Kudo, T.**, **Kotani, T.**, **Minowa, Y.**, **Takato, N.**, **Tamura, M.**, **Takami, H.**, **Hayashi, M.**: 2016, The SCExAO High Contrast Imager: Transitioning from Commissioning to Science, SPIE Adaptive Optics Systems V, (Edinburgh, UK, Jun. 26, 2016).

Jovanovic, N., **Guyon, O.**, **Kawahara, H.**, **Kotani, T.**: 2017, Application of Multicore Optical Fibers in Astronomy, Optical Fiber Communications conference 2017, (Los Angeles, USA, Mar. 19–23, 2017).

Kambe, E.: 2016, High Resolution Spectrographs for Okayama Telescopes, I2 and Astro-Comb, and HIDES FITS Header, Software and Observational Strategy for Precise Radial Velocity Work with Medium Size Telescopes, (Munchen, Germany, Dec. 1–3, 2016).

Kameya, O.: 2016, Twenty Five Years of the Mizusawa 10m Radio Telescope, East Asia VLBI Workshop 2016, (Guiyang, Guizhou, China, Nov. 7–11, 2016).

Kano, R., et al. including **Ishikawa, R.**, **Narukage, N.**, **Bando, T.**, **Katsukawa, Y.**, **Kubo, M.**, **Giono, G.**, **Hara, H.**, **Suematsu, Y.**: 2016, Spectro-polarimetric Observations in UV with CLASP to Probe the Transition Region, 47th Solar Physics Division meeting, (Boulder, USA, May 31–Jun. 3, 2016).

Kano, R., et al. including **Ishikawa, R.**, **Narukage, N.**, **Bando, T.**, **Katsukawa, Y.**, **Kubo, M.**, **Giono, G.**, **Hara, H.**, **Suematsu, Y.**: 2016, Initial Results of Chromospheric Lyman-Alpha Spectro-Polarimeter (CLASP), Theoretical and observational approaches to the solar magnetic field, (Tokyo, Japan, May 27, 2016).

Kano, R., Trujillo Bueno, J., Winebarger, A., Auchere, F., **Ishikawa, R.**, Kobayashi, K., CLASP team: 2016, Lyman-alpha Scattering Polarization Observed with the Chromospheric Lyman-Alpha Spectro-Polarimeter, 8th Solar Polarization Workshop, (Firenze, Italy, Sep. 12–16, 2016).

Karino, S., **Agata, H.**, **Canas, L.**: 2016, An Analysis of the Syllabi of Astronomy in Japanese Universities, 10th East-Asia Meeting on Astronomy (EAMA), (Seoul, Korea, Sep. 26–30, 2016).

Kashikawa, N.: 2017, Wide Survey for Early Universe by Subaru/HSC, Dawn of Galaxies 2017, (Obergurgl, Austria, Jan. 14–18, 2017).

Katsukawa, Y., **Kamata, Y.**, Anan, T., H**ara, H.**, **Suematsu, Y.**, **Bando, T.**, **Ichimoto, K.**, Shimizu, T.: 2016, Development of a Near-infrared Detector and a Ber-optic Integral Field Unit for a Space Solar Observatory SOLAR-C, SPIE Astronomical Telescopes + Instrumentatio, (Edinburgh, UK, Jun. 26–Jul. 1, 2016).

Katsukawa, Y., Kimura, Y., **Okamoto, T. J.**: 2016, Penumbral Micro-jets: Rapid Heating Driven by Magnetic Reonnection in The Chromosphere, AOGS 2016, (Beijing, China, Jul. 31–Aug. 5, 2016).

Katsukawa, Y.: 2016, High-Precision Spectro-Polarimetry in the Visible and Infrared on the SUNRISE Balloon-Borne Solar Observatory, 10th Hinode Science Meeting, (Nagoya, Japan, Sep. 5–8, 2016).

Kawaguchi, T., et al. including **Ozaki, S.**: 2017, Current Status of Our AO-Assisted Optical IFU Study on Galaxy-BH Coevolution, Subaru Users' Meeting FY2016, (Tokyo, Japan, Jan. 10–12, 2017).

Kawaguchi, T., **Ozaki, S.**, Sugai, H., **Matsubayashi, K.**, **Hattori, T.**, Shimono, A., **Minowa, Y.**, **Hayano, Y.**, **Aoki, K.**, Mitsuda, K., Hashiba, Y.: 2016, An AO-Assisted Optical IFU Study on Galaxy-BH Coevolution, Australia-Japan workshop on collaborative science, (North Ryde, Australia, Dec. 15, 2016).

Kawakita, H., **Shinnaka, H.**: 2016, Survey for Ortho-to-Para Abunance Ratios (OPRS) of NH_2 in Comets: Revisit to the Meaning of OPRs of Cometary Volatiles, DPS48/EPSC11 meeting, (Pasadena, CA, USA, Oct. 16–21, 2016).

Kawamura, T., Ishihara, Y., Ogawa, K., Tsuji, T., Kobayashi, T., Yamada, R., Araya, A., Tanaka, S., Takeuchi, N.: 2017, Conceptual Study of Small Active Seismic Exploration Package on Moons and Small Bodies, 48th Lunar and Planetary Science Conference , (the Woodlands TX, USA, Mar. 20–24, 2017).

Kawamura, T., **Yamada, R.**, Tanaka, S., Ishihara, Y., Murakami, H., Shiraishi, H., Shirai, K., Hayakawa, M., Goto, K.: 2016, Scientific significance of internal structure of the Moon and objectives of APPROACH, Joint ISAS_LPL Workshop on Planetary Sceince Enabled by Epsilon Class Missions, (Tucson, AZ, USA, Nov. 15, 2016).

Kawamura, T.: 2016, Dynamics of Deep/Shallow Moonquakes and Impacts, ISSI-BJ Forum on Lunar and Planetary Seismology, (Beijing, China, Jan. 11, 2017).

Kim, J. S.: 2016, Rapid Change of Outflow Morphology in Massive Star-Forming Region Cepheus A, East Asia VLBI Workshop 2016, (Guiyang, Guizhou, China, Nov. 7–11, 2016).

Kim, J. S.: 2016, KaVA Observations of Cyg X-3 in 2016, East Asia VLBI Workshop 2016, (Guiyang, Guizhou, China, Nov. 7–11, 2016).

Kitagawa, Y., Yamagata, Y., Morita, S., Motohara, K., **Ozaki, S.**, Takahashi, H., Konishi, M., Kato, N. M., Kobayakawa, Y., Terao, Y., Ohashi, H.: 2016, Fabrication of a Wide-field NIR Integral Field Unit for SWIMS Using Ultra-precision Cutting, SPIE Advances in Optical and Mechanical Technologies for Telescopes and Instrumentation II, (Edinburgh, UK, Jun. 26–Jul. 1, 2016).

Kiuchi, H., Hills, R., Whyborn, N. D., **Asayama, S.**, **Sakamoto, S.**, **Iguchi, S.**, Corder, S. A.: 2016, An Artificial Calibration Source Based on the Photonic THz Technique for High-frequency Radio Astronomy, Energy Materials Nanotechnology meeting on Terahertz, (San Sebastian, Spain, May 14–18, 2016).

Kiuchi, H., Hills, R., Whyborn, N. D., **Asayama, S.**, **Sakamoto, S.**, **Iguchi, S.**, Corder, S. A.: 2016, Artificial Calibration Source for ALMA Radio Interferometer, SPIE Astronomical Telescopes + Instrumentatio, (Edinburgh, UK, Jun. 26–Jul. 1, 2016).

Kobayashi, H.: 2016, Future of EAVN, East Asia VLBI Workshop 2016, (Guiyang, Guizhou, China, Nov. 7–11, 2016).

Kodama, T.: 2016, The Nature of Star-forming Disc Galaxies in Proto-clusters, Discs in Galaxies, (Garching, Germany, Jul. 11–15, 2016).

Kodama, T.: 2016, The Changing Face of Proto-clusters, The Changing Face of Galaxies: uncovering transformational physics, (Hobart, Tasmania, Australia, Sep. 19–23, 2016).

Kodama, T.: 2016, ULTIMATE-Subaru and PFS Overview, The galaxy life cycle, (Venice, Italy, Oct. 24–28, 2016).

Kodama, T.: 2016, Star Formation Histories across the Cosmic Noon and Environments, In Situ View of Galaxy Formation, (Ringberg Castle, Bavaria, Germany, Oct. 30–Nov. 5, 2016).

Kodama, T.: 2016, Panoramic Mapping of Star Formation Activities across Environments since z~3, Panoramas of the Evolving Cosmos, The 6th Subaru Int. Conf., (Hiroshima, Japan, Nov. 28–Dec. 2, 2016).

Kojima, K., **Takahashi, H.**, **Kroug, M.**, **Uzawa, Y.**: 2017, Performance and characterization of an SIS-mixer-amplifier module with wideband IF for submillimeter-wave receivers, 28th Int. Symp. on Space Terahertz Technology, (Cologne, Germany, Mar. 13-15, 2017)

Kojima, T., **Gonzalez, A.**, **Asayama, S.**, **Uzawa, Y.**: 2016, Development of an RF Waveguide Frequency Multiplexer for a Multiband Heterodyne System, 27th Int. Symp. on Space Terahertz Technology, (Nanjing, China, Apr. 12–15, 2016).

Kojima, T., **Gonzalez, A.**, **Kroug, M.**, **Fujii, Y.**, **Kaneko, K.**, **Shan, W.**, **Asayama, S.**, **Uzawa, Y.**, Makise, K., Terai, H., Wang, Z.: 2016, Superconducting Receivers for ALMA Radio Telescope and Future Development, 29th Int. Symp. on Superconductivity, (Tokyo, Japan, Dec. 13–15, 2016).

Kojima, T., **Kroug, M.**, Sato, K., **Sakai, T.**, **Uzawa, Y.**: 2016, Capacitance Measurement of High Current Density Nb/AlN/Nb Junctions with a 4-K Probe Station, Applied Superconductivity Conference 2016, (Denver, CO, USA, Sep. 4–6, 2016).

Kojima, T.: 2016, Development of SIS Mixers for Future Receivers at NAOJ, ALMA Developer's workshop, (Gothenburg, Sweden, May 25–27, 2016).

Kojima, T.: 2016, Feasibility Studies of a Wideband IF Receiver, NRO-ALMA Joint Science/Development Workshop 2016, (Nagano, Japan, Jul. 20–21, 2016).

Kokubo, E.: 2016, Orbital Architecture of Planetary Systems Formed by Giant Impacts, Japan-Germany Planet and Disk Workshop, (Ishigaki, Japan, Sep. 25–30, 2016).

