Commission J: Radio Astronomy (Novebber 2007 – October 2010)

Edited by H. Kobayashi

J1 Overview of Japanese radio astronomy activity

One of most important activities in Japanese radio astronomy is ALMA project, which is a millimeter and submillimeter large array with 80 telescopes at Atacama Desert of Chili. Japan shares quarter burden for the construction and operation. In concrete terms, Japan has constructed ACA (Atacama Compact Array), which consists of four 12-m telescopes and twelve 7-m telescopes, and 3 band receiver cartridges for whole ALMA telescopes. The construction of ALMA is succeeding and science observations have been started.

In the field of millimeter and submillimeter radio astronomy, ASTE telescope, which is a 10-m submillimeter telescope at Atacama Desert, has started science observations. A large TES bolometer array is used for simultaneously imaging the sky in the two bands (1100 and 850 micron). It discovered a cluster of galaxies, which show ultra star burst formation. And Nobeyama 45-m telescope is continued for science observations and Nobeyama millimeter array was closed for common use.

At the field of VLBI (Very Long Baseline Interferometer) researches, VERA (VLBI Exploration of Radio Astrometry) was started to carry out a precise astrometry project to measure the distance of galactic maser objects by using trigonometric parallax measurement technique. It has revealed the structure of nearby spiral arm structure around the Sun. And a new VLBI correlator is developed under the collaboration with NAOJ (National Astronomical Observatory of Japan) and KASI (Korean Astronomy and Space Science Institute), which will be used for the East Asian VLBI network observations. Also Japanese VLBI network have started science observations with 6, 8 and 22 GHz bands.

And NANTEN telescope, which is a 4-m submillimeter telescope at Chili, has made wide field mapping observations of southern hemisphere sky.

On September 2007, SELENE satellite was launched, which is a lunar probe vehicle. In order to make precise hypsographic map and gravity map of whole lunar globe, Japanese VLBI network has used for the satellite tracking. It revealed the accurate gravitational field of the whole of the moon.

J2. ALMA

The Atacama Large Millimeter/submillimeter Array (ALMA) is most important project for Japanese radio astronomy. It is constructed and operated by Europe, Japan, and North America, in cooperation with the Republic of Chile. ALMA is funded in Europe by the European Organization for Astronomical Research in the Southern Hemisphere, in Japan by the National lnstitutes of Natural Sciences(NINS) in cooperation with the Academia Sinica in Taiwan, and in North America by the U.S. National Science Foundation (NSF) in cooperation with the National Research Council of Canada (NRC). ALMA construction and operations are led on behalf of Europe by ESO, on behalf of Japan by the National Astronomical 0bservatory of Japan (NAOJ), and on behalf of North America by the National Radio Astronomy Observatory (NRAO). ALMA will have 54 12-m telescopes and 12 7-m telescopes with 3-0.3 mm wavelength receivers.

East Asia shares the construction of Atacama Compact Array (ACA), which is a part of ALMA for wide field and extended structure imagings. ACA consists of four 12-m telescopes and twelve

7-m telescopes. Also East Asia has been developing three bands receivers, which are 125-163GHz, 385-500GHz, and 780-950 GHz, and a correlator. Operation and data analysis software is developing with international collaborations.

ALMA was succeded test observations at 230, 345, and 690 GHz with more than 10 telescopes. They already showed the higest feasibilities of sensitivity and spatial resolution in millimeter and submillimeter arrays. And first science program with common use will start within 2011.

J3 .ASTE

ASTE is 12-m single dish telescope for millimeter and submillimeter observations. It has four receivers, which are 350GHz/450GHz heterodyne receivers and the 270GHz/350GHz bolometer camera. It made important scientific results for star busrt galaxies, galactic star forming regions and others. ASTE discovered very active star burst galaxy at 11.5 Giga light-year distances, which shows 1000 time star formation than Milkyway galaxy. Also other star burst galaxies are discovered. These results are important for understanding of the revolution of galaxies.

J4. VLBI

In the field of VLBI, Japan has mainly two activities. One is ground-based arrays, such as VERA, JVN and EAVN. The other is a space-based project, which is VSOP-2. VERA aims to measure the trigonometric parallaxes for galactic maser sources and reveal real structure of the Milkyway galaxy. VERA has started to observe more than 200 sources and determine the distance and proper motions for around 50 sources. And neaby arm structure around Sun is decided. Also JVN (Japanese VLBI Network) has started science observations, which consists of 12 VLBI stations in Japan. Fine structure of jets and disks in star forming regions are revealed by 6.7GHz methanol maser observations. And other high sentivity VLBI observations have been carried out. Moreover EAVN (East Asian VLBI network) is started. Some test observations were done and feasibility is checked between Japan, Korea and China. EAVN has around 20 VLBI stations, which is the biggest in the world. And new VLBI correlator is constructed by the interbational collaborations between Japan and Korea. It has 16 stations correlations with 8Gbps data rate per station, which is the biggest capability in the world. Space VLBI project, which is used space radio telescope as a VLBI station, is started the project. 9-m deployment antenna, which is a key instrument, met some difficulties. It is under the review of project by ISAS/JAXA.

J5. Others

Japan has many activities of radio astronomy. Hokakido University has a 11-m telescope for 22 GHz observations. NH_3 observations for galactic sources are published. Ibaraki University is operating two 32-m telescopes at Takahagi under the collaboration with NAOJ. They have 6, 8, and 22 GHz receivers for single dish and VLBI observations. National Institute of Communication and Trasmission (NICT) has a 32-m telescope at Kashima for VLBI. And NICT has developed VLBI sampler, recorder and software correlator for geodesy VLBI. Geo-Survey Institute (GSI) of Japan has a 32-m telescope at Tsukuba for geodesy VLBI, which is to keep the original point in Japan. GSI has three 11-m telescopes for geodesy VLBI in Shitotsugawa, Aira, and Chichijima. Moreover Tsukuba University uses GSI 32-m telescope for astonomy usage at 22GHz. Institute of Space and Astronaitics Science (ISAS) has a 64-m telescope at Usuda, which is mainly used for satellite tracking. It is used for VLBI. Waseda University has an 8-element array with 20-m fixed telescopes at 1.4 GHz, which is mainly used for pulsar and transient sources. Naogoya University has a 4-m submillimeter telescope at Atacama, which is called as NANTEN.

It made large survey of some star forming regions. Gifu University has a 11-m telescope at 8 and 22GHz, which is used for geodey VLBI and optical fiber VLBI experiments. Osaka Prefecture University has a 1.85-m telescope at Nobeyama and an activity to develop new receivers. 6GHz and 8GHz common polarized and receiver is developed and used at Takahagi and Shanghai telescopes. Yamaguchi University is operating 32-m telescope at Yamaguchi with NAOJ, which has 6GHz and 8GHz receivers. It is used for single dish and VLBI obserbations and made some results of methanol masers and active galactic nuclei sources. Kagoshima Univeristy is collaborating with NAOJ for VERA. Period luminosity relation of Mira variables is deteming.

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  - Following the recent discovery of γ-rays from the radio-loud narrow-line Seyfert 1 galaxy PMN J0948+0022 (z = 0.5846), we started a multiwavelength campaign from radio toγ-rays, which was carried out between the end of 2009 March and the beginning of July. The source displayed activity at all the observed wavelengths: a general decreasing trend from optical toγ-ray frequencies was followed by an increase of radio emission after less than two months from the peak of theγ-ray emission. The largest flux change, about a factor of about 4,

occurred in the X-ray band. The smallest was at ultraviolet and near-infrared frequencies, where the rate of the detected photons dropped by a factor 1.6-1.9. At optical wavelengths, where the sampling rate was the highest, it was possible to observe day scale variability, with flux variations up to a factor of about 3. The behavior of PMN J0948+0022 observed in this campaign and the calculated power carried out by its jet in the form of protons, electrons, radiation, and magnetic field are quite similar to that of blazars, specifically of flat-spectrum radio quasars. These results confirm the idea that radio-loud narrow-line Seyfert 1 galaxies host relativistic jets with power similar to that of average blazars.

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- It is widely accepted that strong and variable radiation detected over all accessible energy

bands in a number of active galaxies arises froma relativistic, Doppler-boosted jet pointing close to our line of sight1. The size of the emitting zone and the location of this region relative to the central supermassive black hole are, however, poorly known, with estimates ranging from light-hours to a light-year or more. Here we report the coincidence of a gamma (c)-ray flare with a dramatic change of optical polarization angle. This provides evidence for co-spatiality of optical and c-ray emission regions and indicates a highly ordered jet magnetic field. The results also require a non-axisymmetric structure of the emission zone, implying a curved trajectory for the emitting material within the jet, with the dissipation region located at a considerable distance from the black hole, at about 105 gravitational radii.

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  - The observations of 3 and 5 minute oscillations in sunspots present information on propagation of MHD waves in the magnetic tubes of sunspots. We present a comparison of wavelet spectra of radio flux oscillations at = 1.76 cm and oscillations of longitudinal component of the velocity at the chromosphere in sunspot umbra and penumbra in AR 10661 (2004, Aug 18). The radio maps of the Sun obtained with the Nobeyama Radioheliograph were used. The spatial resolution of the radio data was about 10-15 arcsec, and 10 sec cadence was used. On the radio maps sunspot-associated sources were identified and time profiles of their maximum brightness temperatures for each radio source were calculated. Radio data consists of information of oscillations of plasma parameters (in the regions with magnetic field B = 2000 G) at the level of the chromosphere-corona transition region. The optical observations were carried out at Sayan observatory. These data included information on longitude component of the magnetic field at the photosphere (line Fe I 6569Å and longitudinal component of the velocity at the chromosphere (line Hα was used). Comparing the wavelet diagrams covering the same periods of observations at radio and optics showed that some wave trains of time profiles are very similar in both kinds of observations (similar oscillation frequencies and their drifts, variations of amplitudes), however, some significant differences were also registered. The best similarity in optical and radio oscillations was found when the active region (AR) was near the center of the solar disk. The phase shifts between the two kinds of observations reflecting the propagation of MHD waves were also analyzed.
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  - The Atacama Large Millimeter/submillimeter Array (ALMA) is a major 21st century international science research facility that will open new windows on celestial origins. ALMA construction is underway in the high-elevation Atacama Desert of northern Chile. Science operations will begin in 2010, and full science operations will start in 2013. The ALMA Education and Public Outreach (EPO) programme is a global collaboration that seeks to communicate the excitement and value of the ALMA mission, science, and technology to international audiences effectively. The ALMA EPO programme is the responsibility of the Joint ALMA Observatory (JAO), the National Radio Astronomy Observatory (NRAO), the European Organisation for Astronomical Research in the Southern Hemisphere (ESO), and the National Astronomical Observatory of Japan (NAOJ). This contribution provides an overview of the ALMA Project and the global ALMA EPO programme.
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- We report present status and the first results from the laser altimeter (LALT) on Kaguya (SELENE) lunar explorer. LALT started its observations on December 30, 2007. New, but preliminary, lunar topography will be obtained after two months observation by LALT.

- Araki, H., S. Tazawa, H. Noda, T. Tsubokawa, N. Kawano, and S. Sasaki [2008b], "Observation of the Lunar Topography by the Laser Altimeter LALT on Board Japanese Lunar Explorer SELENE," Adv. Sp. Res., vol.42, pp.317-322.

- The SELENE Laser Altimeter (LALT) is designed to map the Moon's topography and will be launched in summer 2007. LALT incorporates Q-switched Cr doped Nd:YAG laser (1064 nm) with an output energy of 100 mJ and 1 Hz repetition frequency for about one year mission period. The laser pulse travels to the Moon's surface and reflections from the surface are detected by a silicon avalanche photo-diode. The ranging distance is 50-150 km with about 5 m accuracy. Several corrections for accurate ranging data are investigated. The flight hardware has been qualified and passed all the integration tests. A principal goal of the LALT instrument is to obtain a much more detailed lunar topographic map which is superior in global coverage, measurement accuracy and number of data points to previous observations and models. The overall science objectives of LALT are (1) determination of lunar global figure, (2) internal structure and surface processes, (3) exploration of the lunar pole regions, and (4) reduction of lunar occultation data.

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- Araki, H., Y. Ishihara, H. Noda, S. Goossens, S. Tazawa, N. Kawano, S. Sasaki, and J. Oberst [2008d], "A New Lunar Topographic Map of the Moon by KAGUYA-LALT: The First Precise Topography of the Polar Regions," American Geophysical Union, Fall Meeting 2008, abstract #P13E-04.

- The Japanese lunar explorer KAGUYA (SELENE) was launched successfully on September 14th, 2007. A laser altimeter (LALT) is on board the main orbiter of KAGUYA. The objectives of LALT are (1) determination of lunar global figure, (2) studies in internal structure and surface processes, (3) exploration of the lunar pole regions, and (4) reduction of lunar occultation data. LALT transmits laser pulses whose time width is about 20 nano-seconds and pulse interval is 1 second. Range accuracy is up to 5m. The range data are transformed to the topography of the moon with the aid of position and attitude data of the main orbiter. From the end of December 2007, LALT started continuous operation and a global topography map with unprecedented resolution was produced. Lunar mean radius is estimated as 1737.15±0.01 km and the COM-COF offset is 1.94 km based on the spherical harmonic model STM359_grid-02 derived from LALT topography. The amplitude of the power spectrum of STM359_grid-02 is larger than that of the previous model at L>30 degrees, which may reflect the process of basin formation and/or crustal evolution. In the polar regions where previous CLEMENTINE altimeter did not cover, many topographic features that were difficult to see on the imagery from spacecraft or ground based radar are discovered. The sunlit rate in the lunar polar regions is estimated by using the polar topographic map made from LALT topography. We found that i) the highest sunlit rate is 93~96 % in both polar regions and ii) the eternal shadow area is smaller than previous estimations. These results will be of great use for the planning of the lunar polar exploration in near future.

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  - A global lunar topographic map with a spatial resolution of finer than 0.5 degree has been derived using data from the laser altimeter (LALT) on board the Japanese lunar explorer Selenological and Engineering Explorer (SELENE or Kaguya). In comparison with the previous Unified Lunar Control Network (ULCN 2005) model, the new map reveals unbiased lunar topography for scales finer than a few hundred kilometers. Spherical harmonic analysis of global topographic data for the Moon, Earth, Mars, and Venus suggests that isostatic compensation is the prevailing lithospheric support mechanism at large scales. However, simple rigid support is suggested to dominate for the Moon, Venus, and Mars for smaller scales, which may indicate a drier lithosphere than on Earth, especially for the Moon and Venus.
- Araki, H., S. Tazawa, H. Noda, Y. Ishihara, S. Goossens, N. Kawano, S. Sasaki, I. Kamiya, H. Otake, J. Oberst, and C. K. Shum [2009b], "The Lunar Global Topography by the Laser Altimeter (LALT) Onboard Kaguya (SELENE): Results from the One Year Observation," 40th Lunar and Planetary Science Conference, (Lunar and Planetary Science XL), held March 23-27, 2009 in The Woodlands, Texas, id.1432.
  - A global and precise topographic map of the Moon has been derived by the laser altimeter (LALT) onboard the Japanese lunar explorer Kaguya (SELENE). Results of the one year observation and implications from the LALT topography will be presented.
- Araki, H., S. Tazawa, H. Noda, E. Migita, I. Kamiya, N. Kawano, and S. Sasaki [2010], "Preliminary Results of Lunar Topography by KAGUYA-LALT Mission," Trans. of Sp. Tech. Japan, vol.7, pp.Tk23-Tk25.
  - The Laser Altimeter (LALT) on board the main orbiter of KAGUYA (SELENE) started nominal observation on December 30, 2007 for mapping the lunar topography. As of March 31, 2008, LALT has obtained about 6.7 million topographic data and the return rate is 97%. Several qualifications of the data to produce reliable topography are now in progress. The present status and preliminary results are reported in this article.
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  - We report the advantages and potentials of VSOP-2 observations for studying the central engine of M 87. Extremely high angular resolution of VSOP-2 of 38μ-arcsecond will provide us the unique opportunity to observe M 87 with spatial resolution of 0.0031 pc. This corresponds to around 10 times the Schwarzschild radius so that VSOP-2 can be a powerful tool to reveal the accretion disk and jet launching site, and investigate the formation, acceleration and collimation of the jet in connection with the physics of the accretion disk. A polished plan based on these studies will be proposed as one of the Key Science Programs of VSOP-2 mission in the category of Active Galactic Nuclei.
- Asada, K., S. Kameno, Z.-Q. Shen, H. Shinji, D. C. Gabuzda, and M. Inoue [2009b], "3C 84 Expanding Radio Lobe Revealed by VSOP Observations," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.91-95.
  - We report the detection of the expansion and inner proper motions of a young radio lobe associated with the bright radio source 3C 84 in the Seyfert galaxy NGC 1275 using multi-epoch VSOP observation. The observed inner proper motions are consistent with the evolution scenario of classical double radio sources. The apparent expansion velocity is

0.50±0.09 c, and the age of radio lobe is estimated to be 45.7±8.9 years in 2001. The total flux density at 5 GHz increased at the end of the 1950's, with several peaks in the middle of the 1980's, and is in a decay phase now. The decay of total flux density can be naturally explained by an adiabatic cooling due to the expansion of the radio lobe, and previously measured spectral indices suggest that the emission comes from the surface of the radio lobe.

- Asai, A., K. Shibata, H. Hara, and N. Nitta [2008a], "Characteristics of Anemone Active Regions Appearing in Coronal Holes Observed with the Yohkoh Soft X-Ray Telescope," Astrophys. J., vol.673, pp.1188-1193.
  - Coronal structure of active regions appearing in coronal holes is studied, using data that were obtained with the Soft X-Ray Telescope (SXT) aboard Yohkoh between 1991 November and 1993 March. The following characteristics are found. Many of the active regions (ARs) appearing in coronal holes show a structure that looks like a sea anemone. Such active regions are called anemone ARs. About one-fourth of all active regions that were observed with SXT from their births showed the anemone structure. For almost all the anemone ARs, the order of the magnetic polarities is consistent with the Hale-Nicholson polarity law. These anemone ARs also showed, to a greater or lesser extent, an east-west asymmetry in the X-ray intensity distribution, such that the following (eastern) part of the AR was brighter than its preceding (western) part. This, as well as the anemone shape itself, is consistent with the magnetic polarity distribution around the anemone ARs. These observations also suggest that an active region appearing in coronal holes has a simpler (less sheared) and more preceding-spot-dominant magnetic structure than those appearing in other regions.
- Asai, A., H. Hara, T. Watanabe, S. Imada, T. Sakao, N. Narukage, J. L. Culhane, and G. A. Doschek [2008b], "Strongly Blueshifted Phenomena Observed with {¥it Hinode}/EIS in the 2006 December 13 Solar Flare," Astrophys. J., vol.685, pp.622-628.
  - We present a detailed examination of strongly blueshifted emission lines observed with the EUV Imaging Spectrometer on board the Hinode satellite. We found two kinds of blueshifted phenomenon associated with the X3.4 flare that occurred on 2006 December 13. One was related to a plasmoid ejection seen in soft X-rays. It was very bright in all the lines used for the observations. The other was associated with the faint arc-shaped ejection seen in soft X-rays. The soft X-ray ejection is thought to be a magnetohydrodynamic (MHD) fast-mode shock wave. This is therefore the first spectroscopic observation of an MHD fast-mode shock wave associated with a flare.
- Asai, A., H. Nakajima, M. Shimojo, T. Yokoyama, S. Masuda, and S. Krucker [2009], "Imaging Spectroscopy on Preflare Coronal Nonthermal Sources Associated with the 2002 July 23 Flare," Astrophys. J., vol.695, pp.1623-1630.
  - We present a detailed examination on the coronal nonthermal emissions during the preflare phase of the X4.8 flare that occurred on 2002 July 23. The microwave (17 GHz and 34 GHz) data obtained with Nobeyama Radioheliograph, at Nobeyama Solar Radio Observatory and the hard X-ray (HXR) data taken with RHESSI obviously showed nonthermal sources that are located above the flare loops during the preflare phase. We performed imaging spectroscopic analyses on the nonthermal emission sources both in microwaves and in HXRs, and confirmed that electrons are accelerated from several tens of keV to more than 1 MeV even in this phase. If we assume the thin-target model for the HXR emission source, the derived electron spectral indices (~4.7) is the same value as that from microwaves (~4.7) within the observational uncertainties, which implies that the distribution of the accelerated electrons follows a single power law. The number density of the microwave-emitting electrons is, however, larger than that of the HXR-emitting electrons, unless we assume low-ambient plasma density of about 1.0×10^9 cm^{-3} for the HXR-emitting region. If we adopt the thick-target model for the HXR emission source, on the other hand, the electron spectral index (~6.7) is much different, while

the gap of the number density of the accelerated electrons is somewhat reduced.

- Asaki, Y., S. Deguchi, H. Imai, K. Hachisuka, M. Miyoshi, and M. Honma [2008], "Measurements of Annual Parallaxes and Proper Motions of the Red Supergiant S Per," Proc. of the IAU Symp. 242, "Astrophysical Masers and their Environments", eds. Jessica Chapman and Willem Baan, pp.378-380.
  - VLBI phase-referencing monitoring of water vapor masers around the red supergiant, S Per, was conducted over four years. We successfully obtained proper motions and an annual parallax of the masers and determined the distance to S Per of 2.51±0.09 kpc. The proper motion of the star itself was inferred from the maser proper motions, and it was -0.38 and -1.54 mas/yr for right ascension and declination, respectively. Assuming the distance from the sun to the Galactic center, R0, of 8.5 kpc and the rotation velocity around the sun, θ_0, of 220 km/s, the Galactic rotation velocity around S Per is 200 km/s.
- Asaki, Y., and Y. Kono [2009a], "VSOP-2 Astrometric Accuracy with Phase Referencing," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.435-440.
  - The VSOP-2 mission is expected to conduct phase referencing observations with the unprecedented spatial resolutions at 8.4, 22, and 43 GHz together with the ASTRO-G satellite. In this report, VSOP-2 astrometry with phase referencing is examined in detail based on a simulation tool, ARIS.
- Asaki, Y., and M. Miyoshi [2009b], "A Future Submillimeter-Wave Space VLBI," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.431-434.
  - Submillimeter-wave VLBI is a very attractive idea for future radio astronomy. We discuss a submillimeter space VLBI based on the simulation of (u, v) coverage. We assume observations using three terrestrial submillimeter telescopes and one telescope in a sun-synchronous low-Earth orbit. The simulated array gives a well-filled (u, v) coverage for a specified source. However, the (u, v) coverage becomes much poorer if real-time VLBI data transfer from the satellite to the ground is needed even with a telemetry network with seven ground stations. Alternative methods for the VLBI data acquisition from the space telescope will be required for the proposed space VLBI.
- Asayama, S., S. Kawashima, H. Iwashita, T. Takahashi, M. Inata, Y. Obuchi, T. Suzuki, and T. Wada [2008], "Design and Development of ALMA Band 4 Cartridge Receiver," Proc. of the 19th International Symposium on Space THz Technology, ed. Wolfgang Wild, pp.244-249.
  - This paper describes the design and development of the ALMA Band 4 cartridge receiver. Band 4 is one of the ten bands that will form the ALMA Front End Receiver. It receives radiation in the 125-163 GHz frequency range in two orthogonal polarizations and down-converts the sideband separated signals to intermediate frequencies between 4 and 8 GHz.
- Asayama, S., and M. Kamikura [2009], "Development of Double-Ridged Waveguide Orthomode Transducer for the 2 MM Band," J. IR., Millimeter, and Terahertz Waves, vol.30, pp.573-579.
  - This paper describes the design and development of the 2 mm band orthomode transducer (OMT) for the Band 4 cartridge receivers of the Atacama Large Millimeter/Submillimeter Array (ALMA). The OMT consists of a double-ridged waveguide followed by a B ifot type junction with a main arm and two side arms. The main arm output is a multi-section step transformer followed by an E-plane bend and an oval waveguide to be realized the OMT with a two-split block using conventional Computer Numerical Control (CNC) milling techniques.

The prototype OMT shows return loss of better than 20 dB, cross polarization coupling of better than 30 dB and insertion loss of less than 0.4 dB across 125 - 163 GHz. Furthermore, production feasibility was demonstrated through the evaluation of seven OMTs with a production design. The design of the developed OMT is so simple that it is easily scaled to submillimeter frequencies.

- Baba, J., Y. Asaki, J. Makino, M. Miyoshi, R. Takahashi, T. R. Saitoh, and K. Wada [2009], "The Origin of Large Reculiar Motions of Star-Forming Regions and Spiral Structures of Our Galaxy," Astrophys. J., vol.706, pp.471-481.

➢ Recent Very Long Baseline Interferometer (VLBI) observations determined the distances and proper motions of star-forming regions in spiral arms directly. They showed that star-forming regions and young stars have large peculiar motions as large as 30 km s^{-1} with complex structures. Such a large peculiar motion is incompatible with the prediction of the standard theory of quasi-stationary spiral arms. We use a high-resolution, self-consistent N-body+hydrodynamical simulation to explore how the spiral arms are formed and maintained, and how star-forming regions move. We found that arms are not quasi-stationary but transient and recurrent, as suggested in alternative theories of spiral structures. Because of this transient nature of the spiral arms, star-forming regions exhibit a trend of large and complex non-circular motions, which is qualitatively consistent with the VLBI observations. Owing to this large non-circular motion, a kinematically estimated gas map of our Galaxy has large systematic errors of ~2-3 kpc in the distance from the Sun.

- Bakunina, I. A., V. E. Abramov-Maximov, S. V. Lesovoy, K. Shibasaki, A. A. Solov'ev, and Yu. V. Tikhomirov, [2009], "Long Period Oscillations of Microwave Emission of Solar Active Regions: Observations with NoRH and SSRT," Proc. of the IAU Symp. 257, "Universal Heliophysical Processes", eds. N. Gopalswamy and David F. Webb, pp.155-157.

➢ In this work we present the first results of study and comparison of the parameters of quasi-periodic long-term oscillations of microwave emission of large (>0.7 arcmin) sunspots as a result of simultaneous observations with two radioheliographs – NoRH (17 GHz) and Siberian Solar Radio Telescope (SSRT) (5.7 GHz) with 1 minute cadence. Radioheliographs have been working with quite large time overlap (about 5 hours) and have the high spatial resolution: 10 arcsec (NoRH) and 20 arcsec (SSRT). We have found that quasi-periodic long-term oscillations are surely observed at both frequencies with the periods in the range of 20–150 min. We detected common periods for common time of observations with two radioheliographs and interpret this as the consequence of the vertical-radial quasi-periodic displacements of sunspot as a whole structure.

- Barnes, P. J., Y. Yonekura, S. D. Ryder, A. M. Hopkins, Y. Miyamoto, N. Furukawa, and Y. Fukui [2010], "Discovery of Large-Scale Gravitational Infall in a Massive Protostellar Cluster," Mon. Not. Roy. Astron. Soc., vol.402, pp.73-86.

➢ We report Mopra Australia Telescope National Facility (ATNF), Anglo-Australian Telescope and Atacama Submillimeter Telescope Experiment observations of a molecular clump in Carina, BYF73 = G286.21+0.17, which give evidence of large-scale gravitational infall in the dense gas. From the millimetre and far-infrared data, the clump has a mass of □2×10^4 $M_{\odot}$, luminosity of □$2–3 \times 10^4$ $L_{\odot}$ and diameter of □0.9 pc. From radiative transfer modelling, we derive a mass infall rate of □3.4×10^{-2} $M_{\odot}$ yr^{-1}. If confirmed, this rate for gravitational infall in a molecular core or clump may be the highest yet seen. The near-infrared K-band imaging shows an adjacent compact H ii region and IR cluster surrounded by a shell-like photodissociation region showing H2 emission. At the molecular infall peak, the K imaging also reveals a deeply embedded group of stars with associated H_2 emission. The combination of these features is very unusual, and we suggest that they indicate the ongoing formation of a massive star cluster. We discuss the implications of these data for competing theories of

massive star formation.

- Bridger, A., D. Clarke, N. P. F. Lorente, H. Yatagai, M. Scgilling, L. Testi, and R. H. Warmels [2008], "ALMA Observing Tool," Proc. of the SPIE, vol.7019, pp.70190R-1-12.
  - We present a report on the current development status of the ALMA Observing Tool, describing how the tool operates as an integrated environment for proposal and program preparation. The paper also covers the science-oriented graphical tools for both spatial and spectral setup, their system-oriented equivalents, local oscillator and correlator setup assistants as well as program validation.
- Bronfman, L. [2008a], "Massive Star Formation in the Southern Milky Way. From Large Scale Surveys to High Resolution Observations," Asttrophys. and Sp. Sci., vol.313, pp.81-85.
  - During the past decade we have compiled a large molecular line data base of massive star forming regions in the southern Milky Way. These regions are confined into giant molecular clouds that trace the galactic spiral arms. Their radial distribution has a pronounced peak midway between the Sun and the galactic center, which in the IV quadrant corresponds to the location of the Norma Spiral arm. We study in some detail one of the foremost regions of massive star formation in the Norma arm, using millimeter continuum and line emission maps obtained with the SEST, APEX, and ASTE telescopes. It is a multiple system evolving along a complete GMC core, candidate for future ALMA observations.
- Bronfman, L., G. Garay, M. Merello, D. Mardones, J. May, K. J. Brooks, L.-A. Nyman, and R. Gusten [2008b], "Discovery of an Extremely High Velocity, Massive, and Compact Molecular Outflow in Norma," Astrophys. J., vol.672, pp.391-397.
  - G331.5-0.1 in the Norma spiral arm is one of the most luminous and extended cores of a giant molecular cloud (GMC), containing at least six massive and dense dust condensations. Here we report the discovery, from observations of several submillimeter molecular lines that were made using the Atacama Submillimeter Telescope (ASTE) and the Atacama Pathfinder Experiment Telescope (APEX), of an unresolved, extremely high velocity molecular outflow toward the brightest and most massive dust condensation. The outflow is massive and energetic (flow mass of ~55 Msolar momentum of ~2.4×10^3 Msolar km s-1 kinetic energy of ~1.4×10^{48} ergs). These values are characteristic of flows driven by young massive stellar objects with L_{bol}~1x105 Lsolar. We also report the detection, using the Australia Telescope Compact Array (ATCA), of a compact radio continuum source that is located at the center of the outflow and therefore likely to be its driving energy source. It has an spectral index between 4.8 and 8.6 GHz of 1.1±0.2, suggesting that it might correspond to a collimated jet.
- Bussey, D. B. J., J. A. McGovern, P. D. Spudis, C. Neish, S. Sorensen, H. Noda, and Y. Ishihara [2010], "Lunar Polar Illumination Conditions Derived Using Kaguya Laser Data," LPI Contribution No. 1533, p.2293.
  - We have used the Kaguya laser-derived topography data to fully characterize the lunar polar illumination conditions. We have generated illumination profiles for the areas that receive the most illumination.
- Choi, M., and K. Tatematsu [2009], "Protostellar Accretion Disks for the NGC 1333 IRAS 4A Binary System," Proc. of the "Exoplanets and disks: their formation and diversity", eds. Usuda, T., Tamura, M., and Ishii, M., AIP Conf. Proc., vol.1158, pp.117-118.
  - We present the results of radio imaging observations of the NGC 1333 IRAS 4A protobinary in the ammonia (2, 2) and (3, 3) lines and in the 1.3 cm continuum. Both ammonia and continuum maps show two compact sources, accretion disks of Al and A2. Interestingly, the A2 disk is brighter in the ammonia lines but dimmer in the dust continuum than its sibling disk. This difference suggests that the disks have surprisingly dissimilar characters, one gas-rich and the other dusty. If such a condition can persist until the planet-forming phase of the disk evolution, planetary systems produced in such disks may look very different from each other.

- Choi, Y. K., T. Hirota, M. Honma, and H. Kobayashi [2008a], "Astrometry of Red Supergiant VY Canis Majoris with VERA," Proc. of the IAU Symp. 248, "A Giant Step: from Milli- to Micro-arcsecond Astrometry", eds. Wenjing Jin, Imants Platais, Michael A. C. Perryman, pp.192-193.
  - We present observational results on the red supergiant VY Canis Majoris with VERA. We have observed 22 GHz H_2O masers and 43 GHz SiO masers (v=1 and 2 J=1-0) around VY CMa for 13 months. We succesfully detected a parallax of 0.87±0.08 mas, corresponding to the distance of $1.15\ ^{+0.10}_{-0.09}$ kpc using H_2O masers. As the result of phase-referencing analyses, we have measured absolute positions for both H_2O masers and SiO masers. The H_2O maser features show rapid expansion off the central star.
- Choi, Y. K., T. Hirota, M. Honma, H. Kobayashi, T. Bushimata, H. Imai, K. Iwadate, T. Jike, S. Kameno, O. Kameya, R. Kamohara, Y. Kan-ya, N. Kawaguchi, M. Kijima, M. K. Kim, S. Kuji, T. Kurayama, S. Manabe, K. Maruyama, M. Matsui, N. Matsumoto, T. Miyaji, T. Nagayama, A. Nakagawa, K. Nakamura, C. S. Oh, T. Omodaka, T. Oyama, S. Sakai, T. Sasao, K. Sato, M. Sato, K. M. Shibata, Y. Tamura, M. Tsushima, and K. Yamashita [2008b], "Distance to VY Canis Majoris with VERA," Publ. Astron. Soc. Japan, vol.60, pp.1007-1012.
  - We report on astrometric observations of H_2O masers around the red supergiant VY Canis Majoris carried out with VLBI Exploration of Radio Astrometry (VERA). Based on astrometric monitoring for 13 months, we successfully measured a trigonometric parallax of 0.88±0.08 mas, corresponding to a distance of $1.14\ ^{+0.11}_{-0.09}$ kpc. This is the most accurate determined distance to VY CMa and the first one based on an annual parallax measurement. The luminosity of VY CMa has been overestimated due to a previously accepted distance. With our result, we re-estimate the luminosity of VY CMa to be (3±0.5) x 10^5 Lsun using the bolometric flux integrated over optical and IR wavelengths. This improved luminosity value makes the location of VY CMa on the Hertzsprung-Russel (HR) diagram much closer to the theoretically allowable zone (i.e. the left side of the Hayashi track) than previous ones, though the uncertainty in the effective temperature of the stellar surface still does not permit us to make a final conclusion.
- Choi, Y. K., T. Hirota, M. Honma, and H. Kobayashi [2008c], "Distance to VY Canis Majoris with VERA," Proc. of the 9th European VLBI Network Symposium on The role of VLBI in the Golden Age for Radio Astronomy and EVN Users Meeting, September 23-16, 2008, Bologna, Italy, pp.57-62.
  - We report on observational results of H2O and SiO (J=1 0, v=1 and v=2) masers around VY Canis Majoris (VYCMa) carried out with VERA for 13 months. Our astrometric monitoring measured a parallax of 0.88±0.08 mas, and it corresponds to a distance of $1.14^{+0.11}_{-0.09}$ kpc. This is the first trigonometric parallax measurement for VY CMa. Using our newly obtained distance with a high accuracy, the luminosity of VY CMa was re-estimated to be (3±0.5) × 10^5 L□. This improved luminosity is more consistent with the theoretical evolutionary model than previous values. Moreover, we considered 3-dimensional structure and kinematics of the circumstellar envelopes around VY CMa with propermotions and absolute positions of the H_2O and SiO masers. The 3-dimensional structures and kinematics suggest a bipolar out ° ow around VY CMa along the line of sight.
- Choi, Y. K., T. Hirota, M. Honma, and H. Kobayashi [2009], "Astrometry of the Red Supergiant Star VY Canis Majoris with VERA," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.363-365.
  - We present observational results on the red supergiant VY Canis Majoris with VERA. We have observed 22 GHz H_2O masers and 43 GHz SiO masers (v = 1 and 2 J = 1-0) around VY CMa for 13 months. We successfully detected a parallax of 0.87±0.08 mas, corresponding to

$1.15^{+0.10}_{-0.09}$ kpc of distance using H_2O masers. As results of phase referencing analyses, we have measured absolute positions for both the H_2O masers and SiO masers. The proper motions of the H_2O masers show the tendency of expansion.

- Cirtain, J. W., L. Golub, L. Lundquist, A. van Ballegooijen, A. Savcheva, M. Shimojo, E. DeLuca, S. Tsuneta, T. Sakao, K. Reeves, M. Weber, R. Kano, N. Narukage, and K. Shibasaki [2007], "Evidence for Alfvén Waves in Solar X-ray Jets," Science, vol.318, pp.1580-1582.
  - Coronal magnetic fields are dynamic, and field lines may misalign, reassemble, and release energy by means of magnetic reconnection. Giant releases may generate solar flares and coronal mass ejections and, on a smaller scale, produce x-ray jets. Hinode observations of polar coronal holes reveal that x-ray jets have two distinct velocities: one near the Alfvén speed (~800 kilometers per second) and another near the sound speed (200 kilometers per second). Many more jets were seen than have been reported previously; we detected an average of 10 events per hour up to these speeds, whereas previous observations documented only a handful per day with lower average speeds of 200 kilometers per second. The x-ray jets are about 2×10^3 to 2×10^4 kilometers wide and 1×10^5 kilometers long and last from 100 to 2500 seconds. The large number of events, coupled with the high velocities of the apparent outflows, indicates that the jets may contribute to the high-speed solar wind.
- Deguchi, S., T. Fujii, Y. Ita, H. Izumiura, O. Kameya, A. Miyazaki, Y. Nakada, and M. Ideta [2008a], "Dynamics of Stars in the Inner Galactic Bulge Revealed from SiO Maser Surveys," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., pp.33-38.
  - We surveyed ~300 MSX/2MASS infrared objects in the 7°×2° area of the Galactic center in the ~43 GHz SiO maser lines, obtaining accurate radial velocities of ~160 detected objects. The longitude-velocity diagram of these objects reveals two conspicuous features: one indicating a linear velocity increase with longitude with $|l| < 1.5°$, which is likely to be associated with the inner bar, and the other having eccentric velocities with $|V_{lsr}| > 250$ km s-1. Based on numerical simulations of stellar orbits in the Galactic bulge, we conclude that the latter feature is created as a result of a past star formation in the bulge, when the intersecting point of the x_1 and x_2 orbits was considerably outside of the present position.
- Deguchi, S. [2008b], "SiO Maser Survey of Evolved Stars in the Galaxy: Various Environments of Maser Sources," Proc. of the IAU Symp. 242, "Astrophysical Masers and their Environments", eds. Jessica Chapman and Willem Baan, pp.200-207.
  - Using the SiO J=1-0 v=1 and v=2 lines near 43 GHz, we have detected about 2000 of 3600 sources observed with the Nobeyama 45-m radio telescope. The sources were chosen from IRAS/MSX/2MASS catalogs using color-selection criteria to pick up mass-losing oxygen-rich AGB stars and some post-AGB objects. A number of interesting sources were also found: supergiants in a massive star cluster, a nova with light echo (V838 Mon), AGB stars in globular clusters, and AGB candidates associated with dwarf galaxies. With the exception of the stars in the massive open star cluster, these 'unusual' objects are associated with metal poor environments where mass losing oxygen-rich AGB stars are unexpected. It is inferred that these objects were created by stellar merging which can occur in dense star clusters.
- Deguchi, S. [2009a], "Study of Red Supergiants in Embedded Star Clusters by Radio Lines," Proc. of the "AGB stars and related phenomena", eds. Toshiya Ueta, Noriyuki Matsunaga, and Yoshifusa Ita, p.74.
  - Not Available
- Deguchi, S., N. Matsunaga, H. Fukushi, and T. Kaminski [2009b], "Detection of the SiO J=2-1, v=1 Maser Emission at 86.2 GHz in V838 Mon, an Unusual Nova-Like Variable," ATel, #1996.
  - We report on a new detection of the SiO J=2-1 v=1 maser line at 86.243 GHz in V838 Mon.

The observations were obtained on 2009 March 21-23 using the 45m telescope at Nobeyama with a newly built sensitive dual- polarization receiver. The maser line has a peak intensity of 0.39 Jy at V_{lsr}=53.7 km/s and exhibits a complex asymmetric pedestal with a stronger contribution at the lower velocity side; the total integrated intensity of the emission feature is of 2.8 Jy km/s.

- Deguchi, S., N. Matsunaga, S. Takahashi, N. Kuno, and J. Nakashima [2010a], "Dying SiO Maser in the V407 Cyg System," Atel, #2519.
  - The symbiotic nova, V407 Cyg, is a system having a Mira-type cool stellar component with circumstellar SiO maser emission (Deguchi et al. 2005; PASJ 57, 939). The nova outburst occurred in the V407 Cyg system can significantly influence the structure of the circumstellar shell of the cool star in a short time scale. We have been monitoring the time variation of SiO maser emission in the V407 Cyg system with the Nobeyama 45m telescope every few days since March 16, 2010.
- Deguchi, S., J. Nakashima, Y. Zhang, S. S. N. Chong, K. Koike, and S. Kwok [2010b], "SiO and H_2O Maser Observations of Red Supergiants in Star Clusters Embedded in the Galactic Disk," Publ. Astron. Soc. Japan, vol.62, pp.391-407.
  - We present the results of radio observations of red supergiants in a star cluster, Stephenson (1990, AJ, 99, 1867)'s #2, and of candidates for red supergiants in three star clusters, Mercer et al. (2005, ApJ, 635, 560)'s #4, #8, and #13, in the SiO and H_2O maser lines. The Stephenson's #2 cluster and nearby aggregation at the southwest contain more than 15 red supergiants. We detected one red supergiant at the center of Stephenson's #2 and three in a southwest aggregation in the SiO maser line; three out of these four were also detected in the H_2O maser line. The average radial velocity of the four detected objects is 97 kms^{-1}, giving a kinematic distance of 5.5 kpc, which locates this cluster near the base of the Scutum-Crux spiral arm. We also detected six SiO emitting objects associated with other star clusters. In addition, mapping observations in the CO J = 1-0 line toward these clusters revealed that an appreciable amount of molecular gas still remains around the Stephenson's #2 cluster in contrast to the prototypical red-supergiant cluster, Bica et al. (2003, A&A, 404, 223)'s #122. This indicates that the time scale of gas expulsion differs considerably in individual clusters.
- Deguchi, S., T. Shimoikura, and K. Koike [2010c], "SiO Maser Survey off the Galactic Plane: A Signature of Streaming Motion," Publ. Astron. Soc. Japan, vol.62, 5pp.25-546.
  - A group of Mira variables in the solar neighborhood shows unusual spatial motion in the Galaxy. To study this motion on a much larger scale in the Galaxy, we newly surveyed 134 evolved stars off the Galactic plane by SiO maser lines, obtaining accurate radial velocities of 84 detected stars. Together with the past data of SiO maser sources, we analyzed the radial-velocity data of a large sample of sources distributed in a distance range of about 0.3-6 kpc in the first Galactic quadrant. At Galactic longitudes between 20° and 40°, we found a group of stars with large negative radial velocities, which deviate by more than 100 km s^{-1} from the Galactic rotation. We show that these deviant motions of maser stars are created by periodic gravitational perturbation of the Bulge bar, and that the effect appears most strongly at radii between corotation and outer Lindblad resonances The resonance effect can explain the displacement of positions from the Galactic plane as well.
- Doi, A., K. Fujisawa, M. Honma, K. Sugiyama, Y. Murata, N. Mochizuki, and Y. Isono [2008a], "Japanese VLBI Network Observations of 6.7-GHz Methanol Masers 1. Array," Proc. of the IAU Symp. 242, "Astrophysical Masers and their Environments", eds. Jessica Chapman and Willem Baan, pp.148-149.
  - The Japanese VLBI network (JVN) has begun observations of 6.7-GHz methanol masers associated with massive star-forming regions. The JVN is a newly-established VLBI array with baselines ranging from 50 to 2560 km spread across the Japanese islands. Three observing

bands of 6.7, 8.4, and 22 GHz are now available. The array consists of ten antennas: VERA Mizusawa 20 m, VERA Ishigaki 20 m, VERA Iriki 20 m, Usuda 64 m, Yamaguchi 32 m, Tomakomai 11 m, Tsukuba 32 m, Kashima 34 m, VERA Ogasawara 20 m, and Gifu 11 m, the first five of which have 6.7-GHz receiving systems. In summer 2005, we obtained the first fringes at 6.7 GHz, and VLBI images of 12 methanol maser sites including seven that had not previously been imaged with VLBI at this band. In 2006 summer, we obtained phase-reference observations toward several methanol maser sites.

- Doi, A., K. Asada, H. Nagai, K. Fujisawa, and N. Kawaguchi [2008b], "JVN Observataions of NLS1 Galaxies and BAL Quasars," Proc. of the 9th European VLBI Network Symposium on The role of VLBI in the Golden Age for Radio Astronomy and EVN Users Meeting, September 23-16, 2008, Bologna, Italy, pp.73-75.
  - We are conducting VLBI observations for Narrow-Line Seyfert 1 galaxies (NLS1s) and Broad Absorption Line (BAL) quasars, which are thought to be driven by highly accreting central engines, in order to understand accretion phenomena on such central engines. Because these AGN subclasses are generally very weak radio sources, phase-referencing VLBI observations are being carried out using Japanese VLBI Network (JVN), together with VLBA, EVN, and an optical-fibre-linked JVN subarray "OCTAVE." For NLS1s, 12 out of 14 sources have been successfully imaged in milli-arcsecond resolutions. For BAL quasars, 21 out of 23 sources have been successfully detected with OCTAVE baselines at 8.4 GHz. Several NLS1 sand BAL quasars are investigated in images at multi-frequency. Some evidence of Doppler-boosting on relativistic jets were seen in several radio-loud objects, which is inconsistent with the edge-on view paradigm of BAL quasars.
- Doi, A., M. Tsuboi, Y. Kono, H. Takeuchi, N. Mochizuki, Y. Murata, and ASTRO-G Group [2009a], "ASTRO-G Observing Systems," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.46-50.
  - ASTRO-G for the VSOP-2 project is a radio telescope satellite for a next-generation space very-long-baseline interferometry (VLBI) following HALCA for the VSOP project. It will be launched in 2012. We present the overview of ASTRO-G observing systems and available observing modes.
- Doi, A., N. Kawaguchi, Y. Kono, T. Oyama, K. Fujisawa, H. Takaba, H. Sudou, K. Wakamatsu, A. Yamauchi, Y. Murata, N. Mochizuki, K. Wajima, T. Omodaka, T. Nagayama, N. Nakai, K. Sorai, E. Kawai, M. Sekido, Y. Koyama, S. Asano, and H. Uose, [2009b], "VLBI Detections of Parsec-Scale Nonthermal Jets in Radio-Loud Absorption Line Quasars," Publ. Astron. Soc. Japan, vol.61, pp.1389-1398.
  - We conducted radio detection observations at 8.4 GHz for 22 radio-loud broad absorption line (BAL) quasars, selected from the Sloan Digital Sky Survey Third Data Release, by a very-long-baseline interferometry (VLBI) technique. The VLBI instrument we used was developed by the Optically ConnecTed Array for VLBI Exploration project (OCTAVE), which is operated as a subarray of the Japanese VLBI Network. We aimed to select BAL quasars with nonthermal jets suitable for measuring their orientation angles and ages by subsequent detailed VLBI imaging studies to evaluate two controversial issues of whether BAL quasars are viewed nearly edge-on, and of whether BAL quasars are in a short-lived evolutionary phase of the quasar population. We detected 20 out of 22 sources using the OCTAVE baselines, implying brightness temperatures greater than 105 K, which presumably come from nonthermal jets. Hence, BAL outflows and nonthermal jets can be generated simultaneously in these central engines. We also found four inverted-spectrum sources, which are interpreted as Doppler-beamed, pole-on-viewed relativistic jet sources, or young radio sources: single edge-on geometry cannot describe all BAL quasars. We discuss the implications of the

OCTAVE observations for investigations for the orientation and evolutionary stage of BAL quasars.

- Egusa, F., Y. Sofue, H. Nakanishi, and S. Komugi [2008a], "Determination of Pattern Speed and Star Formation Timescale in Nearby Spiral Galaxies," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., p.320.
  - Without abstract
- Egusa, F., Y. Sofue, S. Komugi, and H. Nakanishi [2008b], "Determination of Star Formation Timescale and Pattern Speed of Spiral Galaxies", Proc. of the "Pathways Through an Eclectic Universe", eds. J. H. Knapen, T. J. Mahoney, and A. Vazdekis, ASP Conf. Ser., vol.390, pp.180-181.
  - We propose a method to determine the star formation timescale and pattern speed simultaneously in spiral galaxies. Though they are important and fundamental parameters in galactic dynamics and star formation scenarios, it has hitherto been difficult to derive their values directly from observations. Our method utilizes azimuthal offsets between arms of HII regions and molecular clouds, and has been successfully applied to three nearby galaxies so far through the use of CO and Hα images. As derived star formation timescales fall into the narrow range of 4-13Myr, which is consistent with typical timescales for molecular clouds to collapse gravitationally, a dominant mechanism of global star formation in spiral arms might be the gravitational collapse of molecular clouds.
- Egusa, F., Y. Sofue, K. Kohno, H. Nakanishi, and S. Komugi [2009], "Determining Star Formation Timescale and Pattern Speed in Nearby Spiral Galaxies," Astrophys, J., vol.697, pp.1870-1891.
  - We present a revised method for simultaneous determination of the pattern speed (Ω_P) and star formation timescale (t_{SF}) of spiral galaxies, which is originally proposed in our previous work. As this method utilizes offsets between molecular and young-stellar arms, we refer to it as the "Offset Method." Details of the method, its application, and results for CO and Hα images of 13 nearby spiral galaxies are described here. CO data are from our observations with the Nobeyama Millimeter Array for two galaxies, and from the BIMA SONG for the rest. Out of 13 galaxies, we were able to derive ゝP and t_{SF} for five galaxies. We categorize them as "C" galaxies as their offsets are clear. Our findings from these galaxies are as follows. (1) The corotation radius calculated by the derived Ω_P is close to the edge of the CO data, and is about half of the optical radius for three galaxies. (2) The derived t_{SF} is roughly consistent with the free-fall time of typical molecular clouds, which indicates that the gravitational instability is the dominant mechanism triggering star formation in spiral arms. (3) The t_{SF} is found to be almost independent of the surface density of molecular gas, metallicity, or spiral arm strengths. The number of "C" galaxies and the quality of CO data, however, are not enough to confirm these relationships. We also find that two other galaxies show no offsets between CO and H , although their arms are clearly traced, and categorize them as "N" galaxies. The presence of a bar could account for this feature, since these two galaxies are both barred. With one galaxy excluded from our analysis due to its poor rotation curve, offsets of the remaining five galaxies are found to be ambiguous. Either their dependence on the rotational frequency cannot be explained by our picture, or the number or quality of data is not sufficient for the analysis. We categorize them as "A" galaxies. The possible reasons for this ambiguity are (1) the density wave is weaker, and/or (2) observational resolution and sensitivity are not enough to detect the spiral arms and their offsets clearly. The former is supported by our finding that the arm strengths of "A" galaxies are slightly weaker than that of "C" galaxies.
- Ezawa, H., K. Kohno, R. Kawabe, S. Yamamoto, H. Inoue, H. Iwashita, H. Matsuo, T. Okuda, T. Oshima, T. Sakai, K. Tanaka, N. Yamaguchi, G. W. Wilson, M. S. Yun, I. Aretxaga, D. Hughes, J. Austermann, T. A. Perera, K. S. Scott, L. Bronfman, and J. R. Cortes [2008], "New

Archevements of ASTE: the Atacama Submillimeter Telescope Experiment." Proc. of the SPIE, vol.7012, pp.101208-1-9.

- ASTE is a 10-m submillimeter telescope operating in Atacama desert in northern Chile since 2002 by NAOJ and collaborators. Thanks to the excellent observing condition at the telescope site, ASTE has been producing numerous astronomical results from star forming regions, Galactic center, Magellanic clouds, nearby galaxies, and galaxy clusters. There has been three major improvements during the years 2007-2008: continuum camera "AzTEC", new SIS receiver "CATS345", and a wide-band spectrometer "WHSF". AzTEC is a 144 element bolometer array at 270 GHz, developed by University of Massachusetts and collaborators. The mapping speed reaches 10-30 $arcmin_2/hr/mJy^2$. CATS345 is a side-band separation (2SB) SIS receiver developed by University of Tokyo and NAOJ. The IF bandwidth is 4 GHz with side-band rejection ratio better than 10 dB. We have achieved the typical system noise temperature of 200-400 K (SSB) within 330-360 GHz, the best value being 150 K (SSB) at the frequency of $^{12}CO(J=3-2)$ at 345 GHz under a typical weather condition. The new spectrometer WHSF employs of an FX type auto-correlator, ultra-high speed sampler, and digital signal transmitter. It can be operated in two modes; 4096 MHz band-width ×2 IFs or 2048 MHz band-width ×4 IFs, both with 4096 channels in spectral resolution.

- Fomalont, E. B., S. Kopeikin, O. Titov, and M. Honma [2009], "VLBA/VERA Test of General Relativity," AAS#15.03/BAAS, vol.41, p.890.
  - We report on VLBA/VERA/geodetic observational tests of General Relativity. First, we will summarize the results from recent VLBA experiments which measured gamma from the bending of radio waves of quasars by the solar gravitational field, and the experiment that measured the the aberration of gravity using the Jovian gravitational field. We will then describe tentative results from several recent experiments that continue the measurements of the aberration of gravity from Jupiter and Saturn using the VLBA, VERA and the geodetic network. Finally, we discuss the limits of precision that can be obtained with VLBI now and in the future.
- Fomalont, Ed., S. Kopeikin, D. Jones, M. Honma, and O. Titov [2010], "Recent VLBA/VERA/IVS Tests of General Relativity," Proc. of the IAU symp. vol.261, "Relativity in fundamental astronomy: dynamics, reference frames, and data analysis", pp.291-295.
  - We report on recent VLBA/VERA/IVS observational tests of General Relativity. First, we will summarize the results from the 2005 VLBA experiment that determined gamma with an accuracy of 0.0003 by measuring the deflection of four compact radio sources by the solar gravitational field. We discuss the limits of precision that can be obtained with VLBA experiments in the future. We describe recent experiments using the three global arrays to measure the aberration of gravity when Jupiter and Saturn passed within a few arcmin of bright radio sources. These reductions are still in progress, but the anticipated positional accuracy of the VLBA experiment may be about 0.01 mas.
- Friesen, R. K., J. Di Franesco, Y. Shimajiri, and S. Takakuwa [2010], "The Initial Conditions of Clusteres Star Formation II: N_2H^+ Observations of the Ophiuchus B Core," Astrophys. J., vol.708, pp.1002-1024.
  - We present a Nobeyama 45 m Radio Telescope map and Australia Telescope Compact Array pointed observations of N_2H^+ 1-0 emission toward the clustered, low-mass star-forming Oph B Core within the Ophiuchus molecular cloud. We compare these data with previously published results of high-resolution NH3 (1,1) and (2,2) observations in Oph B. We use 3D CLUMPFIND to identify emission features in the single-dish N_2H^+ map, and find that the N_2H^+ "clumps" match well similar features previously identified in NH3 (1,1) emission, but are frequently offset to clumps identified at similar resolution in 850μm continuum emission. Wide line widths in the Oph B2 sub-Core indicate that non-thermal motions dominate the Core

kinematics, and remain transonic at densities n ~ 3 × 10^5 cm^{-3} with large scatter and no trend with N(H_2). In contrast, non-thermal motions in Oph B1 and B3 are subsonic with little variation, but also show no trend with H_2 column density. Over all of Oph B, non-thermal N_2H^+ line widths are substantially narrower than those traced by NH_3, making it unlikely NH_3 and N_2H^+ trace the same material, but the vLSR of both species agree well. We find evidence for accretion in Oph B1 from the surrounding ambient gas. The NH_3/N_2H^+ abundance ratio is larger toward starless Oph B1 than toward protostellar Oph B2, similar to recent observational results in other star-forming regions. The interferometer observations reveal small-scale structure in N_2H^+ 1-0 emission, which are again offset from continuum emission. No interferometric N_2H^+ emission peaks were found to be coincident with continuum clumps. In particular, the ~1 M_{sun} B2-MM8 clump is associated with an N_2H^+ emission minimum and surrounded by a broken ring-like N_2H^+ emission structure, suggestive of N_2H^+ depletion. We find a strong general trend of decreasing N_2H^+ abundance with increasing N(H_2) in Oph B which matches that found for NH_3.

- Fujishita, M., K. Torii, N. Kudo, T. Kawase, H. Yamamoto, A. Kawamura, N. Mizuno, T. Onishi, A. Mizuno, M. Machida, K. Takahashi, S. Nozawa, R. Matsumoto, and Y. Fukui [2009], "Discovery of Molecular Loop 3 in the Galactic Center: Evidence for a Positive-Velocity Magnetically Floated Loop towards L=355°-359°, " Publ. Astron. Soc. Japan, vol.61, pp.1039-1053.
  - We have discovered a molecular dome-like feature towards 355° ≤ l ≤ 359° and 0° ≤ b ≤ 2°. The large velocity dispersions of 50-100 km s^{-1} of this feature are much larger than those in the Galactic disk, and indicate that the feature is located in the Galactic center, probably within ~1 kpc of Sgr A*. The distribution has a projected length of ~600 pc and a height of ~300 pc from the Galactic disk, and shows a large-scale monotonic velocity gradient of ~130 km s-1 per ~600 pc. The feature is also associated with HI gas having a more continuous spatial and velocity distribution than that of ^{12}CO. We interpret the feature as being a magnetically floated loop similar to loops 1 and 2, and name it "loop 3". Loop 3 is similar to loops 1 and 2 in its height and length, but is different from loops 1 and 2 in that the inner part of loop 3 is filled with molecular emission. We have identified two foot points at both ends of loop 3. HI, ^{12}CO, and ^{13}CO datasets were used to estimate the total mass and the kinetic energy of loop 3 to be ~3.0 × 10^6 M. and ~1.7 × 10^{52} erg. The huge size, velocity dispersions, and energy are consistent with the magnetic origin of the Parker instability, as in the case of loops 1 and 2, but is difficult to be explained by multiple stellar explosions. We argue that loop 3 is in an earlier evolutionary phase than loops 1 and 2 based on the inner-filled morphology and the relative weakness of the foot points. This discovery indicates that the western part of the nuclear gas disk of ~1 kpc radius is dominated by the three well-developed magnetically floated loops, and suggests that the dynamics of the nuclear gas disk is strongly affected by magnetic instabilities.
- Fukui, Y., N. Furukawa, T. M. Dame, J. R. Dawson, H. Yamamoto, G. P. Rowell, F. Aharonian, W. Hofmann, E. de Oña Wilhelmi, T. Minamidani, A. Kawamura, N. Mizuno, T. Onishi, A. Mizuno, and S. Nagataki [2009a], "A Peculiar Jet and Arc of Molecular Gas toward the Rich and Young Stellar Cluster Westerlund 2 and a TeV Gamma Ray Source," Publ. Astron. Soc. Japan, vol.61, pp.L23-L27.
  - We have discovered remarkable jet- and arc-like molecular features toward the rich and young stellar cluster Westerlund 2. The jet has a length of ~ 100 pc and a width of ~ 10 pc, while the arc shows a crescent shape with a radius of ~30 pc. These molecular features each have masses of ~10^4 M., and show spatial correlations with the surrounding lower density HI gas. The jet also shows an intriguing positional alignment with the core of the TeV gamma-ray source HESS J1023-575 and with the MeV/GeV gamma-ray source recently reported by the Fermi collaboration. We argue that the jet and arc are caused by an energetic event in Westerlund 2,

presumably due to an anisotropic supernova explosion of one of the most massive member stars. While the origin of the TeV and GeV gamma-ray sources is uncertain, one may speculate that they are related to the same event via relativistic particle acceleration by strong shock waves produced at the explosion or by remnant objects, such as a pulsar wind nebula or a microquasar.

- Fukui, Y., A. Kawamura, T. Wong, M. Murai, H. Iritani, N. Mizuno, Y. Mizuno, T. Onishi, A. Hughes, J. Ott, E. Muller, L. Staveley-Smith, and S. Kim [2009b], "Molecular and Atomic Gas in the Large Magellanic Cloud II. Three-Dimensional Correlation between CO and HI," Astrophys. J., vol.705, pp.144-155.
  - We compare the CO (J = 1-0) and H I emission in the Large Magellanic Cloud in three dimensions, i.e., including a velocity axis in addition to the two spatial axes, with the aim of elucidating the physical connection between giant molecular clouds (GMCs) and their surrounding H I gas. The CO J = 1-0 data set is from the second NANTEN CO survey and the H I data set is from the merged Australia Telescope Compact Array (ATCA) and Parkes Telescope surveys. The major findings of our analysis are as follows: (1) GMCs are associated with an envelope of H I emission, (2) in GMCs [average CO intensity] □ [average H I intensity]$^{1.1\pm0.1}$, and (3) the H I intensity tends to increase with the star formation activity within GMCs, from Type I to Type III. An analysis of the H I envelopes associated with GMCs shows that their average line width is 14 km s^{-1} and the mean density in the envelope is 10 cm^{-3}. We argue that the H I envelopes are gravitationally bound by GMCs. These findings are consistent with a continual increase in the mass of GMCs via H I accretion at an accretion rate of 0.05 Msun yr^{-1} over a timescale of 10 Myr. The growth of GMCs is terminated via dissipative ionization and/or stellar-wind disruption in the final stage of GMC evolution.
- Fukui, Y., and A. Kawamura [2010], "Molecular Clouds in Nearby Galaxies," Ann. Rev. Astron. Astrophys., vol.48, pp.547-580.
  - We present a review of spatially resolved giant molecular clouds (GMCs) in nearby galaxies, aiming at providing a template of GMC properties, which may be extrapolated to distant galaxies. We focus on the Magellanic system including the Large and Small Magellanic Clouds (LMC, SMC), M33, and a few dwarfs as observed in the J = 1-0 ^{12}CO transition at 2.6-mm wavelength. The X factor, a conversion factor of the ^{12}CO intensity to total molecular column density, and the GMC mass distribution, dN/dM, are similar among these galaxies, suggesting that GMCs share similar properties in the Local Group. The GMCs are classified into three types according to their level of star-formation activity and the types are interpreted in terms of evolution in 20-30 Myr rather than as three different generic types. A three-dimensional comparison including the velocity axis has revealed that GMCs in the LMC are associated with Hi envelopes. The Hi envelopes are probably gravitationally bound and may be infalling to increase the GMC mass via Hi-H_2 conversion. Recent submillimeter observations are revealing dense and warm clumps in GMCs, suggesting that the interior of a GMC also follows contraction leading to star formation on a similar timescale. Finally, we present an attempt to place these GMC properties among more distant galaxies and discuss future observational prospects.
- Furuya, R. S., R. Cesaroni, S. Takahashi, C. Codella, M. Momose, and M. T. Beltran [2008a], "Candidate Rotating Toroids around High-Mass (Proto)Stars," Astrophys. J., vol.673, pp.363-381.
  - Using the OVRO, Nobeyama, and IRAM millimeter arrays, we searched for "disk"-outflow systems in three high-mass (proto)star-forming regions: G16.59-0.05, G23.01-0.41, and G28.87+0.07. These were selected from a sample of NH_3 cores (Codella, Testi, & Cesaroni) associated with OH and H_2O maser emission (Foster & Caswell) and with no or very faint continuum emission. Our imaging of molecular line (including rotational transitions of

CH_3CN) and 3 mm dust continuum emission revealed that these are compact (<~0.06-0.13 pc), massive (~100-400 M_{solar}), and hot (~100 K) molecular cores (HMCs) that are likely sites of high-mass star formation prior to the appearance of ultracompact HII regions. All three sources turn out to be associated with molecular outflows from ^{12}CO and/or HCO^+ J=1-0 line imaging. In addition, velocity gradients of 10-100 km s^{-1} pc^{-1} in the innermost, densest regions of the G23.01-0.41 and G28.87+0.07 HMCs are identified along directions roughly perpendicular to the axes of the corresponding outflows. All the results suggest that these cores might be rotating about the outflow axis, although the contribution of rotation to gravitational equilibrium of the HMCs appears to be negligible. Our analysis indicates that the three HMCs are close to virial equilibrium due to turbulent pressure support. Comparison with other similar objects where rotating toroids have been identified so far shows that in our case rotation appears to be much less prominent; this can be explained by the combined effect of unfavorable projection, large distance, and limited angular resolution with the current interferometers.

- Furuya, R. S., Y. Kitamura, and H. Shinnnaga [2008b], "Low-Mass Star-Forming Cores in the GF9 Filament," Publ. Astron. Soc. Japan, vol.60, pp.421-428.
  - We carried out an unbiased mapping survey of dense molecular cloud cores traced by the NH_3 (1,1) and (2,2) inversion lines in the GF9 filament which contains an extremely young low-mass protostar GF9-2 (Furuya et al. 2006, ApJ, 653, 1369). The survey was conducted using the Nobeyama 45m telescope over a region of ~1.5°x1° with an angular resolution of 73". The large-scale map revealed that the filament contains at least 7 dense cores, as well as 3 possible ones, located at regular intervals of ~0.9 pc. Our analysis shows that these cores have kinetic temperatures of □10 K and LTE-masses of 1.8 - 8.2 Msun, making them typical sites of low-mass star formation. All the identified cores are likely to be gravitationally unstable because their LTE-masses are larger than their virial masses. Since the LTE-masses and separations of the cores are consistent with the Jeans masses and lengths, respectively, for the low-density ambient gas, we argue that the identified cores have formed via the gravitational fragmentation of the natal filamentary cloud.
- Furuya, R. S., Y. Kitamura, and H. Shinnaga [2009], "Spectroscopic Evidence for Gas Infall in GF 9-2," Astrophys. J. (Letters), vol.692, pp.L96-L99.
  - We present spectroscopic evidence for the infall motion of gas in the natal cloud core harboring an extremely young low-mass protostar GF 9-2. We previously discussed that the ongoing collapse of the GF 9-2 core has agreement with the Larson-Penston-Hunter (LPH) theoretical solution for the gravitational collapse of a core. To discuss the gas infall on firmer ground, we have carried out on-the-fly mapping observations of the HCO^+ (1-0) line using the Nobeyama 45 m telescope equipped with the 25 Beam Array Receiver System. Furthermore, we observed the HCN (1-0) line with the 45 m telescope, and the HCO^+ (3-2) line with the Caltech Submillimeter Observatory 10.4 m telescope. The optically thick HCO^+ and HCN lines show blueskewed profiles whose deepest absorptions are seen at the peak velocity of optically thin lines, i.e., the systemic velocity of the cloud, indicating the presence of gas infall toward the central protostar. We compared the observed HCO^+ line profiles with model ones by solving the radiative transfer in the core under LTE assumption. We found that the core gas has a constant infall velocity of ~0.5 km s^{-1} in the central region, leading to a mass accretion rate of 2.5 x 10^{-5} $M_\odot . yr^{-1}$. Consequently, we confirm that the gas infall in the GF 9-2 core is consistent with the LPH solution.
- Glendenning, B. E., J. Ibsen, G. Kosugi, and G. Raffi [2010], "ALMA Software Management and Deployment," Proc. of the SPIE, vol.7740, pp.77401L-77401L-6.
  - The ALMA Software (~ 80% completed) is in daily use at the ALMA Observatory and has been developed as an end-toend system including: proposal preparation, dynamic scheduling,

instrument control, data handling and formatting, data archiving and retrieval, automatic and manual data processing, and support for observatory operations. This presentation will expand on some software management aspects, procedures for releases, integrated system testing and deployment in Chile. The need for a realistic validation environment, now achieved with a two antenna interferometer at the observatory, and the balance between incremental development and stability of the software (a challenge at the moment) will be explained.

- Gomez, Y., D. Tafoya, G. Anglada, L. Loinard, J. M. Torrelles, L. F. Miranda, M. Osorio, R. Franco-Hernandez, L. Nyman, J. Nakashima, and S. Deguchi [2008], "HCO^+ Emission Possibly Related with a Shielding Mechanism that Protects Water Molecules in the Young PN K 3-35," Proc. of the IAU Symp. 251, "Organic Matter in Space", eds. S. Kwok, and S. Sandford, pp.173-174.

  - Water maser emission has been detected only toward three planetary nebulae (PNe). In particular, in K3-35, the first PN where water vapor maser emission was detected, the components are located in a torus-like structure with a radius of 85 AU and also at the surprisingly large distance of 5000 AU from the star, in the tips of the bipolar lobes. The existence of these water molecules in PNe is puzzling, probably related to some unknown mechanism shielding them against the ionizing radiation. We report the detection of HCO^+ (J = 1 - 0) emission toward K 3-35, that not only suggests that dense molecular gas ($\sim 10^5$ cm^{-3}) is present in this PN, but also that this kind of PN can enrich their surroundings with organic molecules.

- Goossens, S., and K. Matsumoto [2008a], "Determination of the Lunar k2 Love Number from Satellite Tracking Data," 39th Lunar and Planetary Science Conference, (Lunar and Planetary Science XXXIX), held March 10-14, 2008 in League City, Texas. LPI Contribution No. 1391., p.1536.

  - The lunar potential Love number k_2 has been determined from available satellite tracking data. The best estimate in this research yields $k_2 = 0.0213 \pm 0.0075$ (ten sigma), which is closer to results based on lunar laser ranging than a previous satellite-based estimate.

- Goossens, S., K. Matsumoto, Y. Ishihara, Q. Liu, F. Kikuchi, H. Noda, N. Namiki, and T. Iwata [2008b], "Orbit Determination and Quality Assessment Using SELENE Tracking Data and Results," 37th COSPAR Scientific Assembly, held 13-20 July 2008, in Montreal, Canada, p.1055.

  - On September 14, 2007, the SELENE (KAGUYA) spacecraft were launched from Tanegashima Space Center in Japan. SELENE consists of three satellites: a main orbiter in a 100 km by 100 km circular, polar orbit, and two small subsatellites in 100 km by 2400 km (Rstar) and 100 km by 800 km (Vstar) elliptical, polar orbits. Until now, tracking of lunar satellites consisted of 2-way (or 3-way, where the upand downlink stations are different) tracking, leaving a gap in the tracking coverage over the far side of the Moon as the satellite cannot be tracked there from Earth. This severely hampers the determination of the global lunar gravity field, and, consequently, this also puts limits on the precision of orbits of lunar satellites. By employing 4-way Doppler tracking between the main orbiter and Rstar, the first direct tracking data of a satellite over the far side have been obtained, resulting in a newly determined global lunar gravity field. The existing 2-way tracking data set is furthermore complemented by differential VLBI tracking between Rstar and Vstar, providing a sensitivity perpendicular to the line-ofsight from station to satellite. This work focuses on aspects of orbit determination for the SELENE satellites, including the processing strategies for data types using multiple satellites. Orbit determination quality is described in terms of data fit and, where possible, orbit overlap statistics. For the main satellite, the on-board altimeter provides an independent check of orbit quality through crossovers, although they are not yet systematically included in the orbit determination process. The performance of the VLBI data

in the orbit determination of the small subsatellites is also discussed. The newly determined global lunar gravity field models from SELENE are evaluated in several ways: their performance when used in orbit determination of previous lunar satellites, and their ability in orbit prediction. Covariance analysis shows the expected orbit quality. The results presented here are thought to be of importance for oncoming lunar spacecraft, such as LRO, GRAIL and other future missions.

- Goossens, S., K. Matsumoto, Y. Ishihara, Q. Liu, F. Kikuchi, H. Noda, T. Iwata, N. Namiki, and H. Hanada [2008c], "Analysis of Tracking Data and Results from Kaguya (SELENE) Satellites for Lunar Gravity Field Estimation," American Geophysical Union, Fall Meeting 2008, abstract #P31B-1400.
  - On September 14, 2007, the KAGUYA (SELENE) spacecraft were launched from Tanegashima Space Center in Japan. KAGUYA consists of three satellites: a main orbiter in a 100 km by 100 km circular, polar orbit, and two small subsatellites in 100 km by 2400 km (Rstar) and 100 km by 800 km (Vstar) elliptical, polar orbits. By employing 4-way Doppler tracking between the main orbiter and Rstar, the first direct tracking data of a satellite over the far side have been obtained, resulting in a newly determined global lunar gravity field. The existing 2-way tracking data set is furthermore complemented by precise differential VLBI tracking between Rstar and Vstar, providing a sensitivity perpendicular to the line-of-sight from station to satellite. This work focuses on various aspects of processing and analysing the tracking data from the Kaguya satellites for the main purpose of lunar gravity field estimation. This includes particulars of the data processing strategies, multi-satellite analysis and data weighting. Gravity models from Kaguya data are evaluated in terms of data fit and performance in orbit determination. The performance of the differential VLBI data in the orbit determination of the small subsatellites is also discussed, as well as their contribution to the gravity solutions. Results for the polar moment of inertia C/MR2 from the degree 2 coefficients, and for the lunar k2 Love number are also included.
- Goossens, S., K. Matsumoto, Y. Ishihara, Q. Liu, F. Kikuchi, H. Noda, N. Namiki, T. Iwata, and H. Hanada [2009], "Updated Lunar Gravity Results from Kaguya (SELENE) and Historical Tracking Data," American Geophysical Union, Fall Meeting 2009, abstract #P23C-1274.
  - The Kaguya spacecraft were launched from Tanegashima Space Center on September 14, 2007. Kaguya consists of three orbiters: a main orbiter in a low-altitude (100 km) circular polar orbit, and two sub-satellites (Rstar and Vstar) in elliptical orbits. By taking tracking data between Rstar and the main orbiter while the main orbiter was over the farside of the Moon (called 4-way Doppler), Kaguya has obtained the first direct tracking data over the farside. Tracking data were further complemented by differential VLBI tracking between Rstar and Vstar and stations on Earth, with a sensitivity perpendicular to the line-of-sight, thus offering further improvement in three-dimensional positioning of the relay satellites. On February 12, 2009, Rstar crashed into the Moon because of its natural orbital evolution, finishing the opportunities for 4-way data. On June 10, the main orbiter finished its lifetime by a controlled crash into the Moon, and tracking for Vstar was ended on June 29, comprising the end of data collection from Kaguya. Here, results from incorporating all Kaguya Doppler tracking (including all collected 4-way data over the farside) are presented. Spherical harmonics expansions up to degree and order 100 have been determined, and they will be evaluated in terms of geophysical content, correlations with topography, and orbit determination performance. It is shown that unconstrained solutions can be obtained up to degree and order 70 without loss of correlations with topography. A preliminary high-resolution 150 degrees and order model for low-lunar orbit determination is also presented. Furthermore, preliminary results from the analysis of same-beam differential VLBI data are also included, showing how these data can especially

help to improve orbit determination for the sub-satellites. The VLBI data will also contribute to a precise determination of the lower-degree gravity coefficients.

- Gopalswamy, N., S. Yashiro, and K. Shibasaki [2008], "Heating and Kinematics of an Eruptive Prominence Associated with a Fast Coronal Mass Ejection," American Geophysical Union, Fall Meeting 2007, abstract #SH31C-07.
  - The fast (1800 km/s) coronal mass ejection (CME) on 2005 July 27 had a bright bubble-shaped prominence core observed by the Nobeyama Radioheliograph (NoRH) in microwaves (17 and 34 GHz), TRACE at 171 A, and the Extreme-ultraviolet Imaging Telescope (EIT) on board SOHO. NoRH has the largest field of view among the non- white light instruments, so the prominence could be tracked until it reached a height of about 0.75 solar radii from the limb. The prominence remained optically thick at both 17 and GHz, even though it was significantly heated. Comparison with TRACE observations suggest that the prominence was heated in individual fibers within the prominence, making it multi-thermal plasma.
    The prominence maintained its overall shape as it entered into the field of view of SOHO/LASCO coronagraphs with a speed of about 1400 km/s, so the height-time history could be studied over a distance of more than 20 solar radii from the Sun. NoRH data indicated that the initial acceleration was extremely high (about1.4 km/s/s). During the slow-rise phase of the prominence, EUV loops overlying the prominence also moved out, which when combines with CME leading-edge measurements from LASCO/C2 yielded an acceleration of about 300 m/s/s. This was comparable to the average acceleration of the prominence over the same height range. When we consider the just the LASCO field of view, both the prominence core and the CME leading edge showed deceleration, but to vastly different extents (-32 m/s/s for the CME leading edge compared to -3 m/s/s for the prominence core). Our preliminary conclusion is that the prominence was insulated from interacting with the non-CME ambient medium, which might explain the weaker slowing down of the prominence.
- Gopalswamy, N., S. Yashiro, K. Shibasaki, and D. Hathaway [2010], "Polar Chromospheric Signatures of the Subdued Cycle 23/24 Solar Minimum," American. Astron. Soc., AAS Meeting #216, #401.03.
  - Coronal holes appear brighter than the quiet Sun in microwave images, with a brightness enhancement of 500 to 2000 K. The brightness enhancement corresponds to the upper chromosphere, where the plasma temperature is about 10000 K. We constructed a microwave butterfly diagram using the synoptic images obtained by the Nobeyama radioheliograph (NoRH) showing the evolution of the polar and low latitude brightness temperature. While the polar brightness reveals the chromospheric conditions, the low latitude brightness is attributed to active regions in the corona. When we compared the microwave butterfly diagram with the magnetic butterfly diagram, we found a good correlation between the microwave brightness enhancement and the polar field strength. The microwave butterfly diagram covers part of solar cycle 22, whole of cycle 23, and part of cycle 24, thus enabling comparison between the cycle 23/24 and cycle 22/23 minima. The microwave brightness during the cycle 23/24 minimum was found to be lower than that during the cycle 22/23 minimum by 250 K. The reduced brightness temperature is consistent with the reduced polar field strength during the cycle 23/24 minimum seen in the magnetic butterfly diagram. We suggest that the microwave brightness at the solar poles is a good indicator of the speed of the solar wind sampled by Ulysses at high latitudes.
- Grechnev, V. V., V. G. Kurt, I. M. Chertok, A. M. Iralov, H. Nakajima, A. T. Altyntsev, A. V. Belov, B. Yu. Yushkov, S. N. Kuznetsov, L. K. Kashapova, N. S. Meshalkona, and N. P. Prestage [2008a], "An Extreme Solar Events of 20 January 2005: Properties of the Flare and the Origon of Energetic Particles," Solar Phys., vol.252, pp.149-177.
  - The famous extreme solar and particle event of 20 January 2005 is analyzed from two

perspectives. Firstly, using multi-spectral data, we study temporal, spectral, and spatial features of the main phase of the flare, when the strongest emissions from microwaves up to 200 MeV gamma-rays were observed. Secondly, we relate our results to a long-standing controversy on the origin of solar energetic particles (SEP) arriving at Earth, i.e., acceleration in flares, or shocks ahead of coronal mass ejections (CMEs). Our analysis shows that all electromagnetic emissions from microwaves up to 2.22 MeV line gamma-rays during the main flare phase originated within a compact structure located just above sunspot umbrae. In particular, a huge ($\approx 10^5$ sfu) radio burst with a high frequency maximum at 30 GHz was observed, indicating the presence of a large number of energetic electrons in very strong magnetic fields. Thus, protons and electrons responsible for various flare emissions during its main phase were accelerated within the magnetic field of the active region. The leading, impulsive parts of the ground-level enhancement (GLE), and highest-energy gamma-rays identified with π^0-decayemission, are similar and closely correspond in time. The origin of the π^0-decay gamma-rays is argued to be the same as that of lower-energy emissions, although this is not proven. On the other hand, we estimate the sky-plane speed of the CME to be 2000-2600km s^{-1}, i.e., high, but of the same order as preceding non-GLE-related CMEs from the same active region. Hence, the flare itself rather than the CME appears to determine the extreme nature of this event. We therefore conclude that the acceleration, at least, to sub-relativistic energies, of electrons and protons, responsible for both the major flare emissions and the leading spike of SEP/GLE by 07 UT, are likely to have occurred nearly simultaneously within the flare region. However, our analysis does not rule out a probable contribution from particles accelerated in the CME-driven shock for the leading GLE spike, which seemed to dominate at later stages of the SEP event.

- Grechnev, V. V., A. M. Uralov, V. A. Slemzin, I. M. Chertok, I. V. Kuzmenko, and K. Shibasaki [2008b], "Absorption Phenomena and a Probable Blast Wave in the 13 July 2004 Eruptive Event," Solar Phys., vol.253, pp.263-290.
  - We present a case study of the 13 July 2004 solar event, in which disturbances caused by eruption of a filament from an active region embraced a quarter of the visible solar surface. Remarkable are the absorption phenomena observed in the SOHO/EIT 304 Å channel, which were also visible in the EIT 195 Å channel, in the H line, and even in total radio flux records. Coronal and Moreton waves were also observed. Multispectral data allowed reconstructing an overall picture of the event. An explosive filament eruption and related impulsive flare produced a CME and blast shock, both of which decelerated and propagated independently. Coronal and Moreton waves were kinematically close and both decelerated in accordance with an expected motion of a coronal blast shock. The CME did not resemble a classical three-component structure, probably because some part of the ejected mass fell back onto the Sun. Quantitative evaluations from different observations provide close estimates of the falling mass, ~3×10^{15} g, which is close to the estimated mass of the CME. The falling material was responsible for the observed large-scale absorption phenomena, in particular, shallow widespread moving dimmings observed at 195 Å. By contrast, deep quasi-stationary dimmings observed in this band near the eruption center were due to plasma density decrease in coronal structures.
- Greenhill, L., E. Humphreys, W. Hu, L. Macri, D. Murphy, K. Masters, Y. Hagiwara, H. Kobayashi, and Y. Murata [2009], "Estimation of the Hubble Constant and Constraint on Descriptions of Dark Energy," Astro2010: The Astronomy and Astrophysics Decadal Survey, Science White Papers, no. 103-0-7.
  - Joint analysis of Cosmic Microwave Background, Baryon Acoustic Oscillation, and supernova data has enabled precision estimation of cosmological parameters. New programs will push to 1% uncertainty in the dark energy equation of state and tightened constraint on curvature,

requiring close attention to systematics. Direct 1% measurement of the Hubble constant (H0) would provide a new constraint. It can be obtained without overlapping systematics directly from recessional velocities and geometric distance estimates for galaxies via the mapping of water maser emission that traces the accretion disks of nuclear black holes. We identify redshifts $0.02<z<0.06$ as best for small samples, e.g., 10 widely distributed galaxies, each with 3% distance uncertainty. Knowledge of peculiar radial motion is also required. Mapping requires very long baseline interferometry (VLBI) with the finest angular resolution, sensitivity to individual lines of a few mJy-km/s, and baselines that can detect a complex of ~10 mJy lines (peak) in < 1 min. For 2010-2020, large ground apertures (50-100m diameter) augmenting the VLBA are critical, such as EVLA, GBT, Effelsberg, and the Large Millimeter Telescope, for which we propose a 22 GHz receiver and VLBI instrumentation. A space-VLBI aperture may be required, thus motivating US participation in the Japanese VSOP-2 mission (launch c.2013). This will provide 3-4x longer baselines and ~5x improvement in distance uncertainty. There are now 5 good targets at $z>0.02$, out of ~100 known masers. A single-dish discovery survey of >10,000 nuclei (>2500 hours on the GBT) would build a sample of tens of potential distance anchors. Beyond 2020, a high-frequency SKA could provide larger maser samples, enabling estimation of H0 from individually less accurate distances, and possibly without the need for peculiar motion corrections.

- Hagiwara, Y., and VSOP-2 Science Working Group [2009], "Extragalactic Water Maser Observations with VSOP-2," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.266-269.
  - Space-VLBI is known to achieve greatly increased angular resolution compared with ground-based VLBI observations. VSOP-2 will offer 75μ arcsec angular resolution at 22 GHz. With this improved angular resolution, VSOP-2 observations of H_2O megamaser will refine the measurements of proper motions, accelerations, distances to galaxies, and other physical parameters of galactic nuclei. In this presentation, the prospects of VSOP-2 observations of extragalactic H_2O maser with strong emphasis on H_2O megamaser are presented.
- Hanada, H., T. Iwata, N. Namiki, N. Kawano, K. Asari, T. Ishikawa, F. Kikuchi, Q. Liu, K. Matsumoto, H. Noda, S. Tsuruta, S. Goossens, K. Iwadate, O. Kameya, Y. Tamura, X. Hong, J. Ping, Y. Aili, S. Ellingsen, and W. Schlüter [2008a], "VLBI for Better Gravimetry in SELENE," Adv. Sp. Res., vol.42, pp.341-346.
  - The Japanese lunar explorer SELENE (SElenological and Engineering Explorer), to be launched in 2007, will for the first time utilize VLBI observations in lunar gravimetry investigations. This will particularly improve the accuracy to which the low degree gravitational harmonics and the gravity field near the limb can be measured, and when combined with Doppler measurements will enable three-dimensional information to be extracted. Differential VLBI Radio sources called VRAD experiment involves two on-board sub-satellites, Rstar and Vstar. These will be observed using differential VLBI to measure the trajectories of the satellites with the Japanese network named VERA (VLBI Exploration of Radio Astrometry) and an international VLBI network. We will use a multi-frequency VLBI method to measure the angular distance between the two sub-satellite radio sources Rstar and Vstar. The observations will be at three frequencies in S-band, 2212, 2218 and 2287 MHz, and one in X-band, 8456 MHz. This method uses low power consumption carrier waves, and is suitable for the positioning of spacecraft. The Japanese domestic VLBI network, VERA, will conduct VLBI observations for the whole mission period of one year. In addition, we will conduct two periods of intensive observations, each one month in duration, which will also include the international stations, Shanghai, Urumqi (China), Hobart (Australia) and Wettzell (Germany). These observations will measure the phase delay to an accuracy of better than 0.17

rad (10 deg) in X-band. For a baseline length of 2000 km this is equivalent to a positioning accuracy of about 20 cm on the Moon. Combining the data from the tracking of the 3 SELENE satellites (main orbiter, Rstar and Vstar) at different altitudes and from four-way Doppler measurements, and by making long term observations of the sub-satellites (in excess of one year without any maneuvering), we will be able to improve the accuracy to which the lunar gravitational field is known by an order of magnitude. We have completed the development of on-board instruments, and are carrying out pre-flight tests under a variety of conditions. We have also undertaken test VLBI observations of orbiters such as Geotail, Nozomi and Smart-1 with the international network.

- Hanada, H. [2008b], "VLBI Observation of Okina and Ouna in Kaguya (SELENE) for Improvement of Orbit Determination and Lunar Gravity Field Model," 37th COSPAR Scientific Assembly, held 13-20 July 2008, in Montreal, Canada, p.1168.
  - KAGUYA consists of the main orbiter, and two small free-flying sub-satellites, called Rstar (OKINA) and Vstar (OUNA). We are observing OKINA and OUNA using differential VLBI observa-tions with the aim of improving the lunar gravity field model. Our observations will particularly improve the accuracy to which the low degree gravitational harmonics and the gravity field near the limb can be measured, and when combined with Doppler measurements will enable three-dimensional information to be extracted. Differential VLBI will be used to accurately measure the trajectories of the satellites, both with the Japanese VERA (VLBI Exploration of Radio Astrometry) telescopes and an array including the international VLBI stations, Shanghai, Urumqi (China), Hobart (Australia), and Wettzell (Germany). We are using multi-frequency VLBI to determine the angular distance between OKINA and OUNA using three frequencies in S-band, (2212, 2218 and 2287 MHz), and one in X-band, (8456MHz). Two periods of international observations, each of one month in duration, with the participation of VERA and the international stations, (in addition to the normal observations by VERA only) are planned for the one year mission period. VLBI observation was started on Nov.5, 2007 and the first international VLBI observation was per-formed in Jan, 2008. We have succeeded in obtaining phase delays with an accuracy of several pico-seconds in S-band.
- Hanada, H., T. Iwata, N. Namiki, N. Kawnao, S. Sasaki, K. Matsumoto, H. Noda, S. Tsuruta, K. Asari, T. Ishikawa, F. Kikuchi, Q. Liu, S. Goossens, K. M. Shibata, K. Iwadate, O. Kameya, Y. Tamura, X. Hong, J. Ping, Y. Aili, S. Ellingsen, and W. Schluter [2009], "The Explorations of Lunar Gravity by VLBI Observations of SELENE (Kaguya)," Trans. of Sp. Tech. Japan, vol.7, pp.Tk1-Tk5.
  - SELENE (Kaguya), which was successfully launched on Sep. 14, 2007, consists of the main orbiter, and two small free-flying sub-satellites, called Rstar (OKINA) and Vstar (OUNA). We use multi-frequency VLBI to measure the angular distance between the two sub-satellite radio sources Okina and Ouna in order to improve the accuracy of the low degree gravitational harmonics and the gravity field near the limb. The observations are made at three frequencies in S-band, (2212, 2218 and 2287 MHz), and one in X-band, (8456MHz) with carrier waves. The Japanese domestic VLBI network, VERA, will conduct VLBI observations for the whole mission period of one year. In addition, we will conduct two periods of international observations, each one month in duration, which will also include the international stations, Shanghai, Urumqi, Hobart, and Wettzell. We have succeeded in making VLBI observations of Okina/Ouna with VERA and the international network, and have also succeeded in correlating of signals from Okina/Ouna. We obtained phase delays with an accuracy of several pico-seconds in S-band.
- Haruyama, J., M. Ohtake, T. Matsunaga, T. Morota, C. Honda, Y. Yokota, M. Abe, Y. Ogawa, H. Miyamoto, A. Iwasaki, C. M. Pieters, N. Asada, H. Demura, N. Hirata, J. Terazono, S. Sasaki, K. Saiki, A. Yamaji, M. Torii, and J.-L. Josset [2009], "Long-Lived Volcanism on the

Lunar Farside Revealed by SELENE Terrain Camera," Science, vol.323, pp.905-908.

- We determined model ages of mare deposits on the farside of the Moon on the basis of the crater frequency distributions in 10-meter-resolution images obtained by the Terrain Camera on SELENE (Selenological and Engineering Explorer) (Kaguya). Most mare volcanism that formed mare deposits on the lunar farside ceased at ~3.0 billion years ago, suggesting that mare volcanism on the Moon was markedly reduced globally during this period. However, several mare deposits at various locations on the lunar farside also show a much younger age, clustering at ~2.5 billion years ago. These young ages indicate that mare volcanism on the lunar farside lasted longer than was previously considered and may have occurred episodically.

- Hasegawa, T., T. Arai, N. Yamaguchi, and F. Sato [2008], "ASTE Observations of the Massive-Star Forming Region Sgr B2: a Giant Impact Scenario," Astrophys. and Sp. Sci., vol.313, pp.91-94.

- We report mapping observations of a 35 pc x 35 pc region covering the Sgr B2 molecular cloud complex in the ^{13}CO (3-2) and the CS (7-6) lines using the ASTE 10 m telescope with high angular resolution. The central region was mapped also in the $C^{18}O$ (3-2) line. The images not only reproduce the characteristic structures noted in the preceding millimeter observations, but also highlight the interface of the molecular clouds with a large velocity jump of a few tens of km s^{-1}. These new results further support the scenario that a cloud-cloud collision has triggered the formation of massive cloud cores, which form massive stars of Sgr B2. Prospects of exciting science enabled by ALMA are discussed in relation to these observations.

- Hatsukade, B., D. Iono, K. Motohara, K. Nakanishi, M. Hayashi, K. Shimasaku, T. Nagao, Y. Tamura, M. Malkan, C. Ly, and K. Kohno [2009], "A Search for Molecular Gas toward a BzK-Selected Star-Forming Galaxy at z = 2.044," Publ. Astron. Soc. Japan, vol.61, pp.487-491.

- We present a search for CO (3-2) emission in SDF-26821, a BzK -selected star forming galaxy (sBzK) at z = 2.044, using the 45-m telescope of the Nobeyama Radio Observatory and the Nobeyama Millimeter Array. We did not detect significant emission, and derived the 2σ limits: CO luminosity of $L'_{CO} < 3.1$ x 10^{10} K km s^{-1} pc^{-2}, ratio of far-infrared luminosity to CO luminosity of $L_{FIR}/L'_{CO} > 57$ L .(K km s^{-1} $pc^2)^{-1}$, and molecular gas mass of $M_{H2} < 2.5$ x 10^{10} M , assuming a velocity width of 200 km s^{-1} and a CO-to-H_2 conversion factor of $\alpha_{CO} = 0.8$ M .(K km s^{-1} $pc^2)^{-1}$. The ratio L_{FIR}=L'_{CO}, a measure of the star-formation efficiency (SFE), is comparable to, or higher than, the two z ~ 1.5 sBzKs detected in CO (2 1) previously, suggesting that sBzKs can have a wide range of SFEs. Comparisons of far-infrared luminosity, gas mass, and stellar mass among the sBzKs suggest that SDF-26821 is at an earlier stage of forming stars with a similar SFE and/or more ef ciently forming stars than the two z ~ 1.5 sBzKs. The higher SFEs and speci c star-formation rates of the sBzKs compared to local spirals are indicative of a difference in the star-formation modes between these systems, suggesting that sBzKs are not just scaled-up versions of local spirals.

- Hatsukade, B., D. Iono, M. Akiyama, T. Yoshikawa, J. S. Dunlop, R. J. Ivison, A. B. Peck, S. Ikarashi, A. Briggs, H. Ezawa, H. Hanami, P. Ho, D. H. Hughes, R. Kawabe, K. Kohno, S. Matsushita, K. Nakanishi, N. Padilla, G. Petitpas, Y. Tamura, J. Wagg, D. J. Wilner, G. W. Wilson, T. Yamada, and M. S. Yun [2010a], "Unveiling the Nature of Submillimeter Galaxy SXDF 850.6," Astrophys. J., vol.711, pp.974-979.

- We present an 880 μm Submillimeter Array (SMA) detection of the submillimeter galaxy SXDF 850.6. SXDF 850.6 is a bright source ($S_{850\mu m}$ = 8 mJy) detected in the SCUBA Half Degree Extragalactic Survey and has multiple possible radio counterparts in its deep radio image obtained at the VLA. Our new SMA detection finds that the submillimeter emission coincides with the brightest radio emission that is found ~8" north of the coordinates

determined from SCUBA. Despite the lack of detectable counterparts in deep UV/optical images, we find a source at the SMA position in near-infrared and longer wavelength images. We perform spectral energy distribution (SED) model fits to UV-optical-IR photometry (u, B, V, R, i', z', J, H, K, 3.6 μm, 4.5 μm, 5.8 μm, and 8.0 μm) and to submillimeter-radio photometry (850 μm, 880 μm, 1100 μm, and 21 cm) independently, and we find both are well described by starburst templates at a redshift of z □ 2.2± 0.3. The best-fit parameters from the UV-optical-IR SED fit are a redshift of $z = 1.87^{+0.15}_{-0.07}$, a stellar mass of $M_{□} = 2.5^{+2.2}_{-0.3} \times 10^{11}$ M ., an extinction of $A_V = 3.0^{+0.3}_{-1.0}$ mag, and an age of 720^{+1880}_{-210} Myr. The submillimeter-radio SED fit provides a consistent redshift of z ~ 1.8-2.5, an IR luminosity of $L_{IR} = (7\text{-}26)\times 10^{12}$ L ., and a star formation rate of 1300-4500 M .yr^{-1}. These results suggest that SXDF 850.6 is a mature system already having a massive amount of old stellar population constructed before its submillimeter bright phase and is experiencing a dusty starburst, possibly induced by major mergers.

- Hatsukade, B., K. Kohno, Y. Tamura, K. Nakanishi, D. Iono, G. W. Wilson, M. S. Yun, D. H. Hughes, S. Matsuura, M. Shirahata, T. T. Takeuchi, K. S. Scott, J. E. Austermann, T. Perera, I. Aretxaga, K. Tanaka, T. Tosaki, H. Matsuo, H. Ezawa, R. Kawabe, and ADF-S team [2010b], "AzTEC/ASTE 1.1-mm Survey of the AKARI Deep Field-South," Proc. of the "AKARI, a light to illuminate the misty universe", eds. T. Onaka, G. J. White, T. Nakagawa, and I. Yamamura, ASP Conf. Ser. vol.418, pp.307-312.

➢ We present the first results of a deep 1.1-mm survey of the AKARI Deep Field-South (ADF-S) with the AzTEC camera on the Atacama Submillimetre Telescope Experiment (ASTE). This survey covers ~400 arcmin^2, of which the central 202 arcmin^2 is a uniform low-noise region with an rms noise level of 0.48-0.71 mJy. This is one of the deepest surveys at 1-mm wavelength, to cover such a large contiguous region. We detected 37 sources with a significance of 3.5–10 σ. The expected number of false detections at ≥3.5 σ is at most one, indicating that the detected sources are highly reliable. We construct differential and cumulative number counts and find a difference in number counts among 1-mm blank field surveys: the number counts of the ADF-S are less than those of GOODS-N and COSMOS fields. Most of the sources are not detected in the far-infrared bands of the AKARI, suggesting that they lie mostly at z ga 1 given the detection limits. In this survey, about 10% of cosmic infrared background at 1.1 mm is resolved into discrete sources.

- Hatsukade, B., K. Kohno, I. Aretxaga, J. E. Austermann, H. Ezawa, D. H. Hughes, S. Ikarashi, D. Iono, R. Kawabe, H. Matsuo, K. Nakanishi, T. Oshima, T. Perera, K. S. Scott, M. Shirahata, T. T. Takeuchi, Y. Tamura, K. Tanaka, T. Tosaki, G. W. Wilson, and M. S. Yun [2010c], "AzTEC/ASTE 1.1 mm Deep survey: Number Counts and Clustering of Millimeter-Bright Galaxies," AIP Conf. Proc., vol.1279, pp.324.

➢ We present number counts and clustering properties of millimeter-bright galaxies uncovered by the AzTEC camera mounted on the Atacama Submillimeter Telescope Experiment (ASTE). We surveyed the AKARI Deep Field South (ADF-S), the Subaru/XMM Newton Deep Field (SXDF), and the SSA22 fields with an area of ~0.25 deg^2 each with an rms noise level of ~0.4-1.0 mJy. We constructed differential and cumulative number counts, which provide currently the tightest constraints on the faint end. The integration of the best-fit number counts in the ADF-S find that the contribution of 1.1 mm sources with fluxes ≥1 mJy to the cosmic infrared background (CIB) at 1.1 mm is 12-16%, suggesting that the large fraction of the CIB originates from faint sources of which the number counts are not yet constrained. We estimate the cosmic star-formation rate density contributed by 1.1 mm sources with >=1 mJy using the best-fit number counts in the ADF-S and find that it is lower by about a factor of 5-10 compared to those derived from UV/optically-selected galaxies at z~2-3. The average mass of dark halos hosting bright 1.1 mm sources was calculated to be 10^{13}-10^{14} M.. Comparison of

correlation lengths of 1.1 mm sources with other populations and with a bias evolution model suggests that dark halos hosting bright 1.1 mm sources evolve into systems of clusters at present universe and the 1.1 mm sources residing the dark halos evolve into massive elliptical galaxies located in the center of clusters.

- Higuchi, A. E., Y. Kurono, M. Saito, and R. Kawabe [2009], "A Mapping Survey of Dense Clumps Associated with Embedded Clusters : Evolutionary Stages of Cluster-Forming Clumps," Astrophys. J., vol.705, pp.468-482.
  - We have carried out a survey of the dense clumps associated with 14 embedded clusters in the $C^{18}O$ (J = 1-0) line emission with the Nobeyama 45 m telescope in order to understand the formation and evolution of stellar clusters in dense clumps of molecular clouds. We have selected these clusters at distances from 0.3 to 2.1 kpc and have mapped about 6'x6'-10' x 10' regions (corresponding to 3.8 pc x 3.8 pc at 2.1 kpc) for all the clumps with 22" resolution (corresponding to Jeans length at 2.1 kpc). We have obtained dense clumps with radii of 0.40-1.6 pc, masses of 150-4600 $M_\odot$, and velocity widths in FWHM of 1.4-3.3 km s^{-1}. Most of the clumps are found to be approximately in virial equilibrium, which implies that $C^{18}O$ gas represents parental dense clumps for cluster formation. From the spatial relation between the distributions of clumps and clusters, we classified $C^{18}O$ clumps into three types (Type A, B, and C). Type A clumps have emission distributions with a single peak at the stellar clusters and higher brightness contrast than that of other target sources. Type B clumps have double or triple peaks, which are associated with the cluster, and moderately high brightness contrast structure. Type C clumps also have multiple peaks, although they are not associated with the cluster, and low brightness contrast structure. We suggest that our classification represents an evolutionary trend of cluster-forming dense clumps because dense gas in molecular clouds is expected to be converted into stellar constituents, or dispersed by stellar activities. Moreover, although there is a scatter, we found a tendency that the star formation efficiencies of the dense clumps increase from Type A to Type C, which also supports our scenario.
- Higuchi, A. E., Y. Kurono, M. Saito, and R. Kawabe [2010], "A Mapping Survey of Dense Associated with Embedded Clusters II: Can Clump-Climp Collisions Induce Stellar Clusters?," Astrophys. J., vol.719, pp.1813-1827.
  - We report the $H^{13}CO^+$ (J = 1-0) survey observations toward embedded clusters obtained using the Nobeyama 45 m telescope, which were performed to follow up our previous study in the $C^{18}O$ survey with a dense gas tracer. Our aim is to address the evolution of cluster-forming clumps. We observed the same 14 clusters in $C^{18}O$, which are located at distances from 0.3 to 2.1 kpc with a 27" resolution (corresponding to the Jeans length for most of our targets) in $H^{13}CO^+$. We detected the 13 clumps in $H^{13}CO^+$ line emission and obtained the physical parameters of the clumps with radii of 0.24-0.75 pc, masses of 100-1400 Msun, and velocity widths in FWHM of 1.5-4.0 km s^{-1}. The mean density is ~3.9 x 10^4 cm^{-3} and the equivalent Jeans length is ~0.13 pc at 20 K. We classified the $H^{13}CO^+$ clumps into three types, type A, type B, and type C according to the relative locations of the $H^{13}CO^+$ clumps and the clusters (see our previous study). Our classification represents an evolutionary trend of cluster-forming clumps because dense clumps are expected to be converted into stellar constituents, or dispersed by stellar activities. We found a similar, but clearer trend than our previous results, for derived star formation efficiencies to increase from type A to C in the $H^{13}CO^+$ data, and for the dense gas regions within the clumps traced by $H^{13}CO^+$ to be sensitive to the physical evolution of the clump-cluster systems. In addition, we found that 4 out of 13 $H^{13}CO^+$ clumps, which we named "Distinct Velocity Structure Objects" (DVSOs), have distinct velocity gradients at their central parts, i.e., at the location of the embedded clusters. Assuming that the velocity gradients represent the rigid-like rotation of the clumps, we calculated the virial parameter of the $H^{13}CO^+$ clumps by taking into account the contribution of the rotation and

found that the DVSOs tend to be gravitationally unbound. In order to explain the above physical properties for DVSOs in a consistent way, we propose a clump-clump collision model as a possible mechanism for triggering the formation of clusters.

- Higuchi, K., N. Kishimoto, T. Mizuno, K. Kawahara, S. Tachikawa, Y. Murata, M. Tsuboi, H. Ogawa, S. Kimura, H. Ujihara, A. Meguro, H. Tanaka, M. Yoshihara, and S. IIkura [2009], "VSOP-2 Antenna and its Structure," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.41-45.
  - To achieve scientific improvements from VSOP (HALCA) to VSOP-2 (ASTRO-G), the satellite design incorporates the engineering characteristics of a large-scale deployable antenna of offset Cassegrain type with observation bands of 8, 22, and 43 GHz. The antenna subsystem requires the surface accuracy of 0.4mm RMS on the main reflector named LDR (Large-scale Deployable Reflector) of about 9m in diameter. An off-axis paraboloid reflector is adopted to achieve this surface accuracy for millimeter-wave observation. The main reflector is composed of seven deployable modular antennas, and each of the modules employs a new idea of radial-rib/hoop-cable reflector construction to stretch metal mesh and to satisfy the required surface accuracy. The deployment mechanism employs most of the LDR technology developed for JAXA's ETS-VIII satellite, which was launched in December 2006, and both of the two antennas on the ETS-VIII deployed successfully on orbit. Some prototype models of one module have been made to investigate the surface accuracy. In addition, the antenna will have a two-axis adjustment mechanism for the main reflector, and a three-axis adjustment mechanism for the sub-reflector in order to optimize the antenna gain after deployment in orbit.
- Hiramatsu, M., N. Hirano, and S. Takakuwa [2010], "Outflow - Core Interaction in Barnard 1," Astrophys, J., vol.712, pp.778-789.
  - In order to study how outflows from protostars influence the physical and chemical conditions of the parent molecular cloud, we have observed the Barnard 1 (B1) main core, which harbors four Class 0 and three Class I sources, in the CO (J = 1 - 0), CH_3OH ($J_K = 2_K - 1_K$), and the SiO (J = 1 - 0) lines using the Nobeyama 45 m telescope. We have identified three CO outflows in this region: one is an elongated (~0.3 pc) bipolar outflow from a Class 0 protostar B1-c in the submillimeter clump SMM 2, another is a rather compact (~0.1 pc) outflow from a Class I protostar B1 IRS in the clump SMM 6, and the other is an extended outflow from a Class I protostar in SMM 11. In the western lobe of the SMM 2 outflow, both the SiO and CH_3OH lines show broad redshifted wings with the terminal velocities of 25 km s^{-1} and 13 km s^{-1}, respectively. It is likely that the shocks caused by the interaction between the outflow and ambient gas enhance the abundance of SiO and CH_3OH in the gas phase. The total energy input rate by the outflows ($1.1 \times 10_{-3}$ L.) is smaller than the energy-loss rate (8.5×10^{-3} L.) through the turbulence decay in the B1 main core, which suggests that the outflows cannot sustain the turbulence in this region. Since the outflows are energetic enough to compensate the dissipating turbulence energy in the neighboring, more evolved star-forming region NGC 1333, we suggest that the turbulence energy balance depends on the evolutionary state of the star formation in molecular clouds.
- Hirata, N., O. S. Barnouin-Jha, C. Honda, R. Nakamura, H. Miyamoto, S. Sasaki, H. Demura, A. M. Nakamura, T. Michikami, R. W. Gaskell, and J. Saito [2009], "A Survey of Possible Impact Structures on 25143 Itokawa," Icarus, vol.200, pp.486-502.
  - We determined the morphologies and dimensions of possible impact craters on the surface of Asteroid 25143 Itokawa from images taken by the Hayabusa spacecraft. Circular depressions, circular features with flat floors or convex floors, and circular features with smooth surfaces were identified as possible craters. The survey identified 38 candidates with widely varying

morphologies including rough, smooth and saddle-shaped floors, a lack of raised rims and fresh material exposures. The average depth/diameter ratio was 0.08±0.03: these craters are very shallow relative to craters observed on other asteroids. These shallow craters are a result of (1) target curvature influencing the cratering process, (2) raised rim not being generated by this process, and (3) fines infilling the craters. As many of the crater candidates have an unusual appearance, we used a classification scheme that reflects the likelihood of an observed candidate's formation by a hypervelocity impact. We considered a variety of alternative interpretations while developing this scheme, including inherited features from a proto-Itokawa, spall scars created by the disruption of the proto-Itokawa, spall scars following the formation of a large crater on Itokawa itself, and apparent depressions due to random arrangements of boulders. The size-frequency distribution of the crater candidates was close to the empirical saturation line at the largest diameter, and then decline with decreasing diameter.

- Hiroi, T., T. Nimura, Y. Ueda, S. Sasaki, and C. M. Pieters [2008a], "Deriving the Distribution of Ordinary Chondrite (H, L, LL)-like Materials in Asteroids from Their Visible and Near-Infrared Reflectance Spectroscopy," 39th Lunar and Planetary Science Conference, (Lunar and Planetary Science XXXIX), held March 10-14, 2008 in League City, Texas. LPI Contribution No. 1391, p.1997.

➢ We have attempted to identify asteroid surface materials similar to ordinary chondrite types by examining reflectance spectra of the S, A, R, and V asteroids over the 1- m band range, and derive their distributions.

- Hiroi, T., M. Abe, T. Nimura, K. Kitazato, S. Abe, Y. Takagi, S. Sasaki, and M. Ishiguro [2008], "Danger in Interpreting the 2-Micron Band of Reflectance Spectra of Small Asteroids: A Lesson from Hayabusa/NIRS Data of Itokawa," Meteoritics and Planetary Sci. Suppl., 43, paper id. 5283.

➢ Not Available

- Hirota, A., N. Kuno, N. Sato, T. Tosaki, H. Nakanishi, and K. Sorai [2008b], "GMCs in the Nearby Galaxy IC 342," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., p.334.

➢ Without abstract

- Hirota, A., N. Kuno, N. Sato, H. Nakanishi, T. Tosaki, H. Matsui, A. Habe, and K. Sorai [2009], "Determination of the Pattern Speed of Barred Spiral Galaxies," Publ. Astron. Soc. Japan, vol.61, pp.441-450.

➢ We evaluated the availability of a method proposed by Kuno et al. (2000, PASJ, 52, 775) for measuring the pattern speed of barred galaxies, and applied it to observational data. We made error estimations using a hydro-dynamical galaxy model to test the validity of the method. Error estimations suggest that the method is able to determine the pattern speed within an error of 10%-20%. The method was applied to ^{12}CO(1-0) data of three late-type barred galaxies: NGC 2903, M 83, and NGC 3627. The derived pattern speed was 40 km s^{-1} kpc^{-1} for NGC 2903, 57 km s^{-1} kpc^{-1} for M 83, 39 km s-1 kpc-1 for NGC 3627, respectively. For the sake of a comparison with measurements in other galaxies, we used the distance-independent value R (R_{CR}/R_{bar}), and found that bars in the three late-type spirals are “slow” ($R > 1.4$). Our results support recent claims that bars are not always “fast” ($R \leq 1.4$), at least for late-type spiral galaxies.

- Hirota, A., N. Kuno, N. Sato, H. Nakanishi, T. Tosaki, and K. Sorai [2010], "Variation of Molecular Gas Properties Across the Spiral Arms in IC 342: Large-Scale ^{13}CO (1-0) Emission," Publ. Astron. Soc. Japan, vol.62, pp.1261-1275.

➢ We present a ^{13}CO (1-0) mapping survey of the nearby galaxy IC 342 carried out with the Nobeyama 45m radio telescope. The map covers a 32" x 32" region including its center, bar, and most of one of the spiral arms. The 13CO (1-0) data were compared with ^{12}CO (1-0), Hα,

24μm, and K_s-band images to investigate spatial relations among molecular clouds, star-forming regions, and the stellar potential. The line ratio between both CO lines, I [^{13}CO (1-0)]=I [^{12}CO (1-0)] ≡ $R_{13/12}$, was also derived to investigate the variation of molecular gas properties. The mean value of $R_{13/12}$ in the center of IC 342 is low (~0.10±0.01) compared to the disk region (~0.15±0.01). While $R_{13/12}$ in the central region is rather uniform, significant variations of $R_{13/12}$ were found in the spiral arms; that is, while it is low (~0.1) at both ends of the bar and at the giant molecular cloud association (GMA) found in the spiral arm, it is high (0.14-0.20) downstream from the low $R_{13/12}$ region. The low- and high-$R_{13/12}$ regions in the disk correspond to the ^{12}CO peak and star-forming regions, respectively. The low $R_{13/12}$ in the galactic center is likely due to the higher gas temperature in the starburst region. The most probable explanation of the $R_{13/12}$ variation in the disk is that a low $R_{13/12}$ in the GMA and the ends of the bar reflects an increased fraction of the diffuse molecular component, which has a low column density and low volume density. Around the GMA and the north end of the bar, not only are the star-forming regions downstream from the CO distributions, but $R_{13/12}$ is also higher downstream implying the presence of gas compression and ionized/molecular gas spatial offsets, as predicted by density wave models.

- Hirota, T. [2008a], "Observations of H_2O Maser Sources in Nearby Molecular Clouds with VERA," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., p.335.

➢ Without abstract

- Hirota, T., T. Bushimata, Y. K. Choi, M. Honma, H. Imai, K. Iwadate, T. Jike, S. Kameno, O. Kameya, R. Kamohara, Y. Kan-ya, N. Kawaguchi, M. Kijima, M. K. Kim, H. Kobayashi, S. Kuji, T. Kurayama, S. Manabe, K. Maruyama, M. Matsui, N. Matsumoto, T. Miyaji, T. Nagayama, A. Nakagawa, K. Nakamura, C. S. Oh, T. Omodaka, T. Oyama, S. Sakai, T. Sasao, K. Sato, M. Sato, K. M. Shibata, M. Shintani, Y. Tamura, M. Tsushima, and K. Yamashita [2008b], "Astrometry of H_2O Maser Sources in Nearby Molecular Clouds with VERA," Proc. of the IAU Symp. 242, "Astrophysical Masers and their Environments", eds. Jessica Chapman and Willem Baan, pp.158-159.

➢ We have carried out multi-epoch VLBI observations of the H_2O maser sources associated with young stellar objects (YSOs) in nearby molecular clouds with VERA (VLBI Exploration of Radio Astrometry), which is a newly constructed VLBI network in Japan (Kobayashi et al. 2003). The main goal of our study is to measure the absolute proper motions and distances to nearby molecular clouds within 1 kpc from the Sun, to reveal their 3-dimensional structures and dynamical properties. Using the VERA dual-beam receiving system (Honma et al. 2003), we have carried out phase-referencing VLBI observations and measured annual parallaxes and absolute proper motions of the H_2O maser features with respect to the extragalactic radio sources. We have successfully detected the annual parallax of one of the H_2O maser features in Orion KL to be 2.29±0.10 mas, corresponding to the distance of 437±19 pc from the Sun (Hirota et al. 2007). In addition, the annual parallax of SVS13 in NGC 1333 is also determined to be4.10±0.17 mas, corresponding to the distance of 244±10 pc from the Sun, although the life time of the maser features are only 6 months. The absolute proper motions of the H_2O maser features associated with Orion KL and NGC 1333 are derived, possibly indicating the outflow motions from the YSOs as well as the systemic motions of the powering sources.

- Hirota, T., T. Bushimata, Y. K. Choi, M. Honma, H. Imai, K. Iwadate, T. Jike, O. Kameya, R. Kamohara, Y. Kan-ya, N. Kawaguchi, M. Kijima, H. Kobayashi, S. Kuji, T. Kurayama, S. Manabe, T. Miyaji, T. Nagayama, A. Nakagawa, C. S. oh, T. Omodaka, T. Oyama, S. Sakai, T. Sasao, K. Sato, K. M. Shibata, Y. Tamura, and K. Yamashita [2008c], "Astrometry of H_2O Maserss in Nearby Star-Forming Regions with VERA. II. SVS13 in NGC 1333," Publ. Astron. Soc. Japan, vol.60, pp.37-44.

- We report on the results of multiepoch very long baseline interferometry (VLBI) observations with VERA (VLBI Exploration of Radio Astrometry) of the 22 GHz H_2O masers associated with the young stellar object SVS13 in the NGC1333 region. We carried out phase-referencing VLBI astrometry, and measured the annual parallax of the maser features in SVS13 of 4.25±0.32mas, corresponding to a distance of 235±18pc from the Sun. Our result is consistent with a photometric distance of 220pc, previously reported. Even though the maser features were detectable only for 6 months, the present result provides the distance to NGC1333 with much higher accuracy than photometric methods. The absolute positions and proper motions have been derived, revealing that the H_2O masers with LSR (local standard of rest) velocities of 7-8kms^{-1} are most likely associated with VLA4A, which is a radio counterpart of SVS13. It is currently difficult to attribute the observed proper motions of the maser features to either the jet or the rotating circumstellar disk associated with VLA4A, which should be investigated through future high-resolution astrometric observations of VLA4A and other radio sources in NGC1333.

- Hirota, T., K. Ando, T. Bushimata, Y. K. Choi, M. Honma, H. Imai, K. Iwadate, T. Jike, S. Kameno, O. Kameya, R. Kamohara, Y. Kan-ya, N. Kawaguchi, M. Kijima, M. K. Kim, H. Kobayashi, S. Kuji, T. Kurayama, S. Manabe, M. Matsui, N. Matsumoto, T. Miyaji, A. Miyazaki, T. Nagayama, A. Nakagawa, D. Namikawa, D. Nyu, C. S. Oh, T. Omodaka, T. Oyama, S. Sakai, T. Sasao, K. Sato, M. Sato, K. M. Shibata, Y. Tamura, K. Ueda, and K. Yamashita [2008d], "Astrometry of H_2O Masers in Nearby Star-Forming Regions with VERA III. IRAS22198+6336 in Lynds 1204G," Publ. Astron. Soc. Japan, vol.60, pp.961-974.

- We present results of multi-epoch VLBI observations with VERA (VLBI Exploration of Radio Astrometry) of the 22 GHz H_2O masers associated with a young stellar object (YSO) IRAS 22198+6336 in a dark cloud, L1204G. Based on the phase-referencing VLBI astrometry, we derived an annual parallax of IRAS 22198+6336 to be 1.309±0.047 mas, corresponding to the distance of 764 ㅈ 27 pc from the Sun. Although the most principal error source of our astrometry is attributed to the internal structure of the maser spots, we successfully reduced the errors in the derived annual parallax by employing position measurements for all of the 26 detected maser spots. Based on this result, we reanalyzed the spectral energy distribution of IRAS 22198+6336 and found that the bolometric luminosity and total mass of IRAS 22198+6336 are 450Lsolar and 7Msolar, respectively. These values are consistent with an intermediate-mass YSO deeply embedded in the dense dust core, which has been proposed to be an intermediate-mass counterpart of a low-mass Class 0 source. In addition, we obtained absolute proper motions of the H_2O masers for the most blue-shifted components. We propose that the collimated jets aligned along the east-west direction are the most plausible explanation for the origin of the detected maser features.

- Hirota, T., M. Ohishi, and S. Yamamoto, [2009a], "A Search for Carbon-Chain-Rich Cores in Dark Clouds," Astrophys. J., vol.699, pp.585-602.

- We present results of a survey of CCS, HC_3N, and HC_5N toward 40 dark cloud cores to search for "Carbon-Chain-Producing Regions (CCPRs)," where carbon-chain molecules are extremely abundant relative to NH3, as in L1495B, L1521B, L1521E, and the cyanopolyyne peak of TMC-1. We have mainly observed toward cores where the NH_3 lines are weak, not detected, or not observed in previous surveys, and the CCS, HC_3N, and HC_5N lines have been detected toward 17, 17, and 5 sources, respectively. Among them, we have found a CCPR, L492, and its possible candidates, L1517D, L530D, L1147, and L1172B. They all show low abundance ratios of [NH_3]/[CCS] (hereafter called the NH_3/CCS ratio) indicating the chemical youth. Combining our results with those of previous surveys, we have found a significant variation of the NH_3/CCS ratio among dark cloud cores and among molecular cloud complexes. Such a variation is also suggested by the detection rates of carbon-chain molecules. For

instance, the NH_3/CCS ratios are higher and the detection rates of carbon-chain molecules are lower in the Ophiuchus cores than in the Taurus cores. An origin of these systematic abundance variation is discussed in terms of the difference in the evolutionary stage or the contraction timescale. We have also identified a carbon-chain-rich star-forming core, L483, where intense HC_3N and HC_5N lines are detected. This is a possible candidate for a core with "Warm Carbon-Chain Chemistry."

- Hirota, T., T. Bushimata, Y. K. Choi, M. Honma, H. Imai, K. Iwadate, T. Jike, S. Kameno, O. Kameya, R. Kamohara, Y. Kan-ya, N. Kawaguchi, M. Kijima, M. K. Kim, H. Kobayashi, S. Kuji, T. Kurayama, S. Manabe, K. Maruyama, M. Matsui, N. Matsumoto, T. Miyaji, T. Nagayama, A. Nakagawa, K. Nakamura, C. S. Oh, T. Omodaka, T. Oyama, S. Sakai, T. Sasao, K. Sato, M. Sato, K. M. Shibata, M. Shintani, Y. Tamura, M. Tsushima, and K. Yamashita [2009b], "Astrometry of H_2O Maser Sources in Nearby Molecular Clouds with VERA," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.456-459.
  - We report on the recent results of astrometic observations of H_2O maser sources associated with the nearby molecular clouds with VERA. We carried out phase-referencing VLBI astrometry of H_2O masers in a high-mass star-forming region Orion KL and successfully detected an annual parallax of Orion KL to be 2.29±0.10 mas, corresponding to the distance of 437±19 pc from the Sun. In addition, we obtained an annual parallax of a nearby low-mass star-forming region NGC 1333 to be 4.25±0.32 mas, corresponding to the distance of 235±18 pc from the Sun. Our results demonstrate the high capability of astrometry with VERA, which can provide the most accurate distances to nearby molecular clouds.
- Hirota, T., N. Sakai, and S. Yamamoto [2010], "Depletion of CCS in a Candidate Warm-Carbon-Chain-Chemistry Source L483," Astrophys. J., vol.720, pp.1370-1373.
  - We have carried out an observation of the CCS ($J_N = 2_1$-1_0) line with the Very Large Array in its D-configuration toward a protostellar core L483 (IRAS 18140-0440). This is a candidate source of the newly found carbon-chain-rich environment called "Warm-Carbon-Chain-Chemistry (WCCC)," according to the previous observations of carbon-chain molecules. The CCS distribution in L483 is found to consist of two clumps aligned in the northwest-southeast direction, well tracing the CCS ridge observed with the single-dish radio telescope. The most remarkable feature is that CCS is depleted at the core center. Such a CCS distribution with the central hole is consistent with those of previously observed prestellar and protostellar cores, but it is rather unexpected for L483. This is because the distribution of CS, which is usually similar to that of CCS, is centrally peaked. Our results imply that the CCS ($J_N = 2_1$-1_0) line would selectively trace the outer cold envelope in the chemically less evolved phase that is seriously resolved out with the interferometric observation. Thus, it is most likely that the high abundance of CCS in L483 relative to the other WCCC sources is not due to the activity of the protostar, although it would be related to its younger chemical evolutionary stage, or a short timescale of the prestellar phase.
- Hodokuma, T., K. Kuriki, N. Asada, H. Demura, J. Terazono, H. Hirata, J. Haruyama, M. Ohtake, T. Matsunaga, and H. Araki [2009], "Integration of Multi-Instrumental Data Sets of Kaguya, LISM and LALT," 40th Lunar and Planetary Science Conference, (Lunar and Planetary Science XL), held March 23-27, 2009 in The Woodlands, Texas, id.1637.
  - We report current status on integration of multi-instrumental data sets of Kaguya, LISM and LALT, such as digital terrain model, altitude profiles, multiband images, and spectral data.
- Honma, M., T. Bushimata, Y. K. Choi, T. Hirota, H. Imai, K. Iwadate, T. Jike, O. Kameya, R. Kamohara, Y. Kan-ya, N. Kawaguchi, M. Kijima, H. Kobayashi, S. Kuji, T. Kurayama, S. Manabe, T. Miyaji, T. Nagayama, A. Nakagawa, C. S. Oh, T. Omodaka, T. Oyama, S. Sakai, K.

Sato, T. Sasao, K. M. Shibata, M. Shintani, H. Suda, Y. Tamura, M. Tsushima, and K. Yamashita [2008a], "VERA Project," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., pp.27-32.

- Is this paper we review the current status VERA (VLBI Exploration of Radio Astrometry) project. First, we present an overview of VERA, and then we report on recent results from VERA, particularly the parallax measurement of Galactic star forming region S269 at the distance of 5.3 kpc.

- Honma, M., T. Bushimata, Y. K. Choi, T. Hirota, H. Imai, K. Iwadate, T. Jike, O. Kameya, R. Kamohara, Y. Kan-ya, N. Kawaguchi, M. Kijima, S. Manabe, T. Miyaji, T. Nagayama, A. Nakagawa, C. S. Oh, T. Omodaka, T. Oyama, S. Sakai, K. Sato, T. Sasao, K. M. Shibata, M. Shintani, H. Suda, Y. Tamura, M. Tsushima, and K. Yamashita [2008b], "Galactic Rotation Measurements Based on H_2O Maser Astrometry with VERA," Proc. of the IAU Symp. 242, "Astrophysical Masers and their Environments", eds. Jessica Chapman and Willem Baan, pp.361-365.

- We present results of astrometric observations of S269 H_2O maser performed with VERA (VLBI Exploration of Radio Astrometry). We have monitored the positions of S269 H_2O masers for 1 year and successfully detected its parallax to be 189 ± 8 micro-arcsecond. This corresponds to a source distance of $5.28_{-0.22}^{+0.24}$ kpc, and is the smallest parallax (and thus the largest distance) that has ever been measured by means of annual parallax. Proper motions of S269 H_2O maser were also measured and used to determine the Galactic rotation velocity at the position of S269. Our measurements show that the Galactic rotation velocity at S269 is the same to that at the Sun within 3%, indicating that the Galactic rotation curve is flat out to R~13 kpc.

- Honma, M., T. Bushimata, Y. K. Choi, T. Hirota, H. Imai, K. Iwadate, T. Jike, S. Kameno, O. Kameya, R. Kamohara, Y. Kan-ya, N. Kawaguchi, M. Kijima, M. K. Kim, H. Kobayashi, S. Kuji, T. Kurayama, S. Manabe, N. Matsumoto, T. Miyaji, T. Nagayama, A. Nakagawa, K. Nakamura, C.-S. Oh, T. Omodaka, S. Sakai,K. Sato, M. Sato, T. Sasao, K. M. Shibata, Y. Tamura, and K. Yamashita [2008c], "Astrometry of Galactic Star-Forming Regions with VERA," Proc. of the IAU Symp. 248, "A Giant Step: from Milli- to Micro-arcsecond Astrometry", eds. Wenjing Jin, Imants Platais, Michael A. C. Perryman, pp.198-199.

- We present an overview of recent astrometric results with VERA. Since 2004, we have been conducting astrometry of tens of Galactic maser sources with VERA, and recently obtained trigonometric parallaxes for several sources, with distances ranging from 180 pc to 5.3 kpc. In this paper, we briefly summarize the results for Galactic star-forming regions, including S269, Orion-KL, NGC 1333, ρ-oph, NGC 281 and others.

- Honma, M., K. Kijima, H. Suda, N. Kawaguchi, H. Kobayashi, T. Bushimata, R. Shimizu, A. Yoshimura, T. Sasao, T. Hirota, H. Imai, K. Iwadate, T. Jike, O. Kameya, R. Kamohara, S. Kuji, T. Kurayama, S. Manabe, T. Miyaji, A. Nakagawa, T. Omodaka, T. Oyama, S. Sakai, K. Sato, K. M. Shibata, and Y. Tamura [2008d], "Dual-Beam Delay Calibration for VERA," Publ. Astron. Soc. Japan, vol.60, pp.935-950.

- We present the technique of instrumental delay calibration for the dual-beam system of VLBI Exploration of Radio Astrometry (VERA), namely, the horn-dish method, in which artificial noise sources are mounted on the antenna feedome base and a wide-band radio noise is injected into the dual-beam receivers after reflection by a subreflector. We introduce the basic concept of calibration with the horn-on-dish method, and also present results of the experiments to evaluate its calibration accuracy. Detailed comparisons between model path calculations and measured paths from the noise sources show that the horn-on-dish method can calibrate the dual-beam delay difference in the antenna structure and receiver within an ~ 0.1mm level. We estimated that the systematic error in the calibration does not exceed

0.127mm, which was evaluated at an elevation angle of 15°. This error corresponds to an astrometric error of ~11μas with VERA's maximum baseline. An experimental confirmation of the systematic error in the horn-on-dish method has also been obtained by sing a pair of 10m and VERA's 20m antennas at the Mizusawa station, demonstrating that the systematic difference between the dual-beam delay difference measured with noise sources and that for celestial objects was 0.118mm, being consistent with the above estimate.

- Honma, M., Y. Tamura, and M. J. Reid [2008e], "Tropospheric Delay Calibrations for VERA," Publ. Astron. Soc. Japan, vol.60, pp.951-960.
  - We present techniques for the tropospheric delay calibration, which is the key to increasing the accuracy of the phase-referencing astrometry with Very Long Baseline Interferometry (VLBI). We study three methods, and make a comparison of these methods to discuss the accuracy in calibration. Our results show that all three methods can calibrate the tropospheric zenith delay within accuracy of ~ 2 cm. We also present simulations of positional errors in VLBI Exploration of Radio Astronomy (VERA) at the presence of an error in the tropospheric zenith delay, showing that parallax measurements with accuracy of 10μas can be readily achieved for sources at high declination and with small separation angles between the target Galactic maser and extragalactic position references.
- Honma, M. [2008f], "Galaxy-Scale Astrometry and Galactic Rotation Measurement with VERA," Proc. of the 9th European VLBI Network Symposium on The role of VLBI in the Golden Age for Radio Astronomy and EVN Users Meeting, September 23-16, 2008, Bologna, Italy, pp.77-79.
  - We present results of Galaxy-scale astrometry with VERA (VLBI Exploration of Radio Astrometry). VERA had been conducting regular monitoring of Galactic radio sources since 2004, and we have already detected parallaxes for several sources, ranging from a few 100 pc to 5 kpc. In this paper, we summarize the recent results of astrometric measurements and discuss the Galaxy rotation obtained with VERA.
- Honma, M. [2009a], "AGB Star Observations with VERA," Proc. of the "AGB Stars and Related Phenomena", eds. Toshiya Ueta, Noriyuki Matsunaga, and Yoshifusa Ita, p.54.
  - Not Available
- Honma, M., T. Bushimata, Y. K. Choi, T. Hirota, H. Imai, K. Iwadate, T. Jike, S. Kameno, O. Kameya, R. Kamohara, N. Kawaguchi, M. Kijima, K. M. Kim, H. Kobayashi, S. Kuji, T. Kurayama, S. Manabe, M. Matsui, N. Matsumoto, T. Miyaji, T. Nagayama, A. Nakagawa, K. Nakamura, C. S. Oh, T. Omodaka, T. Oyama, S. Sakai, K. Sato, M. Sato, T. Sasao, K. M. Shibata, Y. Tamura, and K. Yamashita [2009b], "Maser Astrometry with VERA and VSOP-2," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.460-464.
  - We present recent results of maser astrometry obtained with VERA (VLBI Exploration of Radio Astrometry), which is a Japanese VLBI array dedicated to phase-referencing astrometry to explore the 3-D structure of the Milky Way Galaxy. Since 2004 we have been conducting regular monitoring of maser sources with VERA, and we have already detected parallaxes for several sources, ranging from a few 100 pc to 5 kpc. These results include mea- surements for Galactic star-forming regions such as ORI-KL, S269, NGC 281 as well as those for late type stars such as VY CMa. We also discuss the VERA-VSOP-2 connection in the near future, and propose astrometric observations with VSOP-2.
- Hsieh, P.-Y., S. Matsushita, J. Lim, K. Kohno, and S. Sawada-Satoh [2008], "Interferometric ^{12}CO J = 1-2 Image of the Nuclear Region of Seyfert 1 Galaxy NGC 1097," Astrophys. J., vol.683, pp.70-77.
  - We have mapped the central region of the Seyfert 1 galaxy NGC 1097 in ^{12}CO J=2-1 with the

Submillieter Array (SMA). The ^{12}CO J-2-1 map shows a central concentration and a surrounding ring coinciding, respectively, with the Seyfert nucleus and a starburst ring. The line intensity peaks at the nucleus, whereas in a previously published ^{12}CO J=1-0 map the intensity peaks at the starburst ring. The azimuthally averaged ^{12}CO J-1-0 intensity ratio R21 of the ring is about unity, which is similar to those in nearby active star-forming galaxies, suggesting that most of the molecular gas in the ring is involved in fueling the starburst. The ratio of molecular gas to dynamical mass in the starburst ring shows a somewhat lower value than that found in nearby star-forming galaxies, suggesting that the high R21 of unity may be caused by additional effects, such as shocks induced by gas infall along the bar. The molecular gas can last for about 1.2×10^8 yr without further replenishment, assuming a constant star formation rate. The central gas is rotating with the molecular ring in the same direction, while its velocity gradient is steeper than that of the ring, and similar to what usually observed in Seyfert 2 galaxies. To view the Seyfert nucleus without obscuration, the central gas can be a low-inclined disk or torus but not too low to be less massive than the mass of the host galaxy, or be a highly inclined thin disk or clumpy and thick torus, inner part of the galactic disk is also possible. The R21 of ~1.9 of the central gas is significantly higher than that of the ring, indicates that the activity of the Seyfert nucleus may significant influence the central gas.

- Hughes, A., T. Wong, J. Ott, E. Muller, J. L. Pineda, Y. Mizuno, J.-P. Bernard, D. Paradis, S. Maddison, W. T. Reach, L. Staveley-Smith, A. Kawamura, M. Meixner, T. Kim, T. Onishi, N. Mizuno, and Y. Fukui [2010a], "Physical Properties of Giant Molecular Clouds in the Large Magellanic Cloud," Mon. Not. Roy. Astron. Soc., vol.406, pp.2065-2086.

  - The Magellanic Mopra Assessment (MAGMA) is a high angular resolution ^{12}CO (J = 1 -> 0) mapping survey of giant molecular clouds (GMCs) in the Large Magellanic Cloud (LMC) and Small Magellanic Cloud using the Mopra Telescope. Here we report on the basic physical properties of 125 GMCs in the LMC that have been surveyed to date. The observed clouds exhibit scaling relations that are similar to those determined for Galactic GMCs, although LMC clouds have narrower linewidths and lower CO luminosities than Galactic clouds of a similar size. The average mass surface density of the LMC clouds is 50 Msolarpc-2, approximately half that of GMCs in the inner Milky Way. We compare the properties of GMCs with and without signs of massive star formation, finding that non-star-forming GMCs have lower peak CO brightness than star-forming GMCs. We compare the properties of GMCs with estimates for local interstellar conditions: specifically, we investigate the HI column density, radiation field, stellar mass surface density and the external pressure. Very few cloud properties demonstrate a clear dependence on the environment; the exceptions are significant positive correlations between (i) the HI column density and the GMC velocity dispersion, (ii) the stellar mass surface density and the average peak CO brightness and (iii) the stellar mass surface density and the CO surface brightness. The molecular mass surface density of GMCs without signs of massive star formation shows no dependence on the local radiation field, which is inconsistent with the photoionization-regulated star formation theory proposed by McKee. We find some evidence that the mass surface density of the MAGMA clouds increases with the interstellar pressure, as proposed by Elmegreen, but the detailed predictions of this model are not fulfilled once estimates for the local radiation field, metallicity and GMC envelope mass are taken into account.

- Hughes, A. M., S. M. Andrews, D. J. Wilner, M. R. Meyer, J. M. Carpenter, C. Qi, A. S. Hales, S. Casassus, M. R. Hogerheijde, E. E. Mamajek, S. Wolf, T. Henning, and M. D. Silverstone [2010b], "Structure and Composition of Two Transitional Circumstellar Disks in Corona," Astron. J., vol.140, pp.887-896.

  - The late stages of evolution of the primordial circumstellar disks surrounding young stars are poorly understood, yet vital to constraining theories of planet formation. We consider basic

structural models for the disks around two ~10 Myr old members of the nearby RCrA association: RX J1842.9-3532 and RX J1852.3-3700. We present new arcsecond-resolution maps of their 230 GHz continuum emission from the Submillimeter Array and unresolved CO(3-2) spectra from the Atacama Submillimeter Telescope Experiment. By combining these data with broadband fluxes from the literature and infrared fluxes and spectra from the catalog of the Formation and Evolution of Planetary Systems Legacy program on the Spitzer Space Telescope, we assemble a multiwavelength data set probing the gas and dust disks. Using the Monte Carlo radiative transfer code RADMC to model simultaneously the spectral energy distribution and millimeter continuum visibilities, we derive basic dust disk properties and identify an inner cavity of radius 16 AU in the disk around RX J1852.3-3700. We also identify an optically thin 5 AU cavity in the disk around RX J1842.9-3532, with a small amount of optically thick material close to the star. The molecular line observations suggest an intermediate disk inclination in RX J1842.9-3532, consistent with the continuum emission. In combination with the dust models, the molecular data allow us to derive a lower CO content than expected, suggesting that the process of gas clearing is likely underway in both systems, perhaps simultaneously with planet formation.

- Iguchi, S., and T. Okuda [2008], "The FFX Correlator," Publ. Astron. Soc. Japan, vol.60, pp.857-869.
  - We established a new algorithm for a correlation process in radio astronomy. This scheme consists of a 1st-stage Fourier transform as a filter and a 2nd-stage Fourier transform for spectroscopy. The "FFX" correlator stands for Filter and FX architecture, since the 1st-stage Fourier transform is performed as a digital filter, and the 2nd-stage Fourier transform is performed as a conventional FX scheme. We developed FFX correlator hardware not only for verifying the FFX scheme algorithm, but also for applying to the Atacama Submillimeter Telescope Experiment (ASTE) telescope toward high-dispersion and wideband radio observations at submillimeter wavelengths. In this paper, we present of the FFX correlator and its properties, as well as evaluation results with the production version.
- Iguchi, S., K.-I. Morita, M. Sugimoto, B. Vila-Vilaro, M. Saito, T. Hasegawa, R. Kawabe, K. Tatematsu, S. Sakamoto, H. Kiuchi, S. K. Okumura, G. Kosugi, J. Inatani, S. Takakuwa, D. Iono, T. Kamazaki, R. Ogasawara, and M. Ishiguro [2009], "The Atacama Compact Array (ACA)," Publ. Astron. Soc. Japan, vol.61, pp.1-12.
  - For realizing high fidelity of imaging with mosaicing observations, the Atacama Large Millimeter/submillimeter Array (ALMA) consists of a homogeneous array of 12 m antennas (12 m Array) and the Atacama Compact Array (ACA) in order to cover all spatial frequency Fourier components of the brightness distribution of observed sources. The array is located at an altitude site of about 5000 m with an operating wavelength range of 0.3 to 3 mm. ACA is an array composed of four 12 m dishes [TP (Total Power) Array] and twelve 7 m dishes (7 m Array). The 7 m Array has a very compact con ˚ guration to take short-baseline data corresponding to the low spatial frequency Fourier components. The 7 m Array has two con ˚ gurations extended over 30-50 m to avoid shadowing at low elevation. The scientific importances and operation concepts of ACA, and the system design of ACA and its performance are presented in this paper.
- Ikeda, N., Y. Kitamura, and K. Sunada [2009a], "A Survey of Dense Cores in the Orion B Cloud," Astrophys. J., vol.691, pp.1560-1582.
  - We have carried out an $H^{13}CO^{+}$(J = 1-0) core survey in a large area of 1 deg2, covering most of the dense region in the Orion B molecular cloud, using the Nobeyama 45 m radio telescope with the 25-BEam Array Receiver System. We cataloged 151 dense cores using the clumpfind method. The cores have mean radius, velocity width, and mass of 0.10±0.02 pc, 0.53±0.15 km s^{-1}, and 8.1± 6.4 M ., respectively, which are very similar to those in the Orion A cloud. We

examined the spatial relation between our $H^{13}CO^+$ cores and the 850 μm cores observed by Johnstone and colleagues in 2001 and 2006, and found that there are two types of spatial relationships: $H^{13}CO^+$ cores with and without the 850μm cores. Since the mean density of the 850μm cores is higher than that of the $H^{13}CO^+$ cores, we can interpret the $H^{13}CO^+$ cores with 850μm cores as being more centrally concentrated and hence more evolved, compared with those without. Considering the relationship between the masses of the $H^{13}CO^+$ and 850μm cores, we estimate the 850μm core mass function (CMF) using the $H^{13}CO^+$ CMF through the generalization of the confusion model proposed by Ikeda and colleagues in 2007. Our predicted 850μm CMF is found to be quite consistent with that directly derived by Johnstone and colleagues. Furthermore, we predict the initial mass function (IMF) by the generalized confusion model assuming a star formation efficiency of 40% for the $H^{13}CO^+$ cores, and found that our predicted IMF is consistent with the Galactic field-averaged IMF within uncertainties. This agreement may indicate that the origin of the IMF goes back to the cloud structures with densities of less than 10^4 cm^{-3}.

- Ikeda, N., and Y. Kitamura [2009b], "A $C^{18}O$ Study of the Origin of the Power-Law Nature in the Initial Mass Function," Astrophys. J. (Letters), vol.705, pp.L95-L98.
  - We have performed $C^{18}O$ (J = 1-0) mapping observations of a 20' x 20' area of the OMC-1 region in the Orion A cloud. We identified 65 $C^{18}O$ cores, which have a mean radius, a velocity width in FWHM, and an LTE mass of 0.18 ± 0.03 pc, 0.40 ± 0.15 km s^{-1}, and 7.2 ± 4.5 Msun, respectively. All the cores are most likely to be gravitationally bound by considering the uncertainty in the $C^{18}O$ abundance. We derived a $C^{18}O$ core mass function, which shows a power-law-like behavior above 5 Mun. The best-fit power-law index of -2.3 ± 0.3 is consistent with those of the dense core mass functions and the stellar initial mass function (IMF) previously derived in the OMC-1 region. This agreement strongly suggests that the power-law form of the IMF has been already determined at the density of ~10^3 cm^{-3}, traced by the $C^{18}O$ (J = 1-0) line. Consequently, we propose that the origin of the IMF should be searched in tenuous cloud structures with densities of less than 10^3 cm^{-3}.
- Imada, S., H. Hara, T. Watanabe, A. Asai, T. Minoshima, L. K. Harra, and J. T. Mariska [2008], "Non-Gaussian Line Profiles in a Large Solar Flare Observed on 2006 December 13," Astrophys. J. (Letters), vol.679, pp.L155-L159.
  - We have studied the characteristics of the non-Gaussian line profile of the Fe xiv 274.20 Å line in and around a flare arcade. We found that broad non-Gaussian line profiles associated with redshifts are observed in the flare arcade. There were two typical types of broad line profiles. One was a distorted line profile caused by multiple flows, and the other was a symmetric line profile without any additional component. We successfully distinguished those two types using higher order statistical moments or M-the additional component contribution-defined in this Letter. The distorted/symmetric broad line profiles were preferentially observed in new/old flare loops, respectively.
- Imai, H., K. Nakashima, T. Bushimata, Y. K. Choi, T. Hirota, M. Honma, K. Horiai, N. Inomata, K. Iwadate, T. Jike, O. Kameya, R. Kamohara, Y. Kan-ya, N. Kawaguchi, M. Kijima, H. Kobayashi, S. Kuji, T. Kurayama, S. Manabe, T. Miyaji, T. Nagayama, A. Nakagawa, C. S. Oh, T. Omodaka, T. Oyama, S. Sakai, S. Sakakibara, K. Sato, T. Sasao, K. M. Shibata, R. Shimizu, M. Shintani, Y. Sofue, K. Sora, H. Sudo, Y. Tamura, M. Tsushima, Y. Ueno, and K. Yamashita [2007], "Astrometry of H_2O Masers in Nearby Star-Forming Regions with VERA I. IRAS 16239-2422 in ρOph East," Publ. Astron. Soc. Japan, vol.59, pp.1107-1113.
  - We report on results of multi-epoch VLBI observations of H_2O masers associated with a low-mass young stellar object, IRAS 16239-2422 in ρOph East, and a fringe-phase and position reference sources, ICRF J162546.8-252738, using the VLBI Exploration of Radio Astrometry (VERA) for high-precision astrometry. We obtained an annual parallax of a maser

feature to be $\pi=5.6^{+1.5}_{-0.5}$ mas, corresponding to a distance of $D=178^{+18}_{-37}$ pc. We also found 10 relative proper motions of maser feature with respect to the maser feature mentioned above. The motion of the accompanying young stellar object (YSO) has already been found in thermal continuum emission previously observed with the Very Long Array. The intrinsic motions of masers have been estimated from the relative proper motions after the YSO's motion is subtracted from, and a systemic secular motion of the position reference feature is added to the proper motions originally measured. The intrinsic maser kinematical structure may trace a bipolar outflow.

- Imai, H., T. Fujii, T. Omodaka, and S. Deguchi [2008a], "JVN Observations of H_20 Masers around the Evolved Star IRAS 22480+6002," Publ. Astron. Soc. Japan, vol.60, pp.55-62.

➢ We report on the H_2O maser distributions around IRAS 22480+6002 (=IRC+60370) observed with the Japanese VLBI Network (JVN) at three epochs spanning 2 months. This object was identified as a K-type supergiant in 1970s, which was unusual as a stellar maser source. The spectrum of H_2O masers consists of 5 peaks separated roughly equally by a few km/s each. The H_2O masers were spatially resolved into more than 15 features, which spread about 50 mas along the east-west direction. However, no correlation was found between the proper motion vectors and their spatial distributions; the velocity field of the envelope seems random. A statistical parallax method applied to the observed proper-motion data set gives a distance of 1.0±0.4 kpc for this object, that is considerably smaller than previously thought. The distance indicates that this is an evolved star with L~5800 Lsun. This star shows radio, infrared, and optical characteristics quite similar to those of the population II post-AGB stars such as RV Tau variables.

- Imai, H., T. Omodaka, T. Hirota, T. Umemoto, K. Sorai, T. Kondo, and the VERA collaboration [2008b], "A Collimated Jet and an Infalling-Rotating Disk in G192.16-3.84 Traced by H_2O Maser Emission," Proc. of the IAU Symp. 242, "Astrophysical Masers and their Environments", eds. Jessica Chapman and Willem Baan, pp.340-341.

➢ We present H_2O masers associated with the massive-star forming region G192 observed with the Japan VLBI network since the year 2005, The spatio-kinematical structure of the maser feature clusters has well persisted since previous observations, in which the masers are associated with two young stellar objects (YSOs) separated by ~1200 AU and expected to be associated with a highly-collimated bipolar jet and an infalling-rotating disk in the northern and southern YSOs, respectively. We estimated a jet speed of ~100 km s^{-1} and re-estimated a dynamical age of the whole jet to be $5.6x10^4$ years. The spatial distribution of maser Doppler velocities found during the previous and present observations, relative proper motions of H_2O maser features in the southern cluster found in the present observations, a relative bulk motion between the two maser clusters are well explained by a model of an infalling-rotating disk with a radius of ~1000 AU and a central stellar mass of ~8 M_{solar}.

- Imai, H., J.-H. He, J. Nakashima, N. Ukita, S. Deguchi, and N. Koning [2009], "CO J=3-2 Emission from the "Water Fountain" Sources IRAS 16342-3814 and IRAS 18286-0959," Publ. Astron. Soc. Japan, vol.61, pp.1365-1372.

➢ We observed CO J=3-2 emission from "water-fountain" sources, which exhibit high-velocity collimated stellar jets traced by H_2O maser emission, with the Atacama Submillimeter Telescope Experiment (ASTE) 10 m telescope. We detected CO emission from two sources: IRAS 16342-3814 and IRAS 18286-0959. The IRAS 16342-3814 CO emission exhibits a spectrum that could be well fit to a Gaussian profile, rather than to a parabolic profile, with a velocity width (FWHM) of 158 ㄱ 6 km s-1 and an intensity peak at $V_{LSR}=50\pm2$ km s^{-1}. The mass-loss rate of the star is estimated to be $\sim2.9\times10^{-5}$ M.yr^{-1}. Our morpho-kinematic models suggest that the CO emission is optically thin, and associated with a bipolar outflow rather than with a (cold and relatively small) torus. The IRAS 18286-0959 CO emission has a

velocity width (FWHM) of 3.0±0.2 km s^{-1}, smaller than typically seen in AGB envelopes. The narrow velocity width of the CO emission suggests that it originates from either an interstellar molecular cloud or a slowly-rotating circumstellar envelope that harbors the H_2O maser source.

- Imai, H., J. Nakashima, S. Deguchi, A. Yamauchi, A. Nakagawa, and T. Nagayama, [2010], "Japanese VLBI Network Mapping of SiO v=3 J=1-0 Maser Emission in W Hydrae," Publ. Astron. Soc. Japan, vol.62, pp.431-439.

➢ We report first on two-epoch mapping observations of SiO v = 3 J = 1-0 maser emission in the semiregular variable W Hydrae using the Japanese VLBI Network. The flux density of the v = 3 J = 1-0 emission detected on 2009 February 28 was two orders of magnitude smaller than those of the v = 1 and v = 2 emissions, while a month and half later the v = 3 flux density suddenly increased by a factor of ˜25. In contrast, the v = 1 and v = 2 flux densities decreased during this period, as expected from the optical light curve. At the first epoch, the v = 3 maser features were located inside of a ring composed of the v = 1 and v = 2 features by 6 mas (gtrsim0.5 AU) toward the central star. These offsets are meaningfully larger than the error of the fitted ring radius and the difference in the ring sizes of v = 1 and v = 2 masers (lesssim 0.2 AU). The present result at the first epoch suggests that v = 3 J = 1-0 SiO masers are predominantly excited in a pumping mechanism (e.g., collisional pumping) different from that recently proposed on the basis of the line overlap with infrared H_2O lines. Interestingly, the second-epoch observation revealed that the v = 3 features were located on almost the same ring as the v = 2 ring, which is consistent with what line-overlap theory suggests.

- Imamura, T., T. Iwata, Z. Yamamoto, K.-L. Oyama, A. Nabatov, Y. Kono, M. Matsumoto, Q. Liu, H. Noda, H. Hanada, Y. Futaana, and A. Saito [2008a], "Initial Results of the Lunar Ionosphere Observation with SELENE Radio Science," 39th Lunar and Planetary Science Conference, (Lunar and Planetary Science XXXIX), held March 10-14, 2008 in League City, Texas. LPI Contribution No. 1391, p.1659.

➢ The electron density distribution near the lunar surface in various conditions are being observed by radio occultation technique in the Kaguya (SELENE) mission using the Vstar sub-satellite. Initial results from this experiment are presented.

- Imamura, T., K.-I. Oyama, T. Iwata,Y. Kono, K. Matsumoto, Q. Liu, H. Noda, Y. Futaana, and A. Nabatov [2008b], "The Possibility of Studying the Lunar Ionosphere with the SELENE Radio Science Experiment," Earth Planets and Space, vol.60, pp.387-390.

➢ The electron density profiles above the lunar surface will be observed by the radio occultation technique during the SELENE mission using the Vstar sub-satellite. Previous radio occultation observations have indicated the existence of an ionosphere with densities of up to 1000 cm^{-3} above the dayside lunar surface. The measured densities are difficult to explain theoretically when the removal of plasma by the solar wind is considered, and thus the generation mechanism of the lunar ionosphere is a major issue, with even the validity of previous observations still under debate. The SELENE radio science experiment will establish the morphology of the lunar ionosphere and will reveal its relationship with various physical conditions to provide possible clues to the mechanism.

- Imamura, T., T. Iwata, Z. Yamamoto, N. Mochizuki, Y. Kono, K. Matsumoto, Q. Liu, H. Noda, H. Hanada, K. Oyama, A. Nabatov, Y. Futaana, A. Saito, and H. Ando [2008c], "Studying the Lunar Ionosphere with SELENE Radio Science Experiment," American Geophysical Union, Fall Meeting 2008, abstract #P51D-04.

➢ Lunar ionosphere is generally thought to be as thin as 1 cm^{-3}; the process that will prevent the accumulation of newly produced ions near the lunar surface is the impingement of the solar wind magnetic field on the lunar surface, which induces an electric field that sweeps away ions. In harmony with this prediction, most of the radio occultation experiments performed with

radio stars failed to detect the lunar ionosphere. Radio occultation experiments conducted with the Soviet Luna 19 and 22 spacecraft, on the other hand, detected large electron densities near the dayside lunar surface. Vyshlov (1974) obtained peak electron densities of 500-1000 cm^{-3} at heights of 5-10 km, with a gradual decrease at higher altitudes with a scale height of 10-30 km. The measured densities are difficult to explain theoretically, and thus the generation mechanism of the lunar ionosphere is a major issue, with even the validity of the previous observations still under debate. If a thick lunar ionosphere exists, possible mechanisms to maintain the ionized layer are the effect of the remnant magnetic field which stands off the solar wind magnetic field, certain processes that enhance the neutral gas concentration, or charged dust grains that are lifted up by the near-surface electric field. The electron density profiles above the lunar surface are being observed by radio occultation during the SELENE (KAGUYA) mission using sub-satellites. The systematic measurements will establish the morphology of the lunar ionosphere and reveal its dependence on various conditions, thereby providing clues to the generation mechanism. The S-band (2.2GHz) and X-band (8.5GHz) signals transmitted by the Vstar sub- satellite is received at the Usuda Deep Space Center in Japan. The most serious error source is the temporal variation in the terrestrial ionosphere during measurements. In the region where the contribution of the lunar ionosphere is virtually absent, i.e. at altitudes above ~100 km, a gradual variation caused by the terrestrial ionosphere is observed. This variation is extrapolated into the near-moon portion and subtracted from the observed one, thereby eliminating the influence of the terrestrial ionosphere to some extent. In addition to this method, we also use the Rstar sub- satellite, which transmits coherent two signals in S-band, to measure the terrestrial ionosphere during the lunar occultation of Vstar; the subtraction of the Rstar's measurement from the Vstar's measurement gives the lunar ionosphere. The opportunities of the latter method are rather limited, however. More than 100 measurements using Vstar and more than 10 measurements using Rstar and Vstar have been conducted during the first half of the mission. Although the error due to the fluctuation of the terrestrial ionosphere is rather significant, there seems to be a tendency that the electron density increases on the morning side of the moon.

- Imanishi, M., K. Nakanishi, Y. Tamura, N. Oi, and K. Kohno [2007], "Millimeter Interferometric HCN(1-0) and HCO^+(1-0) Observations of Luminous Infrared Galaxies," Astron. J., vol.134, pp.2366-2384.
  - We present the results on millimeter interferometric observations of four luminous infrared galaxies (LIRGs), Arp 220, Mrk 231, IRAS 08572+3915, and VV 114, and one Wolf-Rayet galaxy, He 2-10, using the Nobeyama Millimeter Array (NMA). Both the HCN(1-0) and HCO^+(1-0) molecular lines were observed simultaneously, and their brightness-temperature ratios were derived. High-quality infrared L-band (2.8-4.1μm) spectra were also obtained for the four LIRGs to better constrain their energy sources deeply buried in dust and molecular gas. When combined with other LIRGs we have previously observed with NMA, the final sample comprised nine LIRGs (12 LIRG nuclei) with available interferometric HCN(1-0) and HCO^+(1-0) data, sufficient to investigate the overall trend in comparison with known AGNs and starburst galaxies. We found that LIRGs with luminous buried AGN signatures at other wavelengths tend to show high HCN(1-0)/HCO^+(1-0) brightness-temperature ratios as seen in AGN-dominated galaxies, while the Wolf-Rayet galaxy He 2-10 displays a small ratio. An enhanced HCN abundance in the interstellar gas surrounding a strongly X-ray-emitting AGN, as predicted by some chemical calculations, and/or infrared radiative pumping, are possible explanations of our results.
- Imanishi, M. [2008], "Nobeyama Millimeter Array Observations of Luminous Infrared Galaxis," EAS Publication Series, vol.31, pp.93-96.
  - We present the results of systematic millimeter interferometric observations of luminous

infrared galaxies (LIRGs), using the Nobeyama Millimeter Array. We observed HCN (J = 1-0) and HCO^+ (J = 1-0) emission lines simultaneously, and derived their brightness-temperature ratios, to investigate whether the observed ratios are similar to those found in AGN-dominated nuclei or starburst galaxies. LIRGs with (without) luminous buried AGN signatures in our infrared spectra tend to show high (low) HCN (J = 1-0) to HCO^+ (J = 1-0) brightness-temperature ratios as seen in galaxy nuclei dominated by AGNs (starbursts). The high ratios in buried AGN candidates could be explained by the enhanced HCN abundance, and/or infrared radiative pumping of the HCN molecule, in the close vicinity of an AGN.

- Imanishi, M., K. Nakanishi, Y. Tamura, and C.-H. Peng [2009], "Nobeyama Millimeter Interferometric HCN(1-0) and HCO^+(1-0) Observations of Further Luminous Infrared Galaxies," Astron. J., vol.137, pp.3581-3598.
  - We report the results of interferometric HCN(1-0) and HCO^+(1-0) observations of four luminous infrared galaxies (LIRGs), NGC 2623, Mrk 266, Arp 193, and NGC 1377, as a final sample of our systematic survey using the Nobeyama Millimeter Array. Our survey contains the most systematic interferometric, spatially resolved, simultaneous HCN(1-0) and HCO^+(1-0) observations of LIRGs. Ground-based infrared spectra of these LIRGs are also presented to elucidate the nature of the energy sources at the nuclei. We derive the HCN(1-0)/HCO^+(1-0) brightness-temperature ratios of these LIRGs and confirm the previously discovered trend that LIRG nuclei with luminous buried active galactic nucleus (AGN) signatures in infrared spectra tend to show high HCN(1-0)/HCO^+(1-0) brightness-temperature ratios, as seen in AGNs, while starburst-classified LIRG nuclei in infrared spectra display small ratios, as observed in starburst-dominated galaxies. Our new results further support the argument that the HCN(1-0)/HCO^+(1-0) brightness-temperature ratio can be used to observationally separate AGN-important and starburst-dominant galaxy nuclei.
- Imanishi, M., K. Nakanishi, M. Yamada, Y. Tamura, and K. Kohno [2010], "ASTE Simultaneous HCN(4-3) and HCO^+(4-3) Observations of the Two Luminous Infrared Galaxies NGC 4418 and Arp 220," Publ. Astron. Soc. Japan, vol.62, pp.201-209.
  - We report the results of HCN (J = 4-3) and HCO^+ (J = 4-3) observations of two luminous infrared galaxies, NGC 4418 and Arp 220, made using the Atacama Submillimeter Telescope Experiment (ASTE). The ASTE wide-band correlator provided simultaneous observations of HCN (4-3) and HCO^+(4-3) lines, and a precise determination of their fiux ratios. Both galaxies showed high HCN (4-3) to HCO^+ (4-3) fiux ratios of > 2, possibly due to AGN-related phenomena. The J = 4-3 to J = 1-0 transition fiux ratios for HCN (HCO^+) are similar to those expected for fully thermalized (sub-thermally excited) gas in both sources, in spite of HCN's higher critical density. If we assume collisional excitation and neglect an infrared radiative pumping process, our non-LTE analysis suggests that HCN traces gas with significantly cantly higher density than HCO^+. In Arp 220, we separated the double-peaked HCN (4-3) emission into eastern and western nuclei, based on velocity information. We confirmed that the eastern nucleus showed a higher HCN (4-3) to HCN (1-0) fiux ratio, and thus contained a larger amount of highly excited molecular gas than the western nucleus.
- Inoue, H., K. Muraoka, T. Sakai, A. Endo, K. Kohno, S. Asayama, T. Noguchi, and H. Ogawa [2008], "350 GHz Sideband Separating Receiver for ASTE," Proc. of the 19th International Symposium on Space THz Technology, ed. Wolfgang Wild, pp.281-285.
  - We have developed a 350 GHz Sideband Separating Receiver for ASTE (Atacama Submillimeter Telescope Experiment). The RF frequency range is 330-360 GHz and the IF frequency range is 4-8 GHz. The receiver noise temperature was 150 - 200 K (SSB) and the image rejection ratio was typically 10 dB. This receiver
    was installed on the ASTE telescope in October 2007. The system noise temperature at the

atmosphere condition ofτ220 ~ 0.6 - 0.8 was 200 K (SSB). This is almost half of that of the previous DSB receiver.

- Inoue, M., A. Haba, K. Asada, H. Nagai, Y. Murata, and P. Edwards [2008a], "Possible Detection of Outer Plasma Around AGN Jets," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., p.338.
  - Without abstract
- Inoue, M., K. Asada, and H. Nagai [2008b], "A New Method to Detect Faraday Screen," Proc. of the "Extragalactic Jets: Theory and Observation from Radio to Gamma Ray", eds. Travis A. Rector and David S. De Young, ASP Conf. Ser., vol.386, pp.459-461.
  - We point out a possible method to investigate a plasma sheath, or Faraday screen, which has been revealed by recent Faraday rotation studies of AGN jets. When a jet is spiral in shape, it may happen to go across a jet trajectory behind the front jet. The plasma sheath around the front jet can be seen as an absorption feature against the jet behind the front jet. This configuration should not be a special case when the jet trajectory is spiral in shape, and the point overlapping the jet with each other provides opportunity to investigate the plasma sheath. However, it might be difficult if the sheath is thin, and high angular resolution observations are required. VSOP observation shows a sharp absorption feature to suggest free-free absorption by the plasma sheath, which demonstrates a reality to study the sheath.
- Inoue, M., H. Nagai, K. Asada, H. Saito, and M. Tsuboi [2008c], "The Next Generation Space VLBI Project: VSOP-2," Proc. of the "Extragalactic Jets: Theory and Observation from Radio to Gamma Ray", eds. Travis A. Rector and David S. De Young, ASP Conf. Ser., vol.386, pp.262-264.
  - The second space VLBI project VSOP-2 has just approved, and started construction of the satellite Astro-G in the Institute of Space and Astronautical Science (ISAS). Its key science targets are to investigate physical phenomena around massive black holes with its superb spatial resolutions up to 40 micro arcsec. By the dual polarization capability at all the three observing frequencies at 8, 22, and 43 GHz, VSOP-2 is anticipated to be a powerful tool to investigate structures of the magnetic field in AGN jets to see the acceleration and collimation mechanisms.
- Inoue, M., M. Sato, H. Saito, and M. Tsuboi [2008d], "Next Generation Space VLBI Project: VSOP-2," Proc. of the "Observational Evidence for Black Holes in the Universe", AIP Conf. Proc., vol.1053, pp.377-379.
  - The second space VLBI Project (VSOP-2) was approved, and just started construction of the satellite ASTRO-G in the Institute of Space and Astronautical Science (ISAS). Discussion for worldwide collaboration has also been started. Its key science targets are to investigate physical phenomena around massive black holes with its superb spatial resolutions up to 40 micro arc seconds. By the dual polarization capability at all the three observing frequencies of 8, 22, and 43 GHz, VSOP-2 is anticipated to be a powerful tool to investigate structure of accretion disk and the magnetic field structure in AGN jets to see the acceleration and collimation mechanisms.
- Ishihara, Y., S. Sasaki, H. Araki, H. Noda, S. Tazawa, Laser Altimeter (Lalt) in Migita, E. Kaguya, and N. Kawano [2008a], "A Preliminary Lunar Topographic Model by KAGUYA/LALT - New Views of Lunar Topographic Features, Slope -," 37th COSPAR Scientific Assembly, held 13-20 July 2008, in Montreal, Canada, p.1326.
  - Japanese lunar explorer KAGUYA (SELENE) was successfully lunched on September 14, 2007, and installed planed lunar orbit on October 19, 2007. The Laser ALTimeter (LALT) aboard a main orbiter of KAGUYA is a ranging instrument that measures the distance between the satellite and the lunar surface with accuracy of 5m by round trip time of the laser light. As Kaguya is in a polar orbit, the first global and precise topographic map is expected to be

obtained. Especially, previous experiments (ex. Clementine LIDAR) had not been gathered high latitude regions (above 75-degree north and south). Our LALT will measure those regions for the first time. The LALT nominal measurement was started on 30th, December 2007 after the some test and adjustment phase on orbit. As of the middle of February 2008, the LALT footprints cover thrice of the entire moon, and measurement points are reached 30,00,000. It is enough to make a preliminary LALT lunar topographic model. We started to build LALT lunar topographic model, and compare with a previous model. Before LALT, the Unified Lunar Control Network 2005 (ULCN2005) was most precise lunar global topographic model based on a combination of Clementine images and a previous lunar control network derived from Earth-based & Apollo photographs, and Mariner 10, & Galileo images. Comparing our preliminary model with ULCN2005, it is obviously showed that lunar topographic model would be totally (not only polar region, but also equatorial region) refined by our LALT model. Our model is already more accurate and detail model than ULCN2005. For example, our model expresses some ridge feature that had never been shown in any previous models on near-side mare regions. In our paper, we will show preliminary LALT lunar topographic map and slope map derived from topography. Moreover, we shall show the reflectance (@ 1micrometer) map derived from analysis of return laser light intensity.

- Ishihara, Y., K. Matsumoto, S. Goossens, H. Araki, N. Namiki, H. Hanada, T. Iwata, H. Noda, and S. Sasaki [2008b], "Localized Gravity/Topography Correlation Spectra on the Moon," Meteoritics and Planetary Sci. Suppl., vol.43, paper id. 5213.
  - Not Available
- Ishihara, Y., H. Noda, S. Sasaki, H. Araki, E. Migita, S. Goossens, S. Tazawa, and N. Kawano [2008c], "Investigation of Lunar Impact Structures and Ridge Features by KAGUYA Altimetry (LALT) Data," American Geophysical Union, Fall Meeting 2008, abstract #P31B-1418.
  - The Laser ALTimeter (LALT) aboard a main orbiter of Japanese lunar explorer KAGUYA (SELENE) is a ranging instrument that measures the distance between the satellite and the lunar surface with accuracy of 5m by round trip time of the laser light every 1 second. Kaguya is in a polar orbit, the first global, precise, high-resolution topographic map has been obtained. Especially, previous experiments (ex. Clementine LIDAR) had not been gathered at high latitude regions (above 75-degree north and south). Our LALT measured that region for the first time. Using LALT data, we built a new lunar topographic mode and compared it with a previous model. As of LALT, the Unified Lunar Control Network 2005 (ULCN2005) was most precise lunar global topographic model based on a combination of Clementine images and a previous lunar control network derived from Earth-based & Apollo photographs, and Mariner 10, & Galileo images. Comparing our model with both ULCN2005 and Clementine LIDAR model, it is obviously shown that lunar topographic model would be totally (not only polar region, but also equatorial region) refined by our LALT model. LALT model can clarify the presence and shape of craters as well as large impact structure. Previously unresolved heights of central peaks of large craters are obtained. Several large impact structures in far side high land regions show multi-ring morphologies some of which were obscure in the previous map. LALT data clarified the presence of new ring structure around Moscoviense basin. The center of newly defined ring structure is offset from that of other Moscoviense rings. It means that, the new ring is not the third ring of Moscoviense, but it is predated impact structure. In near side, LALT data could express some tectonic ridges and rimas within the mare region.
- Ishihara, Y., N. Namiki, S. Sugita, K. Matsumoto, S. Goossens, H. Araki, H. Noda, S. Sasaki, T. Iwata, and H. Hanada [2009a], "Localized Gravity/Topography Correlation and Admittance Spectra on the Moon," 40th Lunar and Planetary Science Conference, (Lunar and Planetary Science XL), held March 23-27, 2009 in The Woodlands, Texas, id.1623.
  - We show the results of localized correlation and admittance analysis using new lunar gravity

and topography models from Kaguya mission.

- Ishihara, Y., S. Goossens, K. Matsumoto, H. Noda, H. Araki, N. Namiki, H. Hanada, T. Iwata, S. Tazawa, and S. Sasaki [2009b], "Crustal Thickness of the Moon: Implications for Farside Basin Structures," Geophys. Res. Letters, vol.36, CitelD L19202-1-4.
  - Based on the latest SELENE lunar gravity and topography model obtained by Kaguya mission, we compute the lunar crustal thickness map to investigate differences between farside basin structures. The thickest crust is located in the southern rim of the Dirichlet-Jackson basin and the thinnest crust at the Moscoviense basin. The thickest crust corresponds to the highest topography and is consistent with Airy isostasy. The thinnest crust is due to an abnormally large mantle plug. The crustal thicknesses at Apollo 12/14 sites of our crustal thickness model are 45.1 and 49.9 km. The crustal thickness map indicates that the differences between recently proposed type I and type II basins are probably controlled by the ratio between pre-impact crustal thickness and impact scale.
- Ishihara, Y., T. Morota, T. Iwata, K. Matsumoto, S. Goossens, and S. Sasaki [2010], "Lunar Large Impact Basin Structures and Implications for Thermal History," LPI Contribution No. 1533, p.1559.
  - We reconstruct excavate cavity geometry of large impact basins on the Moon (including farside basins) using the Kaguya crustal thickness model. We discuss the impact structures and thermal history.
- Isobe, N., H. Seta, M. Tashiro, Y. Yaji, M. Hayashida, M. Terashima, K. Nakanishi, T. Tosaki, K. Kohno, Y. Shimajiri, M. Fukuhara, M. Sasada, A. Arai, and M. Uemura [2008], "Suzaku Observation of the Blazar OJ287; Quiescence and Predicted Flare in 2007," 37th COSPAR Scientific Assembly, held 13-20 July 2008, in Montreal, Canada, p.1330.
  - OJ 287 is a famous blazar at a redshift of z = 0.306. Optical monitors of OJ 287 over more than 100 years indicate periodic flares every about 12 years, which make the source one of the most promising candidates for a supermassive binary black holes. Since OJ 287 was predicted to flare up in the autumn of 2007, based on the periodicity, we conducted a Suzaku X-ray observation of OJ 287 on 2007 November 7 - 9, in corporation with radio, optical and gamma-ray observation with Nobeyama Millimeter Array, Kanata telescope, and MAGIC telescope, respectively. Suzaku has detected the significant X-ray signals up to about 30 keV, for the first time from OJ 287, with a very hard X-ray spectrum of a photon index, Gamma ~1.5. The X-ray flux of the source, ~4.5×10^{-12} ergs cm^{-2} s^{-1} in the 0.5 - 10 keV range, was found to nearly double up, compared with that of the quiescent phase obtained in the Suzaku observation of 2007 April. We present a discussion on the nature of the quiescent and flare emissions of OJ 287, with the simultaneously obtained multi-wavelength information.
- Isobe, N., M. S. Tashiro, P. Gandhi, A. Hayato, H. Nagai, K. Hada, H. Seta, and K. Matsuta [2009], "Suzaku Observation of the Giant Radio Galaxy 3C 326," Astrophys. J., vol.706, pp.454-463.
  - A Suzaku observation of a giant radio galaxy, 3C 326, which has a physical size of about 2 Mpc, was conducted on 2008 January 19-21. In addition to several X-ray sources, diffuse emission was significantly detected and associated with its west lobe, but the east lobe was contaminated by an unidentified X-ray source WARP J1552.4+2007. After careful evaluation of the X-ray and non-X-ray background, the 0.4-7 keV X-ray spectrum of the west lobe is described by a power-law model modified with the Galactic absorption. The photon index and 1 keV flux density were derived as $\Gamma = 1.82^{+0.26}_{-0.24} \pm 0.04$ and S_X = 19.4+3.3-3.2 ± 3.0 nJy, respectively, where the first and second errors represent the statistical and systematic ones. The diffuse X-rays were attributed to be inverse Compton (IC) radiation by the synchrotron radio electrons scattering off the cosmic microwave background photons. This radio galaxy is the largest among those with lobes detected through IC X-ray emission. A comparison of the radio

to X-ray fluxes yields the energy densities of electron and magnetic field as $u_e = (2.3 \pm 0.3 \pm 0.3) \times 10^{-13}$ erg cm^{-3} and $u_m = (1.2^{+0.2}_{-0.1} \pm 0.2) \times 10^{-14}$ erg cm^{-3}, respectively. The galaxy is suggested to host a low-luminosity nucleus with an absorption-corrected 2-10 keV luminosity of $<2 \times 10^{42}$ erg s^{-1}, together with a relatively weak radio core. The energetics in the west lobe of 3C 326 were compared with those of moderate radio galaxies with a size of ~100 kpc. The west lobe of 3C 326 is confirmed to agree with the correlations for the moderate radio galaxies, u_e □ $D^{-2.2\pm0.4}$ and u_m □$D^{-2.4\pm0.4}$, where D is their total physical size. This implies that the lobes of 3C 326 are still being energized by the jet, despite the current weakness of the nuclear activity.

- Iwata, T., K. Imai, H. Misawa, H. Noda, T. Kondo, T. Nakajo, H. Takeuchi, A. Kumamoto, F. Tsuchiya, Y. Nariyuki, K. Asari, and N. Kawano [2010], "A Study on the Moon-Earth Interferometry for Jovian Low Frequency Radio Observation," LPI Contribution No. 1533, p.1677.
  - Lunar Low Frequency Astronomy Telescope (LLFAST) is the Moon-Earth baseline interferometry which is a candidate mission instrument of Japan ㅋs lunar explorer SELENE-2. It will shed light on the mechanism of Jovian radio sources.
- Jung, T., B. W. Sohn, H. Kobayashi, T. Sasao, T. Hirota, O. Kameya, Y. K. Choi, and H. S. Chung [2008], "Phase Solution Analysis for the Simultaneous Dual Frequency VLBI Observations," Proc. of the 9th European VLBI Network Symposium on The role of VLBI in the Golden Age for Radio Astronomy and EVN Users Meeting, September 23-16, 2008, Bologna, Italy, pp.2-6.
  - We present the results of the first simultaneous dual-frequency VLBI observation using VERA(VLBI Exploration of Radio Astrometry). This experiment is a pilot study to test the feasibility of multi-frequency phase referencing technique, which will be a main phase referencing method for KVN (Korean VLBI Network). A pair of bright continuum sources NRAO 512 at 22 GHz and 3C 345 at 43 GHz were simultaneously observed with dual beams of VERA, and the fringe phases obtained for the two sources were compared to monitor the phase fluctuation at the two different frequencies. The connected phase solutions clearly showed the non-dispersive characteristics of the neutral atmosphere at the observing frequencies. For the differential phases of the two sources, the Allan standard deviation shows the white phase noise behaviour up to the time scale of ~1000 sec. These preliminary results demonstrate that the multi-frequency phase referencing technique, which will be implemented in KVN is a promising tools to remove the atmospheric phase fluctuation effectively.
- Kamata, S., S. Sugita, Y. Abe, Y. Ishihara, Y. Harada, N. Namili, H. Hanada, and H. Araki [2010], "Viscoelastic Deformation of Lunar Basins: Implications for Lunar Farside Thermal History Based on Selenodetic Data of Kaguya," LPI Contribution No. 1533, p.1727.
  - Using our newly developed numerical code for viscoelastic motion of a Maxwell body, we analyzed the result of lunar farside gravity and topography data obtained by Kaguya, yielding several important constraints on lunar farside thermal history.
- Kameno, S., M. Tsuboi, Y. Murata, A. Doi, Y. Asaki, N. Mochizuki, Y. Hagiwara, M. Kino, H. Nagai, K. Asada, M. Inoue, H. Sudou, and S. Sawada-Satoh [2010], "VSOP-2 : A Space VLBI Mission to Image Central Engines and Jet Launching Regions," 38th COSPAR Scientific Assembly, 18-25 July 2010, symposium E, p.2(E11-0036-10).
  - VSOP-2 is a space VLBI program using the spacecraft ASTRO-G to be launched in 2015 by the Japan Aerospace eXploration Agency. The array consisting of a 9-m antenna in orbit and ground radio telescopes offers angular resolutions of 40, 80, and 210 microarcsec at 43, 22, and 8 GHz, respectively. The resolution allows us to image accretion disks and jet launching regions in nearby active galactic nuclei such as M 87. Dual polarization receivers enable full Stokes images at all frequency to illustrate magnetic fields in jets. Phase referencing is capable

for astrometry by 60-sec-cycle switching maneuvers. Higher sensitivity than the VSOP (HALCA) is achieved by cooled receivers at 22 and 43 GHz, 1-Gbps wideband downlink, and longer coherent integration. We will introduce the mission overview, observational specifications, and key sciences of the VSOP-2. We call for community's scientific contributions to the mission.

- Kameya, O., and VERA Team [2009], "Water Vapor Masers in the NGC7538 Region," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.369-371.
  - Water vapor masers in the NGC7538 molecular cloud were observed with VERA. This region has at least three active regions (IRS1-3,IRS9, and IRS11) in a dense molecular gas core. Each region consists of IR sources, ultra-compact HII regions, CO outflows, high-dense gas cores, water vapor masers, OH masers, methanol masers, etc. We have performed multi epoch observations of water vapor masers in IRS1-3 and IRS11 regions with VERA for more than one year. The purpose of these observations are to determine the detailed distribution of water vapor spots. The detailed distribution of the maser spots are compared with the position and shape of velocity structure of the other activities.
- Kamikura, M., M. Naruse, S. Asayama, N. Satou, W. Shan, and Y. Sekimoto [2010], "Development of a Submillimeter Double-Ridged Waveguide Ortho-Mode Transducer (OMT) for the 385-500 GHz Band," J. of Infrared, Millimeter, and Terahertz Waves, vol.31, pp.697-707.
  - We present design and evaluations of a submillimeter double-ridged waveguide ortho-mode transducer (OMT) for ALMA Band 8 (385-500 GHz) cartridge receiver. The measured transmission loss of the OMT at 4 K was 0.4-0.5 dB according to noise measurements with an SIS mixer. The polarization isolation was measured to be larger than 29 dB from quasioptical measurements. The OMT consists of a B□ifot junction and a double-ridged guide. A robust design with allowable mechanical errors of 20μm has been demonstrated.
- Kamohara, R., and the VERA team [2008a], "VLBI Phase-Referencing Observations of SiO Masers towards R Aquarii," Proc. of the IAU Symp. 242, "Astrophysical Masers and their Environments", eds. Jessica Chapman and Willem Baan, pp.322-323.
  - We show a phase-referenced image of the SiO maser emissions towards the Mira variable R Aqr. These data have been obtained using the VLBI Exploration of Radio Astrometry (VERA). The proper motion we have obtained is different from that obtained using the HST. The proper motion from 2004 to 2005 is not different from that of 1991 to 2005 and supports the current orbital elements.
- Kamohara, R., V. Bujarrabal, T. Bushimata, Y. K. Choi, T. Hirota, M. Honma, H. Imai, K. Iwadate, T. Jike, T. Kameya, Y. Kan-ya, N. Kawaguchi, M. K. Kim, M. Kijima, H. Kobayashi, S. Kuji, T. Kurayama, S. Manabe, T. Miyaji, T. Nagayama, A. Nakagawa, C. S. Oh, T. Omodaka, T. Oyama, S. Sakai, T. Sasao, K. Sato, M. Sato, K. M. Shibata, Y. Tamura, and K. Yamashita [2008b], "VERA Observations of SiO Masers in the Symbiotic Star R Aquarii," Publ. Astron. Soc. Japan, vol.60, pp.1023-1029.
  - We present phase-referenced maps of the SiO maser transitions v=1 J=1-0 and v=2 J=1-0 from the symbiotic stellar system R Aquarii, which hosts an evolved AGB star plus a hot companion. Observations were performed at two epochs: 2004.98 and 2005.98. Accurate absolute coordinates and proper motions of the emission centroid were obtained; the errors expected for these parameters are also given. We compare the VERA data with the previous astrometry by Hipparcos. This represents a possibility to improve the orbital parameters of the system in a different way than that done before. Thanks to our accurate astrometry, we have also estimated the percentage of spot coincidences between both maser transitions, a parameter that has been

proposed to be relevant to discriminate between different maser pumping schemes. Although the overall distributions of both lines are always similar, the spots are rarely coincident, in a percentage ranging between 3% and 20% of the cases. The lack of systematic coincidence favors, in principle, radiative pumping. However, we argue that no firm conclusion can be reached due to a lack of models that include an overlap of rovibrational lines, and that accurately address the coincidence of very intense spots of different maser transitions.

- Kaneko, H., N. Kuno, D. Iono, T. Tosaki, T. Sawada, H. Nakanishi, and A. Hirota [2010], "Molecular Gas in the Early Stage of Interacting Galaxies: The NGC 4567/8 Pair," Proc. of the "Galaxy Wars: Star Formation and Stellar Populations in Interacting Galaxies", eds. B. J. Smith, N. Bastian, S. J. U. Higdon, and J. L. Higdon, ASP Conf. Ser. vol.423, pp.26-31.
  - We present the results of ^{12}CO(J=1-0) observations with the NRO 45m radio telescope of the interacting galaxy pair NGC4567/8, known to be in the early stage of the interaction. Our goal is to investigate the influence of the interaction of galaxies on molecular gas in the early stage. This is the first CO observations covering the whole system for this galaxy pair. Their CO and HI gas distributions suggest NGC 4567/8 are surely colliding. We found high molecular gas fraction, fmol and high star formation efficiency (SFE) in their overlap region though the low surface density of molecular gas is low. The discrepancy of the regions with high fmol and high SFE may be reflecting the progression of the interaction.
- Kano, R., T. Sakao, H. Hara, S. Tsuneta, K. Matsuzaki, K. Kumagai, M. Shimojo, K. Minesugi, K. Shibasaki, E. E. Deluca, L. Golub, J. Bookbinder,D. Caldwell, P. Cheimets, J. Cirtain, E. Dennis, T. Kent, and M. Weber [2008], "The Hinode X-Ray Telescope (XRT): Camera Design, Performance and Operations," Solar Physics, vol.249, pp.263-279.
  - The X-ray Telescope (XRT) aboard the Hinode satellite is a grazing incidence X-ray imager equipped with a 2048×2048 CCD. The XRT has 1 arcsec pixels with a wide field of view of 34×34 arcmin. It is sensitive to plasmas with a wide temperature range from < 1 to 30 MK, allowing us to obtain TRACE-like low-temperature images as well as Yohkoh/SXT-like high-temperature images. The spacecraft Mission Data Processor (MDP) controls the XRT through sequence tables with versatile autonomous functions such as exposure control, region-of-interest tracking, flare detection, and flare location identification. Data are compressed either with DPCM or JPEG, depending on the purpose. This results in higher cadence and/or wider field of view for a given telemetry bandwidth. With a focus adjust mechanism, a higher resolution of Gaussian focus may be available on-axis. This paper follows the first instrument paper for the XRT (Golub et al., Solar Phys. 243, 63, 2007) and discusses the design and measured performance of the X-ray CCD camera for the XRT and its control system with the MDP.
- Kato, M., Y. Takizawa, S. Sasaki, and Selene Project Team [2008a], "The Kaguya (SELENE) Mission: Present Status and Science Goals," 39th Lunar and Planetary Science Conference, (Lunar and Planetary Science XXXIX), held March 10-14, 2008 in League City, Texas. LPI Contribution No. 1391, p.1232.
  - Japanese lunar orbiter Kaguya (SELENE) was successfully launched on September 14, 2007. We report the present status of the Kaguya mission and its science goals in this session.
- Kato, M., Y. Takizawa, S. Sasaki, and Project Team [2008b], "The Kaguya (SELENE) Mission: Present Status and Lunar Science," