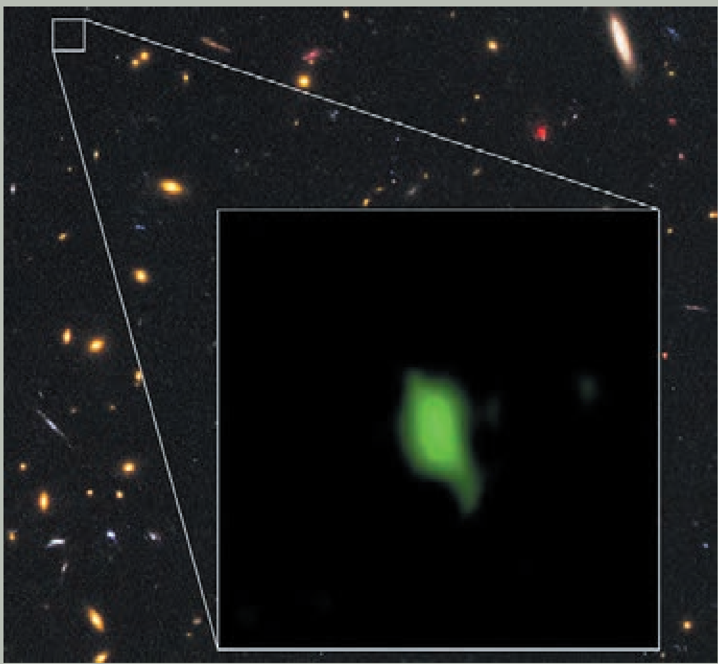
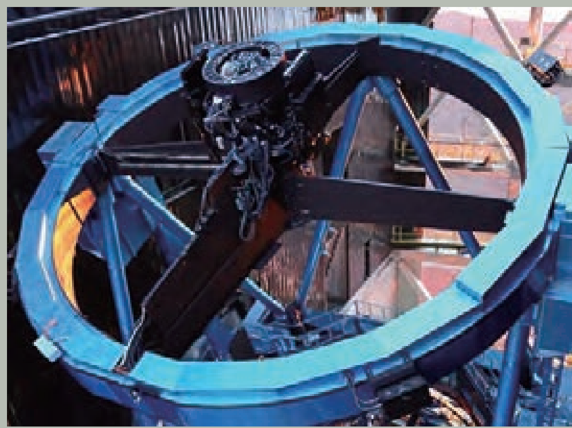
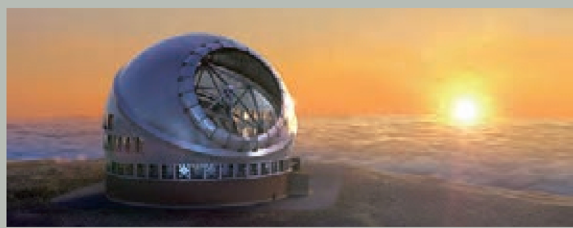
Inter-University Research Institute Corporation
National Institutes of Natural Sciences

National Astronomical Observatory of Japan







https://www.nao.ac.jp/en/

NAOJ

2022

NAOJ Facilities

Our research facilities have been set up throughout Japan and around the world in the best observational environments to explore the Universe.

Japanese Branches

NAOJ Mizusawa

Mizusawa VLBI Observatory (VERA)

NAOJ Mizusawa has a long history since its founding as a part of the International Latitude Observatories. Now with a strong focus on VLBI research, it operates the VERA array including one of its four radio telescopes located at Mizusawa.

Center for Computational Astrophysics

NAOJ Mizusawa hosts ATERUI II, the world's fastest supercomputer dedicated to astronomy.

RISE Project

The first accurate gravity and topography maps of the Moon were obtained using the KAGUYA mission's laser altimeter, relay satellite, and VLBI satellite. We intend to develop our research further by promoting exploration of not only the Moon but also asteroids and the Jovian System.