Kokubo, E.: 2017, Formation of Terrestrial Planets, Formation of the Solar System and the Origin of Life, (Leiden, The Netherlands, Feb. 20–24, 2017).

Kokubo, T., **Mori, T.**, **Kurokawa, T.**, Kashiwagi, K., **Tanaka, Y.**, **Kotani, T.**, **Nishikawa, J.**, **Tamura, M.**: 2016, 12.5-GHz-spaced Laser Frequency Comb Covering Y,J, and H Bands for Infrared Doppler Instrument, SPIE Astronomical Telescopes + Instrumentatio, (Edinburgh, UK, Jun. 26–Jul. 1, 2016).

Komiyama, Y.: 2016, Subaru Hyper Suprime-Cam Survey for Local Group Dwarf Galaxies, Panoramas of the Evolving Cosmos, The 6th Subaru Int. Conf., (Hiroshima, Japan, Nov. 28–Dec. 2, 2016).

Koyama, Y.: 2016, Unveiling the Environmental Effects on Internal Star/gas/dust Properties in Galaxies Across Cosmic Time, ALMA workshop "Extensive CO survey of nearby galaxies", (Mitaka, Tokyo, Japan, Dec. 7–9, 2016).

Koyama, Y.: 2016, From Panoramic to Microscopic: Probing the Nature of cluster galaxy population Across Cosmic Time with Subaru, Panoramas of the Evolving Cosmos, The 6th Subaru Int. Conf., (Hiroshima, Japan, Nov. 28–Dec. 2, 2016).

Koyama, Y.: 2016, Environmental Impacts on Various Galaxy Properties across Cosmic Time, In Situ View of Galaxy Formation, (Ringberg Castle, Bavaria, Germany, Oct. 30–Nov. 5, 2016).

Koyama, Y.: 2016, From MAHALO-Subaru to the New World: Environmental Impacts on Various Properties of Galaxies Across Cosmic Time, ALMA workshop "Extensive CO survey of nearby galaxies", (Mitaka, Tokyo, Japan, Dec. 7–9, 2016).

Koyama, Y.: 2017, An Overview of Galaxy Cluster and Environment Science with Subaru, Subaru International Partnership Science and Instrumentation Workshop, (Tokyo, Japan, Mar. 22–24, 2017).

Kroug, M., **Ezaki, S.**, **Kojima, T.**, **Noguchi, T.**: 2016, High Current Density SIS Junctions Based on Nb / Al,AlN / Al / Nb Multi Layers, Applied Superconductivity Conference 2016, (Denver, CO, USA, Sep. 4–6, 2016).

Kroug, M., Ikeya, M., **Kojima, T.**, **Noguchi, T.**: 2016, Niobium SIS Junction Technology for Sub-mm Wave Mixers, 29th Int. Symp. on Superconductivity, (Tokyo, Japan, Dec. 13–15, 2016).

Kroug, M., **Kojima, T.**, Makise, K., **Uzawa, Y.**: 2017, Material Study for a THz SIS Mixer, 28th Int. Symp. on Space Terahertz Technology, (Cologne, Germany, Mar. 13–15, 2017)

Kroug, M., **Uemizu, K.**, **Ezaki, S.**, **Niizeki, Y.**, **Kojima, T.**: 2016, High Current Density SIS Mixers for the 400–500 GHz Band, 2016 URSI Asia-Pacific Radio Science Conference, (Seoul, South Korea, Aug. 21–25, 2016).

Kubo, M., et al. including **Kano, R.**, **Ishikawa, R.**, **Narukage, N.**, **Bando, T.**, **Katsukawa, Y.**, **Giono, G.**, **Hara, H.**, **Suematsu, Y.**, **Yoshida, M.**: 2017, Results & Future of CLASP Project - From CLASP1 to CLASP2 -, Solarnet IV Meeting, (Lanzarote, Spain, Jan. 16–20, 2017).

Kubo, M., **Katsukawa, Y.**, **Suematsu, Y.**, **Kano, R.**, **Bando, T.**, **Narukage, N.**, **Ishikawa, R.**, **Hara, H.**, **Giono, G.**, Tsuneta, S., Ishikawa, S., Winebarger, A., Kobayashi, K., Trujillo Bueno, J., Auchere, F.: 2016, Ubiquitous Fast Propagating Intensity Disturbances in Solar Chromosphere, 10th Hinode Science Meeting, (Nagoya, Japan, Sep. 5–8, 2016).

Kubo, M., **Katsukawa, Y.**, **Suematsu, Y.**, **Kano, R.**, **Bando, T.**, **Narukage, N.**, **Ishikawa, R.**, **Hara, H.**, **Giono, G.**, Tsuneta, S., Ishikawa, S., Winebarger, A., Kobayashi, K., Trujillo Bueno, J., Auchere, F.: 2017, Discovery of Ubiquitous Fast Propagating Intensity Disturbances by CLASP/SJ, Solarnet IV Meeting, (Lanzarote, Spain, Jan. 16–20, 2017).

Kusakabe, M., Koh, S., Kim, K. S., Cheoun, M.-K., **Kajino, T.**, Mathews, G. J.: 2016, Effects of the f(R) and f(G) Gravities and the Exotic Particle on Primordial Nucleosynthesis, 14th Int. Symp. on Nuclei in the Cosmos (NIC2016), (Niigata, Japan, Jun. 19–24, 2016).

Kusakabe, N., **Tamura, M.**: 2016, SEEDS Direct Imaging Survey of Exoplanet and Disks, and Next Steps (I), 10th East-Asia Meeting on Astronomy (EAMA), (Seoul, Korea, Sep. 26–30, 2016).

Kusakabe, N.: 2016, Exoplanet to Lives in the Universe, Asian Astronomical Forum, (Chiang Mai, Thai, Nov. 11, 2016).

Kuzanyan, K., Otsuji, K., **Sakurai, T.**, **Hagino, M.**, Yokoi, N.: 2016, Current Helicity in the Solar Cycle, the Properties of Turbulent Magnetic Field from Mosaic SOT/SP Raster Scans and Messages for Dynamo Theory, 10th Hinode Science Meeting, (Nagoya, Japan, Sep. 5–8, 2016).

Kuzuhara, M.: 2017, Exploring Exoplanet and Disk with Subaru Telescope, from SEEDS to Next, Subaru International Partnership Science and Instrumentation Workshop, (Tokyo, Japan, Mar. 22–24, 2017).

Kwon, Y. G., Ishiguro, M., **Kuroda, D.**, **Hanayama, H.**, Kawabata, K. S., Akitaya, H., Itoh, R., Nakaoka, T., **Toda, H.**, Yoshida, M., Kawai, N., **Watanabe, J.**: 2016, A Study of Polarimetric Properties of Comet C/2013 US10 (Catalina) in Optical and Near-Infrared Wavelength Regions, 2015 KAS FALL MEETING, (Daejeon, Korea, Oct. 13–14, 2016).

Kwon, Y. G., Ishiguro, M., **Kuroda, D.**, **Hanayama, H.**, Kawabata, K. S., Akitaya, H., Itoh, R., Nakaoka, T.: 2016, A Polarimetric Study of Long-Period Comet C/2013 US10 (Catalina) and Estimation of Its Gas Contamination in Optical and Near-Infrared Wavelengths, 2016 KAS FALL MEETING, (Daejeon, Korea, Oct. 13–14, 2016).

Kwon, Y. G., Ishiguro, M., **Kuroda, D.**, **Hanayama, H.**, Kawabata, K. S., Akitaya, H., Itoh, R., Nakaoka, T.: 2016, An Optical and Infrared Polarimetric Study of Non-Periodic Comet C/2013 US 10, Catalina, AOGS 2016, (Beijing, China, Jul. 31–Aug. 5, 2016).

Labadie, L., Berger, J.-P., Cvetojevic, N., Haynes, R., Harris, R., **Jovanovic, N.**, Lacour, S., Martin, G., Minardi, S., Perrin, G., Roth, M., Thomson, R. R.: 2016, Astronomical Photonics in the Context of Infrared Interferometry and High-resolution Spectroscopy, SPIE Optical and Infrared Interferometry and Imaging V, (Edinburgh, UK, Jun. 26, 2016).

Lee, J.-W., Je, D.-H., Lee, B., Kang, H., Kim, J., Wagner, J., **Asayama, S.**, **Gonzalez, A.**, **Kroug, M.**, **Kojima, T.**, **Shan, W.**, **Iguchi, S.**, **Iono, D.**: 2016, ASTE Focal Plane Array as Prototype FPA for ALMA TP Array, 2016 URSI Asia-Pacific Radio Science Conference, (Seoul, South Korea, Aug. 21–25, 2016).

Lee, K.-S.: 2016, Quantitative Estimation of the Energy Flux During Evaporation in a White Light Flare Kernel Observed by Hinode, IRIS, SDO, and RHESSI, 10th Hinode Science Meeting, (Nagoya, Japan, Sep. 5–8, 2016).

Lozi, J., **Guyon, O.**, **Jovanovic, N.**, Singh, G., **Goebel, S.**, Norris, B., **Okita, H.**: 2016, Characterizing and Mitigating Vibrations for SCExAO, SPIE Adaptive Optics Systems V, (Edinburgh, UK, Jun. 26, 2016).

Lu, X., Zhang, Q., Liu, H. B.: 2016, High-mass Star Formation in Filamentary Molecular Clouds, TOPSCOPE workshop, (Beijing, China, Dec. 13–15, 2016).

Lu, X.: 2017, SMA/JVLA Synergetic Study of Onset of Star Formation in the Central Molecular Zone, East-Asian ALMA Science Workshop 2016, (Hsinchu, Taiwan, Mar. 10–12, 2017).

Maehara, H.: 2016, Starspot Activity and Superflares on Solar-type Stars, IAUS 328: Living Around Active Stars, (Maresias, Brazil, Oct. 17–21, 2016).

Maehara, H.: 2016, Solar /Stellar Flares on K-M Dwarfs, Impact of Exoplanetary Space Weather On Climate and Habitability, (New Orleans, LA, USA., Nov. 29–Dec. 2, 2016).

Maehara, H.: 2017, Starspot Activity and Superflares on Solar-type Stars, 2nd PSTEP International Symposium, (Kyoto, Japan, Mar. 23–24, 2017).

Males, J., Close, L., **Guyon, O.**, Morzinski, K., Hinz, P., Esposito, S., Pinna, E., Xompero, M., Briguglio, R., Riccardi, A., Puglisi, A., Mazin, B., Ireland, M., Weinberger, A., Conrad, A., Kenworthy, M., Snik, F., Otten, G., **Jovanovic, N.**, **Lozi, J.**: 2016, The Path to Visible Extreme Adaptive Optics with MagAO-2K and MagAO-X, SPIE Astronomical Telescopes + Instrumentatio, (Edinburgh, UK, Jun. 26–Jul. 1, 2016).

