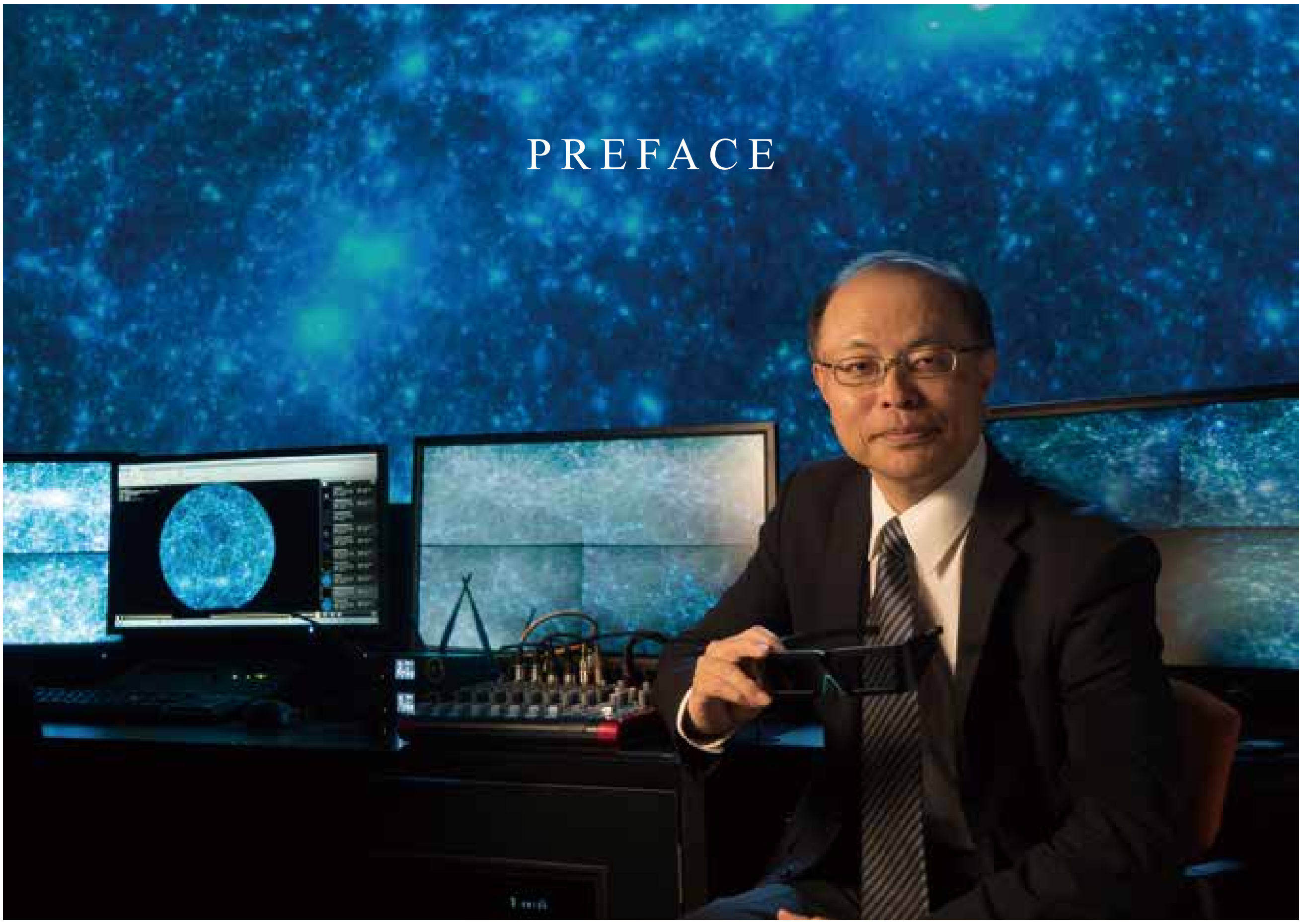
PREFACE



Masahiko HAYASHI
Director General of NAOJ

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

In 2015, the new 4D2U system, with an updated control computer network and projectors, was opened to the public. The overall brightness increased and the colors become more vivid. During simulations of the large-scale structure of the Universe or of Saturn's Ring you actually accept the illusion that you are really floating in space. So that as many people as possible can experience this feeling, which words cannot adequately convey, the seating of the Dome Theater has been doubled and the number of days offering public screenings has also been increased.

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

ALMA continues to show its true capabilities through long baseline observations which became possible with ALMA Cycle 3 observations starting from October 2015. Multiplering structures, like the protoplanetary disk of HL Tauri observed year before last, have been found surrounding other young stars. From variations in the submillimeter spectrum emitted by dust at different locations within the disk, the spatial distribution of the dust sizes continues to be clarified. It has reached a point where we can do research into the essence of planetary system formation by observing where in the disk dust particles are growing and planetesimals are forming, etc.

It is worth noting that thanks to ALMA's extremely high sensitivity, it is now possible to detect the far-infrared fine-structure lines of carbon and oxygen from galaxies in the distant Universe. These emission lines are good indicators of star formation activity. But because they are in the far infrared, they can't be observed from the ground, so previously they had only been observed by using flying instruments. But when the redshift exceeds 3 (i.e. the distance exceeds 12 billion light-years) the observed wavelengths of these emission lines shift to submillimeter waves, making them visible to ALMA. This is an excellent observational method to understand the details of star formation in the early Universe and the history of element production. Recently, the redshifted 88 μm wavelength emission line of ionized oxygen has been detected coming from a galaxy more than 13.1 billion light-years away discovered by the Subaru Telescope.

At the Subaru Telescope, the strategic program using the ultra-wide-field prime-focus camera (Hyper Suprime-Cam) is proceeding smoothly. This camera's survey speed (= limiting magnitude x field of view area) is more than 10 times that of previous surveys. Equipped with this camera, the Subaru Telescope will without a doubt be on the world's leading edge of observations until the U.S.A.'s Large Synoptic Survey Telescope starts operation in the mid-2020's. Observations by this camera will elucidate the distribution of dark matter across wide regions (and a wide range of distances) in the Universe. Hopefully we will be able to pursue the evolution of the large-scale structure of the Universe and get closer to understanding the true nature of dark matter and dark energy.

In addition there is KaVA (KVN and VERA Array), the joint research observation project utilizing both the Japanese and the South Korean VLBI networks which started in Fiscal Year 2014. Combining the strengths of VERA, which obtains high resolution, and KVN, which can detect spatially extended elements with high sensitivity, it ascertained that jets from active galactic nuclei (black holes) are accelerated to nearly the speed of light at their bases.

Regarding TMT, the next-generation extremely large optical-infrared telescope scheduled to be constructed in Hawai`i, the Maunakea Conservation District Use Permit was invalidated by the Hawai`i Supreme Court in December of 2015. This was extremely disappointing, especially since the construction of TMT near the summit of Maunakea is now supported by about 70 % of the people in the State of Hawai`i. The reason given for invalidating the permit was that there was a problem in the procedure used by the State of Hawai`i to grant the Conservation District Use Permit. The actual construction of TMT near the top of Maunakea has not been condemned. At NAOJ, together with the TMT International Observatory, we have reapplied for a Conservation District Use Permit for the summit area of Maunakea while working even harder than before to obtain the understanding of the local people.

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

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