VERA Mizusawa Station.

ATERUI II.

NAOJ Nobeyama

Nobeyama Radio Observatory

Nobeyama Radio Observatory raised Japanese radio astronomy to the top tier internationally. The 45-m Radio Telescope is one of the largest millimeter radio telescopes in the world. It has achieved epoch-making results, such as discovery of new interstellar molecules and detection of the signature of an intermediate black hole in our galaxy. Nobeyama Campus is open daily to the public.

GWPO Kamioka Branch, KAGRA

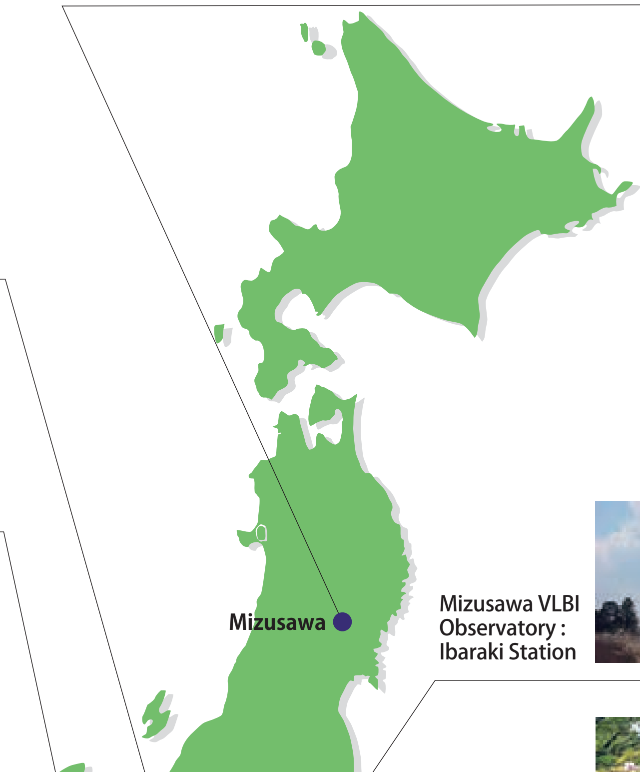
KAGRA, a gravitational wave telescope constructed in the Kamioka Mine, aims to expand the field of gravitational wave astronomy. The Kamioka Branch of the Gravitational Wave Project Office (GWPO) supports the installation and commissioning of KAGRA.