Marchio, M., **Flaminio, R.**, Forest, D., Pinard, L., **Tatsumi, D.**, Sakai, K.: 2017, Development of an Absorption Bench and Some Results about Crystalline Coatings, KAGRA F2F Meeting, (Niigata, Japan, Mar. 28–30, 2017).

Martinache, F., **Jovanovic, N.**, **Guyon, O.**: 2016, Subaru Coronagraphic eXtreme Adaptive Optics: On-sky Performance of the Asymmetric Pupil Fourier Wavefront Sensor, SPIE Adaptive Optics Systems V, (Edinburgh, UK, Jun. 26, 2016).

Maruyama, T., Cheoun, M.-K., **Kajino, T.**, Mathews, G. J.: 2016, Pion Production from Proton Synchrotron Radiation in Strong Magnetic Fields, 14th Int. Symp. on Nuclei in the Cosmos (NIC2016), (Niigata, Japan, Jun. 19–24, 2016).

Mathews, G. J., Shibagaki, S., **Kajino, T.**: 2016, Origin of r-Process Elements and Galactic Chemodynamical Evolution, 14th Int. Symp. on Nuclei in the Cosmos (NIC2016), (Niigata, Japan, Jun. 19–24, 2016).

Matsuda, Y., et al. including **Hatsukade, B.**, **Iono, D.**, **Kawabe, R.**, **Kubo, M.**, **Nakanishi, K.**: 2016, ALMA 860 μm Continuum Observations of Lyman-alpha Blobs at z=3.1, Half a Decade of ALMA: Cosmic Dawns Transformed, (Indian Wells, CA, USA, Sep. 20–23, 2016).

Matsumoto, K., Ikeda, H.: 2016, Moments of Inertia of Phobos with Inhomogeneous Internal Structure, ISLPS2016, (Wuhan, China, Jun. 9–10, 2016).

Matsumoto, K., Ikeda, H.: 2016, Moments of Inertia of Phobos with Inhomogeneous Internal Structure, Japan Geoscience Union Meeting 2016, (Chiba, Japan, May 22–26, 2016).

Matsumoto, K., Ikeda, H.: 2016, Moments of Inertia of Phobos with Inhomogeneous Internal Structure, AOGS 2016, (Beijing, China, Jul. 31–Aug. 5, 2016).

Matsuo, H., **Ezawa, H.**, **Honma, M.**, **Kiuchi, H.**, Murata, Y.: 2016, Terahertz Intensity Interferometry for Very High Angular Resolution Observations, The 27th Internatiional Symposium on Space Terahertz Technoloty, (Kurume, Fukuoka, Jul. 17–21, 2016).

Matsuo, H., **Ezawa, H.**, **Honma, M.**, **Kiuchi, H.**, Murata, Y.: 2016, Terahertz Intensity Interferometry for Milli-arcsecond Resolution, SPIE Astronomical Telescopes + Instrumentatio, (Edinburgh, UK, Jun. 26–Jul. 1, 2016).

Matsuo, H., **Ezawa, H.**, **Honma, M.**, **Kiuchi, H.**, Murata, Y.: 2017, Feasibility Studies on Photon Counting Terahertz Interferometry, The 28th Internatiional Symposium on Space Terahertz Technoloty, (Cologne, Germany, Mar. 13–15, 2017).

Matsuo, H., Inoue, A., Tamura, Y.: 2016, ALMA observation of star forming galaxies in the early Universe, Dark Ages and White Nights, (Saint Petersburg, Russia, Jun. 20–24, 2016).

Matsuo, H.: 2016, CMB Photon Statistics, Dark Ages and White Nights, (Saint Petersburg, Russia, Jun. 20–24, 2016).

Matsuo, H.: 2017, Study on Exoplanet Imaging using Intensity VLBI, Black Hole Astrophysics with VLBI - Past, Present and Future, (Mitaka, Japan, Mar. 27–29, 2017).

Matsuo, K., **Otsubo, T.**: 2016, Interannual Geocenter Motion with Relation to El Nino Southern Oscillation, 20th Int. Workshop on Laser Ranging, (Potsdam, Germany, Oct. 10–Oct. 14, 2016).

McKenzie, D. E., et al. including **Ishikawa, R.**, **Narukage, N.**, **Kano, R.**, Yoshida, M.: 2016, CLASP2: The Chromospheric LAyer Spectro-Polarimeter, 8th Solar Polarization Workshop, (Firenze, Italy, Sep. 12–16, 2016).

Mitsuda, K., Hashiba, Y., **Minowa, Y.**, **Hayano, Y.**, Sugai, H., Shimono, A., Matsubayashi, K., **Hattori, T.**, **Kamata, Y.**, **Ozaki, S.**, Doi, M., Sako, S.: 2016, CCD System Upgrading of the Kyoto3DII and Integral Field Spectroscopic Observation with the New System, SPIE Ground-based and Airborne Instrumentation for Astronomy VI, (Edinburgh, UK, Jun. 26–30, 2016).

Miyamoto, H., Araya, A., **Matsumoto, K.**, Terada, N., Nishibori, T., Kikuchi, H., Hemmi, R., Niihara, T., Tanaka, H., Ogawa, K.: 2016, Key Observations to Understand the Internal Structure of Phobos, Japan Geoscience Union Meeting 2016, (Chiba, Japan, May 22–26, 2016).

Miyamoto, Y., **Yamauchi, A.**, **Nakai, N.**, **Okumura, T.**, **Zhou, B.**, **Isami, K.**, **China, K.**, Taniguchi, K., Kaneko, H., **Matsumoto, N.**, **Salak, D.**, **Nishimura, A.**: 2016, H_2O Maser Survey of Obscured AGNs, NRO-ALMA Joint Science/Development Workshop 2016, (Nagano, Japan, Jul. 20–21, 2016).

Miyazaki, S.: 2016, Subaru Contribution to Euclid Photo-Z, Uclid Consortium Meeting, (Lisbon, Poltogal Jun. 1, 2016).

Miyazaki, S.: 2016, Hyper Suprime-Cam, Subaru International Conference, (Hiroshima, Japan, Dec. 2, 2016).

Mizuno, T., et al. including **Noda, H.**, **Namiki, N.**: 2016, Development and Initial Operation of Hayabusa2 LIDAR, ISLPS2016, (Wuhan, China, Jun. 9–10, 2016).

Momose, M.: 2016, Sintering-Induced Dust Ring Formation In Protoplanetary Disks: Application To The Hl Tau Disk, Resolving planet formation in the era of ALMA and extreme AO, (Santiago, Chile, May 16–20, 2016).

Mori, K., Famiano, M. A., **Kajino, T.**, Suzuki, T., Hidaka, J., Honma, M., Iwamoto, K., Nomoto, K., Otsuka, T.: 2016, Impact of New Gamow-Teller Strengths on Explosive Type Ia Supernova Nucleosynthesis, 14th Int. Symp. on Nuclei in the Cosmos (NIC2016), (Niigata, Japan, Jun. 19–24, 2016).

Moriya, T.: 2016, Superluminous Supernovae and Their Origins, 2nd NAOJ-ECT Workshop on Many Riddles About Core-Collapse Supernovae: Bethe and Beyond, (Mitaka, Japan, Jun. 27–Jul. 1, 2016).

Moriya, T.: 2016, Type Ic Superluminous Supernovae and Possible Signatures of Their Progenitor Binary Companions, ISSI Workshop on Supernovae, (Bern, Switzerland, Oct. 3–7, 2016).

Moriya, T.: 2016, Signatures of a Progenitor Binary Companion in Type Ic Superluminous Supernovae, The Mysterious Connection Between Superluminous Supernovae and Gamma-Ray Bursts, (Baltimore, MD, USA, May 23–25, 2016).

Moriya, T.: 2016, Rapidly-evolving Faint Transients from Stripped-envelope Electron-capture Supernovae, European Week of Astronomy and Space Science 2016, (Athens, Greece, Jul. 4–8, 2016).

Moriya, T.: 2016, Light-curve and Spectral Properties of Ultra-stripped Core-collapse Supernovae, European Week of Astronomy and Space Science 2016, (Athens, Greece, Jul. 4–8, 2016).

Moriya, T.: 2016, Light-curve and Spectral Properties of Ultra-stripped Core-collapse Supernovae, Supernovae Through the Ages, (Easter island, Chile, Aug. 8–13, 2016).

Moriya, T.: 2016, Light-curve and Spectral Properties of Ultra-stripped Core-collapse Supernovae, IAUS 329: The Lives and Death-throes of Massive Stars, (Auckland, New Zealand, Nov. 28–Dec. 2, 2016).

Moriya, T.: 2016, Constraining the Ellipticity of Magnetars Powering Superluminous Supernovae, 4th DTA Symp., (Mitaka, Japan, May 13–14, 2016).

Moriya, T.: 2017, Light-curve and Spectral Properties of Ultra-stripped Core-collapse Supernovae, Transient Universe in the Big Survey Era: Understanding the Nature of Astrophysical Explosive Phenomena, (Kyoto, Japan, Jan. 23–24, 2017).

Nagai, H.: 2017, 3C 84: Past, Present, and Future, Black Hole Astrophysics with VLBI - Past, Present and Future, (Mitaka, Japan, Mar. 27–29, 2017).

Nagai, H.: 2017, Latest Results from ALMA Polarimetry, Cosmic Polarimetry from Micro to Macro Scales, (Hiroshima, Japan, Feb. 17–18, 2017).

Nakanishi, K., Sorai, K., Nakai, N., Kuno, N., Matsubayashi, K., Sugai, H., Ando, R., Kohno, K.: 2016, Dense Ionized Gas Embedded with Infant Massive Stellar Clusters in the NGC 253 Nuclear Starburst, Half a Decade of ALMA: Cosmic Dawns Transformed, (Indian Wells, CA, USA, Sep. 20–23, 2016).

Nakanishi, K.: 2016, ALMA polarization calibration, NRO-ALMA Joint Science/Development Workshop 2016, (Nagano, Japan, Jul. 20–21, 2016).

Narita, N.: 2016, Introduction of Subaru IRD and Okayama MuSCAT, TESS Science Team Meeting, (Cambridge, MA, USA, May, 19, 2016).

Narita, N.: 2016, MuSCAT and MuSCAT2 / IRD, TESS Science Team Meeting/TFOP splinter session, (Cambridge, MA, USA, Dec. 8–9, 2016).

