II Status Reports of Research Activities

1. Subaru Telescope

1. Subaru Telescope Staff

As of the end of FY 2014, the Subaru Telescope Project staff consisted of 19 dedicated faculty members including six stationed at Mitaka, six engineers, and three administrative staff members. Additional staff members include five research experts, one postdoctoral fellow, and seven administration associates, all of whom are stationed at Mitaka. Moreover, 11 research/teaching staff members, 10 of whom are stationed at Mitaka, and two engineers at Mitaka are posted concurrently. The project also has 83 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 for Grant-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 the FY 2014, Subaru Telescope produced many outstanding scientific outcomes which were published in major international journals. Below are some examples:

(1) Deep high-z imaging observation with Suprime-Cam, the optical wide-field camera, discovered seven Ly-alpha emitters at $z \sim 7$. The very low number density of such high-z galaxies (only 1/5 of that at $z < 6.6$) strongly suggests that the neutral gas fraction (HI) in the Universe increases rather abruptly from $z = 6.6$ towards $z \sim 7$, which thus prevents Ly-alpha photons from escaping and reaching us. This result has a strong impact on the study of re-ionization in the early Universe.

(2) High resolution optical spectroscopy with HDS of a very metal poor star in the Milky Way Galaxy revealed an abnormal abundance pattern of chemical elements, characterized by low abundances of Carbon, Magnesium and Cobalt. This pattern can only be reproduced by a model of the supernova explosion of a super massive star (1000 times more massive than the Sun). Such a high mass for the first generation of stars had been theoretically favored and proposed, but this was the first observational evidence to support this scenario.

(3) High resolution optical spectroscopy with HDS of a nova, which was discovered in Aug 2013, revealed that a large amount of Lithium has been synthesized in this nova. Lithium is thought to be synthesized in many ways and at various places such as the Big-Bang, the inter-stellar medium, or in stars like novae and supernovae. Thus Lithium provides us key information about the origin and evolution of matter in the Universe. This was the first direct detection of a site where Lithium was synthesized and ejected. This confirmed that nova explosions are indeed the major supplier of the Lithium seen in the present-day Universe.

(4) High spatial resolution imaging of one of Jupiter's Galilean satellites with NIR camera IRCS assisted by adaptive optics unveiled the fact that the satellite is illuminated, though only at low level (1/100 of the normal brightness), even when it's eclipsed by Jupiter. This indicates that sun light refracted by the matter in the atmosphere above Jupiter's surface illuminates the Galilean satellite in Jupiter's shadow.

3. Open Use

The Subaru call for open use proposals is issued every six months. The periods are from February 1 to July 31 (S14A) and from August 1 to January 31 (S14B). The Mitaka office of the Subaru Telescope at the National Astronomical Observatory of Japan (NAOJ) campus accepts the submitted proposals. The Subaru Time Allocation Committee, established under the NAOJ advisory committee for optical and infrared astronomy, selects the proposals to accept, based on the evaluations and comments of the referees. In S14A, 70 programs (104 nights) were accepted out of 163 submitted proposals, requesting 403.6 nights in total. In S14B, 58 proposals (103 nights) were accepted out of 133 submitted proposals, requesting 366.7 nights in total. In S14A and S14B respectively, there were 11 and 3 accepted open use proposals by foreign principal investigators, excluding University of Hawai`i observing time. The number of applicants involved in the submitted proposals was 1806 for Japanese researchers (Japanese astronomers at any institute and non-Japanese astronomers belonging to Japanese institutes) and 642 for foreign researchers. The number of researchers in accepted proposals was 891 for Japanese astronomers and 260 for foreign astronomers.

In S14A and S14B, the number of open use visiting observers was 422, of which 60 were foreign astronomers. 34 astronomers observed remotely from Mitaka. The Mitaka office of the Subaru Telescope takes care of proposal handling and evaluation, travel procedures and travel support for the observers. The Hawai`i office makes the observing schedule and supports the accommodations and transportation for visiting observers in Hawai`i. In S14A and S14B, 94.8 % of the open use time (including University of Hawai`i time) was used for actual astronomical observations, after excluding the weather factor and downtime due to primary mirror coating. About 3.4 %, 0.2 %,

and 1.6 % of observing time was lost due to instrument trouble, communication trouble, and telescope trouble, respectively.

In S14A and S14B, remote observations from Hilo were not conducted. However, remote observations from Mitaka, where observers in Mitaka could participate in observations remotely, in addition to on-site observers at the summit, were conducted with limited function as a trial, for 8 programs with 30 nights.

Service observations were made for 7 nights. To make the best use of the limited resources at observatories on top of Maunakea, Subaru Telescope has been exchanging telescope time with Keck and Gemini. The number of time exchange nights between Subaru Telescope and W. M. Keck Observatory was 5 in S14A and 3 in S14B. That between Subaru Telescope and Gemini was 6 in S14A and 5 in S14B.

4. Telescope Maintenance and Performance Improvement

The general performance of the Subaru Telescope continues to be maintained the same as in the previous year. This year, both the optical tertiary mirror and infra-red tertiary mirrors were recoated. During the recoating work, the mechanical drive of the tertiary mirrors was re-adjusted to improve reliability. Day crews took over the installation and removal work of both Hyper Suprime-Cam (HSC) and its filter exchange unit (FEU). As troubleshooting, the mirror cover open/close sensors, main shutter open/close sensors, and shutters of the Shack-Hartmann sensor were replaced. The rubber springs of the dome bogie have been replaced. Some new functions were added to the Top Unit Exchanger (TUE) for secure operation. The dome barcode system has also been upgraded. We also strived to conduct preventive maintenance.

In addition, while promoting improvements in the performance and operational efficiency of the Subaru Telescope, renovation proceeded for the telescope control units which have been in place for more than 10 years since installation. The following local control units were renovated or modified in this year: cover control unit (CVCU), field rotator control unit for primary focus (FRCU (PF)), atomic dispersion corrector control unit (ADCU), dome rotation servo control processor unit (DRPU), dome control unit (DCU), tertiary mirror control unit (TMCU), balancer control unit (BLCU), telescope control workstations (TWS), and primary mirror actuator CPU cards.

This year, maintenance of the main shutters, dome bogies, and the top screens was also carried out in addition to the annual mechanical maintenance. Of special note this year is the development of a script that checks whether certain telescope conditions should be expected or not. This script is run every morning and can find some minor problems, which indicate a potentially critical situation.

5. Instrument Operation and New Development

The nine open-use facility instruments of Subaru Telescope have been operated stably in FY 2014. 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), Fiber Multi-Object Spectrograph (FMOS), and 188-elements Adaptive Optics and Laser Guide Star system (AO188/LGS).

Since the beginning of open-use observations in FY 2013, the software and hardware of HSC have been continuously improved. As a result, the operation of the filter exchange system, shutter, and auto-guider system have been stabilized significantly. Discussions on how to handover the operation and maintenance of HSC from the development team to the observatory are underway.

There are several upgrade projects for the other facility instruments: a MOS unit for HDS, an upgrade of the MOIRCS detectors, and implementation of polarimetric functions to IRCS and COMICS. For the HDS MOS unit, the supporting structure was transported to Hawai`i and study of its mechanical interface to the telescope has been started. The fabrication of optical components such as fibers is still ongoing in Japan. For the MOIRCS detectors, we have succeeded in operating the arrays and started characterization and parameter optimization. The IRCS polarization function has been tested on sky and, after characterizing the polarimetric performance and examining the calibration strategy, it was decided to open the polarimetry mode starting from S15B.

In parallel to those upgrade projects, discussions on how we maintain or stop operations of the facility instruments are underway. To establish the plan for Subaru Telescopes's instrumentation, we summarized information such as competitiveness, demand, publications, and work load for maintenance/troubleshooting of the facility instruments. Based on the results, an instrument plan was proposed to the community in the User's Meeting. Discussions and planning of Subaru Telescope's instrumentation including decommission of facility instruments are still ongoing.

In FY 2014, two carry-in (PI-type) instruments HiCIAO (high-contrast coronagraph imager) and Kyoto-3DII (optical integral field spectrograph) have continued to be operated. The commissioning of a coronagraphic extreme adaptive optics (SCExAO) instrument has been performed. The tests of some operation modes of SCExAO including low-order wavefront correction, quasi-static speckle nulling, and the aperture masking interferometer (VAMPIRE) which enables high-spatial resolution imaging in visible bands, have been completed in FY 2014. These operation modes have been used in open use observations since the S14B semester and are taking an important role in the direct imaging observation of extra-solar planets. SCExAO has been commissioning a high-order wavefront correction mode, which realizes extreme adaptive optics correction. There are plans to open this mode to open use observes on a trial basis starting from S15A.

A Multi-Object Adaptive Optics (MOAO) science demonstrator (RAVEN), which has been developed in collaboration with Canadian institutes, successfully saw first

light at the Subaru Telescope in May 2014 and demonstrated the performance of the MOAO system. As a science demonstrator for a future TMT MOAO system, RAVEN will conduct additional test observations for evaluating its performance and perform science observation in S15A.

There are new PI-type instruments, IRD (InfraRed Doppler instrument) and CHARIS (Coronagraphic High Angular Resolution Imaging Spectrograph), which are currently being developed. The IRD project has been reviewed by the observatory since FY 2013 and officially approved in FY 2014. These two instruments are planned to be transported to the Subaru Telescope in FY 2015 and to conduct commissioning observations in FY 2016.

Other than these approved new instruments, there are new PI-type instrument carry-in proposals from the University of Tokyo: SWIMS (Simultaneous-color Wide-field Infrared Multi-object Spectrograph) and MIMIZUKU (mid-infrared multi-field imager and spectrograph). We are reviewing the acceptance of SWIMS and MIMIZUKU by considering the impacts to the existing observatory resources.

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). The PFS has about 2400 optical fibers distributed over the 1.3 degree field of view of the prime focus which feed the light of the astronomical objects to four identical spectrographs which will be placed in the telescope dome. The spectrograph modules cover wavelengths ranging from 0.38 μm to 1.26 μm simultaneously. Since the PFS is being developed through international collaborations between several countries with a large budget scale, the project has been reviewed by the NAOJ headquarter in terms of the management of the project before approving the PFS as an official project of the Subaru Telescope. In FY 2014, the Subaru Telescope officially approved the PFS project by considering the astronomical importance of the project and the future instrument plan of the Subaru Telescope.

We are conducting a conceptual study of 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 era of TMT. We have studied the concept of a wide-field near-infrared imager and multi-object spectrograph assisted by ground-layer adaptive optics (GLAO), which uniformly improves image quality over a wide field of view by correcting only for the turbulence at the ground layer of the Earth's atmosphere by using an adaptive secondary mirror. In FY 2014, the design of the wide-field near-infrared multi-object spectrograph has been discussed in collaboration with an Australian institute. We are planning to have a conceptual design review which summarizes the studies of GLAO and near-infrared instruments discussed so far.

6. Computers and Network

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

Archiving observation data on the current system has been ongoing since the pervious year. The archive is operational without serious problems. We have been developing a user interface that is suitable to download large amounts of data in a batch process per requests by users who wish to download data taken by Hyper Suprime-Cam (HSC) with the Strategic Science Program (SSP).

The data archive system in Mitaka is also operating stably.

We officially rolled out remote observations from Mitaka using the Remote Observation Monitor System for a limited amount of time. In this fiscal year, 25 observation programs utilized the remote observation monitor system for 28 nights. More programs will use the remote system in the future. The proposal Management System (ProMS) also worked very well.

Computers for HSC data analysis were procured in Fiscal Years 2010 and 2011. This year, storage, an interactive processing server, and a database server were added to the system. The current system requires the storage to send and receive large amounts of data to/from the clients. But the current storage is not fast enough to handle that amount of data and makes overall performance subpar. Therefore, we decided to test a fast data I/O software replacing NFS. The test system including hardware and filesystem software was delivered by the end of this fiscal year. Setting up the test system is planned for early in the coming fiscal year.

The dedicated network link between Hawai`i and Mitaka has been procured with a single year contract since April 2014. Bidding was conducted to select the provider to supply the network link in this fiscal year. The link speed will become 2 Gbps, double the past speed, considering the increase in traffic due to HSC observations. A provider was selected successfully and we prepared our own network system so that it can connect to the network service that the provider will start from April 2015.

We have rolled out the online visitor form replacing paper/fax starting from the S14B semester. We are also developing another visitor form for Remote Observation Monitor users at Mitaka.

7. Education (Under-Graduate and Graduate Courses)

The number of Subaru staff members in Hilo who were concurrently appointed by SOKENDAI (graduate school) was ten. The number of SOKENDAI students who had primary supervisors affiliated with Subaru Telescope (including those concurrently belonging to Subaru Telescope) was 18 which constituted more than a half of the entire 32 SOKENDAI students hosted in NAOJ. Of which nine had supervisors who primarily belonged to Subaru Telescope.

In FY 2014, Subaru Telescope hosted four graduate students for long stays, of which two were SOKENDAI students. 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 throughout Japan who obtained master's degrees and PhD's based on Subaru Telescope data were 11 and 4, respectively. Of which 3 and 1 belonged to the division of Optical and IR Astronomy, respectively.

We also regularly hosted a series of educational programs at Subaru Telescope. In September 2014, we hosted a Subaru autumn school in which 6 graduate and 6 under-graduate students from all over Japan participated and learned the reduction and analysis of Subaru Telescope data and heard a series of lectures. In November, under the recommendation of the Subaru advisory committee, we co-hosted the 1st China-Subaru workshop in Shanghai in which many students and postdocs participated. Moreover, in October, we hosted two Subaru Telescope observation training courses, one for undergraduate students from all over Japan, and the other for new SOKENDAI students at NAOJ. In the Subaru Telescope Hilo office, we had regular Subaru seminars in English 2–3 times a month, where open-use observers, visitors, and Subaru Telescope staff members presented their newest research. Also in the Subaru Telescope Mitaka office, we had numerous 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 of 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 2014, there were 21 web-postings (10 in Japanese, 11 in English) about the discoveries from the Subaru Telescope. Articles about the instrument development, the work and the activities at the Subaru Telescope and other announcement totaled 45 (24 in Japanese, 21 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 the 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 30 (28 in Japanese, 4 in English), 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. Except for December when the tour program was suspended to allow safe work for the tertiary mirrors' recoating, a total of 559 people visited through this program. There are 111 additional groups who visited through special tour programs and resulted in the total head count of 1,252 people who visited the summit facility. The tours are all escorted by the assigned staff, in either Japanese or English language.

Facility tours of the base building 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 41 groups, with 451 people, visited the base facility this year.

Task3: Public outreach which includes lectures in the local community, special presentation in the schools, and remote presentation for Japanese schools or museums. PIO provided/coordinated 56 lectures at the base facility or in its vicinity such as at the 'Imiloa Astronomy Center. There were 12 lectures outside of the island, and 14 remote lectures for off-site locations. The local lectures included 26 classroom presentations during the Journey Through The Universe program, and reached out to 736 students in the local schools.

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. 600 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 4 hands-on workshops and an exhibit booth.

2. Okayama Astrophysical Observatory

The Okayama Astrophysical Observatory, (hereafter the Observatory) serves as the observing and research base of 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.

About 230 nights at the 188-cm telescope are exploited for observations by researchers from across the country through open use every year. The Observatory maintains and operates the observing instruments and provides the observers with support for observations, travel expenses, accommodations, every day needs, etc. It also engages in improving the open-use observing instruments, developing new open-use instruments, and supporting brought-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 and the Tokyo Institute of Technology's Gamma-Ray Burst Optical Afterglow Follow-up Project. Meanwhile, the 188-cm telescope, the 50-cm telescope, and the 91-cm telescope of the Observatory are involved in "The Optical & Near-Infrared Astronomy Inter-University Cooperation Program" supported by MEXT, which commenced in 2011.

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) and use it in a comprehensive survey of infrared-variable objects in the Galactic plane. Another project is the upgrade of the functionalities of the 188-cm telescope in order to improve significantly its planet searching capability through a Grant-in-Aid for Scientific Research (Basic Research (A), FY 2011–2015). Collaborations with foreign researchers are also continued positively.

The personnel breakdown as of March 2015 was six full-time staff members, including two associate professors, one assistant professor, one chief research engineer, one engineer, and one chief clerk; twelve contracted staff members, including three research experts, one postdoctoral fellow, three research supporters, three administrative supporters, and two administrative maintenance staffs; and one temporary staff member.

1. Open Use

(1) Overview

The numbers of nights allotted to the open use in 2014 were 122.5 nights for the first semester (2014A, January to June) and 110.5 nights for the second semester (2014B, July to December). Observing proposals were called for publicly each semester. The Okayama program subcommittee reviewed the submitted proposals and accepted 1 project observation program, 1 academic degree support program, and 12 general observation proposals in 2014A, and did 1, 1, and 12 in 2014B. A proposal from Turkey, one from the Republic of Korea, and one from Hawai`i were accepted in 2014B and the Observatory supported their observations with human resources. The anonymous application system was abolished after 2014A as planned and reverted to the previous system starting from 2014B. Open-use observation generally proceeded without incident.

(2) Observation/Research Results

The majority of objects observed through the open use in 2014 were stellar sources including pre-main sequence stars. Others included Solar System objects, AGNs, and quasi-stellar objects. The following primary observation themes were noted: searching for exoplanets via precise radial velocity measurement; exploration of the physical properties and activities of binary stars via high-dispersion spectroscopy; and the observation of exoplanet transits by precise near-infrared differential photometry, which increased precipitously in recent years. Optical low-dispersion spectroscopic observations of stars for classification and of sudden phenomena for follow-ups remained significant since last year. 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's drive and controller were renewed and the connections between the telescope and the observing instruments were established by the end of FY 2013. A report was published on the details of the refurbishment in FY 2014 (Kuroda et al. 2015, Report of the National Astronomical Observatory of Japan, Vol.17, 19–39). The telescope control software was elaborately improved to enhance its user-friendliness and safety while observing as well as its maintainability.

During the maintenance period in June, the annual re-aluminization of the primary mirror of the 188-cm telescope and the subsequent optical axis alignment of the smaller mirrors against the primary were completed. The 1.5-m primary mirror of the KANATA telescope at Hiroshima University and the primary mirror of the ISAS 1.3-m telescope were also accepted for re-aluminization in the period this year. Participants in the aluminization work from these organizations were given NAOJ-mandated safety and hygiene training as necessary. Lubrication of the telescope and dome was conducted in July. Utmost efforts were made to maintain high observing efficiency by conducting monthly cleaning of the primary, secondary, and tertiary mirrors of the 188-cm telescope after October. Also intensive maintenance was applied to the hydraulic system of the aluminization vacuum chamber, to prevent oil leakage which had been an issue to be solved for years, including refurbishment of the oil cylinders and renewal of the oil pipes from September

to March.

The dome was checked daily. Other maintenance work was also performed, including repairing the worn-down guiding rails for the upper and lower slit doors in August, repairing the external panels of the dome hemisphere to prevent rain leakage in June and August, repainting the dome periphery in July, replacing deteriorated metal mesh at the bottom of the dome wind channel in August and November, installing an internal roof east of the north pier of the telescope inside the dome to prevent rain leakage from falling onto the observing instruments in September, repairing the painting of the cat walk floor in March, renewing deteriorated power lines and contactors (at any time), and replacing old lighting equipment on the first floor with LED lights in August. Asphalt pavement around the telescope dome was renewed as well.

Much attention was paid to the operation and maintenance of the facility and equipment. It is to be noted that sound-proofing work was done for the second time to a visitor's room on the second floor of the main building, resulting in four proofed rooms. Work safety was given priority in accomplishing the aforementioned maintenance work and observing instrument exchanges. As a result, no accidents or incidents whatsoever occurred during FY 2014.

(4) Conferences

The program subcommittee for the 188-cm telescope met on May 16 and November 14 to evaluate proposals for open use in 2014B and 2015A (first semester of 2015), respectively, and formulated an observation program for each semester. The Okayama Users Meeting, also known as the 25th Optical and Infrared Users Meeting, was held at Mitaka Campus of NAOJ on August 11 and 12.

Various reports were made: current status of the Observatory, execution summary of the program subcommittee, preparation status of remote observing facilities of the 188-cm telescope, two user-led plans to develop new observational instruments for the 188-cm telescope, etc. Reports by others included research results from open-use projects. Also discussed were the operations of other optical and infrared observational facilities such as the Higashi–Hiroshima Observatory and the networking of small- and mid-sized telescopes. On the second day of the meeting, a report was given on the progress of Kyoto University's Okayama 3.8-m New Technology Optical and Infrared Telescope project and proposals were presented for the initial research themes, observing instrument plan, and operation systems before and after completion. The proposals were followed by a stimulating debate.

In addition, the seventeenth liaison conference on cooperation for astronomical observations at Okayama Astrophysical Observatory of the National Astronomical Observatory of Japan led by the Okayama prefectural office was held in Okayama-city in October 2014, aiming at preserving the environment for astronomical observations. In the meeting, continuation of the cooperative framework was confirmed among the participants.

2. Developing 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. Major work pursued in FY 2014 included replacing the controller computer; improving the autoguider to cope with dimmer stars through stray light mitigation and software version-ups; and preparing for the adoption of KOOLS-IFU (see "(3) KOOLS" below) into the Cassegrain unit of the HIDES fiber link (see below). Accepted proposals to HIDES as a whole were 6 and 6 in 2014A and 2014B, including 1 and 1 project observations, respectively.

The observing capability of HIDES is currently being improved by introducing fiber links. The high-efficiency fiber link with approximately 50-K wavelength resolution now 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 link test observations were conducted in 2010, and it has been provided for open use since 2011. Two academic journal papers were published from the use of the fiber link in FY 2014. Seven open-use programs including those from three new PIs and one ToO observation were performed with it in 2014. It's usage increased steadily. Besides, a high resolution fiber link with a spectral resolution of nearly 100,000 was also developed. It was evaluated by providing it for trial use with the project observation program since 2015A. It will be provided for open use in CY 2016.

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

The instrument ISLE is a near-infrared imager and low- or mid-dispersion spectrograph, and has been available for the project observations and the academic degree support programs since the second semester of 2011 (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). Having achieved a high precision for relative photometry of one milli-magnitude level, ISLE is in greater demand for observations of exoplanet transits. The numbers of open-use programs using ISLE conducted in semesters 2014A and 2014B were 5 and 3, respectively, which included 1 and 1 academic degree support programs, respectively. Four of them were spectroscopy and the other four were imaging photometry of exoplanet transits.

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

This instrument was made available for open use as a PI-type instrument in FY 2008 and has since been in stable operation. The CCD output linearity is good enough. Non-sidereal motion objects can be tracked for long integration times. The open-use applications for KOOLS have increased due to a recent rise in demand for spectral classification and monitoring observations. There are 4 and 6 accepted proposals for 2014A and 2014B, respectively. An integral field unit (IFU) using a fiber-bundle was developed by a team at Kyoto University, as one of the

candidate first generation instruments for Kyoto University's Okayama 3.8 m New Technology Optical and Infrared Telescope project. Its input part was installed into the Cassegrain unit of the HIDES fiber link and its output part into KOOLS under the support from the Observatory. Its commissioning was performed on two nights provided from the Observatory time. IFU will be delivered as a PI-type open-use instrument starting from semester 2015B. However, KOOLS itself has begun to have various small troubles and is in need of intensive maintenance for long-term usage.

(4) Others

A remote observing environment was prepared to enable observers to perform their open-use observations with the 188-cm telescope from remote sites over the internet in FY 2014. After testing it many times inside the Observatory, it was confirmed that smooth observations are feasible from outside the Observatory with the help of some open-use observers at remote sites. It will be further polished preparing to open the environment for open-use.

Meanwhile, a carry-in instrument newly developed for the 188-cm telescope, "MuSCAT," was accepted for performance verification (MuSCAT is an acronym for Multicolor Simultaneous Camera for studying Atmospheres of Transiting exoplanets). The Observatory allowed four observing nights from the Observatory time for the commissioning.

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 Nagoya University and Nano Optonics Energy Inc., regarding the 3.8-m telescope project as part of the future plan for the Observatory. Discussions were held on technological issues regarding the telescope and dome through weekly TV conferences and in-person meetings held every three months. The main telescope was constructed and tuned in a temporary hanger placed in the Observatory in FY 2014.