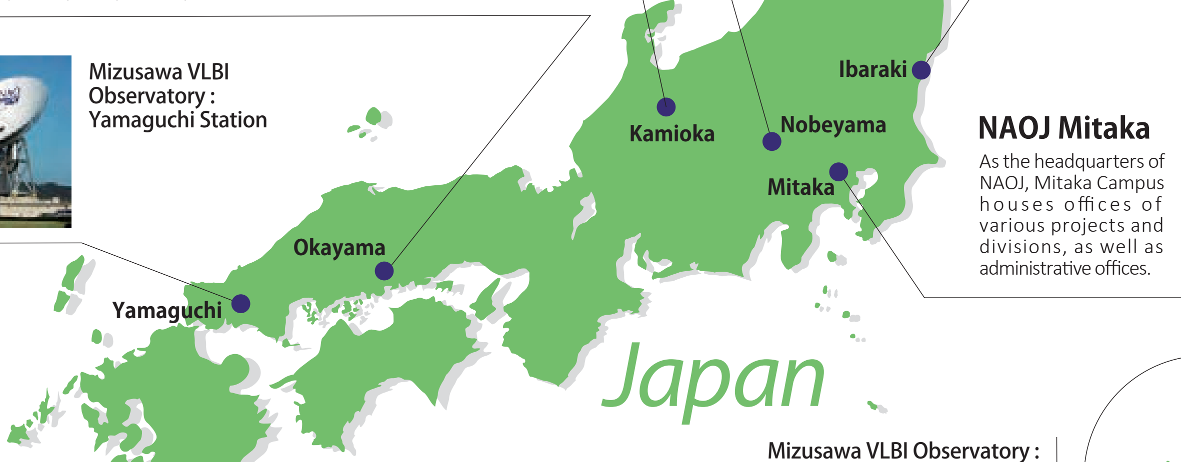
Subaru Telescope Okayama Branch

Open-use observations are conducted by NAOJ at the 3.8-m telescope of the Okayama Observatory, the Astronomical Observatory of the Graduate School of Science, Kyoto University. Open-use observing opportunities with the largest optical and near-infrared astronomy facility in Japan are provided.

Mizusawa VLBI Observatory : Ibaraki Station

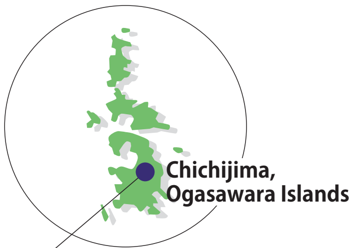
Mizusawa VLBI Observatory : Yamaguchi Station





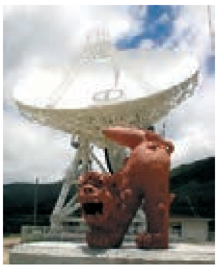

NAOJ Mitaka

As the headquarters of NAOJ, Mitaka Campus houses offices of various projects and divisions, as well as administrative offices.



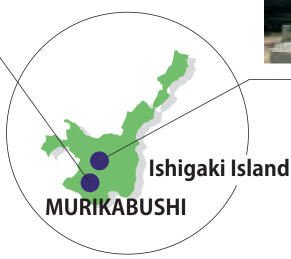
Mizusawa VLBI Observatory : Ogasawara Station (VERA)

Mizusawa VLBI Observatory : Ishigaki-jima Station (VERA)



Ishigakijima Astronomical Observatory

MURIKABUSHI is a 105-cm telescope in Ishigakijima Astronomical Observatory.



Mizusawa VLBI Observatory : Iriki Station (VERA)

Overseas Branches

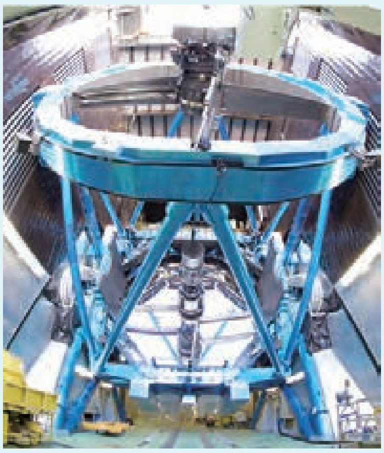
NAOJ Hawai'i

Subaru Telescope, NAOJ TMT Project Office

With many clear nights and stable airflow, the summit region of Maunakea (4200 meter altitude) is well suited for astronomy observations. Here, NAOJ constructed and operates the Subaru Telescope, and the 30 meter optical-infrared telescope TMT is being constructed through international collaboration.

Hilo Base Facility

The base facility of Subaru Telescope is located in Hilo on the Island of Hawai'i. As the base for the unified operation of the Subaru Telescope and TMT, this facility has laboratories, a machine shop, computer room, a remote observation room, etc.

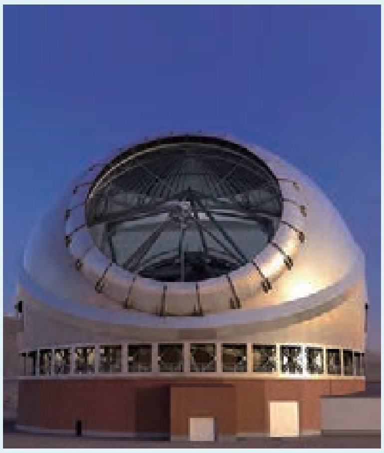


The Subaru Telescope (left)

An optical-infrared telescope with a world-class 8.2 meter aperture. Full-scale observations started from FY 2000. In FY 2022, a new project called "Subaru Telescope 2.0" started to investigate the evolution of the Universe and the origin of elements with core instruments.