Narita, N.: 2017, MuSCAT and MuSCAT2 for Detection and Characterization of Transiting Exoplanets, Formation and Dynamical Evolution of Exoplanets, (Aspen, CO, USA, Mar. 26–Apr. 1, 2017).

Narita, N.: 2017, TRAPPIST-1 and Future Surveys of Habitable Transiting Earth-like Planets, Astrobiology Center Internatioal Workshop, (Hiroshima, Japan, Mar. 22–24, 2017).

Narita, N.: 2017, Subaru-TESS Synergy, Subaru Users' Meeting FY2016, (Tokyo, Japan, Jan. 10–12, 2017).

Narukage, N., et al. including **Ishikawa, R.**, **Kubo, M.**, **Kano, R.**, **Suematsu, Y.**, **Yoshida, M.**: 2016, Chromospheric LAyer SpectroPolarimeter (CLASP2), SPIE Astronomical Telescopes + Instrumentatio, (Edinburgh, UK, Jun. 26–Jul. 1, 2016).

Narukage, N., **Kano, R.**, **Ishikawa, R.**, **Kubo, M.**, **Katsukawa, Y.**, **Giono, G.**, **Bando, T.**, **Hara, H.**, **Suematsu, Y.**, Ishikawa, S., Shimizu, T., Sakao, T., Tsuneta, S., Winebarger, A., Kobayashi, K., Trujillo Bueno, J., Auchere, F., Stepan, J., CLASP team: 2016, Temporal Variation in the Ly-alpha Linear Polarization Observed with the CLASP sounding Rocket, 10th Hinode Science Meeting, (Nagoya, Japan, Sep. 5–8, 2016).

Narukage, N., **Kano, R.**, **Ishikawa, R.**, Winebarger, A., Kobayashi, K., Trujillo Bueno, J., CLASP team: 2016, Temporal Variation in the

Ly-alpha Linear Polarization Observed with the CLASP Sounding Rocket (poster), 8th Solar Polarization Workshop, (Firenze, Italy, Sep. 12–16, 2016).

Nemoto, S.: 2017, Dynamic preservation of Tangible Cultural Properties in NAOJ, Symposium: Is the Collaboration between the Natural Science and the Human Sciences Possible?, (Osaka, Japan, Mar. 10, 2017).

Niino, Y., Totani, T., Okumura, J. E.: 2017, Separating an FRB Optical Counterpart from Contaminating Supernovae, Fast Radio Bursts: New Probes of Fundamental Physics and Cosmology, (Aspen, CO, USA, Feb. 12–17, 2017).

Niino, Y., **Aoki, K.**, Hashimoto, T., **Hattori, T.**, **Ishikawa, S.**, **Kashikawa, N.**, **Kosugi, G.**, **Onoue, M.**, **Toshikawa, J.**, Yabe, K.: 2016, The Redshift Selected Sample of Long Gamma-Ray Busrt Host Galaxies: The Complete Metallicity Measurements at $z \leq 0.41$, The Eighth Huntsville Gamma-Ray Burst Symposium, (Huntsville, AL, USA, Oct, 24–28. 2016).

Noda, H., Kunimori, H., Mizuno, T., Senshu, H., Ogawa, N., Takeuchi, H., Moore, C., Pollard, A., Yamaguchi, T., **Namiki, N.**, Kase, T., Saiki, T., Tsuda, Y.: 2016, Laser Link Experiment between Hayabusa2 Laser Altimeter and SLR Stations, 20th Int. Workshop on Laser Ranging, (Potsdam, Germany, Oct. 10–Oct. 14, 2016).

Nozawa, T.: 2016, On Properties of Interstellar Dust Responsible for Steep Extinction Curves Measured toward Type Ia Supernovae, International Molecule-type Workshop "Transient Universe in the Big Survey Era: Understanding the Nature of Astrophysical Explosive Phenomena", (Kyoto, Japan, Jan. 23–24, 2017).

Nozawa, T.: 2016, Physical Conditions of Supernova Ejecta as Viewed from the Measured Sizes of Presolar Al_2O_3 Grains, The 9th meeting on Cosmic Dust, (Sendai, Japan, Aug. 15–19, 2016).

Nozawa, T.: 2016, Properties of Interstellar Dust as Probed by Extinction Laws toward Type Ia Supernovae, Multiple Faces of Interstellar Dust, (Garching, Germany, Sep. 15–19, 2016).

Nozawa, T.: 2016, Mass of Dust in Core-collapse Supernovae as Viewed from Energy Balance in the Ejecta, IAUS 329: The Lives and Death-throes of Massive Stars, (Auckland, New Zealand, Nov. 28–Dec. 2, 2016).

Nozawa, T.: 2017, Properties of Dust Accounting for Extinction Laws toward Type Ia Supernovae, International Molecule-type Workshop "Transient Universe in the Big Survey Era: Understanding the Nature of Astrophysical Explosive Phenomena", (Kyoto, Japan, Jan. 23–24, 2017).

Nozawa, T.: 2017, Overall Dust Input from Core-collapse Supernovae in the Galaxy, The AGB-Supernovae Mass Transition, (Rome, Italy, Mar. 27–31, 2017).

Oe, M.: 2016, The Introduce of Network Research Topics in the Field of Astronomy, 20th Anniversary of AI3 & 15th Anniversary of SOI Asia, (Bangdung, Indonesia, Sep. 4–6, 2016).

Ogawa, K., et al. including **Yamada, R.**: 2016, Geophysical Experiments on Phobos Proposed for JAXA Mars Moon Exploration Mission, Japan Geoscience Union Meeting 2016, (Chiba, Japan, May 22–26, 2016).

Ogihara, M.: 2016, Terrestrial Planet Formation in Disks Evolving via Disk Winds, New Directions in Planet Formation, (Leiden, The Netherlands, Jul. 11–15, 2016).

Ogihara, M.: 2016, Formation of Terrestrial Planets in Disks Evolving via Disk Winds, Japan-Germany Planet and Disk Workshop, (Ishigaki, Japan, Sep. 25–30, 2016).

Ohashi, N., **Kobayashi, K.**, Fujitake, M.: 2016, IAM(-LIKE) Tunneling Matrix Formalism for One- and Two-Methyl-Top Molecules Based on the Extended Permutation-Inversion Group Idea and Its Application to the Analyses of The Methyl-Torsional Rotational Spectra, 71st International Symposium on Molecular Spectroscopy, (Urbana-Champagne, IL, USA, Jun. 20–24, 2016).

Ohishi, M.: 2016, Sensitive Observations on CH_2NH and CH_3NH_2 — Precursors to Glycine, Space Talk, (Hanoi, Vietnam, Dec. 6, 2016).

Ohishi, M.: 2016, Sensitive Observations on CH_2NH and CH_3NH_2 — Precursors to Glycine, Seminar, (Buon Ma Thout, Vietnam, Dec. 7, 2016).

Ohishi, M.: 2016, Astrochemistry, Training School on Basics of Astrobiology, (Quy Nhon, Vietnam, Dec. 9, 2016).

Ohishi, M.: 2016, ALMAWebQL, IVOA Interoperability meeting, (Stellenbach, South Africa, May 5–13, 2016).

Ohishi, M.: 2016, ALMA WebQL2 via JVO, NRO-ALMA Joint Science/Development Workshop 2016, (Nagano, Japan, Jul. 20–21, 2016).

Ohsuga, K.: 2016, Theory of Ultra Luminous X-ray Sources, Breaking the Limits: Super-Eddington Accretion on Compact Objects, (Sardinia, Italy, Sep. 19–23, 2016).

Ohtani, Y., Suzuki, A., Shigeyama, T.: 2016, Scattered X-ray Photons due to Axisymmetric Shock Breakout in a Circumstellar Medium, 14th Int. Symp. on Nuclei in the Cosmos (NIC2016), (Niigata, Japan, Jun. 19–24, 2016).

Ohtani, Y., Suzuki, A., Shigeyama, T.: 2016, Influence of Shock Asymmetry on Observable Features of Shock Breakout, 2nd NAOJ-ECT Workshop on Many Riddles About Core-Collapse Supernovae: Bethe and Beyond, (Mitaka, Japan, Jun. 27–Jul. 1, 2016).

Ohtani, Y., Suzuki, A., Shigeyama, T.: 2017, Properties of X-ray Emission of an Aspherical Shock Breakout, IAU focus meeting 331, (Reunion Island, France, Feb. 20–24, 2017).

Ohtawara, K., et al. including **Ishii, S.**, **Oshima, T.**, **Takekoshi, T.**, **Izumi, N.**, **Uemizu, K.**, **Ito, T.**, **Fujii, Y.**, **Arai, H.**, **Hirota, A.**, **Minamidani, T.**, **Iwashita, H.**, **Maekawa, J.**, **Saito, T.**, **Miyamoto, Y.**, **Kaneko, H.**, **Morokuma, K.**, **Matsuo, H.**, **Kawabe, R.**: 2016, On-site Measurement of TES bolometer Camera for the ASTE Telescope: (3) Calibration, ALMA/45m/ASTE Users Meeting 2016, (Mitaka, Japan, Dec. 19–20, 2016).

Oi, Y., Yokoyama, T., **Toriumi, S.**: 2016, Flux Rope Formation and Eruption in a Quadrupolar Active Region Holding a Delta-spot, Hinode-10 Science Meeting, (Nagoya, Japan, Sep. 5–8, 2016).

Oka, T., Geballe, T. R., Goto, M., **Usuda, T.**, Indriolo, N.: 2016, Central 300 PC of the Galaxy Probed by the Infrared Spectra of H_3^+ and Co: I. Predominance of Warm and Diffuse Gas and High H_2 Ionization Rate, 71st International Symposium on Molecular Spectroscopy, (Urbana-Champagne, IL, USA, Jun. 20–24, 2016).

Okamoto, J., Liu, W., Tsuneta, S.: 2016, High Resolution Observations of Prominence Rotation by Hinode and IRIS, AGU Fall Meeting 2016, (San Francisco, CA, USA, Dec. 12–16, 2016).

Okamoto, J., Liu, W., Tsuneta, S.: 2016, Rotation of Helical Prominence Threads Observed by Hinode and IRIS, Hinode-10 Science Meeting, (Nagoya, Japan, Sep. 5–8, 2016).

Okamoto, J., Liu, W., Tsuneta, S.: 2016, 3D Motion of Active-region Prominences: Rotation, IAU Symp. 327, (Cartagena, Colombia, Oct.

9–13, 2016).

Okamoto, J., Liu, W., Tsuneta, S.: 2016, Helical Motions of Fine-structure Prominence Threads Observed by Hinode and IRIS, IRIS-6: The Chromosphere, (Stockholm, Sweden, Jun. 20–23, 2016).