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

The Program has entered its fourth 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 provided a total of 35 nights worth of observational data on seven objects this year. Four of the objects were gamma-ray bursts, which are the main target of the Program. Afterglows were detected at multiple sites in the network for three of them. Another source was observed simultaneously by the Program and the inter-university VLBI cooperation program as a first trial. Two peer-reviewed papers were published utilizing OISTER. Another 61 peer-reviewed papers that have something to do with the Program were published, in 9 of which OISTER played a vital role. A joint special session "Inter-university cooperation across radio, optical, and infrared" between the Program and the inter-university VLBI cooperation program was held at the annual autumn meeting of the Astronomical Society of Japan in 2014. The fifth workshop of the Program was held, this time open for the first time to general researchers who did not belong to the network. Priority was given to publicizing the research results from the Program on the web page of OISTER this FY.

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

Optical follow-up observations of GRBs are in progress in cooperation with the Tokyo Institute of Technology's Kawai Laboratory. During FY 2014, the automatic observation scheduler performed observations on nearly every possible night; 27 GRBs were observed, with optical afterglows successfully detected in three. Observation results were published as 16 GRB Coordinates Network (GCN) circulars. Besides, six peer-reviewed papers were produced from monitoring of Mira variables and comets and observations of supernovae, AGNs, and exoplanet transits that were conducted when the telescope was free.

(4) Other

The Observatory welcomed five third-year undergraduate students and the supervisor from the University of Tokyo between August 14 and 15 and provided them with an opportunity to conduct high-dispersion spectroscopic observation using the 188-cm telescope during the early half of the night on August 14. A summary of this activity over the past several years was presented by the supervisor on a poster at the users' meeting held on August 11 and 12.

4. Unique Research Projects

(1) Detection of the Afterglow of Distant GRBs and Survey of Variable Stars in the Galactic Plane Using the Ultra-Wide-Field Infrared Camera

A project is underway to identify infrared counterparts for objects such as distant GRBs and gravitational wave sources and to comprehensively survey infrared variable stars in the Galactic plane by converting the 91-cm telescope into an infrared camera with an ultra-wide field of view of 1 square degree. Almost uniform imaging quality was achieved across a square field of view of 0.48 degree by 0.48 degree (for 1-k detector) after a fine adjustment of the telescope optics in FY2014. An automatic focusing mechanism was installed and semi-automatic observations became available. A pilot monitoring program was initiated in the Ks-band toward a selected area in the Galactic Plane to assess the feasibility of variable star surveys.

(2) Automation of Exoplanetary System Searches

Through a Grant-in-Aid for Scientific Research (Basic

Research (A), "Automation of exoplanetary system searches," representative: Hideyuki Izumiura, FY 2011–2015), a project is underway to improve the functionality of the 188-cm telescope and its dome, to enhance the precision and stability of the telescope, to facilitate automation of observation, and to further expand the search for exoplanetary systems. A function was developed to automatically correct for the drift of the best focus position by inferring the drift based on the temperature distribution across the telescope tube through thermos-sensors attached to the telescope truss tube in FY 2014 (see Kamiya et al. 2014, V220a at the Annual assembly of the autumn ASJ meeting 2014). Another new functionality was investigated to further improve the telescope pointing by measuring the small movement of the primary mirror in the cell and correcting the pointing error due to the movement, which would help advance the automation of the telescope operation and observation.

(3) East Asian Planet Search Network

The Observatory also conducts studies focusing on the search for exoplanetary systems, involving researchers from The Republic of Korea, the People's Republic of China, the Republic of Turkey, and Russia. The efforts continued in FY 2014 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 1.88-m telescope for continued searches for exoplanetary systems around G-type giant stars. One exoplanet candidate was discovered from the collaboration with Chinese colleagues, and four binary systems consisting of a G-type giant and a low-mass companion were identified through the collaboration with Turkish and Russian colleagues in this fiscal year. Both results were published in peer-reviewed journals.

5. PR/Awareness Promotion Activities

An Observatory representative delivered a lecture to nearly 20 people in Okayama City on Monday, July 7 as part of the Nation-Wide Tanabata Participatory Lectures. Nearly 50 astronomy-related questions from the public were posed irregularly to the Observatory and were answered appropriately this year. The 4D2U screening, co-hosted with the Okayama Astronomical Museum, attracted 3,854 visitors.

Twenty-two Observatory tours were conducted, including those for pupils from local elementary schools in Asakuchi city and Yakage town. The Observatory also responded to six lecture requests made by local boards of education and community centers.

6. Contract Staff Transfers

The following transfers of contract staff members took place in FY 2014: Kouki Kamiya joined as a Research Supporter in October and Hiroyuki Maehara did so as a Research Expert in November. Research Supporter Yasuhiro Shimizu left at the expiration of his term at the end of March. Postdoctoral Fellow Akihiko Fukui left the position at the end of March when his term expired.

3. Nobeyama Radio Observatory

1. 45-m Radio Telescope

(1) Open Use Observations

The 33rd open use observations started on December 15, 2014 as scheduled (observers for the backup program stayed in the observatory starting from December 1, 2014).

The statistics of the proposals are as follows,
"General Proposal 1st period": 16 accepted including 5 from abroad (34 submitted),
"General Proposal 2nd period": 13 accepted including 4 from abroad (21 submitted),
"Short Program": 9 accepted (15 submitted),
"Education Program" (1st and 2nd periods): 0 accepted (0 submitted).
"Backup Program", which is carried out when weather is not acceptable for the main observations: 1 accepted (1 submitted).
In addition, the 45-m telescope joined the VERA open use observations: 3 proposals.

The multi-beam receiver BEARS and the AC45 spectrometer were decommissioned.

(2) Improvements and Developments

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

- The antenna foundation made of concrete was leveled because of its unacceptable amount of tilt. The design was completed for the subreflector servo system replacement to be installed next year.
- End to end holographic measurement tests were done aiming to improve the surface accuracy of the 45-m telescope.
- Test measurements for the improvement of the performance of the beam transmission system were carried out.
- The new multi-beam receiver FOREST was installed and used for the legacy project observations (observatory internal use) after basic performance evaluation and test observations.
- New AD converters were installed in the 4 intermediate frequency lines among the 16 lines and were used in open-use observations. They exhibit smaller frequent-spurious-signals

and show better linearity performance.
- NRO supported user instrument including the Z45 receiver at 45 GHz band, digital spectrometer ROACH, and a 90/150 GHz continuum camera.
- The help desk for open-use observers became operational, and its manual was released.

(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. The star formation project and the Galactic plane survey project obtained scientific data and their results are described below.

(a) Star Formation Legacy Project

In the Star Formation Legacy Project, we conducted large-scale mapping observations toward nearby star-forming regions: the Orion A molecular cloud and W40 HII region in ^{13}CO and C^{18}O. For the Orion A cloud, we combined the 45-m ^{13}CO data with the CARMA interferometer data to obtain a ^{13}CO large-scale map whose angular resolution is about 5 arcsecond. From the combined map, we identified many filaments in the cloud. For the W40 region, we found shell-like dense molecular gas clumps around the HII region. The comparison between the infrared data and the 45-m data suggest that the gas clumps are interacting with the expanding shell created by the HII region.

(b) Galactic Plane Survey Project

We are conducting a simultaneous survey of the ^{12}CO, ^{13}CO, and C^{18}O J = 1–0 emission lines in the Galactic Plane using the new multi-beam receiver FOREST installed on the 45-m telescope. We plan to make maps of the inner Galaxy (10d < l < 50d, b = ±1d) and the outer Galaxy (198d < l < 236d, b = ±1d) including the spiral arms and bar structure. In 2014, we covered areas with 24 and 7 square degree for a total of 31 square degree. We have revealed a wide range of molecular clouds and their fine structures, e.g. filaments that have not been seen in previous surveys.

2. SPART

To better understand the influence of the activities of host stars on the middle and lower atmospheres of terrestrial planets, including solar system planets and exoplanets, we have been performing monitoring observations for millimeter-waveband spectral lines of carbon monoxide (^{12}CO J = 1−0: 230.538 GHz, J = 2−1: 115.2712018 GHz, ^{13}CO J = 2−1: 230.3986765 GHz) in the middle atmospheres of Mars and Venus with a 10-m telescope, the Solar Planetary Atmosphere Research Telescope (SPART), since it was launched in 2011. The SPART employs highly sensitive 100- and 200-GHz double-band superconducting SIS heterodyne detectors and a 1-GHz-band digital fast-Fourier transform spectrometer with a frequency resolution of 61 kHz. Heterodyne spectroscopy with high frequency resolution is a powerful tool for observing the weak and narrow spectral lines of minor constituents in the middle atmospheres of planets.

This season we repaired the elevation-motor of the telescope. An example of the results we found from the SPART monitoring is that the disk-averaged mixing ratio of carbon monoxide derived at an altitude of approximately 80 km in Venus has slightly changed since 2012. This phenomenon may be linked to solar activities in the current 24th solar cycle. Middle atmospheres of terrestrial planets like Mars and Venus lacking magnetospheres may be directly affected by energetic events of the host stars.

Over the coming six years solar activities will be lowered toward the solar minimum phase. Therefore, it is important to continue the monitoring research with the SPART for understanding of how atmospheric conditions of terrestrial planets balance physically and chemically under activities of host stars.

3. Development of a Multicolor Millimeter/Submillimeter Camera for the Atacama Submillimeter Telescope Experiment (ASTE)

Extensive large-scale sky surveys in the millimeter/submillimeter bands with a multicolor continuum camera are indispensable for various types of research including estimating the redshift of submillimeter galaxies, using the Sunyaev-Zel'dovich effect to study the internal structure of hot plasma in clusters of galaxies, and constraining the physical properties of the dust in star-forming regions and the spectral index of the initial submillimeter afterglow of gamma ray bursts (GRBs).

Thus, we, in collaboration with the University of Tokyo, Hokkaido University, the University of California Berkeley, and McGill University, are developing a multicolor millimeter/submillimeter camera based on a very sensitive Transition Edge Sensor (TES) bolometer for observations at wavelengths of 1.1 mm, 0.87 mm, and 0.46 mm.

We deployed our bolometer camera on the ASTE Telescope during March and April of 2014. At that time, thanks to the excellent observing conditions, we managed to explore the star-forming regions in our Galaxy, submillimeter galaxies, and GRBs outside our Galaxy. Thus, this year, we've been focused on analyzing the observational data obtained in that run, and improving the performance and efficiency of the observing system based on these results. We've worked out the solution to the problems in the yield of the bolometer array and the readout device, and the time consuming algorithm for tuning the operating parameters of the bolometers. Solving these problems will increase the observing sensitivity and efficiency, respectively. Furthermore, we've worked on an issue inherent to bolometers with TES sensors; namely that they lose sensitivity if the weather improves after they have been tuned. We came up with a solution to overcome this issue by employing a movable blackbody radiation source. This will drastically widen the range of weather conditions for which observations are possible.

In order to increase the number of observing bands in the future, increasing the number of pixels read out is inevitable. Therefore, the multiplexing technologies to double the number of bolometer pixels read out per readout device from 8 to 16 were carefully considered. As a result, we showed that increasing

the multiplexing factor to 12 pixels per a readout device is possible with minor changes to the current readout system. Finally, we've started the development of the add-on fore optics which will open a new window to conduct polarization sensitive observations with our bolometer camera.

4. Misc.

(1) PR Activities at the Nobeyama Campus

The Nobeyama Campus has been accessible to the public since the inauguration of the observatory in 1982. The number of visitors this summer decreased compared with previous years due to bad weather. The campus received a cumulative total of 51,535 visitors throughout the year, including participants of the special open house events in August. This is the smallest number except the opening year 1982. Staff members conducted 30 guided tours, including tours for Science Partnership Programs (SPPs) participants, Super Science High School (SSH) students, and the Campus Tour Week. Additionally, five requests for lectures and 22 requests for on-site filming and interviews were granted. These kinds of requests increased owing to improved relations with Local Communities.

The Campus Tour Week was scheduled during summer and was aimed at educational institutions (elementary, junior high, and high schools). Staff members gave guided tours for this program as well. Six groups took advantage of this opportunity. Most visitors from the participating schools said they thoroughly enjoyed their visits. For the workplace visit initiative conducted between July and October, 18 students from 7 schools, primarily local junior high schools, visited the observatory and had a chance to experience the observatory's routine work under staff guidance. For SPP/SSH initiatives, six schools visited the NRO and participated in lectures, student presentations, and hands-on guidance of future activities. Furthermore, the Radio Astronomical Observations workshop using the 45-m radio telescope was held again this year from June 2 to 6, with 12 undergraduate students in attendance. Because senior students can take part in the workshop in June, the grade composition of the participants is different from the normal year. Although instruction to the students, from observations to presentation of the results, requires significant staffs' effort, the event offers an invaluable opportunity for undergraduates to experience observations using a radio telescope.

In the area for permanent public access, an antenna model is available along with posters and panel displays. A video continuously played in the visitor room shows various facilities, introduces the history of the NRO, and explains research results with the 45-m telescope. For Internet-based PR activities, the NRO runs a website which is expanding to include observational results as well as introductory descriptions of radio astronomy. In particular, these posters, panel displays, and web pages were modified to reflect the close of Nobeyama Solar Radio Observatory at the end of the fiscal year.

(2) Cooperation with Local Communities

The annual Nobeyama Special Open House Day was held with contributions by Nagano Prefecture as well as Minamimaki Village, and the Minamimaki Chamber of Commerce along with its youth division. Jimoto Kansha Day (Thanks Day for the Locals) was held as the Special Open House for locals (Minamimaki and Kawakami villages) with Nobeyama Station of Education and Research, Center of Alpine Field Science, in the Faculty of Agriculture of Shinshu University and Yatsugatake-forest in the Agriculture and Forestry research center of Tsukuba University. Special sponsorship was provided to the Sora-girl event "Tebura de Hoshizora Kansho-kai" ("Drop-by Star Gazing Event") hosted by the Minamimaki Tourism Association. The NRO also joined the Japan Three Major Scenic Location for Star Gazing with the Minamimaki Tourism Association: Night Sky Summit that took place in Ishigaki City, Okinawa Prefecture. Also, two lectures were held 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).

(3) Referbishment Plan for the Nobeyama Millimeter Array Building

The building for the Nobeyama Millimeter Array will be renovated to install an exhibition area focusing on the National Institutes of Natural Science (NINS) as well as the NAOJ, in order to establish a PR center for not only astronomy, but also for all of the natural sciences. The preliminary survey and the design of the building were complete before the construction work scheduled in the next year.

(4) NRO Conference Workshops

- July 15, 2014
  NRO Galactic Plane Survey Mini-Workshop (representative: Tomofumi Umemoto)
- July 23-24, 2014
  32nd NRO Users Meeting (representative: Shuro Takano)
- July 28-31, 2014
  44th Summer School on Astronomy and Astrophysics for Young Researchers 2014 (representative: Akira Oka)

(5) Education

NRO accepted two postgraduate students. The one visiting student from Kagoshima University got a Ph.D. on polarization capability of a new receiver this year. The other visiting student from Toho University got her Master degree on chemical reaction of carbon chain molecules.

(6) Part-time Research Staff Transfers

- Specially Appointed Research
  Tatsuya Takekoshi: Specially Appointed Research, NAOJ Chile Observatory
- Researcher
  Kana Morokuma: Specially Appointed Research, NAOJ Chile Observatory
- Researcher Supporter
  Hiroyuki Nishitani: Engineer, NAOJ Nobeyama Radio Observatory

4. Nobeyama Solar Radio Observatory

1. Closure of the Nobeyama Solar Radio Observatory Project and Future Operation of the Nobeyama Radioheliograph and the Nobeyama Radiopolarimeters

The termination of the operation of the Nobeyama Radioheliograph (NoRH), which has been the main observational instrument of the Nobeyama Solar Radio Observatory (NRSO), was scheduled to occur in FY 2014. Along with this, the closure of NSRO was also scheduled at the end of the FY 2014. On the other hand, some users had thought to continue the operation of the Radioheliograph. They proposed that the Solar Terrestrial Environment Laboratory (STEL) of Nagoya University borrows the instrument from NAOJ and operates it through cooperation with an international consortium (ICCON) formed by some institutes, both foreign and domestic, who are willing to help the operation financially. NAOJ approved this proposal, and an agreement between NAOJ and Nagoya University was made to continue the operation of NoRH for three (six at maximum) years, with technical support by the Nobeyama Radio Obseravtory (NRO).

The continuation of the operation of the Nobeyama Radiopolarimeters (NoRP) was also requested by some users. NAOJ decided to transfer it to NRO from NSRO to continue the operation.

Data from these instruments will be released by the Astronomical Data Center of NAOJ and STEL of Nagoya University from now on, and the environment for the data analysis has been prepared. Researchers in the world can freely access the data as always.

Because it was decided to continue to operate instruments, maintenance work has been done intensively in this fiscal year to operate the instruments steadily after next fiscal year. It was decided to move the personnel of NSRO who are working at the Nobeyama campus to NRO, where they will deal with the remaining work for the solar radio instruments as a part of their duties. Various duties of NSRO were mainly taken over by NRO, and the NSRO project was dissolved at the end of FY 2014 as scheduled.

2. Radioheliograph- and Radio Polarimeter-Based Solar Observations

At the beginning of FY 2014, operation of NoRH and NoRP were assumed to be terminated in the middle of the fiscal year to wind up the NSRO project. However, because it was decided to continue the operation of both of the instruments from FY 2015 on, the termination of the operation was cancelled and the solar observations until the end of the fiscal year were continued almost stably, though there was some instrument trouble.

3. Open Use, Joint Research, and Consortium Activities

All observational data are made available to the public, and researchers working in relevant fields in Japan and abroad have utilized this information for their studies on solar phenomena, space weather, and space climate. The data are also leveraged for the purposes of education and PR. A consortium of university users, represented by Satoshi Masuda, promotes open use in Japan (http://solar.nro.nao.ac.jp/HeliCon_wiki/). A data analysis workshop (CDAW14: September 29–October 3, 2014) held to actively promote open use in Japan had 18 participants. Lectures and exercises were offered; four groups practiced data analysis, and attendees subsequently reported the experience at various research conferences and to the astronomical society. The Japan Solar Physics Community held a symposium entitled “Solar Activity at the 24th Solar Maximum and Future Prospect for Solar Physics” at Nagoya University from February 16 to 18, and the Observatory presented its undertakings as well as studies conducted during CDAW14.

Drs. H. Ezawa and H. Matsuo of NAOJ carried out an experiment to use NoRH as an intensity interferometer, and they confirmed that NoRH element antennas can work as an intensity interferometer.

Regarding visiting international researchers, Drs. B. Hnat, D. O'Connell, and D. Kolotkov from the University of Warwick (UK) studied oscillatory phenomena using the data from NoRH. Drs. J. Huang and Y. Zhang from the National Astronomical Observatories of China studied solar flares and their precursors. From the USA, Dr. S. White made synoptic charts of the circular polarization to investigate the global chromospheric magnetic field, and Dr, S. Yashiro (NASA) prepared tools for remote operation by members of ICCON.

4. Other

An issue of the Astronomical Herald, entitled “The Special Issue for the Nobeyama Radioheliograph”, including six articles related to NoRH, was published by the Astronomical Society of Japan. Graduate students of SOKENDAI, Tokai University, and Ibaraki University, and undergraduate students of Shinshu University and Meisei University studied solar physics with the data from NSRO. The Cutting Edge Solar Research Experience Tour, which was organized jointly by solar-related research institutions in Japan, offered lectures and a guided tour of the observatory to 11 participants. Regarding initiatives aimed for high schools, Komagane Technical High School in Nagano installed its own radio telescope, for which the observatory rendered support, and its students participated in the SPP program, and the observation results from this telescope were presented to the junior session of the Annual Spring Meeting of ASJ.

At the end of the fiscal year, K. Shibasaki (Professor)

retired. K. Iwai (Postdoctoral Fellow) departed upon completion of his term. From the next fiscal year, M. Shimojo (Assistant Professor) will belong to the Chili Observatory, and N. Shinohara (Senior Engineer), M. Takemura and H. Shinkai (Administrative Supporters) will belong to NRO.

5. Mizusawa VLBI Observatory

At NAOJ Mizusawa VLBI Observatory, we operate VLBI (Very Long Baseline Interferometry) facilities such as VERA (VLBI Exploration of Radio Astrometry) and KaVA (KVN and VERA Array), and provide these unique facilities to the user community in Japan and East Asia to support the research activities at universities and research institutes. At the same time, we conduct astronomical research using these VLBI arrays on the Galactic structure, star-forming regions, late-type stars, AGNs and so on. In addition to the operation of VERA, which is a dedicated array for VLBI astrometry, we support the maintenance and operation of the Yamaguchi 32-m Radio Telescope and two 32-m radio telescopes at Ibaraki in collaboration with local universities. Furthermore, we promote international collaboration, particularly in the East Asian region through the joint operation of KaVA and the East Asian Correlation Center at KASI (Korea Astronomy and Space Science Institute) as well as through preparatory operation of the East Asian VLBI Network which is a joint array between the People's Republic of China, Japan, and the Republic of Korea.

Also we keep Japan Central Standard Time as an obligation of NAOJ, and maintain Esashi Earth Tides Station for geophysics researches, and Ishigaki-jima Astronomical Observatory mainly for public outreach.

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 2014, we conducted a total of 399 (3,733 hours) observations with VERA, such as common use observations, project observations, 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 Mitaka VLBI Correlation Center in NAOJ Mitaka Campus.

VERA common-use call-for-proposals with the 43, 22, and 6.7 GHz bands for semesters 2014B (July to December) and 2015A (January to June) were released in June and November, respectively. A total of 15 proposals, which requested a total time of 632.5 hours, were submitted.

Referees elected from scientists in related fields and by the VLBI program committee evaluated the proposals and a total of 9 proposals (270.5 hours) were accepted in 2014B and 2015A.

(2) Science Result

Last year, we continued the project observations of VERA and produced science outputs on high-accuracy maser astrometry. In particular, we have published the third VERA Special Issue in PASJ (Publications of the Astronomical Society of Japan) succeeding the previous ones in FY 2008 and FY 2011. In this special issue, seven papers were published in FY 2014, and more papers are to come in another volume. The published outputs in FY 2014 include astrometric measurements of Galactic star-forming regions IRAS 20056+3350, IRAS 20143+3634, IRAS 22555+6213, NGC 2264, NGC 6334, and late-type stars RW Lep, T Lep and so on. Also, we have been continuously trying to improve the astrometric accuracy of VERA. We are now getting hints of parallaxes for 10-kpc sources. We will continue this activity and will hopefully be able to regularly obtain parallaxes for 10-kpc sources.

We also conducted simulation work to evaluate the accuracy of Galactic parameters that would be obtained by VLBI astrometry of 300 to 500 maser sources. It turned out that those Galactic rotation parameters would be determined to the level of a few percent and parameters of perturbations (such as spirals) would be determined to the 10 percent level, provided parallaxes could be measured for a few hundred sources. In addition to this work, we published a review paper summarizing the most up to date science outputs and technology development of high-accuracy VLBI astrometry.

Beyond VLBI astrometry, VERA produced interesting results on Orion-KL source I through joint observations with ALMA, and also on gamma-ray active AGN monitoring as a part of GENJI (Gamma-ray Emitting Notable AGN monitoring with Japanese VLBI) program.

2. JVN (Japanese VLBI Network)

JVN is operated as a joint research project of NAOJ and seven universities. JVN consists of VERA and radio telescopes operated by universities and research institutes, ISAS, JAXA, NICT, and GSI, distributed throughout Japan. VLBI observations by JVN were done for 400 hours at 3 bands of 6.7, 8, and 22 GHz in FY 2014. Single Dish Observations related to JVN were also done from 2,000 to 4,000 hours at each telescope.

The main subjects of research are active galactic nuclei and masers-star formation.