TMT (right)

An extremely large optical-infrared telescope being constructed through international collaboration between Japan, the United States, Canada, China, and India. With more than 10 times the light collecting power of the Subaru Telescope, it aims to discover signs of life in the atmospheres of exo-planets and capture the light from the earliest stars in the Universe.



NAOJ Chile

NAOJ Chile, NAOJ ALMA Project

The Atacama Desert in northern Chile, one of the driest places on Earth, is an ideal location for short wavelength radio wave (millimeter and submillimeter wave) observation. ALMA and ASTE have been established here. The NAOJ Chile office and the Joint ALMA Observatory Santiago Central Offices are located in Santiago, the capital of Chile.

ALMA

ALMA, led by NAOJ, the National Radio Astronomy Observatory (US), and the European Southern Observatory, is a giant radio telescope array with 66 antennas operated on a 5000 meter elevation plateau in Chile. NAOJ collaborates in East Asia with the Academia Sinica Institute of Astronomy and Astrophysics in Taiwan and the Korea Astronomy and Space Science Institute.

ASTE

ASTE observes submillimeter radio waves with wavelengths shorter than 1 millimeter. Established in the Atacama Desert with optimal conditions for submillimeter astronomy, it applies its strength to observations of the southern sky including the Galactic center region, nearby star-forming regions, and distant galaxies.

ALMA Operations Support Facility

The Operations Support Facility is located 30 kilometers away from the ALMA Array Operations Site. It serves as the "base camp" for ALMA with lodgings and a cafeteria for ALMA staff in addition to the control room for remote operation of ALMA and laboratories where instrument maintenance is performed.

Public Access to NAOJ facilities

To widely disseminate our research results to the public, the major facilities of NAOJ offer visitors' areas, annual open house days, or regular stargazing parties.

NAOJ's Leading Edge Projects

NAOJ is involved in many world-class observatories and research facilities, either as the leader or as a partner with other research organizations. Major projects include Subaru Telescope, ALMA, KAGRA, ATERUI II, and Mizusawa VLBI Observatory. Moreover NAOJ promotes future-development projects like TMT. Here we introduce our major telescopes and instruments.

Subaru Telescope

The Subaru Telescope is an optical-infrared telescope with an 8.2-m monolithic primary mirror. It is installed near the summit of Maunakea, Hawaiʻi. The Subaru Telescope is accessible to the world astronomical community through open-use observations. The new project “Subaru Telescope 2.0” started in FY 2022, centering on large-scale survey observations by strengthening its wide field of view and high-resolution observation capabilities. Subaru Telescope 2.0 has the scientific goals of investigating dark matter and dark energy; the evolution of galaxies and the large-scale structure of the Universe and galaxies; multi-messenger astronomy; and extrasolar planets.

The Subaru Telescope illuminated by moonlight and the Pleiades star cluster (Subaru).

ALMA

The ALMA Compact Array, also known as the Morita Array.
(C) ALMA (ESO/NAOJ/NRAO)

The Atacama Large Millimeter/submillimeter Array (ALMA), located at an altitude of 5000 meters at the Chajnantor plateau in northern Chile, is a cutting-edge telescope array operated by a global partnership led by Japan, the United States, and Europe. ALMA observes astronomical objects in millimeter and submillimeter waves in ultra-high resolution using 66 antennas. Japan has contributed 16 of the antennas, called the Atacama Compact Array (ACA), receiver cartridges for three frequency bands, and a high-performance supercomputer called the ACA Correlator. In addition, Japan has led East Asian collaboration for receiver cartridges for an additional band and a high-performance spectrometer for the ACA. ALMA is delivering breakthroughs in understanding the formation of early galaxies, the origins of planetary systems, and the evolution of matter in the Universe.