Okamoto, J.: 2016, Waves in Prominences and Approaching to the Coronal Heating, AOGS 2016, (Beijing, China, Jul. 31-Aug. 5, 2016).

Okamoto, T. J.: 2016, Introduction to the operation of HINODE, IRIS-7 Workshop, (Weihai, China, Apr. 11–15, 2016).

Okutomi, K., et al. including **Takahashi, R.**, **Shoda, A.**, **Fujii, Y.**, **Sekiguchi, T.**, **Peña Arellano, F. E.**, **Barton, M.**, **Hirata, N.**, **Ishizaki, H.**, **Akutsu, T.**, **Ohishi, N.**, **Aso, Y.**, **Flaminio, R.**: 2016, Vibration Isolation System for KAGRA: Overview and Results in the First Operation, GWADW2016, (Elba, Italy, May 22–28, 2016).

Onishi, T., **Kawabe, R.**, **Oshima, T.**, **Takekoshi, T.**, Kohno, K., Tamura, Y., Ishii, S. and LST Working Group: 2016, Large Submillimeter Telescope (LST), Metrology and Control of Large Telescopes, (Green Bank, WV, USA, Sep. 19–24, 2016).

Onishi, T.: 2016, Science Review of Nearby Galaxy and Star Formation, ALMA/45m/ASTE Users Meeting 2016, (Mitaka, Japan, Dec. 19–20, 2016).

Onishi, T.: 2016, Physical Properties and Evolution of Giant Molecular Clouds in the MagellanicClouds, Star Formation in Different Environments, (Quy Nhon, Vietnam, Jul. 25–29, 2016).

Onodera, M., Carollo, C. M., Lilly, S., Renzini, A., **Arimoto, N.**, Capak, P., Daddi, E., Scoville, N., Tacchella, S., **Tatehora, S.**, Zamorani, G.: 2016, ISM Excitation and Metallicity of Star-forming Galaxies at z~3.3 from Near-IR Spectroscopy, Panoramas of the Evolving Cosmos, The 6th Subaru Int. Conf., (Hiroshima, Japan, Nov. 28–Dec. 2, 2016).

Onodera, M.: 2016, PFS Operation from the Observatory Perspectives, PFS software collaboration meeting, (Princeton, USA, Sep. 5–6, 2016).

Onodera, M.: 2016, Stellar Populations as a Key Diagnostics in the Size Evolution of Passive Galaxies, Deconstructing Galaxies at Cosmic Noon: The Present and Future of Deep Spectroscopic Surveys at High Redshift, (Leiden, The Netherlands, Aug. 1–5, 2016).

Oshigami, S., Hirata, N., Kimura, J., **Namiki, N.**: 2016, Slope and Roughness Characteristics Derived from High-resolution Images of Galilean Satellites, Japan Geoscience Union Meeting 2016, (Chiba, Japan, May 22–26, 2016).

Oshigami, S., Hirata, N., Kimura, J., **Namiki, N.**: 2016, Slope and Roughness Characteristics of Galilean Moons Derived from High-Resolution Images, AOGS 2016, (Beijing, China, Jul. 31–Aug. 5, 2016).

Oshima, T., et al. including **Takekoshi, T.**, **Ohtawara, K.**, **Izumi, N.**, **Ishii, S.**, **Arai, H.**, **Hirota, A.**, **Minamidani, T.**, **Iwashita, H.**, **Maekawa, J.**, **Uemizu, K.**, **Ito, T.**, **Fujii, Y.**, **Saito, T.**, **Miyamoto, Y.**, **Kaneko, H.**, **Morokuma, K.**, **Matsuo, H.**, **Kawabe, R.**, TESCAM commissioning team: 2016, On-site Measurement of TES Bolometer Camera for the ASTE Telescope: (1) Project Overview, ALMA/45m/ASTE Users Meeting 2016, (Mitaka, Japan, Dec. 19–20, 2016).

Ozaki, S., **Miyazaki, S.**, **Tsuzuki, T.**, **Tanaka, Y.**: 2016, Polishing Test of a Poly-crystal Calcium Fluoride Lens: toward the Development of TMT WFOS, SPIE Ground-based and Airborne Instrumentation for Astronomy VI, (Edinburgh, UK, Jun. 26–30, 2016).

Ozeki, H., Miyahara, R., Ihara, H., Todaka, S., **Kobayashi, K.**, **Ohishi, M.**: 2016, The Millimeter-Wave Spectroscopy of Hydantoin, A Potential Precursor of Glycine, 71st International Symposium on Molecular Spectroscopy, (Urbana-Champagne, IL, USA, Jun. 20–24, 2016).

Pathak, P., **Guyon, O.**, **Jovanovic, N.**, **Lozi, J.**, Martinache, F., **Minowa, Y.**, **Kudo, T.**, **Takami, H.**, **Hayano, Y.**, **Narita, N.**: 2016, First On-sky Closed Loop Measurement and Correction of Atmospheric Dispersion, SPIE Astronomical Telescopes + Instrumentatio, (Edinburgh, UK, Jun. 26–Jul. 1, 2016).

Phillips, A. C., **Suzuki, R.**, Larkin, J. E., Moore, A. M. **Hayano, Y.**, **Tsuzuki, T.**, Wright, S. A.: 2016, The Infrared Imaging Spectrograph (IRIS) for TMT: the ADC optical design, SPIE Astronomical Telescopes + Instrumentatio, (Edinburgh, UK, Jun. 26–Jul. 1, 2016).

Rains, A., Ireland, M., **Jovanovic, N.**, Feger, T., Bento, J., Schwab, C., Coutts, D., **Guyon, O.**, Arriola, A., Gross, S.: 2016, Precision Single Mode Fibre Integral Field Spectroscopy with the RHEA Spectrograph, SPIE Ground-based and Airborne Instrumentation for Astronomy VI, (Edinburgh, UK, Jun. 26–30, 2016).

Sagawa, H.: 2016, Planetary & Solar System Science in the Era of ALMA, NRO-ALMA Joint Science/Development Workshop 2016, (Nagano, Japan, Jul. 20–21, 2016).

Sakai, N.: 2016, Current Status of KaVA Galactic Astrometry Sub-WG, East Asia VLBI Workshop 2016, (Guiyang, Guizhou, China, Nov. 7–11, 2016).

Sasaki, H., **Takiwaki, T.**, **Kajino, T.**, Hidaka, J., Maruyama, T., Pehlivan, Y., Balantekin, B.: 2016, Collective Neutrino-Flavor Oscillations and Application to Supernova Nucleosynthesis, 14th Int. Symp. on Nuclei in the Cosmos (NIC2016), (Niigata, Japan, Jun. 19–24, 2016).

Sato, K., **Kojima, T.**, **Kroug, M.**, **Sakai T.**, **Uzawa, Y.**: 2016, Capacitance Measurements of Niobium SIS Junctions at Microwave Frequencies, 29th Int. Symp. on Superconductivity, (Tokyo, Japan, Dec. 13–15, 2016).

Sawada, T., **Hasegawa, T.**, **Koda, J.**: 2016, Internal Structures of Molecular Clouds in the LMC Revealed by High-Fidelity Imaging with ALMA, Half a Decade of ALMA: Cosmic Dawns Transformed, (Indian Wells, CA, USA, Sep. 20–23, 2016).

Schwab, C., **Jovanovic, N.**, Feger, T., Bakovic, M., Gurevich, Y. V., Stürmer, J., Apodaca, R., Vanzi, L., Rukdee, S., Lawrence, J. S., Coutts, D. W., Cvetojevic, N., Mahadevan, S., Stefánsson, G. K., Halverson, S. P., **Guyon, O.**: 2016, Adaptive Optics Fed Single-mode Spectrograph for High-precision Doppler Measurements in the Near-infrared, SPIE Advances in Optical and Mechanical Technologies for Telescopes and Instrumentation II, (Edinburgh, UK, Jun. 26, 2016).

Sekine, Y., Tabata, H.: 2016, Runaway Acidification of Surface Water on Early Mars in Response to Atmospheric Evolution, AOGS 2016, (Beijing, China, Jul. 31–Aug. 5, 2016).

Shan, W., **Ezaki, S.**, **Kaneko, K.**, **Kroug, M.**, **Gonzalez, A.**, **Kojima, T.**, **Fujii, Y.**, **Asayama, S.**, **Noguchi, T.**: 2017, Design and Fabrication of a Dual-Polarization, Balanced SIS Mixer Integrated Circuit, 28th Int. Symp. on Space Terahertz Technology, (Cologne, Germany, Mar. 13–15, 2017)

Shibagaki, S., **Takiwaki, T.**, **Kajino, T.**: 2016, 1.5D GRMHD Simulation of Core-Collapse Supernova, 14th Int. Symp. on Nuclei in the Cosmos (NIC2016), (Niigata, Japan, Jun. 19–24, 2016).

Shibata, Y., **Agata, H.**, **Usuda-Satoh, K.**, **Cheung, S.**, **Canas, L.**: 2016, To Overcome the Language Barrier – Case Study in Japan, CAP2016, (Medellín, Colombia, May 16–20, 2016).

Shibata, Y.: 2016, To Overcome the Language Barrier — Casestudy in

Japan, Communicating Astronomy with the Public 2016, (Medellin, Colombia, May 16–20, 2016).

Shimojo, M., ALMA Solar Development Team: 2016, Solar Observations in Cycle 4 of ALMA, Cool Star 19, (Uppsala, Sweden, Jun. 6–10, 2016).

Shimojo, M., ALMA Solar Development Team: 2016, What Solar Data will ALMA Provide to Us in Cycle 4 and Beyond?, Hinode-11, (Nagoya Japan, Sep. 5–8, 2016).

Shimojo, M., ALMA Solar Development Team: 2016, What Solar Data will ALMA Provide to Us in Cycle 4 and Beyond?, Solar Physics with Radio Observations 2016, (Nagoya Japan, Sep. 9–10, 2016).

Shimojo, M., ALMA Solar Development Team: 2016, Solar Observations in Cycle 4 of ALMA, 2016 URSI Asia-Pacific Radio Science Conference, (Seoul, South Korea, Aug. 21–25, 2016).

Shimojo, M., ALMA Solar Development Team: 2017, New window of solar physics: Solar observations with ALMA, East-Asian ALMA Science Workshop 2016, (Hsinchu, Taiwan, Mar. 10–12, 2017).

Shin, J. W., Park, T.-S., **Kajino, T.**, Cheoun, M.-K.: 2016, Neutrino Interactions with Matter by a New Neutrino Source From the Isotope Radioactive Decay Produced by the Proton Accelerator, 14th Int. Symp. on Nuclei in the Cosmos (NIC2016), (Niigata, Japan, Jun. 19–24, 2016).