Scientific results obtained with JVN were published as four papers, while eight more papers reported JVN related scientific

studies. FUJISAWA Kenta et al. (2014) reported the first result of a 6.7 GHz methanol maser survey by JVN, where the Shanghai 25-m Telescope took part in the observation. This is the first result of EAVN (East-Asian VLBI Network) Observatory. Masers can be used as tracers for gases around high-mass young stellar object. SUGIYAMA Kouichiro et al. (2014) reported the first detection of rotation and infalling motions around a high-mass YSO, Cepheus A-HW2. The Astronomical Society of Japan held a special session of "University Collaboration in Astronomy" in "The 2014 Autumn Meeting", in which more than 30 invited contribution review talks were presented.

Education is also one of the aims of university collaboration in VLBI. More than 20 students conducted under-graduate study using JVN. Similarly, more than 10 master-course students completed their master's theses using JVN, and two Ph.D. students finished their theses using JVN directly or indirectly. Research meetings related to JVN were held six times in FY 2014, and many university students made presentations and talks in these meetings.

3. Japan-Korea VLBI

(1) Observations and Common Use Observations

A total of 80 (757 hours) VLBI observations, common use 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 call-for-proposals for semesters in 2014B and 2015A were made in June and November, respectively. In total, 14 proposals requesting a total time of 498 hours were submitted. Through the evaluations by referees elected from scientists in related fields and subsequent decision made by the VERA and KVN combined Time Allocation Committee, a total of nine proposals (330 hours) were accepted in 2014B and 2015A.

(2) Results of Research

Last year, we published two refereed papers reporting on the initial results of KaVA observations. One of the reports was on the first VLBI images of 44 GHz methanol masers in massive-star-forming regions, and the other showed the AGN jet imaging capability of KaVA. These papers are the first papers ever made based on KaVA data, and both demonstrate the high imaging capability of the seven station array. Furthermore, another paper is under preparation to report multi-transition SiO maser observations of late-type stars. These activities are made through KaVA science working groups consisting of researchers not only at NAOJ and KASI, but also at universities and research institutes in Japan and Korea. These KaVA science working groups have been discussing and preparing the KaVA large programs, in which relatively large amounts of KaVA observation time will be invested, so that the science outputs and uniqueness of KaVA will be further extended.

4. EAVN

EAVN has been developed under the agreement of our Consortium. An observation team for conducting EAVN test experiments, which consists of representatives from Japan, China, and Korea, was organized in FY 2013. Since then, the team has been leading VLBI experiments linking existing radio telescopes in East Asia through close international collaboration.

In FY 2014, VLBI experiments aiming to detect interferometric fringes from the telescopes in East Asia have been conducted several times. The telescopes which participated in the experiments were: VERA and 32-m telescopes located at Yamaguchi and Ibaraki Universities, the Tsukuba 32-m Telescope, Shanghai 25-m and 65-m Telescopes, Kunming 40-m Telescope, Urumqi 25-m Telescope, and three telescopes of the Korean VLBI Network. The experiments were conducted at 8 and 22 GHz, and VLBI data were processed by using the "Korea-Japan Correlation Center" located at Daejong in Korea. VLBI fringes were detected from most of these telescopes and detailed data analysis is ongoing.

These activities are being reported in EAVN workshops which are held almost every year, where future plans for experiments are discussed as well. The latest EAVN workshop was held in the Republic of Korea. And this year, the workshop will take place in July at Sapporo.

5. Geodesy and Geophysics

The regular geodetic sessions of VERA are allocated two or three times every month to maintain baseline accuracy. Among these geodetic sessions, VERA internal geodetic observations are performed once or twice every month at K-band, and Mizusawa and Ishigaki-jima participate in IVS sessions at S/X-band on a once per month basis. Thanks to the high sensitivity at K-band, the maximum number of scans at K-band is 800 per station per day. In FY 2014, we participated in six T2 sessions and four JADE sessions.

VERA internal geodetic observations were carried out 17 times. The final estimation of the geodetic parameters is derived by using the software developed by the VERA team.

After "The Great East Japan Earthquake" (Mw=9.0), VERA Mizusawa was displaced by coseismal crustal movement and postseismic creeping. For FY 2014, the creeping continued, though the speed declined. According to the newest analysis, the coseismal steps are X = −2,013 mm, Y= −1,380 mm, and Z = −1,072 mm, and the displacement by creeping during 2014 is X = −91 mm, Y = −61 mm, and Z = −31 mm.

Continuous GPS observations at VERA stations are carried out in order to detect short term coordinate changes and to estimate atmospheric propagation delay. The results of GPS positioning also show large postseismic creeps even though 4 years have passed since the occurrence of "The Great East Japan Earthquake." The crustal deformation observed by the strainmaters at "Esashi Earth Tides Station" is consistent with the postseismic displacements observed by VLBI and GPS.

Continuous gravity observations with superconducting

gravimeters are carried out at Mizusawa and Kamioka. Similar observation is carried out at Ishigaki-jima as a joint project with other university groups. The features of the annual change are observed and studied by several techniques including VLBI, GPS, and gravimeters.

6. System Development

We replaced the magnetic tape recorders with new hard disk recorders and also replaced the FX correlator working at a 1 Gbps data rate with software correlation. We confirmed sufficient performance in scientific processing and continuous operation after small revisions to the software. We allocated the software correlator systems to Mizusawa, and contributed modifications to the KJCC (Korea-Japan Correlation Center) system with scientific evaluations of the observations by KaVA. We started intense consideration of future plans for the observatory. A possible plan to join the SKA (Square Kilometer Array) project and the development of high frequency VLBI are being discussed. We performed several basic development projects including ultra-wideband A/D convertors and a high-accuracy antenna surface for the primary reflector for mm/sub-mm VLBI observations.

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 900,000 daily visits have been recorded last year.

The master clock has been changed from Cs8 to Cs6, which showed better stability characteristics than Cs8 last year. The layout of the Timekeeping Operation Room has been reorganized because VERA AOC has been moved from Mitaka to Mizusawa.

8. Ishigaki-Jima Astronomical Observatory

Thirteen years have passed since the completion of VERA Ishigakijima and the start of the "Star Festival of South Island" in Ishigakijima. As the main event of the star festival, 8,000 people participated in the "Light-down Starry Sky Party", even though it was cloudy.

In unison with "Star Festival of South Island", the first "Meteorite Exhibition" ever held in Okinawa Prefecture was held in cooperation with Nayoro Municipal Observatory, and 754 people enjoyed the exhibition.

The Annual Planetarium Screenings were held from August 7 to 10, and 734 people participated.

The Second Japan Starlight Sky Summit was held in Ishigakijima on October 19 in cooperation with the Bisei Astronomical Observatory and the Nobeyama Radio Observatory.

Professor HASEGAWA Tetsuo who is the director of NAOJ Chile Observatory gave a memorial lecture in which 350 people participated. At the same time, we performed the planetarium program "Wish upon a star of the Southern Island", which was jointly hosted by Ishigaki-jima Observatory and Ishigaki-City. 1,364 people came and enjoyed this program from October 17 to 23.

These activities of NAOJ Ishigakijima Astronomical Observatory greatly contribute to not only observational studies, but also to regional development such as school education, lifelong learning, tourism, and so on, through cooperation with local communities.

9. Public Relations (PR) and Awareness Promotion Activities

(1) Open House Events

On April 13, 2014: the Fifth Open Observatory Event held at the Ibaraki University Center for Astronomy, and NAOJ Mizusawa VLBI Observatory, Ibaraki Station, with approximately 700 visitors.

On July 6: 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 350 visitors.

On August 10: the Special Open House of VERA Iriki Station was supposed to be jointly held with "The Yaeyama Kogen Star Festival 2014", but was called off due to a strong typhoon.

On August 16: A mission briefing session by WAKATA Koichi, an astronaut of JAXA (Japan Aerospace Exploration Agency) who stayed on the ISS (International Space Station) as the commander, held as an event related to "Iwate Galaxy Festival 2014", with approximately 1,000 visitors.

On August 30: "Iwate Galaxy Festival 2014", open house of the NAOJ Mizusawa Campus, held with 847 visitors.

On October 19: In cooperation with Bisei Astronomical Observatory and Nobeyama Radio Observatory, "The second Japan Starlit Sky Summit" was held in Ishigaki-city, and 350 came to the main meeting places such as a memorial lecture by HASEGAWA Tetsuo (ALMA), 1,364 entered screenings of the planetarium "Wish upon a star of the Southern Island" which were held at the same time (October 17 to 23) in Ishigaki-jima Astronomical Observatory and Ishigaki-city.

On February 15, 2015: "The 14th Star Island" open house event of VERA Ogasawara Station was held, with 213 visitors.

(2) Regular Public Visiting

Throughout the year, the following stations are open to public on a regular basis.

The numbers of visitors to each facility is as follows,

a) VERA Mizusawa Observatory 17,021
b) VERA Iriki Observatory 2,000
c) VERA Ogasawara Observatory 7,535
d) VERA Ishigaki-jima Observatory 2,754

e) Ishigaki-jima Astronomical Observatory 12,790

(3) Review of the Contents of Our Website

Websites related to the Mizusawa VLBI Observatory and the number of visitors are:

Contents list	Sessions	Internet users	Page Views
Mizusawa VLBI Observatory	23,894	15,247	75,769
VERA Mizusawa Observatory	9,163	6,307	30,829
KIMURA Memorial Museum	1,657	1,313	5,319
VERA Ishigaki-jima Observatory	80,920	51,662	185,037

10. Education

(1) Undergraduate and Graduate Education

The Observatory accepted three graduate students from the University of Tokyo and two from SOKENDAI (Graduate University for Advanced Studies). A student from the University of Tokyo was conferred a Ph.D. and awarded the University of Tokyo President's Prize. Two master's students, one from Tokai University and another from Kagoshima University, were accepted as visiting graduate students and completed master's theses. Undergraduate students from Tohoku University, Okayama University, Yamaguchi University, and Kyushu University were accepted as summer students of SOKENDAI. The University of the Ryukyus and NAOJ began offering this joint course in FY 2009. Classroom lectures at the university took place on August 11, 13, 14, and 15, and observational workshops were held in Ishigaki-jima from August 25 to 28, with a total of 31 participants. A hands-on radio observation program was conducted at the VERA Ishigaki-jima Station and Ishigaki-jima Astronomical Observatory. In addition, staff members at the station visited these universities to deliver lectures.

(2) High School Student Hands-On Events

"The 8th Z-Star Research Team Workshop" was held to use the VERA Mizusawa antenna; five high school students from Iwate prefecture were accepted. A preliminary session was held June 28 and 29, and observations were done August 2 to 4. As a result, students successfully discovered a new maser source. During August 18 to 20, VERA Ishigaki-jima Station and Ishigaki-jima Astronomical Observatory held "The Churaboshi Research Team Workshop" for thirteen high school students from Okinawa, Fukushima, and Fukuoka prefectures. It was organized with support from JSPS. One of the groups detected a new maser source using the VERA Ishigaki-jima antenna. The Observatory supported the SSH (Super Science High School) research activities for a high school in Akita Prefecture using the Mizusawa 20-m antenna.

6. Solar Observatory

The Solar Observatory primarily engages in the operation of solar observational facilities on the west side of Mitaka Campus. It conducts both observational and theoretical studies of the structure of the outer solar 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 development of new observational instruments and the planning of future ground-based solar observations. Regular observations of sunspots and flares have been carried out for extended periods, and the resulting data are provided to 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 continued observations of active region photospheric vector magnetic fields and H-alpha flares since its completion of 1992. The main instrument on the SFT since 2010 is an infrared Stokes polarimeter. Whereas previous magnetic field observations covered part of the solar surface, this instrument is designed to perform full-disk polarimetric observation to obtain high accuracy vector magnetic field information in order to shed light upon 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, 1.56 μm line; chromosphere: helium, 1.08 μm line), which are sensitive to the magnetic field. 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 Sun with a slit scan for each wavelength range, but a new system which enables us to observe two wavelength ranges simultaneously using two cameras has just been installed. Now the new system is under testing, and after its completion, the data acquisition will be conducted more efficiently.

In this fiscal year, concentrated maintenance work for the SFT was done, and some deteriorated parts of the telescope were replaced.

(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 261 days in 2014, from January to December. A huge sunspot, which is the largest one in the last 24 years, appeared in this year. The Hinode project and the Solar Observatory jointly released some related images to the public on November 19.

Although full-disk solar image data are a widely needed resource in the astrophysics/geophysics community, some of these synoptic instruments are becoming out of date. 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 H-alpha with high temporal resolution, allowing it to more completely capture active phenomena, and a broad dynamic range through a combination of multiple exposure times. This advancement has enabled us to observe many phenomena in recent heightened solar activity, such as flares and prominence eruptions. The observatory also uses the SFT to conduct regular imaging observations in the G-band (430 nm) and continuum wavelengths. The regular observational data described above, including real-time images, are available on the website of the observatory. Using a Grant-in-Aid for Scientific Research, a spectrograph system with a coelostat is under development to perform long-term, full-disk observations, including more quantitative velocity and magnetic field observations. An improvement to the coelostat was conducted this year. The observatory maintains other existing equipment to allow for everyday observation, as well as experimental use.

2. Opening of Data Archives to 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, CaII 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 also available to the public because they are digitized and organized. As some of the world's oldest records of solar activities, these materials are expected to add particular insight into future research.

Data publicized via the website were previously stored on a server owned by the observatory. The information has 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.

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.

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, discussions and on-site inspections have been conducted.

A research plus business conference, dubbed as the annual users meeting, has been held every year jointly with other organizations. The meeting is combined with the solar research symposium for the entire solar community, where topics related to open use and future plans are also discussed. The conference was held at Nagoya University between February 16 and 18, 2015.

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, research expert Naomasa Kitagawa replaced a staff member who departed last year. Dr K. Kuzanyan of IZMIR, Russia, started his ten month stay as a JSPS fellow in September 2014.

7. 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) to construct and operate a gigantic millimeter/submillimeter radio telescope deploying 66 high-precision parabolic antennas in the 5000 m altitude Atacama highlands in northern Chile. ALMA is projected to achieve a spatial resolution 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. It has been operated to make headway into submillimeter observations toward the ALMA Era. The report also describes the progress regarding the ASTE telescope.

1. ALMA Project Progress

Along with the scientific observations, commissioning observations of ALMA have been underway. These include long-baseline observation tests, polarimetric observation tests, and solar observation tests.

In particular, intensive long-baseline observation tests were made from September through November 2014 with an extended antenna configuration of up to 15 km for the verification of equipment performance, new observation methods, and efficient calibration methods. As a result of these test observations, astronomers successfully made the first detailed image of a protoplanetary disk around the young star HL Tau at an extraordinary high resolution of 0.035 arcsec (equivalent to 40000/20 vision). The high sensitivity and resolution of ALMA made it possible to reveal several gaps which are seemingly produced by the gravitational influence of planets forming in the disk. This is a remarkable result which could reshape our understanding of planetary formation theory. Another outstanding result with ALMA was an unprecedentedly sharp image of an asteroid Juno and a lensed galaxy SPD.81, which demonstrated the high potential of ALMA. The data for these results have already been made available on the ALMA Archive, and many papers based on them have been written by astronomers. Following the success of these long-baseline test observations, the maximum baseline will be extended up to 10 km in the ALMA Cycle 3 Call for Proposals for scientific observations that will be scheduled from October 2015.

2. ALMA Open-Use and Scientific Observations

The third round of open-use observations of ALMA commenced in June 2014 with Cycle 2. The details of Cycle 2 include interferometric observations using thirty-four 12-m parabolic antennas, Atacama Compact Array (ACA) observations (interferometric observation with nine 7-m antennas and single-dish observations with two 12-m antennas), six frequency bands (Bands 4 and 8 are added to Bands 3, 6, 7, and 9), a maximum baseline of 1.5 km (for Bands 3 to 7) or 1 km (for Bands 8 and 9), and a maximum of 150 fields of view for mosaic observations and polarimetric observations.

An open call for the fourth round of open-use observations was issued for Cycle 3. The details of Cycle 3 as advertised include interferometric observations using thirty-six 12-m antennas, ACA observations (interferometric observation with ten 7-m antennas and single-dish observations with two 12-m antennas), seven frequency bands (Band 10 is newly added to Bands 3, 4, 6, 7, 8, and 9), a maximum baseline of 10 km (for Bands 3 to 6), 5 km (for Band 7), or 2 km (for Bands 8 to 10) and a maximum of 150 fields of view for mosaic observations and polarimetric observations. The deadline of the public calls for proposals for Cycle 3 is set at 00:00 JST on April 24, 2015. Cycle 3 is scheduled to commence in October 2015.

Open use of ALMA has produced a number of scientific achievements. This section describes some of these focusing mainly on East Asian projects. A research group led by Bunyo Hatsukade at NAOJ observed galaxies hosting gamma ray bursts (GRBs), the brightest explosive phenomenon in the Universe, using ALMA and successfully detected radio emissions from molecular gas for the first time. Also, this observation revealed the spatial distribution of molecular gas and dust, showing that gamma ray bursts occurred in a remarkably dust-rich environment. A research team led by Kazuki Tokuda at Osaka Prefecture University conducted ALMA observations of the gas cloud MC27 in the constellation Taurus and found two starless high-density gas cores and an arc-shaped high-density gas region, which is assumed to be formed by the dynamic gravitational interaction of multiple gas cores that are very close to the initial stage of star formation. A research group led by Junko Ueda at NAOJ observed 37 galaxies that are in their final stages of merger using ALMA and several other radio telescopes. The group found that, among the 30 colliding galaxies from which molecular radio emission have been detected, 24 galaxies have rotating molecular gas disks and half of them have extended gas disks that are larger than the stellar bulges at the galactic centers. This is the first observational evidence showing that mergers of two or more galaxies will lead to the formation of a new galaxy with a gas disk structure at a high rate. A research team led by Shigehisa Takakuwa at the Academia Sinica, Institute of Astronomy and Astrophysics, (ASIAA), Taiwan, observed the baby binary stars L1551NE and found a gas disk surrounding both stars (known as a circumbinary disk) with spiral arms of molecular gas extending from the disk toward the binary stars. This is the first image that shows the twin stars shaking the surrounding circumbinary disk and inducing the gas motion falling onto the twin stars. A research team led by Shuro Takano at NAOJ observed the central part of the spiral galaxy M77 and discovered that organic molecules are concentrated in a region surrounding a supermassive black hole

at its center. This result shows that the black hole is surrounded by a large amount of dust and gas which is shielded from X-rays and UV photons. These findings will be a key to understanding the mysterious environment around supermassive black holes. A research group led by Aya Higuchi at Ibaraki University conducted observations of the massive-star forming region IRAS 16547-4247 and revealed the presence of multiple, at least two, gas outflows from a protostar at the center. Also the radio observation results of molecular line emissions of methanol revealed in vivid detail an hourglass structure created by gas outflows spreading outward.

3. Educational Activities and Internship

The NAOJ Chile Observatory held a graduate school guidance session on June 14, 2014. Eight undergraduate students attended the session, engaging in lectures given by teachers and talks with current graduate students.

4. Public Outreach Activities

In April 2014, the NAOJ Chile Observatory hosted a week-long ALMA booth at the Japanese Geoscience Union Meeting in Yokohama. The NAOJ Chile Observatory organized public lecturers and Science Cafe events on 19 occasions in FY 2014 to provide updated information and increase interest in ALMA and its scientific achievements through conversations with a large number of visitors.

The NAOJ ALMA project website published 44 news articles and seven 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 22,000 followers as of the end of FY 2014.

Approximately 50 newspaper/journal articles were posted, reporting scientific discoveries from the Early Science observations and test observations. ALMA was featured in three television programs. In addition to news reports on ALMA's observational achievements, there was a program showing people involved in the ALMA project in depth such as "Fathers Working in the World 6", which effectively increased interests in ALMA and appealed to a mass audience.

As part of the construction film project continuing since FY 2013, the NAOJ Chile Observatory produced a new film showing the development of the receivers at the Advanced Technology Center (ATC) in FY 2014, and filmed interviews with developers of the ACA correlators.

The NAOJ newsletter featured ALMA in the February 2015 issue with an article summarizing the ALMA project and its scientific achievements, including interviews with ALMA staff members stationed in Chile. The series "Bienvenido a ALMA" in which ALMA staff members introduce their work, continues to be featured in the NAOJ newsletter, which is also made public on the ALMA website.

ALMA MUSIC BOX was created by translating the ALMA radio data into music with the support of designers and artists. This work was exhibited in an exhibition titled "THE FAB MIND: Hints of the Future in a Shifting World" from October 2014 through February 2015 at the 21_21 DESIGN SIGHT in Roppongi, Tokyo, which provided a good opportunity for many people who are familiar with design and art to know more about ALMA and its scientific achievements.

5. International Collaboration (committees, etc.)

The ALMA project has various committees, which hold meetings frequently for international collaboration. The ALMA Board has met twice, and the ALMA Scientific Advisory Committee (ASAC) was summoned three times in FY 2014. In addition to these, teleconferences have been held on a near-monthly basis by these committees and the East-Asia ALMA Science Advisory Committee (EASAC). Each working group holds meetings and teleconferences more frequently to maintain close communication in implementing the international project.

6. Workshops and Town Meetings

- June 17 to 18, 2014 NAOJ Mitaka
  ASTE/ALMA Development Workshop
- July 14 to 17, 2014 Jeju, Korea
  EA ALMA Science Workshop
- October 27 to 29, 2014 NAOJ Mitaka
  ALMA/ASTE/Mopra Users Meeting
- December 8 to 11, 2014 Tokyo International Forum
  International Workshop "Revolution in Astronomy with ALMA - the 3rd year -"
- December 13 to 14, 2014 NAOJ Mitaka
  ALMA Postdoc Symposium
- March 5, 2015 Ehime University
  ALMA Cycle 3 Town Meeting
- March 25, 2015 Kogakuin University
  ALMA Cycle 3 Town Meeting
- March 26, 2015 Japan Aerospace Exploration Agency (JAXA) Institute of Space and Astronautical Science
  ALMA Cycle 3 Town Meeting
- April 2, 2015 Kagoshima University
  ALMA Cycle 3 Town Meeting
- April 8, 2015 NAOJ Mitaka
  ALMA Cycle 3 Town Meeting

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

None

8. Research Staff Changes

(1) Hired
- Patricio Sanhueza: project research staff

(2) Departed or transferred

- Hiroshi Nagai: project assistant professor, transferred to the NAOJ Chile Observatory to assume the position of a project associate professor.
- Shinya Komugi: project associate professor, departed to Kogakuin Univeristy to assume the position of an associate professor.
- Hiroko Shinnaga: project associate professor, departed to Kagoshima University to assume the position of an associate professor.
- Chibueze, James: project assistant professor, departed to University Nigeria to assume the position of a lecturer.

9. Main Visitors

- August 5, 2014
  Dr. Kyosuke Nagata, President of University of Tsukuba, visited the Santiago Central Office of the Joint ALMA Office (JAO) and had a meeting with the ALMA Director Pierre Cox.
- November 6, 2014
  Dr. Hiroyuki Takeda, Vice Dean of the School of Science at the University of Tokyo, and others visited the ALMA Operations Support Facility (OSF) and the Array Operations Site (AOS).
- November 26, 2014
  Dr. Kaoru Yamanouchi, Vice Dean of the School of Science at the University of Tokyo, and others visited the ALMA Operations Support Facility (OSF) and the Array Operations Site (AOS).

10. Progress of ASTE Telescope

The ASTE telescope has been operated to promote full-fledged submillimeter astronomical research in the southern hemisphere and to develop/verify observational equipment and observation methods for submillimeter astronomy. With ALMA entering its operation phase, ASTE will be engaged mainly to provide observational evidence for strengthening ALMA observation proposals and to pursue developments for the enhancement of ALMA's future performance.

Two public calls were made in FY 2014 for open-use observation proposals for spectroscopic observations in the 345 GHz band: the first call (2014a) was from June to September and the second call (2014b) from October to December. 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 exclusively to make proposals for GTO slots. A total of 59 proposals for open-use observations and GTO slots had been made including 28 for open use and five for GTO during the first call, and 25 for open use and one for GTO during the second call. These proposals were reviewed by the program subcommittee at the NAOJ Chile Observatory and 38 proposals were subsequently adopted including 20 for open use and five for GTO during the first call, and 12 for open use and one for GTO during the second call. Open-use observations were conducted from the ASTE Mitaka operation room between June 16 and December 19, 2014.

In June 2014, the ASTE/ALMA Development Workshop was held at NAOJ Mitaka Campus to discuss future instruments to improve the observational capability of ASTE and future development for ALMA performance enhancements. In response to a call for proposals for future ASTE instruments made in November 2014, three development proposals were submitted, and subsequently adopted as candidate future instrument development programs for ASTE by the reviewers selected from the Japanese ASAC members.

8. Center for Computational Astrophysics

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), was reinforced this year. Now ATERUI has a theoretical peak performance of 1 Pflops, making it the world's fastest supercomputer for astronomy. The center also continued operation of other computers such as GRAPE-7, GRAPE-DR, and GRAPE-9 which are dedicated to gravitational many-body problems, in addition to general-purpose servers. Efforts in visualizing astronomical data also continue.

2. Open use

(1) Computer Systems

This year marked the second year of the upgraded astronomical simulation system, which includes the main supercomputers of the open-use computers for this project. The CPUs of the main super computer, Cray XC30, which is installed and operating at Mizusawa VLBI Observatory, have all been updated, and its theoretical peak performance is now as high as 1 Pflops. The users have been making academically significant progress as before.

While XC30 is leased from Cray Japan Inc., the center has built the following equipment to aid the open-use 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 conducted 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 the hardware and software of the system this year. One of the major events of this year was the test operation of GRAPE-9. This system has a performance improvement of roughly 10-fold over the current GRAPE-7.

Computational resources are allocated to the XC30, GRAPEs, and minor computational PC clusters in accordance with a formal evaluation process. Their usage and application/results for this year are listed below. The CfCA conducted a survey this year on the number of peer-reviewed papers published in English in FY 2013 on studies that involved the project's open-use computers. It was revealed that 79 papers were published in total in that fiscal year.

Drupal, a content management system introduced for data exchange with users of open-use computers, is presently used for providing information and transmitting various application forms as necessary. The periodical 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 in which the results were obtained by using the center's computers.

One paper was accepted in FY 2013 for payout in FY 2014, while four papers were accepted in FY 2014 for payout in the same year at approximately 400,000 JPY.

□ Statistics on the Cray XC30
Operating hours
- Annual operating hours: 8088.6
- Annual core operating ratio: 88.37 %

Users
- Category S: 1 adopted in the first term, 0 in the second term; total 1
- Category A: 14 adopted at the beginning of the year, 1 in the second term; total 15
- Category B: 56 adopted at the beginning of the year, 9 in the second term; total 65
- Category MD: 13 adopted at the beginning of the year, 3 in the second term; total 16
- Category Trial: 44, annual total
- Category I: 0, annual total

□ Statistics on the GRAPE system
Users
- Category A: 4 adopted at the beginning of the year, 0 in the second term; total 4
- Category B: 6 adopted at the beginning of the year, 3 in the second term; total 9
- Category Trial: 1, annual total

□ Statistics on PC cluster
Operating hours
- Annual operating hours: 8690.0
- Annual job operating ratio: 71.7 %

Total number of users: 39, annual 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, a 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 20, 2014, 6 attendees

□ Cray XC30 workshop for intermediate users: January 19, 2015, 14 attendees

□ IDL visualization workshop: August 21, 2014, 11 attendees

□ AVS visualization workshop: August 22, 2014, 11 attendees

□ N-body simulation Winter School: January 26–28, 2015, 16 attendees

□ Users meeting: January 20-21, 2015, 56 attendees

3. PR Activities

CfCA took part in the special open house of Mizusawa Campus, Iwate Galaxy Festival 2014, held on August 30, 2014. About 600 visitors attended the ATERUI guided tours and experienced a close-up view of the facility. These occasions were featured on local television programs and in newspapers. At the Mitaka Open House held in October 2014, CfCA made the computer room accessible to the public and introduced simulation astronomy with GRAPE and the PC cluster. A live broadcast was also arranged by connecting the supercomputer operation room in Mizusawa Campus to Mitaka Campus to introduce ATERUI to those visiting Mitaka. In addition to the open house, CfCA has accepted five groups of high school students and companies for tours of the computer room in Mitaka Campus.

In FY 2014, three press releases were issued from CfCA; "The K computer simulation indicates that the neutrino-heating mechanism causes supernova explosions" (April 18, 2014, Tomoya Takiwaki, Assistant Professor at CfCA), "Supercomputer for Astronomy "ATERUI" Upgraded to Double its Speed" (November 13, 2014), and "The K computer figures out the mechanism of electron acceleration" (February 27, 2015, Tsunehiko Kato, Research Expert at CfCA). In addition, the press release from the NAOJ Chile Observatory, "Astronomers Identify Gas Spirals as a Nursery of Twin Stars through ALMA Observation" (December 4, 2014), included the results of calculations by ATERUI (Professor Tomoaki Matsumoto, Hosei University).

Moreover, the results obtained by ATERUI were presented with short articles on the CfCA website. "The Astronomical Herald" published by the Astronomical Society of Japan featured CfCA in Vol.108 No.2 and No.3 in 2015. The introduction of CfCA by Prof. Eiichiro Kokubo and six articles about simulation studies by the CfCA computers appeared in these volumes.

CfCA assisted GOTO Inc. in making the planetarium program "Space Analyzer". This program features supercomputers used for astronomical research, and presents results obtained by ATERUI, GRAPE and K computer. This program was screened at the Kobe Science Museum from September 2014 to March 2015.

A Twitter account @CfCA_NAOJ has been operated to provide information about CfCA. In addition, the Youtube CfCA channel was created as part of the PR activities, and the movies of simulations and the videos for press releases were published through this channel.

4. 4D2U Project

In FY 2014, the 4D2U project added a new member for content development. A movie based on simulations titled "Formation and Evolution of Dark Matter Halos (II. Formation of the Large-Scale Structure of the Universe)" was released on the 4D2U website in March 2015. This content was distributed with 360 degree panoramic video for the first time. Viewing this format with a head mounted display (HMD) provides a realistic experience. The updated versions of the four-dimensional digital universe viewer, "Mitaka," were released in December 2014 (ver.1.2.2), February 2015 (ver.1.2.2a, ver1.2.2b and beta version for Oculus Rift) and March 2015 (ver.1.2.3). These versions of Mitaka included new functions, such as displaying the 3D surface of the Moon and plotting the positions of objects observed by the VERA project. In particular, the beta version for Oculus Rift and version 1.2.3 which can project with the Dome Master format expanded the usage of Mitaka. The imaging speed of Mitaka was made faster and faster every update.

The 4D2U project supported and provided contents for exhibitions held in museums and galleries. For example, "mission[SPACExART]—beyond cosmologies" (Museum of Contemporary Art Tokyo, June 7 to August 31, 2014), "Mystery of the Moon" (Konica Minolta Plaza, July 15 to August 10, 2014) and "Depictions of Space" (Tokyo Dome City Space Museum TeNQ, February 28 to June 28, 2015). In addition, 4D2U demonstrations using the dispatch system were conducted at events held by the Hiroshima Astrophysical Science Center (July 20, and August 22–24, 2014). Local visitors enjoyed special programs to experience the latest astronomy findings through 3D vision. Moreover, 4D2U contents were provided for TV programs, planetarium programs, lecture presentations, books and so on.

In cooperation with the Public Relations Center, the 4D2U project installed a new projection system for the 4D2U Dome Theater. On March 17, 2015 the renewal of the 4D2U Dome Theater was announced on the NAOJ website. The newest movie content "Formation and Evolution of Dark Matter Halos (II. Formation of the Large-Scale Structure of the Universe)" was produced and released for this renewal. Mitaka ver.1.2.2 was developed and installed on the new dome system.

A Twitter account @4d2u has been operated to provide information about 4D2U. In addition, a Youtube channel for 4D2U was created as part of the PR activities, and movie contents of 4D2U can be watched on this channel.

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 the basis for collaboration between three organizations (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. The 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 its three member organizations and their communities 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 high-performance computing development of novel algorithms to meet research goals from the perspective of computer specialists. In addition to 'HPCI Strategic Program Field 5 "the origin of matter and the Universe" ', JICFuS has been adopted for 'Research and Development, Application Development of scientific/social issues that require particular attention by the use of POST K-computer' in FY 2014.

In order to implement research plans, Hiroyuki Takahashi and Tomoya Takiwaki (until July) were engaged as project assistant professors, and Tomomhisa Kawashima (from May) was engaged as a project researcher in FY 2014. Takahashi and Kawashima developed a new plasma simulation code to solve basic equations of relativistic radiation magnetohydrodynamics (MHD) based on first principles. By performing global simulations of black hole accretion disks, they revealed that the black holes are able to grow up rapidly via mass accretion. This is closely related to an unresolved issue in astrophysics: how stellar mass black holes grow into supermassive black holes. Takiwaki carried out three-dimensional simulations of core-collapse supernovae using the supercomputer "K." His research is key for various studies within the framework of JICFuS, because supernovae are closely related to elementary particle and nuclear physics. Although the mechanism of supernova explosions is a long-standing enigma that has been debated for more than 60 years, the research into supernovae has progressed considerably through numerical simulations with the most realistic parameters using the K computer.

Representing CfCA, Professor Kohji Tomisaka and Assistant Professors Ken Ohsuga and Tsuyoshi Inoue of NAOJ participate in bimonthly JICFuS steering committee meetings to engage in deliberations on how to spur 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 computer. Although the center is involved with the JICFuS-led HPCI Strategic Program Field 5 as mentioned in (1), its activity in the HPCI consortium is fundamentally independent. The HPCI consortium is an incorporated association established in April 2012, and the center is currently an associate member able to express views, obtain information, and observe overall trends in the planning: however, it is 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 in which participants discuss a next-generation national supercomputing framework to follow the K computer.

This year the budget allocation was officially approved for the development of a next-generation system, called "post-K", by the Ministry of Education, Culture, Sports, Science, and Technology (MEXT). The institutes and groups for its development have been established. Now detailed discussions as to how we develop and use the post-K system have begun in related communities.

Post-K generation equipment is scheduled to commence operation after FY 2019. In principle, therefore, it is possible for NAOJ to play a central role in the post-K generation HPC through participation in this discourse.

6. Contract Staff Transfers

The following staff members were employed on a contract basis in this FY:
(Research experts) Hirotaka Nakayama, Tsunehiko Kato
(Postdoctoral fellows) Shun Furusawa, Tomohisa Kawashima
(Research associates) Yukihiko Hasegawa, Yuji Matsumoto

The following contract staff members departed in this FY:
(Research expert) Tomoya Takiwaki (assistant professor)
(Postdoctoral fellow) Naoki Ishitsu
(Research associates) n/a

9. 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 has 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 elucidate the coronal heating mechanism through a more multifaceted understanding of magnetohydrodynamic (MHD) phenomena occurring in the solar atmosphere. The satellite actually made many 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 corona. The onboard telescopes were developed as part of a wide-ranging international collaboration with assistance from ISAS/JAXA. The 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 regards to 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 three from the Hinode Science Center (HSC): Sakurai (Chairman/project scientist), 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 (Chairman/EIS) and Sekii (SOT).

FY 2014 marks the eighth year since the satellite's launch. Extremely good evaluations were received from the senior review class evaluation committees held at the respective space agencies during FY 2012–2013. These accolades made it possible for the satellite to continue operation for the next few years at its current operational level. The operation of the Focused Mode was conducted in the June and January – February periods of FY 2014 after a test run in January 2014.

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 arcsecond 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 the maintenance of a sound field of view even in the narrow band filter imager system, in which image degradation was detected initially in part of the field of view.

The XRT has the capacity of imaging 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 arcsecond. 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 for the chromosphere, transition region, and coronal plasma thorough 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 observations from the chromosphere and the transition region, located between the photosphere and the corona, to the corona itself.

A mission data processor (MDP) was installed to manage observations and to acquire data via the three telescopes. Coordinated observations using the three telescopes are vital to achieve the scientific goals of the Hinode satellite, in which the MDP plays a crucial oversight role. 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 are primarily downlinked at the Kagoshima station (USC) and at Norway's Svalsat station through collaboration with ESA, allowing for data acquisition during every orbit. Scientific operation was again performed in FY 2014 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 211 days in FY 2014, 68 days of which were for contracted work. Moreover, the contribution rates to the scientific operation of HSC were 24.9% (domestic) and 15.7% (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 observation together with other satellites and terrestrial observational equipment, promote joint observations among solar researchers worldwide. As of March 2015, a total of 284 applications have been accepted. In particular, core HOP proposals made by members of the scientific instrument team have became refined over multiple implementations, and systematic observations have yielded extensive results that can be expanded to studies on solar activity cycles.

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 purpose is to promote rigorous collaborative research between researchers in Japan and abroad by maximizing the scientific outputs gained from the Hinode satellite by providing a suitable environment for analyzing the satellite data, facilitating access to Hinode observational data by distributing the analyzed data, and constructing 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 2014, HSC staff members and students published 14 peer-reviewed papers related to Hinode, bringing the total to 241 papers by the end of March 2015. Cumulatively, a total of 810 peer-reviewed papers have been published on Hinode-related topics. Publication of papers in this category continues at a pace of nearly 100 papers per year, even 8 1/2 years after the satellite's launch. Intensified collaborative research with newly launched missions and advanced ground-based facilities near the solar activity maximum will further enhance the number of research papers for solar activity.

3. Other Activities

In FY 2014, three postdoctoral fellows were engaged as members of HSC, including one project assistant professor, one postdoctoral fellow, and one Japan Society for the Promotion of Science (JSPS) fellow. The project assistant professor (Ishikawa, R.) was hired as an NAOJ assistant professor in June. Hinode Science Meetings for Japanese and international solar researchers are held on a regular basis to promote heliophysical research using the Hinode scientific satellite. The eighth meeting was combined with the "2014 Living With a Star (LWS) science meeting," and took place between November 2 and 6, 2014, in the city of Portland, Oregon (USA). The NASA Marshall Space Flight Center (MSFC) was a co-organizer.

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)
Uitenbork, Han	National Solar Observatory (USA)
Kuhn, Jeffrey	University of Hawaii (USA)

Table 1. Long-Term Visitors.

10. Gravitational Wave Project Office

The activities of the Gravitational Wave Project Office (GWPO) are focused on the realization of the Large-scale Cryogenic Gravitational-wave Telescope in the Kamioka mine (KAGRA). KAGRA is a gravitational wave detector based on a laser Michelson interferometer with arms 3 km in length that is currently under construction. The project is realized in collaboration with ICRR and KEK in the framework of a MoU about the development of gravitational wave astronomy. According to the plan, the project construction should be completed in 2017 and the first observation run should take place shortly afterwards. KAGRA should join the international network of gravitational wave detectors in the USA and in Europe and contribute to the opening of gravitational wave astronomy. In parallel the GWPO is preparing for KAGRA data analysis and is conducting R&D for future upgrades to KAGRA and for the development of DECIGO.

1. Development of KAGRA

In order to further clarify the role of NAOJ within KAGRA, a MoU with ICRR has been established in FY 2014. According to the MoU the GWPO is responsible for the development of the vibration isolation system (VIS), the auxiliary optics system (AOS), part of the mirror characterization equipment (MIR) and the overall interferometer optical design. In FY 2014 JSPS approved a Specially Promoted Research for the development of KAGRA. Part of the funding was allocated to NAOJ for the development of VIS and AOS. In addition, the GWPO is contributing to the project management, particularly for the activities of the executive office, the system engineering office, the committee for publication control, the publication relation committee and the safety committee. The main achievement at the site in FY 2014 has been the installation of the vacuum system and the beginning of the installation of the interferometer. In order to support on-site activity more efficiently, the GWPO made preparations for a branch at Kamioka which just opened on April 1st 2015.

(1) Vibration Isolation

The vibration isolation system (VIS) is composed of the suspensions required to isolate all the interferometer components from ground vibrations. Fifteen VIS's are required for KAGRA. Four different types of suspensions have been developed at NAOJ for this purpose. During FY 2014 the VIS design has been finalized and construction has been completed for most of the components of initial KAGRA. Some of the development work has been done in collaboration with the Advanced Technology Center (ATC) of NAOJ. In particular, the bottom filters were developed in close collaboration with ATC. We also acquired the first ensemble of four inverted pendulums in collaboration with Nikhef. The first prototype of one complete suspension was assembled to be tested at TAMA. In parallel we started installation of the vibration isolation systems for the input mode-cleaner at the Kamioka site.

(2) Auxiliary Optics System

The auxiliary optics subsystem consists of several kinds of optics including optical baffles, beam dumps, beam reducing telescopes, high quality viewports and the optical local sensors (optical levers) for the mirrors of the interferometer. The installation of 250 pieces of the arm-duct optical baffles, which are designed to reduce noise due to stray light, has been completed in both 3 km long arms of KAGRA. Optical simulations to estimate the stray-light noise with the designed

Figure 1: KAGRA construction progress: while the arm ducts are installed at Kamioka, the first full prototype of the vibration isolation system is tested in one of the TAMA vacuum chamber at Mitaka.

optical baffle system in the arm cavities were finished in the last year, and the performance was estimated to fulfill KAGRA's requirement. One of the large baffles (400 mm diameter) should be installed in a cryostat (20 K), and the structure to support such a baffle is being discussed. The beam reducing telescope will sense the tilts of the main cryogenic mirrors in the 3-km arms, making it indispensable for the long-term stability of the interferometer operation. Its conceptual design was finished and some of the required optics were delivered.

(3) Mirrors Development

Sapphire mirrors are the most important optics for KAGRA. Therefore, tests to determine their quality are necessary. NAOJ GWPO already made a scatter-meter for the mirrors. It can measure the total amount of scattering with a level of 1 ppm. In FY 2014, an optical absorption measurement system was introduced in the TAMA experimental room. It has the potential to measure absorption less than 1.5 ppm/cm for the sapphire substrates. Now it is being fine-tuned to improve its stability.

2. Data analysis and theory

(1) Data Analysis Preparation

Based on the approved Grant-in-Aid for Scientific Research on Innovative Areas "New Developments in Astrophysics through Multi-Messenger Observations of Gravitational Wave Sources," preparations for multi-messenger analysis are in progress. To reduce the false alarm rate of the KAGRA detector, a physical environmental monitoring system is necessary. Now the system has been installed in the X-end room at the Kamioka site. The recorded data were analyzed by the KAGRA detector characterization sub-group. The noise veto information will be shared by GW search systems.

(2) Theoretical Research on General Relativity

General-relativistic higher-order perturbation theories have very wide applications for cosmology, black holes, and gravitational waves. Therefore, a framework for general-relativistic higher-order gauge-invariant perturbation theory has been discussed from a general point of view. In 2014 it was shown that the general framework developed by Dr. Kouji Nakamura is applicable to any-order perturbations on an arbitrary background space-time. In addition Dr. Nakamura together with Dr. Masaki Ando also proposed a precise derivation of the resultant response of a rotating torsion bar antenna when acted upon by gravitational waves.

3. R&D

(1) R&D for Upgrades of KAGRA

In parallel with the development of KAGRA, the GWPO continues to carry out an R&D program to prepare future detector upgrades. We seek external funds to support this program. In FY 2014 we completed a cryogenic infrastructure to test optical components for KAGRA at cryogenic temperature. In parallel we started a collaboration with the Institute for Molecular Science to study the quantum behavior of macroscopic objects. For this purpose, a large vacuum chamber was funded by NINS via an intra-institute funding program. Finally we started R&D to study the capabilities of mirrors based on crystalline coatings. The goal is to reduce the thermal noise in precision measurements based on optical cavities such as GW detectors. This project was funded by JSPS. In FY 2014 we also submitted to JSPS a larger scale project hoping to realize frequency dependent squeezed states of light using the TAMA infrastructure.

(2) DECIGO/DPF

In FY 2014 the DECIGO Pathfinder (DPF) proposal, submitted to JAXA for the next scientific mission, was rejected. One of the main reasons was the lack of available manpower since the gravitational-wave community in Japan is concentrating on the construction of KAGRA. However the scientific significance of DECIGO has been recognized by JAXA. So we revised the roadmap to DECIGO.

As a "pathfinder," we will do R&D on the ground and use airplanes to make a free-fall environment to test each unit developed for DECIGO. The revised R&D plan was submitted to JSPS and was approved.

In NAOJ, an interferometric sensor is being developed. In this fiscal year, we made a test bench with balancing masses ("yajirobee") for simulating the test masses to achieve free-fall in some degrees of freedom on the ground. The controllability of the masses are shown experimentally.

4. Education

During FY 2014 one master's student from SOKENDAI and one undergraduate student each from Ochanomizu University and from Tokyo University of Science did their research projects in the GWPO. All of them obtained their degrees. In addition, one PhD student from ICRR is continuing his research at NAOJ to do his thesis on the KAGRA vibration isolation system. The GWPO also hosted one PhD student from Niigata University under the NAOJ research visitor program; an undergraduate student from the USA under the International REU program in Gravitational-Wave physics funded by NSF; and two undergraduate students under the SOKENDAI summer student program. Within the SOKENDAI program we also hosted a master's student from the University of Pisa who then applied and was accepted as a PhD student at the U-Tokyo. The GWPO also contributed to teaching with regular classes given at the Department of Astronomy of U-Tokyo and at Hosei University. Punctual classes were given also at Ochanomizu University, the SOKENDAI summer school and at the department of Engineering of U-Tokyo.

5. Publications, presentations and workshops organization

The office members were authors of 34 publications in international journals and of 11 presentations to international

conferences. 30 presentations were also given to conferences in Japan.

During FY 2014 we organized the 6th Korea-Japan workshop that took place at NAOJ on June 20th and 21st, 2014. We also contributed to the organization of the Gravitational Wave Advanced Detector Workshop in Takayama in May 2014.

6. Outreach

KAGRA had a tunnel completion ceremony in July. Following this event, a TV program by NHK featured KAGRA and the office contributed to it. We also had an interview by Mainichi-shinbun about KAGRA yielding a newspaper article in January. The office contributed to the NAOJ open days in October by showing the TAMA facility and the ATC's clean room for assembling KAGRA components to the public. Visits to the TAMA facility were also given to several groups of high school students, college students, and people from private companies.

7. Relationships with industry

We continue the collaboration with a Japanese company aimed at improving the quality of low loss mirrors. In particular, we fabricated an ultra-low loss rigid cavity using the optical contact method. The specification for the reflectance of the mirrors is 99.999 % and the target loss factor is less than 5 ppm. The cavity is now under inspection.

8. Personnel

At the beginning of FY 2014 the project included a total of 14 personnel, including one specially appointed professor, two associate professors (one of which is affiliated with U-Tokyo), five assistant professors (of which one is assigned to ICRR), three engineers, two administrative staffs (shared with the Jasmine project) and one postdoc. During the year one postdoc, one specially appointed researcher, one specially appointed specialist and one research associate joined the team, so that at the end of the year the GWPO had 18 staff members. In addition one PhD student, one master's student and two undergraduate students did their research project in the GWPO. We also hosted a research director from CNRS (France) who visited our office for one-and-a-half months.

11. TMT-J Project Office

The TMT Project is a construction project to build an extremely large telescope with 30 meter aperture through the collaboration of five partner countries comprised of Japan, the United States of America, Canada, the People's Republic of China and the Republic of India. The TMT-J (TMT Japan) Project Office heads the project for NAOJ. In Fiscal Year 2014, an agreement was executed establishing the key project principles and work share assignment for TMT construction. TMT International Observatory was founded for the purpose of construction and operation of TMT and the commencement of the construction of TMT was declared. For its part in the construction, Japan is fabricating the primary mirror segments, designing the telescope structure, and designing/studying science instruments.