Mizusawa VLBI Observatory

The 20-m radio telescope at Mizusawa VLBI.

As the center of VLBI astronomy in Japan, Mizusawa VLBI Observatory operates the VERA array consisting of four 20-m radio telescopes located at Mizusawa, Iriki, Ogasawara, and Ishigaki Island, which forms a huge virtual radio telescope with a diameter of 2300 km. Having explored the 3D structure of our Milky Way galaxy by measuring the distances to Galactic objects with high accuracy for more than 15 years, now we promote international collaborations to expand the East Asian VLBI Network together with China, the Republic of Korea, Thailand, and so forth, which enables astronomers to obtain images of celestial objects with extremely high angular resolution.

We promote the use of computer systems for simulation including ATERUI II; the world's fastest supercomputer for astrophysics (theoretical peak performance of 3 Pflops), research and development for simulation technology; and astronomy research using simulations. Our objective is to reveal aspects of the Universe that cannot be observed by any telescope through calculations based on the laws of physics. The project office has made many contributions to our understanding of the large-scale structure of the Universe, and the formation and evolution of celestial objects. We strive to provide more realistic simulations and address the unsolved mysteries of the Universe.

The supercomputer for astronomy "ATERUI II".

ATERUI II

The first detection of gravitational waves by LIGO marked the beginning of gravitational-wave astronomy. In collaboration with ICRR, KEK, and other institutes, we promote the KAGRA project; a large interferometer with 3-km L-shaped arms in an underground tunnel at Kamioka Mine. KAGRA was designed based on TAMA300, a 300-m laser interferometer situated underground in NAOJ Mitaka Campus. TAMA300 is now used to develop new technologies for upgrading KAGRA and conduct pre-installation testing of the instruments for KAGRA. The project office also conducts research on improving the sensitivity of gravitational-wave detectors and the possibility of a space-based gravitational-wave observatory.

The KAGRA vacuum duct.

KAGRA

TMT

An artist's rendition of the night sky and TMT.

The Thirty Meter Telescope (TMT) is an extremely large optical-infrared telescope with an aperture of 30 m, slated for construction on Maunakea in Hawai'i. Thanks to its unprecedented assembly of 492 mirror segments, TMT will have 13 times the light-gathering power and 3.6 times the resolving power of the 8.2 m Subaru Telescope. TMT will explore the mysteries of the Universe far beyond the reach of existing telescopes, such as research in astrobiology. Its observations will range from objects within our Solar System to distant stellar explosions, the farthest galaxies, and other traces of the beginning of the Universe. The TMT Project is advancing through international collaboration including Japan, USA, Canada, China, and India.

NAOJ's "Philosophy"

Our Vision

- To be innovators striving to solve the mysteries of the Universe.

Our Mission

- To develop and construct large-scale cutting-edge astronomical research facilities and promote their open access aiming to expand our intellectual horizons.
- To contribute to the development of astronomy as a world leading research institute by making the best use of a wide variety of large-scale facilities.
- To bring benefits to society through astronomy public outreach.

Our Products / Deliverables

- To explore the unknown Universe and provide new insight into astronomy.
- To make our research outcomes widely known to society and pass on our dreams to future generations.
- To mentor next-generation researchers for their role on the world-stage.

Graduate Course Education

NAOJ constitutes the Department of Astronomical Science of the Graduate University for Advanced Studies (SOKENDAI). NAOJ also accepts graduate students from other universities through the Cooperative Graduate School Program and the Visiting Graduate Students Program. Through the educational activities above, NAOJ contributes to fostering the education of graduate students in a variety of leading research fields.