Shinnaka, H.: 2016, Ortho-to-Para Abundance Ratios of Water from High-resolution Spectra of Water Ion in the Optical Wavelength Region, Water in the Universe: From Clouds to Oceans, (Noordwijk, Netherland, Apr. 12–15, 2016).

Shinnaka, H.: 2016, Imaging Observations of Hydrogen Coma of 67P/ Churyumov-Gerasimenko by PROCYON/LAICA, Cometary science after Rosetta, (London, UK, Jun. 14–15, 2016).

Shinnaka, H.: 2016, Lyman-alpha Imaging of Whole Coma for 67P/ Churyumov-Gerasimenko by PROCYON/LAICA, Cometary Science After Rosetta: Future Directions, (London, UK, Jun. 16–17, 2016).

Shinnaka, H.: 2016, Spectroscopic Observations of $^{14}N/^{15}N$ Ratios in both NH_2 and CN in Comet C/2013 US10 (Catalina), DPS48/EPSC11 meeting, (Pasadena, CA, USA, Oct. 16–21, 2016).

Shinnaka, H.: 2017, Ortho-to-Para Abundance Ratios (OPRs) of NH_2 in Comets: The Meaning of OPRs of Cometary Volatiles, Subaru Users' Meeting FY2016, (Tokyo, Japan, Jan. 10–12, 2017).

Shinnaka, H.: 2017, Nitrogen Isotopic Ratios of NH_2 and CN in Comet C/2013 US10 (Catalina) based on high-resolution optical spectra taken by the HDS/Subaru, Subaru Users' Meeting FY2016, (Tokyo, Japan, Jan. 10–12, 2017).

Shirasaki, Y., **Hiramatsu, M.**: 2017, JVO ALMA FITS Data Archive, Data to Dome Workshop, (Tokyo, Japan, Mar. 2–3, 2017).

Shirasaki, Y., **Zapart, C.**, **Ohishi, M.**, **Mizumoto Y.**: 2016, Update of the JVO Subaru Suprime-Cam Mosaic Image Archive, ADASS XXVI, (Trieste, Italy, Oct. 16–20, 2016).

Shirasaki, Y.: 2016, Properties of Galaxies around z=0.6–3.0 QSOs Revealed by Clustering Analysis Using Data from HSC-SSP Wide Survey, HSC-AGN meeting, (Chiba, Japan, Aug. 26–27, 2016).

Shirasaki, Y.: 2016, Delivery of Gaia Source Catalog from NAOJ, Gaia-JASMINE joint meeting, (Mitaka, Japan, Dec. 6–9, 2016).

Shoda, A.: 2016, GWADW 2016: Environment at the Underground GW Detector KAGRA, GWADW2016, (Elba, Italy, May 22–28, 2016).

Singh, G., **Lozi, J.**, Choquet, E., Serabyn, E., **Guyon, O.**: 2016, PSF Calibration Using the Lyot-based Low Order Wavefront Sensor Telemetry: First Simulations, SPIE Astronomical Telescopes + Instrumentatio, (Edinburgh, UK, Jun. 26–Jul. 1, 2016).

Sôma, M.: 2016, Derivation of the Inclination of Mars' Orbit in the Almagest, The 9th International Conference on Oriental Astronomy (ICOA-9), (Pune, India, Nov. 14–19, 2016).

Sôma, M.: 2017, Results from Recent Lunar Graze Observations, 7th International Workshop on Occultation and Eclipse, (Shahr-e kord, Iran, Mar. 8–10, 2017).

Sotani, H.: 2016, Nuclear Symmetry Energy and Crustal Torsional Oscillations in Neutron Stars, 6th International Symposium on Nuclear Symmetry Energy (NuSYM16), (Beijing, China, Jun. 13–17, 2016).

Sotani, H.: 2016, Crustal Torsional Oscillations and Nuclear Symmetry Energy, 14th Int. Symp. on Nuclei in the Cosmos (NIC2016), (Niigata, Japan, Jun. 19–24, 2016).

Sotani, H.: 2016, Gravitational Waves of Core-collapse Supernova at Post-bounce Phase, 21st Int. Conf. on General Relativity and Gravitation (GR21), (New York, USA, Jul. 10–25, 2016).

Sotani, H.: 2016, Scalar-gravitational Waves from Relativistic Stars in Scalar-tensor Gravity, Gravitational Waves from modified gravity theories, (Athens, Greece, Sep. 15–17, 2016).

Sotani, H.: 2016, Gravitational Wave Asteroseismology in Protoneutron Stars, NEB 17 - Recent Developments in Gravity, (Mykonos, Greece, Sep. 19–22, 2016).

Sotani, H.: 2016, Probing the Nuclear Symmetry Energy via Neutron Star Asteroseismology, International Symposium on Neutron Star Matter (NSMAT2016), (Sendai, Japan, Nov. 21–24, 2016).

Sotani, H.: 2017, Gravitational Waves from Protoneutron Stars, Testing Gravity 2017, (Vancouver, BC, Canada, Jan. 26–28, 2017).

Sotani, H.: 2017, Protoneutron Star Properties via Gravitational Wave Asteroseismology, Quarks and Compact Stars 2017 (QCS2017), (Kyoto, Japan, Feb. 20–23, 2017).

Srikanth, S., **Gonzalez, A.**: 2016, ALMA Band 2 Optics: Design, Constraints, Implementation and Measurements, 2016 URSI Asia-Pacific Radio Science Conference, (Seoul, South Korea, Aug. 21–25, 2016).

Suematsu, Y., Saito, K., Koyama, M., Enokida, Y., Okura, Y., Nakayasu, T., Sukegawa, T.: 2016, Compact Integral Field Unit for Optical Telescope of the SOLAR-C Mission, International Conference on Space Optics 2016, (Biarritz, France, Oct. 18–21, 2016).

Suematsu, Y.: 2016, On the Roots of Solar Spicules revealed with Hinode/SOT-NFI Observations in Na I D and Mg I b Lines, 10th Hinode Science Meeting, (Nagoya, Japan, Sep. 5–8, 2016).

Suzuki, T., Honma, M., Mori, K., Famiano, M. A., **Kajino, T.**, Hidakai, J., Otsuka, T.: 2016, Electron-capture Rates for pf-shell Nuclei in Stellar Environments and Nucleosynthesis, 14th Int. Symp. on Nuclei in the Cosmos (NIC2016), (Niigata, Japan, Jun. 19–24, 2016).

Suzuki, T., Yoshida, T., Shibagaki, S., **Kajino, T.**, Otsuka, T.: 2016, Beta-Decay Rates for Exotic Nuclei and R-Process Nucleosynthesis up to Th and U, 14th Int. Symp. on Nuclei in the Cosmos (NIC2016), (Niigata, Japan, Jun. 19–24, 2016).

Takahashi, H. R., **Ohsuga, K.**: 2016, Accretion and Outflows Observed in GRRMHD Simulations, ULXs and their environments, (Strasbourg, France, Jun. 13–16, 2016).

Takahashi, H. R.: 2016, Relativistic Radiation Magnetohydrodynamics of Accretion Disks, International Congress on Plasma Physics (ICPP)-2016, (Kaohsiung, Taiwan, Jun. 27–Jul. 1, 2016).

Takahashi, H. R.: 2017, General Relativistic Radiation Magnetohydrodynamic Simulations of Disk Accretion onto a Black Hole or a Neutron Star, US Japan Workshop and School on Magnetic Reconnection (MR2017), (Matsuyama, Ehime, Japan, Mar. 19–23, 2017).

Takahashi, H. R.: 2017, Black Hole and Neutron Star Accretion Disk, Ultra-Luminous X-ray Source, (Sagamihara, Japan, March. 3–4, 2017).

Takahashi, H. R.: 2017, Radiation Magnetohydrodynamic Simulations of Accretion Disks, East Asian Numerical Astrophysics Meeting, (Beijing, China, Oct. 24–16, 2016).

Takahashi, R.: 2016, Vibration Isolation System for KAGRA, The 1st International Meeting on KAGRA, (Daejon, Korea, Jun. 23–25, 2016).

Takahashi, R.: 2016, Installation Plan of Vibration Isolation System for KAGRA, The 2nd International Meeting on KAGRA, (Beijing, China, Nov. 10–12, 2016).

Takekoshi, T., et al. including **Oshima, T.**, **Ohtawara, K.**, **Izumi, N.**, **Ishii, S.**, **Arai, H.**, **Hirota, A.**, **Minamidani, T.**, **Iwashita, H.**, **Maekawa, J.**, **Uemizu, K.**, **Ito, T.**, **Fujii, Y.**, **Saito, T.**, **Miyamoto, Y.**, **Kaneko, H.**, **Morokuma, K.**, **Matsuo, H.**, **Kawabe, R.**, **Izumi, T.**, TESCAM commissioning team: 2016, On-site Measurement of TES Bolometer Camera for the ASTE Telescope: (2) Optics Evaluation, ALMA/45m/ASTE Users Meeting 2016, (Mitaka, Japan, Dec. 19–20, 2016).

Taki, T., Okuzumi, S., Fujimoto, M., Ida, S.: 2016, Dust and Gas Density Evolution at a Radial Pressure Bump, Japan-Germany Planet and Disk Workshop, (Ishigaki, Japan, Sep. 25–30, 2016).

Takiwaki, T.: 2016, Gravitational Signals from Core-collapase Supernovae: Cutting-edge samples, 4th DTA Symp., (Mitaka, Japan, May 13–14, 2016).

Takiwaki, T.: 2016, Supernova Simulations with Updated Microphysics, 14th Int. Symp. on Nuclei in the Cosmos (NIC2016), (Niigata, Japan, Jun. 19–24, 2016).

Takiwaki, T.: 2016, Supernova Neutrinos, The First Workshop on the Second Hyper-Kamiokande Detector in Korea, (Seoul, Korea, Nov. 22, 2016).

Takiwaki, T.: 2016, Intensive and Extensive Studies of Core-collapse Supernovae: Status Reports of Japanese Group, 2nd NAOJ-ECT Workshop on Many Riddles About Core-Collapse Supernovae: Bethe and Beyond, (Mitaka, Japan, Jun. 27–Jul. 1, 2016).

Takiwaki, T.: 2016, Toward Multi-messenger Observation of Core-collapse Supernovae from Simulations of the Central Engine, Supernovae Though the Ages, (Ester Island, Chile, Aug. 9–13, 2016).

Takiwaki, T.: 2016, A Clockwork Supernova: Precision Numerical Experiments and Their Applications, DTA colloquium, (Mitaka, Japan, Apr. 13, 2016).

Tamura, M.: 2016, Astrobiology Center (ABC) of NINS, EANA, (Athens, Greece, Sep. 27–30, 2016).

Tamura, N., et al. including **Takato, N.**, **Ueda, A.**, **Kamata, Y.**, **Minowa, Y.**: 2016, Prime Focus Spectrograph (PFS) for the Subaru Telescope: Overview, Recent Progress, and Future Perspectives, SPIE Astronomical Telescopes + Instrumentatio, (Edinburgh, UK, Jun. 26–Jul. 1, 2016).

Tanaka, M.: 2016, Galaxy Evolution Science with Hyper Suprime-Cam, Prime Focus Spectrograph, and ULTIMATE, Ultimate Subaru Science Workshop 2016, (Tokyo, Japan, Jun. 16–17, 2016).

Tanaka, M.: 2016, Deep Near-IR Spectroscopy of Massive Galaxies in Proto-clusters, Deconstructing Galaxies at Cosmic Noon: The Present and Future of Deep Spectroscopic Surveys at High Redshift, (Leiden, The Netherlands, Aug. 1–5, 2016).

Tanaka, M.: 2016, Hyper Suprime-Cam Subaru Strategic Program, Cosmology and Structure Formation, (Seul, South Korea, Nov. 1–4, 2016).

Tanaka, M.: 2016, Science Database: NAOJ's perspectives and plans forward, PFS collaboration meeting 2016, (Baltimore, USA, Dec. 12–16, 2016).

Tanaka, M.: 2016, Kilonova/Macronova Emission from Compact Binary Mergers, Gravitational-Wave Astrophysics in the High Event Rate Regime, (Tokyo, Japan, Dec. 5–6, 2016).

Tanaka, M.: 2016, Kilonova/Macronova Emission from Compact Binary Mergers, Compact stars and gravitational waves, (Kyoto, Japan, Oct. 31–Nov. 4, 2016).

Tanaka, M.: 2016, Time-Domain Science with ULTIMATE-Subaru, Ultimate Subaru Science Workshop 2016, (Tokyo, Japan, Jun. 16-17, 2016).

Tanaka, M.: 2016, Three-dimensional Geometry of Core-collapse Supernovae: Observations and Modelling, Bridging the gap: from massive stars to supernovae, (Buckinghamshire, UK, Jun. 1–2, 2016).

Tanaka, M.: 2016, TMT and Gravitational Wave Astronomy, TMT Science Forum 2016, (Kyoto, Japan, May 24–26, 2016).

Tanaka, M.: 2016, Transient Surveys with Subaru/Hyper Suprime-Cam, The Ninth Harvard-Smithsonian Conference on Theoretical Astrophysics "The transient sky", (Boston, USA, May 16–19, 2016).

Tanaka, M.: 2016, Kilonova Emission from Compact Binary Mergers, Supernovae Through the Ages, (Easter island, Chile, Aug. 8–13, 2016).

Tanaka, M.: 2016, Electromagnetic Counterparts of Gravitational Wave Sources, 4th DTA Symp., (Mitaka, Japan, May 13–14, 2016).

Tanaka, M.: 2017, Deep Near-IR Spectroscopy of Massive Galaxies in Proto-clusters, Subaru Users' Meeting FY2016, (Tokyo, Japan, Jan. 10–12, 2017).

Tanaka, M.: 2017, First Data Release of the Hyper Suprime-Cam Subaru Strategic Program, "Accelerated Universe" Symposium, (Tsukuba, Japan, Mar. 8–10, 2017).

Tanaka, M.: 2017, HSC+Huntsman: a Search for Dwarf Galaxies around Nearby Galaxies, Subaru International Partnership Science and Instrumentation Workshop, (Tokyo, Japan, Mar. 22–24, 2017).

Tanaka, M.: 2017, Time-Domain Science with Subaru/HSC, Subaru International Partnership Science and Instrumentation Workshop, (Tokyo, Japan, Mar. 22–24, 2017).

Tanaka, M.: 2017, Multi-Messenger from Supernovae, Workshop on Supernova at Hyper-Kamiokande, (Tokyo, Japan, Feb. 12–13, 2017).

Tanaka, M.: 2017, Rapid Transients from Subaru/HSC Transient Survey, International Molecule-type Workshop "Transient Universe in the Big Survey Era: Understanding the Nature of Astrophysical Explosive Phenomena", (Kyoto, Japan, Jan. 23–24, 2017).

Tanaka, S., Shiraishi, H., Shirai, K., Ishihara, Y., Goto, K., Hayakawa, M., Ozaki, M., Mizuno, T., Yamada, K., Murakami, H., **Yamada, R.**: 2016, Development of a Penetrator Probe Dropping from a UAV for

Disaster Prevention, Japan Geoscience Union Meeting 2016, (Chiba, Japan, May 22–26, 2016).

Tanaka, Y., Heling, C., Suzuki, T. K., Inutsuka, S.: 2016, Atmospheric Escape from Close-in Gaseous Planets Driven by Magnetohydrodynamic Waves, Japan-Germany Planet and Disk Workshop, (Ishigaki, Japan, Sep. 25–30, 2016).

Tanikawa, K., **Sôma, M.**, Shylaja, B., Vahia, M. N.: 2016, Reliability of the Records of Observed Solar Eclipses in India and Comparison with Contemporaneous Eclipse Data of Other Countries, The 9th International Conference on Oriental Astronomy (ICOA-9), (Pune, India, Nov. 14–19, 2016).

Tapia, V., Nesti, R., **Gonzalez, A.**, Barrueta, I., Mena, F.P., Reyes, N., Villa, F., Cuttaia, F., Yagoubov, P.: 2016, An Ultra-broadband Optical System for ALMA Band 2+3, SPIE Conference on Astronomical Telescopes + Instrumentation 2016, (Edinburgh, UK, Jun. 10–15, 2016).

Tei, A., Sakaue, T., Asai, A., Ueno, S., Ichimoto, K., Shibata, K., Kawate, T., **Okamoto, T. J.**: 2016, Dynamic Response of the Chromosphere in a Solar Flare Based on Spectroscopic Observations, Hinode-10 Science Meeting, (Nagoya, Japan, Sep. 5–8, 2016).

Terada, H.: 2016, Observations of Ices in Protoplanetary Disks, Ice Age - The Era of JWST, (Leiden, The Netherlands, Oct. 4–7, 2016).

Terai, T., **Yoshida, F.**: 2017, Jupiter Trojan Survey with Hyper Suprime-Cam, Subaru Users' Meeting FY2016, (Tokyo, Japan, Jan. 10–12, 2017).

Toirumi, S.: 2016, Flux Emergence Studies: Past, Present and Future, 10th Hinode Science Meeting, (Nagoya, Japan, Sep. 5–8, 2016).

Toriumi, S., **Katsukawa, Y.**, Cheung, M. C. M.: 2016, Hinode-IRIS Observation and MHD Modeling of Sunspot Light Bridges, IRIS-7 Workshop, (Weihai, China, Apr. 11–15, 2016).

Toriumi, S., **Katsukawa, Y.**, Cheung, M. C. M.: 2016, Hinode-IRIS Analysis of Various Chromospheric Heatings in Emerging Flux Regions, IRIS-6: The Chromosphere, (Stockholm, Sweden, Jun. 20–23, 2016).

Toriumi, S., Schrijver, C. J., Harra, L. K., Hudson, H., Nagashima, K.: 2016, Properties and Developments of Flaring Active Regions, SDO 2016: Unraveling the Sun's Complexity, (Burlington, VT, USA, Oct. 17–21, 2016).

Toriumi, S., Schrijver, C. J., Harra, L. K., Hudson, H., Nagashima, K.: 2017, Flare-productive Active Regions: Magnetic Properties and Evolutions, Solarnet IV Meeting, (Lanzarote, Spain, Jan. 16–20, 2017).

Toriumi, S.: 2016, Flux Emergence Studies: Past, Present and Future, Hinode-10 Science Meeting, (Nagoya, Japan, Sep. 5–8, 2016).

Toriumi, S.: 2017, Review on Recent Publications of Light Bridge Studies, ISSI UV Bursts Meeting, (Bern, Switzerland, Mar. 6–10, 2017).

Toriumi, S.: 2017, Various Local Heating Events in the Earliest Phase of Flux Emergence, ISSI UV Bursts Meeting, (Bern, Switzerland, Mar. 6–10, 2017).

Toriumi, S.: 2017, Observation and Modeling of Flare-productive Solar Active Regions, 2nd PSTEP International Symposium, (Kyoto, Japan, Mar. 23–24, 2017).

Tsujimoto, T.: 2016, Observational Constraints on r-process Site & Nucleosynthesis from Dwarf Galaxies, the Milky Way, and the Solar System, The r-process nucleosynthesis: connecting FRIB with the cosmos, (Lansing, MI, USA, Jun. 6–17, 2016).

Tsujimoto, T.: 2016, Origina and Evolution of r-process Nuclides in Local Universe, Goldschmidt, (Yokohama, Japan, Jun. 27–Jul. 1, 2016).

Tsujimoto, T.: 2016, r-process Enrichment in the Milky Way and Nearby Dwarf Galaxies, The Milky Way and its environment, (Paris, France, Sep. 19–23, 2016).

Tsuzuki, T., **Suzuki, R.**, **Harakawa, H.**, **Ikenoue, B.**, Larkin, J. Moore, A., **Obuchi, Y.**, Phillips, A. C., **Saito, S.**, **Uraguchi, F.**, Wincentsen, J., Wright, S., **Hayano, Y.**: The Infrared Imaging Spectrograph (IRIS) for TMT: Optical Design of IRIS Imager with "Co-axis Double TMA", SPIE Astronomical Telescopes + Instrumentatio, (Edinburgh, UK, Jun. 26–Jul. 1, 2016).

Uraguchi, F., **Obuchi, Y.**, **Ikenoue, B.**, **Saito, S.**, **Suzuki, R.**, **Hayano, Y.**: The Infrared Imaging Spectrograph (IRIS) for TMT: Prototyping of Cryogenic Compatible Stage for the Imager, SPIE Astronomical Telescopes + Instrumentatio, (Edinburgh, UK, Jun. 26–Jul. 1, 2016).

Usuda, T.: 2016, Thirty Meter Telescope (TMT) Project Status, 10th East-Asia Meeting on Astronomy (EAMA), (Seoul, Korea, Sep. 26–30, 2016).

Usuda, T.: 2017, Direct Detection of Cosmic Acceleration by TMT & High Dispersion Spectrograph B04 Overview & Current Status of TMT, "Accelerated Universe" Symposium, (Tsukuba, Japan, Mar. 8–10, 2017).

Usuda-Sato, K., Canas, L.: 2016, Universal Design Symposium in Japan - International Collaboration -, Astronomy beyond the Common Senses, (Cartagena de Indias, Colombia, Oct. 8, 2016).

Usuda-Sato, K., Mineshige, S., **Canas, L.**: 2016, Sharing Japanese Resources of "Universal Design" for Astronomy, Astronomy beyond the Common Senses, (Cartagena de Indias, Colombia, Oct. 8, 2016).

Usuda-Sato, K., **Shibata, Y.**, **Canas, L.**: 2016, Exploring the Universe Using Mitaka Software, Communicating Astronomy with the Public 2016, (Medellin, Colombia, May 16–20, 2016).

Usuda-Sato, K.: 2016, Participation by non-English Speakers in the Worldwide NameExoWorlds Contest, Communicating Astronomy with the Public 2016, (Medellin, Colombia, May 16–20, 2016).

Usuda-Sato, K.: 2017, Inclusivity at NAOJ Miaka Visitors' Area, Symposium: Is the Collaboration between the Natural Science and the Human Sciences Possible?, (Osaka, Japan, Mar. 10, 2017).

Uzawa, Y., **Fujii, Y.**, **Kroug, M.**, Makise, K., **Gonzalez, A.**, **Kaneko, K.**, **Kojima, T.**, Miyachi, A., Saito, S., Terai, H., Wang, Z.: 2016, Development of Superconducting THz Receivers for Radio Astronomy, 41st International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz 2016), (Copenhagen, Denmark, Sep. 25–30, 2016).

Uzawa, Y., **Kroug, M.**, **Kojima, T.**, Makise, K., **Gonzalez, A.**, Saito, S., **Fujii, Y.**, **Kaneko, K.**, Terai, H., Wang, Z.: 2016, Development of Terahertz SIS Mixers Using Nb/AlN/Nb Tunnel Junctions Integrated with All NbTiN Tuning Circuits, 27th Int. Symp. on Space Terahertz Technology, (Nanjing, China, Apr. 12–15, 2016).

Uzawa, Y., **Kroug, M.**, **Kojima, T.**, Makise, K., **Gonzalez, A.**, Saito, S., **Fujii, Y.**, **Kaneko, K.**, Terai, H., Wang, Z.: 2016, Development of Terahertz SIS Mixers Using Nb/AlN/NbTunnel junctions Integrated with All NbTiNTuning Circuit, Applied Superconductivity Conference 2016, (Denver, CO, USA, Sept. 4–6, 2016).

Uzawa, Y., Makise, K., Saito, S., Terai, H., Wang, Z., **Kojima, T.**, **Kroug, M.**, **Fujii, Y.**, **Gonzalez, A.**, **Kaneko, K.**: 2016, Development of Highly Sensitive Superconducting Receivers for ALMA Band

10 and Future Prospects, 2016 URSI Asia-Pacific Radio Science Conference, (Seoul, South Korea, Aug. 21–25, 2016).

Uzawa, Y., **Shan, W.**, **Kojima, T.**, **Gonzalez, A.**, **Kroug, M.**: 2017, Theoretical Consideration of SIS Up-converters for Frequency Division Multiplexing, 28th Int. Symp. on Space Terahertz Technology, (Cologne, Germany, Mar. 13–15, 2017)

Wakita, S., **Nozawa, T.**, Hasegawa, Y.: 2017, Diffusion Process in Thermally Evolving Planetesimals for Presolar Silicate Grains, 48th Lunar and Planetary Science Conference , (the Woodlands TX, USA, Mar. 20–24, 2017).

Wenlei, S., **Gonzalez, A.**, **Kroug, M.**, **Kojima, T.**, **Fujii, Y.**, **Asayama, S.**, **Noguchi, T.**: 2016, Concept Design of a Dual-Polarization Sideband-Separating Multi-Pixel SIS Receiver, 27th Int. Symp. on Space Terahertz Technology, (Nanjing, China, Apr. 12–15, 2016).

Wong, K. C.: 2016, Cosmology from Gravitational Lens Time Delays, 10th East-Asia Meeting on Astronomy (EAMA), (Seoul, Korea, Sep. 26–30, 2016).

Wong, K. C.: 2016, A Spectroscopically Confirmed Double Source Plane Lens System in the Hyper Suprime-Cam Subaru Strategic Program, Panoramas of the Evolving Cosmos, The 6th Subaru Int. Conf., (Hiroshima, Japan, Nov. 28–Dec. 2, 2016).

Wu, Y. W.: 2016, Maser Survey towards Sgr Stellar Stream, East Asia VLBI Workshop 2016, (Guiyang, Guizhou, China, Nov. 7–11, 2016).

Yagoubov, P., **Gonzalez, A.**, Tapia, V., Reyes, N., Mena, F. P., Nesti, R., Cuttaia, F., Ricciardi, S., Villa, F.: 2016, 67–116 GHz Optics Development for ALMA band 2–3 Receivers, 41st International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz 2016), (Copenhagen, Denmark, Sep. 25–30, 2016).

Yaji, K.: 2016, EPO Coordinated Observations for High School Students - Let's observe the sun with Hinode!, 10th Hinode Science Meeting, (Nagoya, Japan, Sep. 5–8, 2016).

Yaji, K.: 2016, How do you communicate the sun?, Communicating Astronomy with the Public 2016, (Medellin, Colombia, May 16–20, 2016).

Yaji, K.: 2016, Let's Cook Solar Data/Images for Your Classroom!, Global Hands on Universe 2016, (Stord, Norway, Aug. 22–27, 2016).

Yamada, R., Ishihara, Y., Kobayashi, N., Murakami, H. Tanaka, S.: 2016, Scientific Results Expected from the APPROACH Mission, ISLPS2016, (Wuhan, China, Jun. 9–10, 2016).

Yamada, R., Ishihara, Y., Kobayashi, N., Murakami, H., Tanaka, S., Takeuchi, N., Shiraishi, H., Hayakawa, M., Goto, K., Kikuchi, F., Nishida, K.: 2016, Expected Results on the Lunar Science from Scientific Observations in Approach Mission, Japan Geoscience Union Meeting 2016, (Chiba, Japan, May 22–26, 2016).

Yamada, R., Senshu, H., **Namiki, N.**, Mizuno, T., Abe, S., Yoshida, F., **Asari, K.**, **Noda, H.**, Hirata, N., Oshigami, S., **Araki, H.**, Ishihara, Y., **Matsumoto, K.**: 2016, The Instrument Error on Estimation of Normal Albedo of Ryugu Using the Laser Altimeter On-board Hayabusa2 and the Reflectance Measurement of the Carbonaceous Chondrite at zero Phase Angle, Japan Geoscience Union Meeting 2016, (Chiba, Japan, May 22–26, 2016).

Yamada, R., Shiraishi, H., **Asari, K.**, Nébut, T., Lognonné, P., **Hanada, H.**, Tanaka, S.: 2016, Development of the New Broadband Seismometers for Moonquake Observation, AOGS 2016, (Beijing, China, Jul. 31–Aug. 5, 2016).

Yamada., R. Senshu, H., **Namiki, N.**, Mizuno, T., **Noda, H.**, **Asari, K.**, **Araki, H.**, Yoshida, F., Abe, S., **Oshigami, S.**, Hirata, N., Ishihara, Y., Matsumoto, K.: 2017, Albedo observation of near Earth C-type asteroid by Hayabusa2 LIDAR, AGU Fall Meeting 2016, (San Francisco, CA, USA, Dec. 12–16, 2016).

Yamamoto, Y., **Yamada, R.**: 2016, Current Status of Data Restoration of the Seismometer Onboard Viking Lander 2, Japan Geoscience Union Meeting 2016, (Chiba, Japan, May 22–26, 2016).

Yamaoka, H., **Agata, H.**: 2016, NAOJ Public Relations Center, TMT WEPOC meeting, (Shinagawa, Japan, May 27–28, 2016).

Yamaoka, H.: 2016, Scientist Talk: National Astronomical Observatory of Japan (NAOJ) ~From East to Worldwide~, New Scientist Live 2016, (London, UK. Sep. 22–25, 2016).

Yamazaki, D. G., Kusakabe, M., **Kajino, T.**, Mathews, G. J., Cheoun, M.-K.: 2016, The New BBN Model with the Photon Cooling, X Particle, and the Primordial Magnetic Field, 14th Int. Symp. on Nuclei in the Cosmos (NIC2016), (Niigata, Japan, Jun. 19–24, 2016).

Yano, T.: 2016 , Number of Stars Observable with Small-JASMINE and Calibration with Gaia Data, Gaia-JASMINE joint meeting, (Mitaka, Japan, Dec. 6–9, 2016).

Yoshida, M., **Hara, H.**, **Katsukawa, Y.**, **Suematsu, Y.**: 2016, Structures of Turbulent Plasma Motions in the Cusp Region of the 2015 Mar 7 Flare, 10th Hinode Science Meeting, (Nagoya, Japan, Sep. 5–8, 2016).

Zeidler, S., **Akutsu, T.**: 2016, Wide-Angle Baffles and Length-Sensing OpLevs for bKAGRA, KAGRA F2F Meeting, (Toyama, Japan, Aug. 25–27, 2016).

Zeidler, S., **Akutsu, T.**: 2017, Scattering of the ITM and ETM mirrors and Constraints for the Wide-Angle Baffles in bKAGRA, KAGRA F2F Meeting, (Niigata, Japan, Mar. 28–30, 2017).

Zenitani, S.: 2016, The Structure of the Diffusion Region in Collisionless Magnetic Reconnection: Theory, Simulation, and Observation, Dynamical Processes in Space Plasmas (Isradynamics 2016), (Dead sea, Israel, Apr. 3-10, 2016).

Zenitani, S.: 2016, Dissipation in relativistic Pair-plasma Reconnection: Revisited, Workshop on Relativistic Plasma Astrophysics, (Purdue University, IN, USA, May 9–11, 2016).

Zenitani, S.: 2016, Particle Dynamics in the Electron Current Layer in Collisionless Magnetic Reconnection, Japan Geoscience Union Meeting 2016, (Chiba, Japan, May 22–26, 2016).

Zenitani, S.: 2016, Nongyrotropic Electron Orbits in Collisionless Magnetic Reconnection, AGU Fall Meeting 2016, (San Francisco, CA, USA, Dec. 12–16, 2016).

Zenitani, S.: 2017, Electron Particle Dynamics in Collisionless Magnetic Reconnection, US Japan Workshop and School on Magnetic Reconnection (MR2017), (Matsuyama, Ehime, Japan, Mar. 19–23, 2017).

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