At the end of Fiscal Year 2014, 3 Professors, 3 Associate Professors, 1 Chief Research Engineer, 2 Specially Appointed Senior Specialists, 1 Research Administrator Staff, 2 Research Experts, 1 Research Supporter, 1 Public Outreach Official, 1 Specially Appointed Research Staff Member, 1 Specially Appointed Project Research Staff Member, and 2 Administrative Supporters were in full-time positions for the Project Office. In addition, 1 Professor, 4 Associate Professors, and 5 Assistant Professors from the Advanced Technology Center, Subaru Telescope and NAOJ Chile Observatory 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. Commencement of Construction by the TMT Project

The TMT-J Project Office of NAOJ has participated in quarterly TMT Board meetings held since 2007 as well as in the Science Advisory Committee and external review committee meetings to give shape to the international collaboration. By April 2014, this effort led to the execution of agreements by the final authorities of each participating organization that set the key principles and schedules for construction; work share and the basis for observing time allocation; and the establishment of the TMT International Observatory which would assume the role of constructing and operating TMT. In May of the same year, TMT International Observatory (TIO) was incorporated in the USA. At this point, the National Institute of Natural Sciences (NINS), National Astronomical Observatories of Chinese Academy of Sciences, University of California and California Institute of Technology became official members of the project by executing the project agreements. The Department of Science and Technology of India and National Research Council of Canada followed by becoming official members with the approval of the project budget in December of the same year

for India and April 2015 for Canada. Along with the 6 members, the Association of Universities for Research in Astronomy joined the project as an Associate Member representing the USA in anticipation of later becoming a full-fledged member. Japan also has a role in leading the international collaboration with a TMT Board Member representing Japan appointed as Vice Chairperson of the TMT International Observatory Board of Governors.

In July of 2014, commencement of construction was declared with the approval of a sublease from the University of Hawai`i to TMT International Observatory for the TMT construction site on the summit of Maunakea and the completion of all paperwork and procedures to use the land for construction. In October, a groundbreaking ceremony was held in Hawai`i and onsite construction commenced.

In Japan, the construction of TMT was approved as one of the new projects for the Promotion of Large Scientific Research Projects in Fiscal Year 2013 and fabrication of the primary mirror segments and preliminary design of the telescope structure was performed. In Fiscal Year 2014, in addition to domestic progress related to the fabrication of the primary mirror, detailed designs of the telescope structure, and the development of science instruments (explained below), Japan also initiated payments to TMT International Observatory to cover Japan's share of operating expenses that include onsite construction costs.

Figure 1: Conceptual image of TMT once constructed.

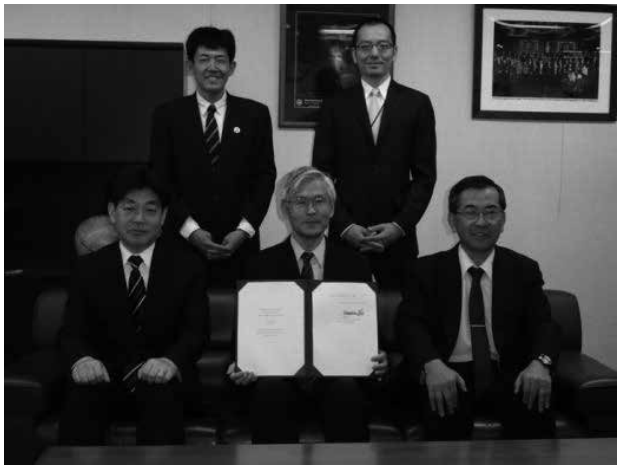

Figure 2: Execution of the TMT agreement by the President of NINS.

2. Japan's Progress on Its Work Share – the Telescope Structure and Fabrication of the Primary Mirror Segments

Japan is officially charged by the executed agreements with responsibility for the design/manufacture of the telescope structure, the primary mirror segments and sections of the science instruments.

(1) Fabrication of the Primary Mirror Segments

The plan for the primary mirror calls for Japan to fabricate all of the segment mirror blanks and to spherically grind the blanks as part of its work share. In 2014, 39 blanks were fabricated, 18 of which were spherically grounded. Because Japan is also in charge of polishing 30 % of the mirror segments, we developed and demonstrated technology with the capacity to mass produce aspherically polished segments. We also performed aspherical grinding on 15 segment blanks.

(2) Design of the Telescope Structure and Its Control System

The plan for the telescope structure is to have the detailed design of the telescope completed in 2 years starting from Fiscal Year 2014, based on the preliminary design from Fiscal Year 2013. The control system of the telescope structure passed its preliminary design review in April 2014, followed by the primary mirror segment exchange mechanism (Segment Handling System) in November, enabling both to continue on to the detailed design phase. In addition, fabrication and evaluation of prototypes are underway for large structures that are difficult to fabricate and require fabrication with extreme precision. In February 2015, the first design review was held for the main telescope structure.

(3) Science Instruments

Japan is responsible for fabricating a portion of the first-light instruments as part of the international collaboration.

Japan is in charge of fabricating the imaging component for the Infrared Imaging Spectrometer (IRIS). In fiscal year 2014, optical design of the imaging system that will enable the addition of a highly demanded high-contrast optics system and wide-field capability in the imaging system was proposed to the TMT Science Advisory Committee and approved.

For the Wide Field Optical Spectrometer (WFOS), Japan continued its conceptual study from Fiscal Year 2013 in anticipation that it will be placed in charge of the camera system. The availability of high quality large diameter glasses for the camera system was confirmed through investigations.

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

Continued effort is made to reflect the opinions of the

community through actions such as the TMT-J Science Advisory Committee (TMT-J SAC). A tool for evaluating science observation performance in the preparation of proposals for scientific research to be undertaken with TMT was proposed by TMT-J SAC and is being developed by the TMT-J Project Office. It has been made internationally available and has been used by many researchers. 14 special feature articles on TMT with a brief overview of the project, current status of construction, and science feasibility studies were published in three special issues of the Astronomical Herald of the Astronomical Society of Japan.

While the Science Advisory Committee of the TMT International Observatory performed a central role in studying the scientific research feasible with TMT, Japan played a major role in the TMT International Science Development Teams (ISDTs) established in 2013 with researchers from Japan participating as conveners in five of the eight science categories.

The TMT Project, particularly the status of Japan's work share, is introduced on the TMT-J Project Office home page. Preparations were made to update the English web page to make information about the progress made on the project by Japan available overseas. TMT Newsletters volumes 40 to 43 were delivered. Public outreach was undertaken by performing lectures all over Japan and through exhibits made available through organizations such as the NINS Symposium and Inter-University Research Institute Symposium. Continued efforts to raise donations for the TMT Project resulted in donations from one corporation and 732 individuals in 2014 (between January and December).

With the support of "Club TMT" formed in 2012 to support the project, TMT was introduced in screenings and lectures at science museums and planetarium all around Japan. About 50 lectures and classes on demand were held for the public.

Public relations/outreach and contributions to workforce development and education were performed by Workforce Pipeline, Education, Public Outreach and Communications (WEPOC), an international study team. In October 2014, WEPOC opened an assembly in Tokyo where outreach activities performed within Japan and at the Subaru Telescope in Hawai`i, as well as Hawai`i instruction courses for high school students that included visits to the Subaru Telescope were introduced. Activities of the assembly also included visits to science museums.

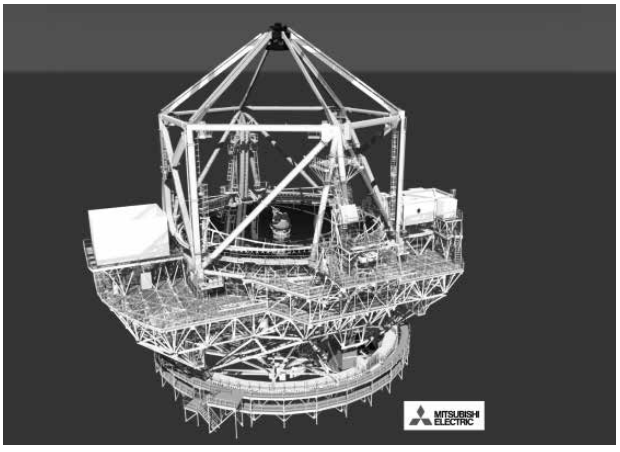

Figure 3: Detailed design of the telescope structure in development.

Figure 4: Aspherical grinding of a primary mirror segment.

12. 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 μ) measurements of annual parallaxes, proper motions, and celestial coordinates of the stars at a high accuracy 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 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 motion and annual parallax. 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 2021. 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 2030s. 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 2014

1) Organization of the office

The JASMINE Project Office is composed of four full-time staff members, six staff members with concurrent posts, two postdoctoral fellows, one research associate, one technical associate, and four graduate students. Significant contributions were made by members of the following organizations: the NAOJ Gravitational Wave Project Office; Kyoto University's Graduate School of Science; the Systems Engineering (SE) Office, Aerospace R&D Directorate (ARD), and 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 technical experience in onboard data acquisition and the like necessary for the upcoming JASMINE project, achieve scientific results in the study of dynamical structures in the vicinity of the Solar System, and the analysis of star formation based on stellar motions in star formation regions.

The satellite is 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 postponed due to delays in construction work at the Alcantara Space Center launch site in Brazil. On the other hand, the construction of the rocket has been completed, and work on interface adjustment between the rocket and the satellite is in progress. 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. The project has continued to prepare terrestrial communication stations related to satellite operation. 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. The Gaia Project involves observational and analytical methods similar to those of Nano-JASMINE. A Japanese WG led by Ryoichi Nishi of Niigata University continued to engage actively in investigating the scientific results obtained in the future by Nano-JASMINE.

3) Overview of Planning and Developing 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 10−20 μas and proper motions, or transverse angular velocities across the celestial sphere, at 10−50 μas/year in the direction of an area of a few degrees from 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 a compact object in a 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, ARD, 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, continued to consider the design of the satellite system to ascertain the target precision in astrometric measurement as a general objective in preparation for submitting a mission proposal for the ISAS call for small-sized scientific satellite mission proposals. The name and submission requirements were altered in FY 2013; it is now known as Epsilon onboard Space Science Missions. 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. As planning progressed, the full mission proposal was prepared and submitted in February 2014. Although Small-JASMINE was not selected as a final candidate, it should be remarked that the evaluation committee gave Small-JASMINE high scores. Furthermore the evaluation committee suggested a specific needed improvement. To date, we have already promised that Small-JASMINE can make this improvement. We have been making a revised mission proposal in preparation for the next ISAS call for proposals.

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, an identical model to that of APOGEE. The joint proposal has been submitted. An official memorandum of understanding has been exchanged among the APOGEE-2 team and 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.

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

The Extra-Solar Planet Detection Project Office (EPO) will manufacture/maintain large-scale instrumentation and develop new technologies and observational methods for exoplanet research. The goal is to make contributions as a center of excellence in this field and promote observations of exoplanets and studies of their formation. The EPO promotes not only instrumentation, but also cutting-edge observational research using these state-of-the-art instruments in collaboration with domestic and international researchers. The science themes are not limited to exoplanets and their formation. They also include brown dwarfs and star/planet formation. The main themes in the last 5 years are:

(1) The development/upgrade/maintenance/operation of the high contrast imager HiCIAO and the promotion of the SEEDS survey project.
(2) The development of the new IR Doppler instrument IRD and planning its observations.
(3) The development of the high contrast instruments SEIT (for TMT) and WACO (for WFIRST, formerly SPICA/SCI and JTPF activities.)
(4) The instrument development and maintenance for smaller telescopes (Okayama/MuSCAT multi-channel optical camera, IRSF/SIRIUS 3-band infrared camera and IRSF/SIRPOL 3-band infrared polarimeter).

In FY 2015, the project consisted of 5 main staff members, 3 joint appointment staff members, and 5 postdocs. There were 36 refereed papers in English, 4 non-refereed papers in English, 14 presentations in English, 1 refereed paper in Japanese, 2 non-refereed papers in Japanese, 5 books in Japanese, and 49 presentations in Japanese.

1. Development of the Subaru next Generation Exoplanet Instruments and Exoplanet Observational Researches

(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 with the 8.2 m Subaru Telescope, which can utilize various differential imaging techniques to distinguish polarization, multi-band observations, and angles. The project started in 2004 and its performance verification was completed in 2009. The main survey of first Subaru Strategic Program SEEDS (Strategic Explorations of Exoplanets and Disks with Subaru) with more than 100 people continued from October 2009 until January 2015, without any serious troubles.

(2) IRD (Infrared Doppler Instrument)

IRD is a high precision (~1 m/s) radial velocity spectrometer working at near-infrared wavelengths. It's 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 (PI: Motohide Tamura). The final manufacturing of the main componets, fiber experiments, laser frenqucy comb, and total asemble are being conducted. Science discussions on habitable planets around M dwarfs are also proceeding.

2. Exoplanet Instrument Developments for Future Space and Ground-Based Telescopes and International Collaborations

(1) WACO (WFIRST-AFTA Coronagraph) and JTPF (Japanese Terrestrial Planet Finder)

These missions aim to directly image and characterize Earth-like planets and super-Earths for signatures of life. As a member of the WACO working group, coronagraph performance tests at the JPL testbed are conducted with collaborators with other Japanese collaborators.

(2) SEIT (Second Earth Imager for TMT)

The aim of the SEIT instrument is direct imaging and characterization with the 30 m telescope TMT. Both technical and science discussions are being conducted, including optical demonstration tests.

3. Science Research, Education, and Outreach

The SEEDS project was successfully completed in January 2015 without any major troubles. In this year, a planet (< 15 Jupiter masses) is confirmed at r ~ 47 au around Herbig Ae star HD100546. The planet is not point-like but extended, probably suggesting the presence of circum-planetary structures. Spiral structures are also detected in the protoplanetary disk.

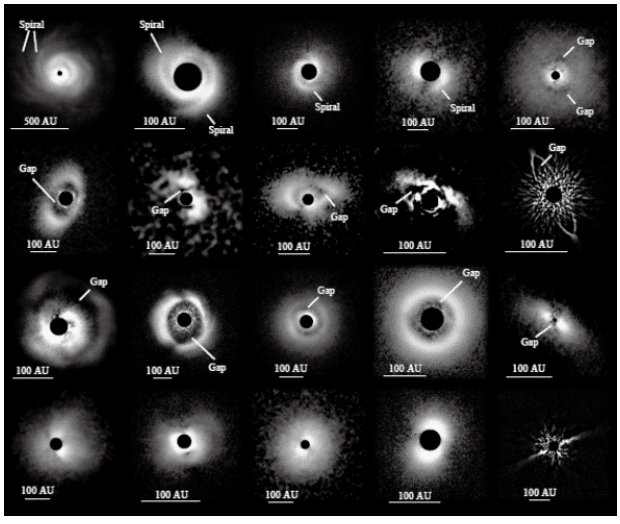

Figure 1: A gallery of protoplanetary and debris disks detected by the SEEDS project in near-infrared wavelengths.

A statistical survey of ~250 SEEDS stars was made and the frequency of stars having objects at 10−100 au around them with masses between 5−70 Jupiter-masses is about 2 %. W. M. Keck Observatory and the Subaru Telescope were used in cooperation for a survey of 120 M stars to search for giant planets.

The SEEDS also directly imaged many protoplanetary disks. It detected scattered light for the first time, which revealed asymmetric structures of the disk around a young star IRS48 (a.k.a. WLY 2−48). A review paper was published on the direct imaging of protoplanetary disks around Herbig Ae stars. An international collaboration using Hubble Space Telescope observations detected about 10 debris disks.

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

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

1. Component Technology Development for Future Lunar/Planetary Exploration Projects

(1) Radio Source for VLBI Observation of Lunar/Planetary Gravity Field:

In 2014, a new lunar gravity field model was publicized based on the recent observations by the GRAIL lunar explorer. The tidal Love number derived from the new gravity model has improved more than expected, and its accuracy exceeds our scientific goal for SELENE-2 VLBI. Therefore, we were required to revise thoroughly our development plan.

i) Analysis of Electric Property and Thermal Tolerance of Macor Antenna

Because financial support from the SELENE-2 mission was terminated when the mission was halted by JAXA, we cancelled fabrication of the Breadboard Model (BBM) for the antenna board. Instead, in the context of future lunar/planetary explorations and component technology development, we investigated the electrical properties of the Macor material that comprises the base substrate of the antenna. We measured the dielectric constant of the base substrate material in relation to changing ambient temperature in a vacuum chamber simulating the environment on the surface of the Moon (−200 °C to +120 °C). The test results have been accepted by a peer-reviewed international journal.

ii) Studies of the Internal Structure of the Moon

Investigation for the elastic and viscous structure of the deep interior of the Moon continued in FY 2014 by combining the selenodetic and seismic data. The expected accuracy of the internal structure based on the accuracy of selenodetic observations was studied quantitatively and submitted to an international journal.

iii) Discussion for Providing Two Beams for the S and X Bands in the 20-m VERA Antenna

Same-beam S-band VLBI observation had been considered for the primary method of differential VLBI observation between the orbiter and the lander. The Vivaldi antenna was selected as the model to be adopted. An antenna element was designed using electromagnetic analysis software, and its shape was optimized. A computer simulation confirmed that the antenna is able to perform at the required performance level.

(2) Development Experiment for Lunar Laser Ranging (LLR)

The distance between the Moon and the Earth can be accurately measured by transmitting a laser from a telescope on Earth to laser retroreflectors that were placed on the lunar surface by the US Apollo missions and Soviet lunar exploration missions and observing the reflected photons, thereby allowing for investigation of lunar rotational variations. Due to the lack of reflectors in the southern hemisphere and the time difference between the two ends of reflector arrays generated by libration, the level of precision has hitherto been insufficient for determining small variations in the process of energy dissipation in the lunar interior.

Aiming to fabricate an LLR retroreflector to be mounted on the lander, material selection and mirror-forming methods were investigated. Preparatory technological development was pursued in conjunction with a tri-party agreement with the Chiba Institute of Technology and Tokyo University of Science, aiming to utilize Ion Beam Figuring (IBF). Monocrystalline silicon and glass ceramics to be used as the mirror material were tested and their stability was verified in a simulated lunar surface environment in a thermal vacuum chamber. Instead of Clearceram-EX, monocrystalline silicon was selected as the best mirror material for thermal-structural and optical analyses.

(3) Development of In Situ Lunar Orientation Measurement (ILOM) Telescope

Research is underway to install an ILOM, which is like a small Photographic Zenith Tube (PZT) telescope, on the lunar surface and to perform high-precision observations of lunar rotational variations to constrain the internal structure of the Moon. Because measurement can be conducted independent from lunar orbital motion, this small telescope is capable of detecting miniscule variations in the rotation of the Moon, allowing us to determine whether or not the lunar core is molten.

The mercury pool developed in FY 2013, which is less

susceptible to vibration, was installed in the Breadboard Model (BBM) of the telescope. The imaging performance of the BBM was examined by using an artificial light source; we determined the relationship between variations of the star-image center, ground vibrations, and the inclination of the telescope tube. Also, the frame of the telescope for ground observation was fabricated.

(4) Development of the Laser Altimeter (LIDAR) of Hayabusa 2

i) ranging tests using a flight model, hardware tests using ground support equipment, and accuracy estimation for asteroid surface albedo calculated through the intensity ratio of the transmitted and received lasers.

ii) development of a quick-look software and verification during the integration tests.

iii) theoretical calculation of the size and density of circum-asteroid dust for hardware development.

(5) Development of a Ganymede Laser Altimeter (GALA) for the Jupiter Icy Moon Explorer (JUICE) Mission

GALA was officially selected by ESA as one of the JUICE mission payloads following a proposal submission in FY 2012, and the RISE Project Office officially commenced activities as a main GALA-Japan team member. Japan will undertake the development of a receiving telescope as a part of the laser altimeter system.

i) detailed laser link calculations (performance model) to serve as the basis for the hardware design.

ii) deliberation on the specifications for the thermal–structural analysis to be outsourced to a manufacturer.

iii) The RISE Project Office leads the gravity/rotational variation subgroup within the Japanese part of the science team.

3. Educational Activities/PR

Six RISE members delivered lectures on a part-time basis to graduate students at the University of Aizu for two semesters; and two RISE members served as part-time lecturers at Iwate University for a half year each. The office accepted two undergraduate students from Iwate University through an internship program, and one undergraduate student from Kobe University in the summer student program of the Graduate University for Advanced Studies (SOKENDAI).

4. Joint Research/International Collaborations

'The Memorandum on Basic Issues Concerning Research and Development of Scientific Instruments for Lunar Landing Exploration' was renewed between members of the RISE Project Office and the Faculty of Engineering at Iwate University in FY 2014. In accordance with this memorandum, joint research into the basic development of a lunar lander/explorer (LLR and ILOM) is conducted by the Faculty of Engineering at Iwate University, with monthly meetings held alternately at Iwate University and NAOJ Mizusawa Campus.

Joint research continues with a group from Kazan Federal University, Russia, which is well respected in theoretical investigation into the internal structure of the Moon, to establish a new theory of lunar rotation, in line with 'the Memorandum of Understanding for Cooperative Research between Kazan Federal University and National Astronomical Observatory of Japan on VLBI and Astrometrical Observations,' which was renewed in 2010. A two-day workshop on the internal structure of the Moon was held at Mitaka and Mizusawa Campuses using a Grant-in-Aid for Bilateral Research from the Japan Society for the Promotion of Science. Seventeen Russian scientists attended at this workshop and visited the RISE office in Mizusawa.

15. Solar-C Project Office

The SOLAR-C Project Office engaged in planning the next solar observation satellite project, SOLAR-C, and implemented the preparation of the flight components for the Chromospheric Lyman-Alpha SpectroPolarimeter (CLASP) to be flown on a sounding rocket experiment. In Fiscal Year (FY) 2014 the JAXA SOLAR-C working group (WG) led by Prof. Watanabe submitted the SOLAR-C proposal for the JAXA Strategic Middle-Class Satellite Mission. The CLASP team has executed the assembly and testing of the CLASP flight model in the ATC cleanroom for the flight operation scheduled in the summer of 2015.

1. SOLAR-C Project

SOLAR-C is a planned project which may become Japan's fourth solar observation satellite, after Hinotori, Yohkoh, and Hinode. The plan is to realize the launch in the early years of the 2020s. The project is intended to investigate the solar magnetic plasma activities that influence space weather and space climate around the Earth. The investigations will be the first to involve the chromospheric magnetic-field and achieve high-resolution imaging/spectroscopic observations from space. The themes include major problems in solar research: the heating of the chromospherice/corona, the origin of solar explosive events, and variation in the solar spectral irradiance. The tasks include resolving the fundamental small-scale magnetic structures derived directly or indirectly from the Hinode observations and visualizing the activities and interactions of magnetic structures. SOLAR-C will conduct high-resolution (0.1−0.3 arcsecs) observations of radiance, polarization, and spectroscopy over the outer atmosphere from the photosphere to the corona by using onboard instruments. The instruments for SOLAR-C consist of SUVIT with a 1.4 m aperture for observing the photosphere and chromosphere; EUVST for spectroscopic observation from the chromosphere to the corona; and HCI for capturing images of the transition region and corona. 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, satellite, and one of the major science instruments, whereas the USA and European space agencies and institutions will deal with other major instruments through a large-scale international collaboration.

The main body in this project is the Next Solar Observation Satellite Project Working Group led by Prof. Watanabe, NAOJ, set up within the Advisory Committee for Space Science at ISAS/JAXA. NAOJ researchers play key roles in the project activities. The SOLAR-C Planning Office was set up at NAOJ in FY 2008 as a sub-project in the Hinode Science Center, dedicated to the SOLAR-C project. It was promoted to become the SOLAR-C Project Office in FY 2013 as an A-project independent from the Hinode Science Center. It continues the preparatory work for the satellite project with four full-time staff members and 11 members with concurrent positions/postdoctoral fellows.

2. 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 of the hydrogen Lyman-alpha spectrum. Planning and basic development of the project started in FY 2009. The project involves an international research team with participation from Japan, the USA, and other countries. The CLASP project entered the development stage fully in the latter half of FY 2012, and received a prospective development budget for the flight equipment during FY 2013. The payload consists of a far-ultraviolet (FUV) telescope and a spectro-polarimeter to conduct polarization observations which were prepared in Japan, with components contributed by the USA (CCD cameras and control computers) and France (a spherical concave grating). The system then will be mounted on an American sounding rocket for launch in the USA in summer 2015. The Japanese PI is R. Kano, an assistant professor at the NAOJ, who leads postdoctoral fellows and assistant professors to pursue design, instrument development, and testing.

3. Major Activity in FY 2014

The major activity on SOLAR-C in FY 2014 was to make and submit the SOLAR-C mission proposal for the JAXA Strategic Middle-class Satellite Mission. The JAXA SOLAR-C WG helped the European scientists with making another SOLAR-C proposal for the ESA M4 opportunity, which was submitted in Jan 2015 to get development funds for the European contribution. The WG submitted the mission proposal to JAXA in Feb 2015. Both examination outcomes will come in the early part of FY 2015.

The instrument assembly, testing, and calibrations were performed on CLASP for the flight operations in summer 2015. For the installation of components supplied by the USA partner group, the USA scientists and engineers joined the assembly and test activities in Japan. The CLASP project has received significant contributions from the ATC in design, fabrication of necessary components, and testing of some of the flight models.

4. Others

Although the SOLAR-C Project Office is reimbursed by the 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 experiment of onboard instruments, and research grants from the private sector.

T. Kobiki is going to leave the SOLAR-C project at the end of FY 2014 and T. Bando is going to move to another project in May 2015.

16. Astronomy Data Center

1. Introduction

The Astronomy Data Center (ADC) is a central core of computing and archiving for astronomical data and supports scientists around the world through the provision of our wide variety of data center services. In addition, ADC is driving forward research and development programs for future generations of services. Our activity is organized into the DB/DA Project, Network Project, JVO Project, Project for HSC Data Analysis/Archiving Software Development, and the Open-use computer system and service.

2. ADC Report

(1) DB/DA Project

The DB/DA-project conducts research and development on astronomical databases 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 presents archival data of the 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 more than 10 million frames (54 TB) as of May 2015. SMOKA contributes to many astronomical products. The total number of refereed papers using SMOKA data is 173.

(2) Network Project

The network project designs and operates NAOJ information network infrastructure for the Mitaka Headquarters and the branch offices. The noteworthy topics of this fiscal year are as follows.

1) Upgrading International circuit between Tokyo and Hawai`i: NAOJ operates a high bandwidth network between Hawai`i and Tokyo for transmitting the huge amount of science data from Subaru Telescope. In this year, we upgraded from ATM based 155 Mbps circuit to Ethernet based 1 Gbps circuit. Also we started a NAOJ data center service in Honolulu and the NAOJ network has been connected to the Honolulu Internet exchange (HIX) and the DRF Internet service provider in the United States.

2) Mizusawa 10 Gbps R&D Project: We are continuing R&D for high traffic data transfer architecture for science data exchange on Mizusawa 10 Gbps circuit committed to the NICT JGN-X project. In this year, we made a partnership with Intel and are now implementing "Renjyaku+" which is based on the Intel Data Plane Development Kit. It's able to exchange digital data with an actual transmitting rate over 100 Gbps.

(3) JVO Project

We continued development of JVO portal version 2. We implemented basic functions such as, "Quick Search," "Basic VO Search," "Parallel VO Search." We also implemented functions to display the search progress, to view the search results, and to access data stored on JVOSpace. We added a new feature to the JVO/ALMA data archive which enables users to search data based on the observed frequencies. The JVO/ALMA data archive system was demonstrated at the ASJ meeting held at Yamagata University. A cross identification system was developed to identify the same objects among big catalogs, which enables cross identification from 20 billion records in 10 minutes. VO school was held in January 2015, and three participants learned how to use the JVO portal and several VO tools. The all-sky image data taken by AKARI/FIS have been incorporated into the JVO database system, and they are now accessible with the VO interface.

(4) Project for HSC Data Analysis/Archiving Software Development

This project started in January 2009. The main purpose is to develop the data analysis pipeline and data archiving software for Hyper Suprime-Cam (HSC). Our main efforts are concentrated on the implementation of the software to achieve effective data analysis/archiving by parallel and distributed processing; precise photometric and astrometric calibrations; and correction of various effects originating from the camera system.

The Strategic Survey Program (SSP) using HSC began in March 2014 and we started to have stable large data output (about 300–400 GB per night). We ran the data analysis pipeline software on the data, produced databases storing the results, and released them to the SSP team collaborators twice during the fiscal year (in September 2014 and February 2015). The amount of released data is about 50 TB, the number of image files is 200 thousand, the number of objects listed in the released catalog is about 80 million and the database size is about 2 TB. We've developed various software for getting images or catalog data using the database through web browsers, and they are now operating stably. We are planning to improve the usability and to also add many functions for effective data search/retrieval to accelerate scientific activities based on the released data. The computers/hardware for the data release are in stable operation and software with minimum functions is in the operational phase. Improvements to the functions and new development for the data analysis pipeline software are still essential for achieving the planned accuracies for the calibration/measurement of celestial objects in the images. The on-site data analysis system developed since 2011 is now in the operational phase, and performed well in SSP and open-use observation with observer support tools, such as an observation log viewer, which allows browsing of the data analysis results through a web browser. This is a large contribution towards the smooth operation of the Subaru Telescope.

(5) 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 2014, the total number of users and data requests were 384 users and 31 TB, respectively.

During the course of inter-university research, we also held or supported some workshops on using software and systems. The dates and numbers of participants in FY 2014 were as follows.

1. SOKENDAI summer school, July 31–September 8, 2014, 3 users (Supported)

2. Subaru autumn school 2014, September 24–26, 2014, 12 users

3. ALMA CASA tutorial, October 29, 2014, 32 users (Support)

4. IDL School for FITS analysis, December 9–10, 2014, 12 users

5. *N*-body simulation winter school, January 26–28, 2015, 13 users

6. VO School, February 26–27, 2015, 3 users

7. SQL school, March 3–4, 2015, 7 users

In FY 2014, the schools were held a total of 7 times for 82 users.

3. Others

As part of outreach and promotion activities, 90 issues of "ADC News" were published from No.386 to No.436 in FY 2014. The news was distributed by e-mail to users and appeared on the ADC webpages.

17. Advanced Technology Center (ATC)

1. Organization and Summary of Activities in ATC

The Advanced Technology Center has been working on developments for astronomy instruments in general. Our programs are divided into "prioritized area developments" and "advanced technology developments" to meet requirements for both current on-going astronomy programs and for future programs.

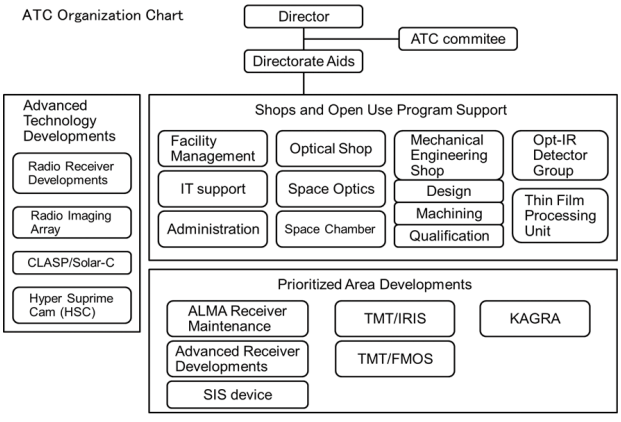

Figure 1: New Organization Chart of ATC from October 2014.

The development of ALMA receivers has been one of the "prioritized area developments," and their fabrication and shipment were concluded in FY 2013. In FY 2014, some of the receivers with degraded performance were sent back to ATC for maintenance. In the ATC management committee, discussions were held about reorganizing ATC for ALMA receiver maintenance and other development activities. The new ATC organization shown in Figure 1 started in October 2014. ALMA receiver development teams were divided into three groups, which are "ALMA receiver maintenance", "advanced receiver development," and "telescope receiver development." The "telescope receiver development" group works on receiver developments within the common use programs.

The "prioritized area developments" includes instrument development for IRIS, to be used with the Thirty Meter Telescope (TMT), and for the gravitational wave telescope KAGRA. The design and production of equipment have been supported by the mechanical engineering shop (ME shop). Another "prioritized area program," Hyper Suprime-Cam (HSC), started observations in March 2014.

The "advanced technology developments" includes development for radio imaging arrays, the solar-observing rocket-borne instrument CLASP, and others. CLASP is scheduled to be launched in summer 2015.

The oversight committee of ATC with non-NAOJ members

discussed ATC activities on current projects and R&D for future programs. In FY 2014, ATC activities for ALMA receiver development were reviewed and will feedback to ongoing programs such as TMT. R&D programs will be reviewed in FY 2015 accordingly.

2. Workshops and Development Support Facilities

(1) Mechanical Engineering Shop (ME shop)

The aim of the ME shop is to work on design, machining, and evaluation of astronomy instruments, in other word to support astronomy "MONOZUKURI" (fabrication). Three teams for the corresponding functions (design, machining, and evaluation) work efficiently using their advanced skills.

The design team worked hard on structural designs of KAGRA's auxiliary optics subsystem (AOS) and TMT/IRIS's focal plane assembly.

For KAGRA, the following items have been performed:
- Design of mirror mount for BRT (Beam Reducing Telescope)
- Vibration analysis of the BRT structure
- Design, assembly, and evaluation of mirror suspension XYθ traverse mechanism
- Assembly of six 'bottom filters'
- Mechanical design and vibration analysis of Type-Bp mirror suspension
- Vibration analysis and improvement of Type-A mirror suspension

For TMT/IRIS, the following items have been performed:
- Design of atmospheric dispersion corrector (ADC), cold stop, filter exchange mechanism and detector mount
- Test fabrication and evaluation of ADC
- Test fabrication of the filter exchange mechanism
- Vibration test of a kinematic lens cell
- Design and fabrication of a medium-sized cryogenic vacuum chamber.

For other programs, there were the following items:
- Support of HSC on-sight evaluation
- Design of a universal support mechanism for ALMA receivers
- Design of a 4-element horn array and a detector mount.

The machining team worked on KAGRA and TMT/IRIS instrumentation as well as numerous requests from NAOJ and non-NAOJ users. For KAGRA it machined 11 sets of bottom filter parts on schedule; this followed the proto-type machining in the previous year. One of the materials for the bottom filter 'maraging steel' with high stiffness was successfully machined within the required accuracy. In FY 2014, an additional request was received to machine the 'recoil masses' from the material Ti-6Al-4V. After test fabrication of 2 sets of recoil masses, 8 sets were successfully fabricated. For TMT/IRIS, mechanical parts and interfaces for ADC were fabricated after component evaluation feedback, which all serves to help realize cryogenic operation of the instrument. Other machining includes kinematic mounts made of invar for CLASP; a waveguide for the ion-engine of ISAS; and waveguide and horn components for radio imaging array development.

In the field of super-precision machining, work has been done in collaboration with other institutes and upon users' requests for precision machining. In one of the collaborative programs, we performed super-precision milling using single-crystal diamond tools in collaboration with the High Energy Accelerator Research Organization (KEK). The program aimed to achieve efficient machining of a mirror surface for the X-band acceleration disk; test fabrication and evaluation were performed. Another collaborative program was conducted with the Institute for Molecular Science and Nagoya University. This one, which continued from FY 2013, involved machining MgF2 aspherical lens using a single-crystal diamond tool and was successfully concluded. For submillimeter-wave camera development, wide-band corrugated feed-horns have been fabricated by a milling process, which resulted in good performance, and machining started for a 4-element corrugated feed-horn array.

The ME shop accepted 132 machining or repair requests in FY 2014. With 7 programs carried over from FY 2013, 133 out of 139 programs have been concluded and 6 programs are carried over to FY 2015. There were 7 programs requested from outside NAOJ. The following table shows the requests in FY 2014. (Numbers in the parenthesis show the programs carried over to FY 2015.)

Carried over from FY 2013	7
ATC	23 (3)
HSC	1
TMT/IRIS	10
KAGRA	17 (2)
SOLAR-C/CLASP	36
Solar Observatory	6
Subaru Telescope	1
ALMA	7
ASTE	1
RISE	2
ADC	2
Exo-Planet	13 (1)
JASMINE	4
FOREST	1
Other Divisions	2
Outside NAOJ	
U Tokyo	4
JAXA/ISAS	2
Total	139 (6)

(2) Optical Shop

A. Management and maintenance
- Measuring instrument maintenance (such as daily inspections)
- Technical consulting for users: 67
- Repair and upgrade

Interferometer ZYGO-GPI alignment camera exchange
Solid Spece-3700 repair
Replacement of HEPA filters in the optical shop

B. Open use of measurement instruments (April 2014 - March 2015)
• The number of annual users: 391
ATC internal: 159
NAOJ and the Institute of Astronomy, University of Tokyo: 196
Other organizations: 36
• Use of LEGEX910 (large-scale 3-D measurement machine): 37
ALMA and HSC: 13
Measurement requests to the optical shop: 24
Number of operating days: 50

(3) Optical and Infrared Detector Group

The group supports domestic and foreign instrument groups who use fully-depleted back illuminated CCDs (FDCCD). Since last year, at the request of a domestic group we have upgraded and tested a cryogenic dewar and a cooler for Kyoto3DII camera, a PI instrument of Subaru Telescope. This new camera will operate on the telescope in FY 2015. Furthermore, for foreign instrument groups using FDCCDs, we responded to their requests by e-mail, upgraded the manual on the website, and also conversed with them at conferences. We also attempted to set up an evaluation system for the detectors of the Solar-C project, which will be evaluated in FY 2015.

(4) Thin Film Processing Unit

For the SuMIRe (Subaru Measurement of Images and Redshifts) project, we fabricated wideband anti-reflection coating on the micro-lenses of input optical fibers. The 3500 lenses were coated successfully by high performance multilayer. The lenses are being evaluated at Subaru Telescope.

(5) Space Chamber Shop

The shop supports common use programs that use vacuum chambers and equipment in clean rooms. Major common use programs include usage of the vacuum chamber at the Institute for Molecular Science to evaluate the CLASP instrument using the UVSOR synchrotron facility, as well as usage of the space chamber in the ATC clean room for various thermal analyses under vacuum. The next generation solar observing satellite program, SOLAR-C, used the space chamber for a variety of experiments. Another program, the Wide-field Imaging Surveyor for High-redshift (WISH), used the facility to evaluate cryogenic motors for the filter exchange mechanism. Subaru Telescope used the facility to evaluate optical filters for instruments. Another small vacuum chamber is often used for out-gas measurements, and a thermostatic oven was used for thermal cycle tests of various components.

(6) Facility Management Unit

This unit manages 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.

Concerning the building facilities and equipment, we changed the lighting apparatus from old fluorescent lamps to new LED balls in 5 laboratories and a machine shop. Illumination was largely improved in each laboratory, and in the machine shop it became bright enough for precision machining anywhere in the room. The coolant water circulation facility underwent annual maintenance and the rust was removed from the duct line. However, an accidental break down of the pump occurred and users had to rely on public tap water for a period. All the crane facilities had annual maintenance, and a 4.8-ton crane had an additional check of its load bearing ability. After an inspection by the Labor Standards Inspection Office, it was revealed that four sets of fume hoods did not meet the required ventilation performance for toxic fumes. In addition, one of the fume hoods needed to neutralize fumes from hydrogen fluoride-based solvent, and a so-called Scrubber is to be installed. Most of the organic solvents, oils, and fats are now stored in a separate hazardous material storehouse. In addition, the unit cooperated with a new building under construction for the TMT program which will be completed in FY 2015.

Concerning the laboratory usage including clean rooms, the main users are ATC members, KAGRA, TMT, the Division of Radio Astronomy, HSC, JASMINE, the Division of Optical and Infrared Astronomy, the Exo-planet team, Subaru Telescope, and the SOLAR-C/CLASP team. KAGRA used a clean room in the south building and CLASP used one in the north building. The CLASP team finished instrument evaluation before March 2015, and was prepared to launch from the United States of America in summer 2015.

3. Open Use Programs

In FY 2014, ATC announced and accepted open use programs twice a year. ATC facilities were used for 7 “collaborative development programs” and 30 “facilities use programs.” Information about these programs is presented in “Common use of ATC facilities” with names of the leaders and research titles. Reports from the open use programs are also presented on the ATC homepage.

4. Prioritized Area Developments

(1) ALMA Band 4, 8, 10

In the ALMA project, mass-production of the Band-4, -8, and -10 receiver cartridges (the development of which Japan is responsible for) and their shipment to Chile were completed within FY 2013. In FY 2014, problems occurring at the Chile site were responded to, and in September, while some of the work still remained, the PAS (Provisionary Acceptance on-Site) tests were completed.

The teams “ALMA receiver maintenance”, “advanced receiver development” and “telescope receiver development” have been created by reorganizing the previous receiver development teams for Bands 4, 8, and 10. The purpose of this was to formalize the framework for receiver cartridge maintenance, to be able to broadly apply the technology

cultivated through the development of ALMA to other telescope receivers, and to propel forward the development of advanced receivers for the future. Under the strong leadership of the director of ATC, work efficiency has been improved by coordination between teams for appropriate placement of personnel, and by sharing instruments and equipments.

Regarding the ALMA project, the "ALMA receiver maintenance" and "advanced receiver development" teams will continue to be placed in the category of "prioritized area developments." With respect to the maintenance of ALMA receivers, we will steadfastly carry out the maintenance of receiver cartridges for Bands 4, 8, and 10. In addition, with regard to "advanced receiver development," we will push forward with receiver development that supports the future of ALMA, such as wide bandwidth, multi-pixel, and higher frequency receivers. Also, "telescope receiver development" will be placed in the "advanced technology developments" and we will push forward with the development of receivers to be installed in telescopes such as the Nobeyama 45-m Telescope and ASTE.

(2) Hyper Suprime-Cam (HSC)

HSC has been used for the regular science operations since March 24, 2014. This includes both Subaru Strategic Program and normal open-use observation. During FY 2014, the number of nights allocated to HSC program was April: 11 nights, June: 18 nights, September: 16 nights, November: 19 nights, January: 12 nights, March: 19 nights; for a total of 95 nights (including engineering nights). We lost four nights in June due to camera hardware trouble. Several incidents occurred simultaneously including shutter failure due to the battery of the real time clock running out and hardware trouble in the HSC control computers. Because the prime focus is hard to reach, it took more nights to solve all of these problems. In the early part of FY 2014, we had minor troubles with the mechanics of the shutters and the filter exchangers which affected the operation. We had a great deal of supports from ATC engineering staff near the end of 2014, and all of the problematic mechanics were fixed. As a result, most of the troubles never occurred during the last two observing runs in Jan.–March.

Through the engineering runs we confirmed the expected image quality as well as the throughput of the camera. Using the engineering runs, we improved coordination between HSC and the telescope control software to make things run parallel. This enables efficient observation; 90 % of the usable time is now dedicated to science exposures.

We have a couple of left over items for FY 2015 including the investigation and replacement of problematic CCDs, the development of the throughput monitoring system, and a new single lamp flat field system.

(3) IRIS Instrument for TMT

We have been continuing development of the IRIS instrument for the Thirty Meter Telescope (TMT) since 2011.

In the preliminary design phase, which started in March 2013, we proposed an optical design which solves all major problems including (1) optimum field configuration between the imager and spectrographs, (2) optical distortion of an atmospheric dispersion corrector (ADC) in the spectrographs, and (3) application of high contrast optics. The new optics design also achieves 4 times larger field of view than the previous conceptual design with all the requirements satisfied without significant increase in the cost. The design has been approved by the TMT Board. The optical design continued evolving to an all reflective design which is now regarded as a baseline.

We also made good progress in fabricating prototype coatings and filters with higher throughput than ever to realize "high throughput, low wavefront error optics."

(4) Gravitational Wave Telescope KAGRA

We developed KAGRA's auxiliary optics subsystem (AOS) and vibration isolation subsystem (VIS) with the Gravitational Wave Project Office.

For AOS, some of the mechanical design aspects for the large optical baffles are ongoing. There are five kinds of such baffles, and their maximum diameter is around 800 mm. Among them, four kinds of baffles are located inside the two 3-km arms of KAGRA, where gravitational wave signals will be converted to optical signals with high sensitivity. In an interferometric gravitational wave detector, noise contributions due to stray lights are generally determined by the product of the seismic fluctuations of the baffles, their surfaces' blackness, and the coupling factor of stray light to the main beam mode of the interferometer. So the baffles should be designed considering not only the blackness of scattering from the baffle surface but also their mechanical stiffness. For the mechanical design of the baffles, the ME shop is supporting finite element analysis of the structures and helping some discussions on how to assemble and install the system.

In addition, we have designed a beam reducing telescope, which also belongs to KAGRA-AOS. The telescope systems will be located at the end of each 3-km arm of KAGRA to monitor the tilt and shift of the beam line, and to provide feedback signals to the control system. It consists of an optical part, vibration isolation part, and signal processing part. In FY2014 we designed the optical part.

KAGRA-VIS is a suspension system to isolate the mirrors required for the KAGRA interferometer from seismic fluctuation. The system consists of multi-stage isolation filters; the ME shop has manufactured some parts for the seven pieces of the bottom filters, and has also performed assembly work, tests, and packing for delivery. The ME shop has also manufactured two units of recoil masses, which will be suspended to reduce the fluctuations of the mirrors. The recoil masses are made of a special metal, Ti-6Al-4V, because of its nice magnetism and conductivity. Though it was the first time for the ME shop to work with the material, it successfully machined them. The traversers which support most of the suspended parts in vacuum and move around smoothly to place the mirrors as planned, have been designed, assembled, and tested.

5. Advanced Technology Developments

(1) Telescope Receiver Developments

Based on the ALMA receiver developments, the "telescope receiver development" team started its activities, including development of the Nobeyama FOREST receiver and the 345/450 GHz band receiver of the ASTE telescope. We have also pushed forward the basic study of a cryostat for enabling simultaneous use of multiple receiver cartridges. ATC can increase the technology standards of the community by giving feedback using the technologies and knowledge accumulated through development of specific projects, and benefit the technology developments of other projects, universities, and research institutions. It is also important to make the best use of the achievements of the projects.

(2) Radio Imaging Array Development

In collaboration with the University of Tsukuba, Saitama University, KEK, and RIKEN, the MKID (Microwave Kinetic Inductance Detector) group of the Advanced Technology Center is developing superconductive cameras in millimeter and submillimeter wavelengths for the Antarctica terahertz telescope, which observes distant galaxies with a wide field of view, and for LiteBIRD, which detects CMB B-mode polarization.

We had progress in the following areas for development of wide-field-of-view millimeter and submillimeter instruments in FY 2014.

1) Wide field and compact 0.1 K cryogenic system
2) Wide field of view (1 degree) terahertz optics
3) Anti-reflection coated 700 pixels Si lens-array
4) CMB B-mode polarization MKID camera

Tom Nitta, a JSPS Research Fellow for Young Scientists, moved to the University of Tsukuba as an assistant professor starting from April 1, 2015.

(3) Terahertz Intensity Interferometry

Intensity measurements of astronomical sources can be used to realize a type of intensity interferometer known as a Hanbury-Brown and Twiss interferometer. These are based on the quantum optical behavior of thermal photons. To advance this technology in terahertz frequencies, we have started a study on the measurement of intensity correlations and delay times, and their applications to aperture synthesis imaging. In collaboration with Nobeyama Solar Radio Observatory, Nobeyama Radioheliograph was used to measure intensity correlation of solar 17 GHz radiation and successfully measured delay time with a precision less than 10 psec with an integration time of 50 msec. Development of superconducting tunnel junction detectors started to measure terahertz photon pulses, and a concept study of photon counting terahertz interferometry was performed. The development activity was supported by a grant from Matsuo Academic Foundation.

(4) Space Optics

Activities to observe astronomical objects from space by using sounding rockets and science satellites have been pursued to realize future space science missions. In FY 2014, fundamental development was executed for the on-going sounding rocket mission CLASP and for future satellite missions WISH and SOLAR-C. In FY 2013 the CLASP project, which is a mission to observe solar magnetic fields in the chromosphere and transition region via the hydrogen Lyman alpha line at 121.6 nm, entered the phase of preparing the flight instrument. In FY 2014, it moved to the stage of assembling and testing the flight instrument in the ATC clean room. The CLASP spectro-polarimetric capability was finally calibrated by the end of FY 2014 with a UV calibration light source that was developed in ATC. The CLASP payload is to be launched in summer 2015 from a launch site in the USA. For a planned future solar observing satellite mission SOLAR-C, the first prototype component developments have been carried out for the waveplate to modulate the polarization state and for an image slicer optical unit to realize the 2D spectro-polarimetry, in addition to performance evaluation of a near-infrared imaging device. A collaborative study on the contamination control for optical surfaces that are exposed to solar UV illumination has been performed with the JAXA research and development branch.