Number of Graduate Students (as of April 1, 2022)

- **Students from SOKENDAI** ······ 32
- **Students from Cooperative Universities** ······ 28
- **Visiting Graduate Students** ······ 14

Department of Astronomical Science, School of Physical Sciences, the Graduate University for Advanced Studies (SOKENDAI)

●Department of Astronomical Science, School of Physical Science, SOKENDAI is graduate school based at NAOJ.

●The graduate school offers two programs: a five-year doctoral program for graduate students and a three-year doctral program for graduates with a Master's degree.

●Course Organization

- **Optical and Infrared Astronomy Course**
- **Radio Astronomy Course**
- **General Astronomy and Astrophysics Course**

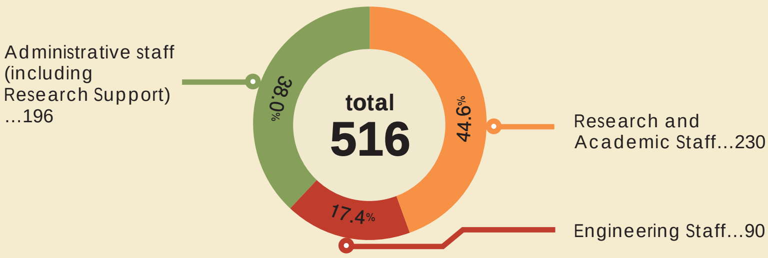
NAOJ accepted students from the following graduate schools in the last five years.

Tohoku University, Ibaraki University, University of Tsukuba, The University of Tokyo, Tokyo Institute of Technology, University of Electro-Communications, Niigata University, Shinshu University, Nagoya University, Yamaguchi University, Kyushu University, Kagoshima University, Osaka Prefecture University, Kyoto Sangyo University, Tokyo City University, Nihon University, Japan Women's University, Hosei University, Tufts University (in no particular order)

An observation training course at the Subaru Telescope.

Profile of NAOJ (as of April 1, 2022)

■Number of Employees



■Campus Area

1,013,425m²
(tenancy 556,309m²)

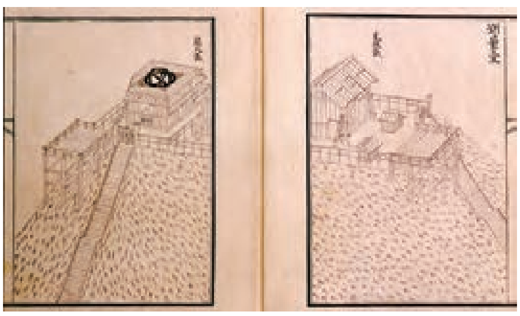
■Budget (including personal salaries)

12,127,876,000 yen

History of NAOJ (1888-2022)

The origin of NAOJ dates back to the latter Edo era (more than 300 years ago) when continuous observations of stars began at Asakusa Observatory of the shogunal tenmon-kata (the shogunal astronomical office).

The first main tasks of the astronomical observatory were determining longitude and latitude by observing stars, calculating the calendar, and determining the time. These were started as national projects in the Meiji era, and have been continued as part of the work of NAOJ.




Latitude Observatory.

1888 The Tokyo Astronomical Observatory was established. (Iikura, Azabu)

1899 The Latitude Observatory was established in Mizusawa

1924 The establishing of Mitaka Campus started.

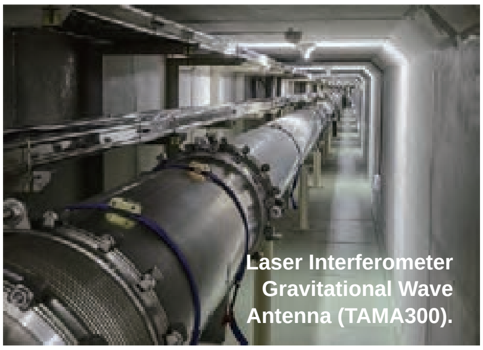
1925 Publication of "Chronological Scientific Tables (Rika Nenpyo)" began.