(5) Near-IR Imaging Sensor Developments

A commercial InGaAs near-infrared image sensor, which is a product of a domestic manufacturer, was evaluated at cryogenic temperatures to improve the readout performance. However, the noise and dark current was still high for astronomical observation. We have designed a low noise CMOS readout integrated circuit to improve the readout performance of the InGaAs image sensors.

General purpose data acquisition systems, MESSIA, have been used at several astronomical observatories over the last decade. We have developed a new version by using a circuit board originally developed for Hyper Suprime-Cam. As a final evaluation, we have installed the new system onto an instrument of the KANATA telescope operated by Hiroshima University, and started test observations.

18. 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. The Center is comprised of seven offices and one unit: the Public Relations Office, the Outreach and Education Office, the Ephemeris Computation Office, the Museum Project Office, the Library Unit, the Publications Office, the IAU Office for Astronomy Outreach (OAO), and the General Affairs Office. The activities of each office are reported hereafter.

2. Personnel

In FY 2014, the Public Relations Center was composed of Director Toshio Fukushima and the following staff members: 2 Professors, 1 Associate Professor, 3 Assistant Professor (2 hold concurrent posts), 4 Research Engineers, 1 Senior Engineer, 1 Engineer, 1 Chief of the Library, 2 Specially Appointed Senior Specialist, 4 Research Experts (1 holding a concurrent post), 23 Public Outreach Official, 1 Research Supporter, and 2 Administrative Supporter.

Cheung Sze-Leung (Specially Appointed Senior Specialist, IAU Office for Astronomy Outreach); Tatsuya Uzumaki (Public Outreach Official, Outreach and Education Office); Hiroshi Futami (Public Outreach Official, Museum Project Office); and Takaaki Takeda (Public Outreach Official, Museum Project Office) joined the Center on April 1, 2014. Yukiko Shibata (Public Outreach Official, Outreach and Education Office) joined on August 1. Shiomi Nemoto, (Public Outreach Official, Museum Project Office) and Satomi Hatano (Public Outreach Official, Outreach and Education Office) joined on March 1, 2015.

The following members relocated: Tatsuya Uzumaki (Public Outreach Official, September 30); Chisato Ikuta (Assistant Professor, November 30); Mayumi Hori (Chief of the Library, March 31, 2015). The following members retired: Norio Ohshima (Research Engineer); Hideo Fukushima (Research Engineer); Shoichi Itoh (Public Outreach Official); Yukie Baba (Public Outreach Official), Hitoshi Masuzawa (Public Outreach Official); and Yuriko Watanabe (Public Outreach Official).

3. Public Relations Office

The Public Relations Office actively promoted scientific developments produced by various NAOJ Projects including the NAOJ Chile Observatory and the Subaru Telescope. It also promoted the results of joint research projects conducted with universities and other research organizations through press conferences and web releases. In cooperation with the Outreach and Education Office, the Public Relations Office also conducted awareness campaigns for the lunar eclipse, meteor showers and other astronomical phenomena of interest to the public. An internet broadcast of the October 8 total lunar eclipse garnered approximately 30,000 viewers.

(1) Multimedia-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 to the website.

In response to trends in society's use of the internet, the Japanese webpage was updated in August to better accommodate smart phones.

NAOJ e-mail newsletters No. 129–142 were issued, containing headlines for major news events with hyperlinks to pages with further details. The Astronomy Information Telephone Service, which provides voice news updated on a semimonthly basis, issued 24 messages in total.

Through the Twitter social networking service, employed since October 2010, the Office disseminates information on the status of various NAOJ projects such as open house events, regular stargazing parties at Mitaka Campus and position openings. As of the end of March 2015, the number of followers exceeds 47,000.

(2) Publicizing Developments

There were 16 research result announcements (compared to 26 in FY 2013 and 17 in FY 2012.) Information releases were actively presented, totaling 26 articles (Tables 2, 3).

In the perennially popular Astronomy Lectures for Science Journalists program, the title of the 21st lecture was "The Start of Construction for TMT," held before the September 30, 2014 groundbreaking ceremony for the Thirty Meter Telescope

Month	Access counts	Month	Access counts	Month	Access counts
April 2014	576,378	August 2014	1,180,446	December 2014	532,836
May 2014	451,804	September 2014	696,725	January 2015	641,761
June 2014	408,358	October 2014	2,179,203	February 2015	470,296
July 2014	634,310	November 2014	581,852	March 2015	642,456
Total: 8,996,425					

Table 1: Monthly website access statistics for the Public Relations Office website, NAOJ Public Relations Center (April 2014–March 2015).

May 21, 2014	Revealing the Complex Outflow Structure of Binary UY Aurigae
July 7, 2014	Still hot inside the Moon: Tidal heating in the deepest part of the lunar mantle
July 29, 2014	Next-Generation Thirty Meter Telescope Begins Construction in Hawaii
August 18, 2014	Mysterious Space Tornado Formation Process Clarified (Japanese Only)
September 17, 2014	Creating Pancakes using Galaxy Collisions-Violent Origins of Disk Galaxies Probed by Radio Telescopes
November 7, 2014	Revolutionary ALMA Image Reveals Planetary Genesis
November 13, 2014	Supercomputer for Astronomy "ATERUI" Upgraded to Double its Speed
November 19, 2014	Huge Sunspots and their Magnetic Structure observed by "Hinode"
December 4, 2014	Astronomers Identify Gas Spirals as a Nursery of Twin Stars through ALMA Observations
February 26, 2015	ALMA Revealed Surprisingly Mild Environment around a Supermassive Black Hole (Japanese, English release by NAOJ Chile Observatory)
March 31, 2015	ALMA Disentangles Complex Birth of Giant Stars

Table 2: Web releases.

June 3, 2014	Giant Explosion Buried in Dust: ALMA Probes Environment around Gamma Ray Bursts
June 19, 2014	Jupiter's Moons Remain Slightly Illuminated, Even in Eclipse
July 3, 2014	Dynamical Star-Forming Gas Interaction Witnessed by ALMA
August 8, 2014	A Chemical Signature of First-Generation Very-Massive Stars
February 2, 2015	Classical Nova Explosions are Major Lithium Factories in the Universe

Table 3: Press Conferences.

	Solar info	Lunar info	Ephemeris info	Time	Solar System	Universe	Astronomy	Other	Total
April–June	204	116	45	6	168	65	107	774	1485
July–September	200	284	46	8	150	68	118	995	1869
October–December	230	324	78	3	294	85	125	669	1808
January–March	214	130	71	15	186	74	106	468	1264

Table 4: Telephone inquiries made to the Outreach and Education Office of the NAOJ Public Relations Center (April 2014–March 2015).

(TMT). A total of 37 participants listened ardently to the project progress report and lectures about the key science. The materials used in the lectures where distributed to participants beforehand. We also concentrated on a way to deliver the lectures via the internet for reporters who can't attend.

(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 produced 6 videos in both English and Japanese to introduce the research activities at NAOJ to a broad public audience. The titles included "Analyzing the Universe at multiple wavelengths," "Telescope: Going back through the Universe's History," and "Research and Education at NAOJ." As of the end of March 2015, these videos have been viewed a total of approximately 10,000 times.

The Office also helped Projects with their own lectures for the general public. In November it assisted with a lecture introducing the successes of the Subaru Telescope, which celebrated its 15th Anniversary, and the expectations for TMT. This was co-sponsored by Sendai Astronomical Observatory. This was the first time one of these lectures was attempted outside of Tokyo. In December, the Office assisted with lectures presenting the latest results from ALMA.

The Office also and cooperated with documentation and offered exhibit materials and image contents for the large events "Space Expo 2014" (presented by NHK and others) and "Hikari- The Wonder of Light" (presented by the National Museum of Science and Nature and others). Training in photography was offered twice, in June and October, to improve the skills of outreach personnel in each project. In July, Social Networking Service (SNS) training was offered to all NAOJ personnel to elucidate communication using SNS.

4. Outreach and Education Office

(1) Handling General Inquiries

The Office received inquiries from the media, government offices, and the general public. The Outreach and Education Office responded to 6,426 telephone inquiries (Table 4) and 141 letters, 69 of which were official documents. The Office stopped accepting inquiries via the internet in April 2014.

(2) Educational and Outreach Activities

The astronomical phenomena awareness campaigns started as bidirectional information sharing initiatives in FY 2004. This year, 2 were conducted: "Summer Nights: Let's Count Shooing Stars, 2014" in August (346 responses) and "Let's Observe the Total Lunar Eclipse" in October (1,293 responses).

The "Fureai (Friendly) Astronomy" project, in its 5th

year, provided events to 51 schools, covering all that applied, with 4,812 pupils in attendance. Many of the responses from the pupils expressed interest in seeing stars or aspiration for becoming astronomers, suggesting that the event was a good opportunity to familiarize the children with astronomy and to inspire them by meeting and learning from astronomers. A total of 42 lecturers participated.

On August 4 (Monday) and 5 (Tuesday) during summer vacation "Summer Vacation Junior Star-Gazing Party + You are Galileo!" events were held for elementary, junior high, and high school students (application required, maximum capacity 50 participants). Including guardians, the number of participants to hear lectures about handcrafting and using telescopes exceeded 100 on both days. There were a total of 217 participants (112 on August 4 and 105 on August 5).

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 18 and 19 with the theme "TMT Challenging the Frontiers of Space." It was co-hosted by the Institute of Astronomy, 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. Both days were graced with clear skies. Events thrived with 4,768 visitors, the most ever, in attendance. 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, mini-lectures, and popular quizzes and games.

The 5th International Science Film Festival was co-hosted between August 1 and September 29, with more than 100 participating affiliates. Screenings of science films and other events such as a stamp-collection rally were held at 36 science museums, planetariums, and film theaters in Japan, with more than 1 million people participating. The Kickoff Event (Hiratsuka City Museum) Dome Festa (Hiroshima Children's Museum) and Closing Event (Koriyama City Fureai Science Center) were held as the core events.

The "NAOJ Tours" cohosted each year with Tamarokuto Science Center were held on Monday, January 5 and Sunday, March 8. These days consisted of a sunspot observation event at the 20-cm Telescope Dome, self-guided tours along the tour course, star chart production, explanations of the theory behind navigation, and a stargazing party at the 50-cm Telescope for Public Outreach. Each day had a total of 40 participants, for a total of 80.

"The 10th Workshop for Popularizing Cutting-Edge Astronomy @ ALMA in Chile" was held at the Chile Observatory focusing on ALMA. A total of 25 researchers and people engaging in education or astronomy promotion took part.

The Office conducted the following events in Mongolia, as part of the "You are Galileo!" project from June 30 to July 6, 2014, in cooperation with the Office of International Relations with support from the Foundation for Promotion of Astronomy. On July 1, a lecture and handmade telescope workshop was held at an elementary school in Byan Ulgi Mongolia with 40 participants. Additionally, a stargazing event was held in a nomad camp with approximately 50 participants. The "1st East Asian Astronomical Education and Outreach Workshop" was held July 3-5, at the National University of Mongolia in the city of Ulaanbaatar. A total of 35 participants from 5 countries (Nepal, Hong Kong, Portugal, Japan and Mongolia) attended.

The data reduction software Makali`i, developed to enable FITS data obtained from Subaru Telescope science observations and other sources to be used in astronomy education and outreach, was distributed via the internet to domestic and international users. The Outreach and Education Office cooperated with the Japan Foundation of Public Communication on Science and Technology to produce the "Hikari-zu" (Light Diagram) poster (A1, A2 sizes, both Japanese only).

(3) Community Activities

The "Mitaka Picture Book House in the Astronomical Observatory Forest" welcomed 38,911 visitors in FY 2014. The Outreach and Education Office participated in planning the "Stars and Constellations" (July 2013 – June 2014) and "Picture Books and Space" (July 2014 – June 2015) exhibits. In addition, it cooperated with staff members from the Mitaka City municipal offices and local volunteers for modern and traditional Tanabata celebrations and Moon-Viewing parties. Furthermore, it cooperated on the "Mitaka Picture Book House in the Astronomical Observatory Forest, Picture Book Original Drawings Hallway Exhibit Contest." The best pieces, "Kimi Ni Mieru Yoni" ("So You Can See" text and pictures by Hiromu Aono) and "Hoshi Miru Ojisan" ("The Man Watching the Stars" text and pictures by Nao Mori), were published with Bun-Shin Publishing as the "Picture Book House in the Astronomical Observatory Forest Compilation Series," created in NAOJ's hometown.

The Outreach and Education Office conducted the 6th "Mitaka Solar System Walk" in cooperation with the non-profit organization (NPO) Mitaka Network University Promotion Organization. Held from September 20 to October 26, stamps were placed at 154 shops and 63 facilities, including NAOJ Mitaka Campus and the Mitaka City Municipal Office, for a total of 217 locations around Mitaka. Approximately 15,000 guide-maps/stamp-sheets were distributed, of which 2,665 people turned theirs in for a prize. The total number of stamps was 275,315; the average number of stamps collected was 103 per person. The number of participants who collected all of the stamps was 63. It was a good chance to tour the Solar System while promoting commerce and industry and providing families with a way to enjoy Mitaka and rediscover the city's charm.

The event "Astronomy Pub" has been held at Mitaka Network University and hosted by the NPO Mitaka Network University Promotion Organization since FY 2009. It provides for 20 participants at a time and is held in the evening on the 3rd Saturday of every month except August. The Outreach and Education Office also assisted in presenting Star Sommelier Mitaka, an astronomical guide training course hosted by

Mitaka Network University that provided telescope operation workshops and other related events.

5. Ephemeris Computation Office

The Ephemeris Computation Office 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) The office published the 2015 edition of the Calendar and Ephemeris, the 2015 version of the calendrical section of the Rika Nenpyo, and the 2016 edition of the Reki Yoko (posted in the official gazette on February 2, 2015). In the 2016 Reki Yoko, DE430 is adopted as the standard ephemeris instead of DE405. The internet edition of the Calendar and Ephemeris was also 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), the contents of the Ephemeris Wiki were expanded and all of the contents were made mobile friendly. The Office cooperated with promotional campaigns again this year. The position of Comet Lovejoy and the radiant points of the Perseids and Geminids meteor showers were published in the Astronomical Information section of the website. Neither the total lunar eclipse nor the New Year's sunrise had good weather, but the page view still exceeded 28 million.

(3) The Japan Association for Calendars and Culture Promotion hosted its 4th General Meeting, the Calendar Presentation Ceremony, and two Symposia on the Traditional Calendar 2033 A.D. Problem.

(4) The Office hosted regular exhibitions in collaboration with the Library, selecting from NAOJ's invaluable collection of historical archives written in Chinese/Japanese. The themes of the 50th and 51st exhibitions were "Weather Documentation from Towns" and "Star Charts" 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) Four staff members, including two full-time and two part-time, handled reports of new astronomical objects and other communications submitted to NAOJ. Lately, about 20 reports per year have been submitted. But this year there was a total of 32 reports including confirmation requests for new celestial object candidates and other reports. The contents were: 12 novae/supernovae, 10 comets (including cometary objects), 8 luminous objects, 1 fixed star, and 1 astronomical phenomena question. Particularly in recent years, there has been an increase in cases where the ghost images of bright stars produced when using a filter to eliminate light pollution have been mistaken for comets. In amongst the many examples reporting an already known comet or a planet as a new object, the report of a supernova in September bares mention. Simultaneous to the discoverer reporting it to NAOJ, it was also reported to Kyushu University's Hitoshi Yamaoka. Hitoshi Yamaoka sent a notice to the International Astronomical Union Central Bureau for Astronomical Telegrams. This event was acknowledged as Supernova 2014cy.

6. Museum Project Office

In FY 2013, the section responsible for managing public access to the facilities was reorganized and the name changed from the Archive Office to the Museum Project Office. Some of these activities are managed in cooperation with the Outreach and Education Office.

(1) Facility Opening Events

Except for the 4 month stoppage from December 2014 to March 2015 to replace worn out equipment, regular showings were held at the 4D2U Dome Theater twice a month (the day before the 2nd Saturday and the 4th Saturday) as in previous years. Advance reservations were required. The 15 events this year attracted 1,359 participants. An additional 54 group screenings were held with 1,543 participants, and 69 tours were organized with 622 participants.

Regular stargazing parties held with the 50-cm Telescope for Public Outreach were scheduled the same days as 4D2U theater screenings. These were held regardless of cloudy or rainy weather. Advance booking (300 people for each session) was introduced in FY 2012 for these events. A total of 23 sessions were held with 5,161 participants.

A total of 19,754 people visited the Mitaka Campus Visitors' Area in FY 2014. We conducted 197 tours for 5,992 guests, including 60 workplace visits by schools. There were also 357 media interviews granted. So that diverse guests can enjoy the open facilities, we developed English, Chinese, Korean, and Spanish versions of the "NAOJ Mitaka Campus Guidebook." We also produced an "NAOJ Mitaka Campus Workbook" with questions elementary students can find the answers to while touring the facilities.

Guided tours of Mitaka Campus began in June 2011 as part of the Archive Office/Open House initiative. Each tour is conducted on an advance booking basis for a group of 20 participants. Tours are organized into two courses: the "South Course" focusing on Registered Tangible Cultural Heritage offered on the 1st Tuesday and 2nd Sunday of the month and the "North Course" focusing on Important Cultural Heritage and Geodesy-related sites held on the 3rd Tuesday and 4th Sunday. The Office accommodated 422 people during the tours. In addition, we created the "Mitaka Campus Guided Tour Handbook" and distributed it to the participants.

(2) Museum Planning and Archive Management

To prevent historically important observations, measuring devices, and documents from being scattered and lost, the Office is conducting investigations to continue improving the collection, sorting, and preservation of articles and improve the

methods and environment for displaying them. The Office also established the basic concept for the NAOJ Museum (tentative name) including both facility opening efforts and archive works.

On April 25, 2014, seven historically important buildings in NOAJ Mitaka Campus became Registered Important Cultural Properties: the Repsold Transit Instrument Housing, Housing of Gautier Meridian Circle, First Meridian Mark Building of Gautier Meridian Circle, Second Meridian Mark Building of Gautier Meridian Circle, Old Library and its Warehouse, Gatehouse, and the Front Gate. This brings the total number of Registered Important Cultural Properties to 10.

Guide Volunteers were registered from among the graduates of the "NAOJ Guide Volunteer Training Course" sponsored by NPO Mitaka Network University Promotion Organization (refereed to below as Mitaka Network University) in FY 2013. Mitaka Network University held the 2nd "NAOJ Guide Volunteer Training Course." Four people enrolled, graduated, and were registered as NAOJ Guide Volunteers.

7. Library Unit

In addition to the normal work of collecting and sorting scientific journals and books focusing on astronomy and offering them to students and researchers inside and outside of NAOJ, the Library continued to digitalize important documents and open the data to the public. Also the library collection was checked and the catalog of contents was maintained.

8. 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:

- NAOJ Pamphlet (Japanese)
- NAOJ Pamphlet (English)
- NAOJ News, No. 249– No.260 (April 2014–March 2015)
- Annual Report of NAOJ Vol. 26, Fiscal 2012 (Japanese)
- Annual Report of NAOJ Vol. 16, Fiscal 2013 (English)
- Annual Report of NOAJ Vol. 15 Supplement Fiscal 2012 (English)

In FY 2014, in addition to normal operations, the Publications Office tried to strengthen its ability to reach international readers. First of all, it produced the "Annual Report of NAOJ Vol. 15 Supplement Fiscal 2012" completing the translation of the Japanese Version. Likewise, English Volume 16 was also a complete translation. NAOJ News also started producing feature articles and series related to internationalization. (The September edition's theme was international education and outreach. The 1st installment of the 'NAOJ Foreign Staff Interviews' series appeared in the December edition.) The Office investigated the possibility of producing an international edition of the Rika Nenpyo. In daily work, to support the outreach activities of various Projects through NAOJ News, special editions focusing on feature series were systematically produced. Extra copies were printed and given to the relevant Project's outreach personnel. The special edition themes were: "Museum" (April), "Library" (June), "TMT" (August), "Vapor Deposition Techniques" (January), and "ALMA" (February). From now, we plan to develop and share NAOJ News articles so that they can be used as a source of content for each Project's outreach activities. To this end, we promote close cooperation to produce comprehensive, fundamental articles. To facilitate this flow, we are reediting various levels of articles issued by the Publications Office to construct integrated NAOJ public relations, outreach, and education contents (and a basic platform for these). At the same time, we are in the process of producing a digital book based on the last 12 years of articles from the "Annual Report of NAOJ Research Highlights" as a prototype for promoting the digitalization and integration of published contents. In addition to periodicals, the Office produced the 2015 calendar "Historical Observational Instruments of NAOJ." This is the 10th calendar produced since 2005. The office also helped to create the poster for the Mitaka Special Open House Event again this year, and support was also given to the publication of the "Rika Nenpyo, Chronological Scientific Tables."

9. International Astronomical Union Office for Astronomy Outreach

In FY 2012 the International Astronomical Union (IAU) and NAOJ exchanged a memorandum of understanding to establish the IAU Office for Astronomy Outreach (OAO) at NAOJ Mitaka Campus. In FY 2014 the IAU OAO was established by the Public Relations Center Outreach and Education Office. Cheung Sze-Leung started work as the Outreach Coordinator in April. Since then the OAO has been located in a new office within the Public Relations Center: the IAU Office for Astronomy Outreach. IAU OAO is responsible for IAU's international outreach activities, in cooperation with the Outreach and Education Office and others. In FY 2014 it primarily conducted the work for the International Year of Light 2015 "Cosmic Light" and the NameExoWorlds Contest.

"The Globe at Night – Sky Brightness Monitoring Network Users Workshop" was held January 7-9, 2015 at NAOJ Mitaka Campus. There were a total of 30 attendees from Hong Kong, the Republic of Korea, Taiwan, Nepal, Mongolia, the Republic of the Philippines, and Japan.

19. Division of Optical and Infrared Astronomy

1. Overview

The Division of Optical and Infrared Astronomy oversees the Okayama Astrophysical Observatory, the Subaru Telescope (C Project), the TMT-Japan Project Office, the Gravitational Waves Project Office (B Projects), the JASMINE Project Office, and Extrasolar Planet Detection Project Office (A Projects). The primary purpose of the division is facilitating and invigorating projects and individual research through personnel exchanges to place researchers in environments more suitable for their individual projects. While pursuing seminal observational and developmental research, the division launches new projects as necessary to further these goals. 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 the Subaru Telescope facility engaging in open use, and universities and research institutes in Japan, focusing on developmental research into new instruments and observational research. This concept was developed when the Subaru Telescope was constructed.

Almost all NAOJ members in optical- and infrared-related fields have positions in the division and engage in either the division or A, B, or C Projects. At times, they may also have affiliated positions in many other projects. The division and the various projects carry equal weight in organizational terms. The primary staff of the Division of Optical and Infrared Astronomy in FY 2014 consisted of one professor, one associate professor, three assistant professors, one specially-appointed assistant professor and two JSPS research fellows.

The division coordinates educational, research, and administrative activities for all research divisions and projects except for the Gravitational Wave, JASMINE, and TMT-Japan (TMT-J) projects. The TMT-J project has come to an expansive stage in which the telescope fabrication has been started. In tandem with this progress, personnel transfer occurs often within the Optical and Infrared Astronomy Division. The division plays an increasingly important role in coordinating between the Subaru Telescope and TMT-J projects. The division as a whole maintains and operates facilities to support research; e.g., a mailing list server for the Mitaka offices of the Subaru Telescope, TMT-J, Extrasolar Planet Detection, and Gravitational Wave Project Offices; and a web server for members of the Mitaka offices of the Subaru Telescope, TMT-J, and Extrasolar Planet Detection Project Offices, as well as graduate students in the division.

The remainder of this report will focus on the research projects conducted by full-time members 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; objects within the Solar System; structures around late-type stars; and the search for exoplanets. A rapid change in the shape of the plasma tail of Comet Lovejoy (C/2013 R1) was analyzed. Observations of extended ionized objects in nearby galaxies and clusters of galaxies were performed, and the data is now being analyzed. The search for extrasolar planets continued using direct imaging methods.

Research in other areas is also in progress, including astronomical phenomena based on old ephemerides and other documents, and statistical research into automatic identification of AGN using public astronomical archive data and astronomical databases.

As part of the research using astronomical archive data, statistical research into stripped gas from galaxies in clusters was performed. Other research undertaken was on the host galaxies of AGN using SDSS imaging/spectroscopy data.

(2) International Cooperative Observational Research

The division also engages in international collaborative studies with overseas researchers. Research on star formation in the outer parts of nearby galaxies, and on low surface brightness dwarf galaxies were conducted with a US researcher. The site survey in western Tibet for constructing a telescope also continues in cooperation with the National Astronomical Observatory of China (NAOC).

3. Subaru Telescope-Related Observational Instrument Development

The division searched for planetary candidates using the HiCIAO infrared coronagraph, and implemented hardware and software improvements for direct imaging and observation of protoplanetary discs. The division analyzed the relation between the real seeing conditions and the environment in the Subaru Telescope's enclosure using a computational fluid dynamics' model provided by other institutions.

In relation to the data archive, the division joins the file-system-based technology WG convened by the Society of Scientific Systems to explore the possibilities for overcoming difficulties arising from storage expansion. For this purpose, guidelines for assessment and analysis of storage system capability were investigated and reported.

4. Operational Support for the 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, and management of open-use-related travel expenses, and promoting PR activities for the Subaru Telescope. The division also gives support to the management of data analysis systems in collaboration with the Astronomy Data Center. Moreover, the division also supports the Subaru Autumn Schools co-hosted with the Subaru Telescope and the Astronomy Data Center, and Subaru Telescope observation classes.

5. Research Environment Maintenance

The division manages the printers and rented multifunction photocopiers in the Mitaka Subaru Building, teleconferencing systems on the second and third floors, sub-networks, and data backup servers for the Subaru Telescope Mitaka office as part of its efforts to maintain the research environment. The division assisted in replacing a UPS battery, updating shared storage for the Subaru Telescope Mitaka office, and setting up computers for newcomers. The teleconferencing system and the web server were replaced. The contents of the division homepage were renewed. An office migration was performed to meet a request from the TMT-J office.

6. Planning of the Next-generation Large-Scale Project

The Division of Optical and Infrared Astronomy is engaged in planning large post-Subaru projects in optical and infrared astronomy such as TMT and the JASMINE series. A framework for collaboration between ISAS and NAOJ also needs to be established.

A study group on next-generation large disk and computing systems was launched with KEK, which will handle voluminous data in five to ten years in the future. Discussions revolve around archival hardware and software 10 years in the future to serve as an astronomical database for the next-generation observational instruments and TMT succeeding the Subaru Telescope.

7. PR, Outreach, and Discovery of New Astronomical Objects

The division cooperates with the Public Relations Center in supporting PR/outreach activities, such as publications and press conferences on Subaru Telescope research results and discoveries of new astronomical objects. An active participant in a special public event held at Mitaka (Mitaka Open House Day), the Division of Optical and Infrared Astronomy provided mini-lectures and exhibits and planned projects appealing to elementary and junior high school students such as magnet puzzles.

8. Educational Activities

The Division of Optical and Infrared Astronomy provides postgraduate education to 19 graduate students from the Graduate University of Advanced Studies, the University of Tokyo, the Tokyo University of Agriculture and Technology, Tokyo Institute of Technology, Nihon University, and International Christian University.

Division staff members made active contributions to seminars and self-directed studies. The division participated in the “Fureai (Friendly) Astronomy” project, dispatching lecturers to various elementary and junior high schools around the country to provide pupils with opportunities to become familiar with and appreciate astronomy.

20. Division of Radio Astronomy

The Division of Radio Astronomy oversees Nobeyama Radio Observatory, Mizusawa VLBI Observatory, RISE Lunar Exploration Project, and NAOJ Chile Observatory operating the Atacama Large Millimeter/submillimeter Array (ALMA) and 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 among themselves. 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/electronic devices, which cause 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 USA 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 optical pollution from artificial light sources is an obstacle in optical observation, artificial radio interference generated by the electrical/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 its ubiquitous nature but because of that unique capability, 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 the 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 2014, 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. New operations involving wireless communications have increased following the Great East Japan Earthquake in 2011, resulting in an increase in radio interference.
- Development of new radio applications. The ultra-wide-band (UWB) technology does not necessitate an operator license because it is operated at low-levels and wide bandwidths. Additionally, there has been a rapid increase in demand for higher frequencies. For example, 76 and 79 GHz automotive radar are being introduced, aiming to 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.
- 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. The radio astronomy observations have been given priority in a number of frequency bands within the range of 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. In terrestrial radio applications, unwanted out-of-band signals (spurious signals), even extremely faint ones, 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; 1600 MHz mobile satellite phones used in emergencies, where the observation of pulsars and the like are affected; and a number of new UWB wireless applications used by logistics and manufacturing industries, where geodetic observations are affected; and high-speed power line communications (PLC), where decameter-band observations are affected. 79 GHz automotive radars around Nobeyama Observatory will cause deterioration in its observation results, or rather tend to make its observations impossible in the near future. Radio astronomy observations in the 60 GHz band are not common because of the high rate of absorption in the atmosphere. Albeit in fact, the 60 GHz system must be watched closely in its second harmonics in terms of adverse effects on CO observations in the 115 GHz band.

(3) International Activities

The ITU' Radio Regulations (RR), which allocates radio frequencies to wireless applications, are revised once every three to four years in the World Radiocommunication Conference (WRC). The most recent meeting was WRC-12, held in February 2012. The RR include frequency bands in which radio astronomy observation is prioritized. Preparatory conferences need to be held in Geneva annually in preparation for the upcoming WRC-15 to discuss necessary matters for the revision of the RR. 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. It has also contributed to opinion-forming through its regular attendance at the Asia/Pacific Region (APG) meetings in preparation for WRC-15, as a delegate representing Japan. In FY 2014, the subcommittee pursued the protection of radio astronomy frequency bands through participation in the ITU-R WP7D meetings held in Geneva in May and October and the ITU-R WP1A meeting held in Geneva in June. The subcommittee also has participated in the APG meetings held in Australia in June 2014 and in Thai in February 2015, in addition to other relevant meetings and conferences.

(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 the MIC, direct negotiations for the 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 the 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 in relation to societal and technological trends.

Several examples of the interference problems discussed in section (2) above are given below. One example is the advent of UWB wireless applications, used in positioning and tracking material flow in manufacturing and logistics industries. The applications in the UWB frequency band induce interference in VLBI geodetic observations to detect movement of the plates in plate tectonics. Although this band is not under RR protection, it is vital from the perspective of predicting earthquakes and is the subject of special consideration by the MIC. 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. A wider scale of distribution is predicted for 76 GHz and 79 GHz band automotive radars, which just emerged in the market. Of particular concern are the possible effects of interference from these radars on the 45-m Radio Telescope at the Nobeyama Radio Observatory, which engages in observations of spectral-lines of deuterated compounds and other molecules in interstellar matter. The observations with the 45-m Radio Telescope located in Japan will continue to carry significance in relation to the international project ALMA, which is based in Chile and involves 66 high-performance radio telescopes at an altitude of 5,000 m. 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.

The 23 GHz band is deployed for emergency wireless communications at times of natural disasters that lead to a breakdown of CATV networks. Ammonia molecular lines (RR-protected band) overlap with the 23 GHz band due to redshifts from the expansion of the Universe. An additional point for consideration is that the 1.6 GHz band may be of important use at times of natural disasters for satellite-based mobile communications rather than terrestrial wireless communications. The MIC performed as a mediator in discussions regarding interference issues caused by satellite phones using geostationary and non-geostationary (orbiting) satellites, and an agreement on usage conditions was concluded between the parties: service providers which create the interference and the Radio Astronomy Frequency Subcommittee representing the radio astronomical observatories, bearing in mind the importance of the emergency use of satellite phones at times of natural disasters.

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 approach the ground from outer space. Their detrimental effects need to be alleviated with a filter at the output stage of the satellite. The filter is currently under development in NHK Science & Technology Research Laboratories based on a series of discussions at NAOJ Mitaka Campus. PLC utilizing home power lines affects radio astronomy observations in low-frequency bands below 30 MHz. A petition against unduly hasty introduction of PLC was submitted to the MIC jointly with ASJ and the Society of Geomagnetism and Earth, Planetary and Space Sciences. A press conference was organized to raise broad public awareness of the relevant facts. 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 the trends 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.

Moreover, the subcommittee engages in making applications to the MIC, requesting frequency protection of NAOJ telescopes, in addition to those owned by the Japanese community of radio astronomers on their behalf.

The collection of actual interference cases at every observatory 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 material for the general public. As optical astronomers are engaging in protection of 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.

21. 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, the Solar-C Project Office, and the Nobeyama Solar Radio Observatory, and conducts research on the Sun in close liaison with these respective projects. The operation of the Nobeyama Radioheliograph was transferred to the Solar-Terrestrial Environment Laboratory of Nagoya University, and the Nobeyama Solar Radio Observatory was closed at the end of fiscal year 2014 (March 2015). Shin Toriumi has been appointed as an NAOJ fellow and joined the division in April. The graduate students supervised by the staff of the above-mentioned projects also belong to the division. All the permanent staff of these projects are 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, 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. Research is also being carried out using the Radioheliograph at Nobeyama and the Solar Flare Telescope and other telescopes in the Mitaka campus. In addition, the division 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 Toriumi published three papers in refereed journals as lead author. They are (1) on the formation and flare activity of delta-type sunspots derived from a combination of data analysis and numerical simulation, (2) on the detection of horizontal flows on the surface of the Sun prior to the emergence of magnetic flux from below, and (3) a review article on the flux emergence phenomenon presented at the 7-th Hinode Symposium. He also has been promoting collaborative research with international partners.

The division has a seminar (on Friday afternoon, roughly twice a month) whose speakers are from both inside and outside of the division. This year's organizer was M. Shimojo.

2. Educational Activities

The teaching staff of the division supervised three graduate students from the University of Tokyo and two from the Graduate University for Advanced Studies (SOKENDAI). Among them Anjali John Kaithakkal of SOKENDAI obtained a Ph.D. in September.

The division, in cooperation with Kyoto University and Nagoya University, supported the annual research-experience tour for undergraduate students; about ten students visited solar-related research organizations and experienced the latest research in the field.

3. International Cooperation

Y. Katsukawa succeeded Y. Suematsu as a member of the Science Working Group of the Daniel K. Inouye Solar Telescope, a 4-m telescope under construction at Haleakala, Hawai`i. Several plans are also under consideration for future ground-based telescopes that would involve collaborations with East Asian countries and Peru.

22. Division of Theoretical Astronomy

1. Overview

The Division of Theoretical Astronomy (DTA) aimed at achieving internationally outstanding research accomplishments both in quality and quantity for the following four goals which were set by the NAOJ Board, and engaged in research activities for FY 2014 accordingly:

- Advance world class cutting-edge theoretical research.
- Pursue theoretical astronomy research, particularly in areas that utilize NAOJ supercomputers or large-scale observational instruments to give further insight into their newest developments.
- 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 structure of the Universe in terms of formation and evolution processes; dynamics; and the physical state of matter. This research spans astronomy and astrophysics from the early Universe to galaxies, stars, planetary formation, activities of compact objects, and plasma phenomena. 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. The division's full-time professors, associates, assistants, and project assistant professors, together with NAOJ postdoctoral fellows and JSPS fellows, conduct a variety of unique research projects involving postgraduate students from the Graduate University of Advanced Studies, the University of Tokyo, the Graduate School of Ochanomizu University, and the Graduate School of Shizuoka University; joint research with observational astronomy using observational facilities of various frequency bands such as the Subaru Telescope, ALMA, and Nobeyama radio telescopes; and interdisciplinary research with the physics of elementary particles and atomic nuclei. 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. It also leads research activities in various related fields of astronomical science. The division started a new series of DTA symposia and organized two meetings in 2014 entitled "Formation and evolution of planets in star forming regions and in the environment of star clusters" and "Activity and magnetic properties of compact astronomical objects."

2. Current Members and Transfers

In FY 2014, the dedicated faculty of the Division of Theoretical Astronomy included two professors, two associate professors, and four assistant professors. Another adjunct professor and one adjunct assistant professor concurrently hold 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 two NAOJ postdoctoral fellows and one JSPS fellow; one EACOA fellow; and one administration associate who gave full support to all activities of the division. Among them Takaya Nozawa and Yasuhiro Hasegawa were appointed project assistant professor and EACOA fellow in April and September 2014, respectively. Takahiro Kudoh, an assistant professor, was promoted to associate professor and moved to Nagasaki University.

3. Research Results

The publication category IV research papers published by the division member(s) as author(s) or presenter(s) are listed below. Categories with fewer than 10 publications have been omitted.

- Peer-reviewed papers in English: 64
- Papers in English (conference proceedings, non-reviewed Papers, etc.): 38
- Reports in English (talks at international conferences): 70
- Reports in Japanese (talks at national meetings, etc.): 84

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:

- Discovery of Dramatic Optical Variability in a Possible Radio-Loud Narrow-Line Seyfert 1 Galaxy (Masaomi Tanaka, et al.)
- High-speed Fluid Dynamics in Magnetic Reconnection in a Low-β Plasma (Seiji Zenitani)
- Formation of Carbon Grains in Red-supergiant Winds of Very Massive Population III Stars (Takaya Nozawa, et al.)
- Origins of Large Amounts of Dust Grains and Unusual Extinction Curves in High-redshift Dusty Quasars (Takaya Nozawa, et al.)
- Opacity of fluffy dust aggregates (Akimasa Kataoka, et al.)
- The initial mass function of star clusters (Michiko Fujii)
- Polarization Structure of Magnetically Supported Molecular Filaments (Kohji Tomisaka)
- Neutrino Oscillation and Nucleosynthesis in Core-Collapse

Supernova Explosion (Toshitaka Kajino, et al.)
- Cosmological solutions to the Big-Bang Lithium problem: Big-bang nucleosynthesis with photon cooling X-particle decay and a primordial magnetic field (Toshitaka Kajino, et al.)
- Supernova Nucleosynthesis of ^{26}Al and Nuclear Structure of ^{26}Si (Toshitaka Kajino, et al.)
- The in-medium effects on the neutrino reaction in dense matter (Toshitaka Kajino, et al.)
- Induced Amino Acid Chirality From Strong Magnetic Fields in Interstellar Environments (Toshitaka Kajino, et al.)
- Asymmetric Neutrino Emission from Magnetized Proto-Neutron Stars: Effects of Absorption Cross-Sections in Iso-entropical Conditions (Toshitaka Kajino, et al.)
- Revised Big-Bang Nucleosynthesis with Exotic Dark Matter Particles: Detailed Quantum Mechanical Calculation (Toshitaka Kajino, et al.)
- Supernova Relic Neutrinos and the Supernova Rate Problem: Analysis of Uncertainties and the role of Failed Supernovae (Toshitaka Kajino, et al.)
- Neutrino Magnetic Moment, CP Violation and Flavor Oscillations in Matter (Toshitaka Kajino, et al.)
- Sterile neutrino oscillations in core-collapse supernova simulations (Toshitaka Kajino, et al.)

The following research results were released on Division's website (http://th.nao.ac.jp/) as research highlights:

- Stochastic electron acceleration during spontaneous turbulent reconnection in a strong shock wave (Tsunehiko Kato, et al.)
- Shocking structure in a supersonic reconnection jet (Seiji Zenitani)
- The initial mass function of star clusters (Michiko Fujii)
- The world's most extensive simulation of the Milky Way galaxy (Michiko Fujii)
- Revealing Large Amounts of Dust and Unusual Extinction Curves in the Early Universe (Takaya Nozawa, et al.)
- Discovery of a Blue Star at the Location of Supernova 2011dh (Takaya Nozawa, et al.)
- Formation of Carbon Grains in Very Massive Primordial Stars (Takaya Nozawa, et al.)
- Two- and Three-dimensional Neutrino-hydrodynamics simulations of Core-collapse Supernovae (Tomoya Takiwaki, et al.)
- Opacity of fluffy dust aggregates (Akimasa Kataoka, et al.)
- Cosmological solutions to the Lithium problem: Big-bang nucleosynthesis with photon cooling, X-particle decay and a primordial magnetic field (Toshitaka Kajino, et al.)
- A New Production Mechanism for Ultra-High-Eneregy Cosmic Ray (UHECR) Neutrinos (Toshitaka Kajino, et al.)

4. Educational Activities

The lecture subjects are listed below to supplement Section III on activities for research and educational adjunct lecturership at the universities and graduate schools:

Toshitaka Kajino: Special lectures on cosmology and nuclear astrophysics at the Graduate School of Hokkaido University; 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.

Takahiro Kudoh: Space and Earth science at the University of Electro-Communications.

Eiichiro Kokubo: Planetary science at the University of Tokyo; special lectures on planetary formation theory at the Graduate School of Kyoto University; introduction of planetary formation at Ryukyu University.

Fumitaka Nakamura: Astronomy investigation at the Graduate University for Advanced Studies.

Takashi Hamana: Geology at the Tokyo University of Agriculture and Technology.

Haruo Yoshida: Gravitational mechanics at the Graduate University for Advanced Studies.

Toshitaka Kajino delivered a Super Lecture entitled "Birth of the Universe, Life and Intelligence and the Future" in SSH-Korea Joint Symposium held at Kashiwazaki Senior High School in Niigata. Kohji Tomisaka and Takahiro Kudoh led a group of undergraduate students in visiting actual research sites during the Summer Student event of the Graduate University of Advanced Studies.

5. 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:

Michiko Fujii: "Spiral galaxies made by gravitational force" at Science Live Show Universe.

Takashi Hamana: "Dark matter and dark energy in Space" at Asahi Culture Center Yokohama.

Toshitaka Kajino: "Origin of the elements in the cosmos; The birth of the Universe and its mysterious connection with life" at the meeting of 1953 class union of the University of Tokyo.

Eiichiro Kokubo: "New travelogue to the Solar System" at Ikebukuro Community College, "The Earth in the Universe" at Mitaka City College, "Hometown of planets" and "New world – exo-planets discovered" at Asahi Culture Center Kyoto and Shinjyuku, "Origin of the Solar System" at Gunma Prefecture Observatory, "Origin of the Earth and Moon" at Sakae China-Japan Center.

Ken Ohsuga: "Computational approach to black holes" at Asahi Culture Center, Yokohama.

Masaomi Tanaka: "Supernova explosions and the origin of elements" at Asahi Culture Center Shinjyuku.

6. International Collaborations

Toshitaka Kajino performed duties of the following posts: editorial board member for the UK Institute of Physics "Journal of Physics G"; review panel member of the European Science Foundation Euro GENESIS Project; international referee for the Science, Technology and Innovation Council of Canada; 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 as a member of the Organizing Committee of the IAU's Extrasolar Planets Commission.

The Division of Theoretical Astronomy played leading roles in organizing the following international conferences:

- The First NAOJ-ECT* International Workshop on "Nuclear Physics and Astrophysics of Neutron-Star Mergers and Supernovae and the Origin of R-Process Elements," Trento in Italy, Sept. 8 - 12 in 2014. This international workshop was held based upon the agreement made between the NAOJ and ECT*, both signing the Memorandum of Understanding mediated through the Division of Theoretical Astronomy. This agreement encompasses the scientific advancement in border areas between astronomy and astro-, nuclear-, particle-, and condensed-matter physics by promoting an exchange of scientists and postgraduate students for international conferences, joint research projects, and university education programs in mutual collaboration.
- NAOJ-RIKEN Joint HPCI Workshop on "Physics of Neutron Stars and Supernova Explosions," RIKEN Wako in Japan, Dec. 16 - 20 in 2014.
- NAOJ-Beihang University Joint International Workshop on Cosmology and Nuclear Astrophysics, Beijing in China, Jan. 20 - 23 in 2015.

7. Awards

Takeshi Inoue received a 2014 Research Encouragement Award of the Astronomical Society of Japan. Akimasa Kataoka was awarded the President's Prize and Nagakura Research Encouragement Prize of The Graduate University of Advanced Studies. Seiji Zenitani was elected an Excellent Reviewer of 2014 for the Journal of Earth, Planets and Science (EPS) of the Society of Geomagnetism and Earth Planetary and Space Sciences. A journal paper written by Toshio Suzuki and Toshitaka Kajino 2013, J. Phys. G40, 083101 was selected as a highlight of 2013.

8. 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 2014 to the division are listed below:

Akif B. Balantekin, (University of Wisconsin–Madison, US)
Myung-Ki Cheoun, (Soongsil University, South Korea)
Cemsinan Deliduman, (Mimar Sinan Fine Arts University, Turkey)
Yamac Deliduman, (Mimar Sinan Fine Arts University, Turkey)
Kyungsik Kim, (Korea Aerospace University, Republic of Korea)
Motohiko Kusakabe, (Korea Aerospace University, Republic of Korea)
Man Hoi Lee, (University of Hong Kong, China)
Grant J. Mathews, (University of Notre Dame, USA)
Steven Rieder, (University of Groningen, Netherland)
Chung-Yoel Ryu, (Hanyang University, South Korea)
Edwin L. Turner, (Princeton University, USA)
Toshiya Ueta, (University of Denver, USA)
Ghil-Seok Yang, (Hangyang University, Republic of Korea)

23. Office of International Relations

The Office of International Relations strives in promoting autonomous research activities by planning and implementing strategies for NAOJ's international research efforts characteristic to the institution as a whole. It also supports efforts to strengthen the foundation for expanded internationalization.

The office's main activities include supporting international collaborative projects; 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.

1. International Collaborative Project Support

The office gathers and provides information necessary for pursuing international research collaborations on its own initiative. It also serves as a liaison point for international activities, engages in international agreements or provides support for doing so, and accumulates procedural and administrative knowledge. The office gathers and accumulates necessary and practical information for arranging agreements and contracts with overseas universities or research institutions, including precautions and problem solving, by means of conducting consultations or investigations on individual cases and provides such information as required. The Office of International Relations also offers advice and consultations, and responds to inquiries on a case-by-case basis. Other matters handled by the office include signing agreements and memoranda for international collaborations and addressing export security control issues in relation to overseas joint research projects.

2. Liaison Work for Overseas Astronomical Research Organizations

The Office of International Relations organized the annual directorate meeting of the East Asian Core Observatories Association (EACOA) on August 17, 2014 at Daejeon, Korea. The four institutions forming EACOA are NAOC (China), KASI (Korea), ASIAA (Taiwan), and NAOJ (Japan). The office also issued a public call for the EACOA postdoctoral fellowship program for 2015. In addition, it presented NAOJ's projects and research results by displaying an exhibit at the IAU Asia-Pacific Regional Meeting held on August 18 – 22 at Deajeon, Korea. Furthermore, the office supported the activities of the IAU Office for Public Outreach. The Office of International Relations also cooperated with EACOA member organizations in supporting the activities of the IAU Office for Astronomy Development (OAD) in the East Asia region.

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 to organizations or individuals for contact as appropriate, coordinating between organizations and gathering relevant information.

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. This involved consultation on visa applications and other procedures as well as general issues in relation to their stays in Japan to help ensure a pleasant experience. The office started to run a new support service called "Support Desk" providing general information useful for everyday activities. Japanese language lessons for newly arrived non-Japanese speaking staff members and students were also conducted.

5. Assistance in International Partnerships Involving Japanese Research Organizations

The Office of International Relations helps 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 OAO, Ishigakijima Astronomical Observatory, and nine Japanese universities. The collaboration with the Office of International Relations at NINS yielded a workshop for international joint research associates in which the office was involved from the planning stages to the preparation of a manual for hosting international researchers and in giving English-language master seminars to various NINS organizations.