Rika Nenpyo

Since its first publication in 1925, we have been publishing Rika Nenpyo for over 90 years in cooperation with many research organizations.


Mitaka Campus in the early Showa Era.


65-cm Refractor Telescope.


Laser Interferometer Gravitational Wave Antenna (TAMA300).


Mizusawa 20-m Radio Telescope.


ALMA.

1926 65-cm Telescope Dome completion.

1929 65-cm equatorial telescope was equipped.

1930 Solar Spectroscopy Photographic Building (The Einstein Tower) was built.

1946 Publication of Almanacs and "Calendar and Ephemeris" began.

1949 Norikura Solar Observatory began observations. (Opening ceremony in July 1950)

1960 Okayama Astrophysical Observatory began observations.

1962 Dodaira Observatory began observations.

1969 Nobeyama Solar Observatory began observations (Opening ceremony on October 9).

1982 Nobeyama millimeter radio telescope began observations (Opening ceremony of Nobeyama Radio Observatory on March 1).

1988 The National Astronomical Observatory of Japan was established.

1992 Nobeyama Radioheliograph began observations.

1999 Subaru Telescope first light (Opening ceremony on September 17).

1999 Laser Interferometer Gravitational Wave Antenna "TAMA300" began observations.

2000 Dodaira Observatory was closed.

2000 Visitors' Area opened at Mitaka Campus.

2001 Agreement of ALMA project among Europe, the United States, and Japan.

2001 VERA Stations began observations.

2004 NAOJ was incorporated as the National Astronomical Observatory of Japan, National Institutes of Natural Sciences, Inter-University Research Institute Corporation.

2006 Ishigakijima Astronomical Observatory began observations.

2006 HINODE began solar observations.

2007 As a part of the Four-Dimensional Digital Universe (4D2U) project, the 3-dimensional dome theater was completed.

2007 The Lunar Explore "KAGUYA" was launched and began observations.

2010 Norikura Solar Observatory was closed after 60 years of service.

2011 ALMA initial operation started.

2013 Regular ALMA observations started.

2014 TMT International Observatory was established. NAOJ participated as an initial member.

2015 Nobeyama Solar Observatory was closed.

2018 Okayama Astrophysical Observatory was closed.

2018 Super Computer ATERUI II started operation.

2020 KAGRA began observations.

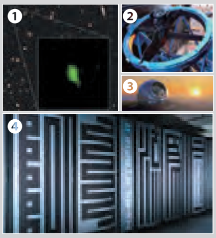

Solar Tower Telescope.


Nobeyama 45-m Radio Telescope.


Subaru Telescope.

Inter-University Research Institute Corporation
National Institutes of Natural Sciences
National Astronomical Observatory of Japan

2-21-1 Osawa, Mitaka, Tokyo, 181-8588, Japan
Phone +81-422-34-3600
https://www.nao.ac.jp/en/



Front Cover

1/ Oxygen distribution detected by ALMA in MACS1149-JD1, a galaxy 13.28 billion light-years away. (Green image, Background image from Hubble Space Telescope) [Image Credit: ALMA (ESO/NAOJ/NRAO), NASA/ESA Hubble Space Telescope, W. Zheng (JHU), M. Postman (STScI), the CLASH Team, Hashimoto et al.] 2/ Hyper Suprime-Cam (HSC) on the Subaru Telescope. 3/ Conceptual image of TMT when completed. 4/ Massively parallel supercomputer Cray XC50 “ATERUI II.”

Back Cover

Near infrared image of the star-forming region S 106 which is at a distance of approximately 2000 light-years from the Earth. A massive star called Infrared Source 4 (IRS 4) exists at the center of S 106. The hourglass appearance of S 106 is thought to be the result of the way material flows outwards from the central star. A huge disk of gas and dust surrounding IRS 4 produces the constriction at the center (Subaru Telescope).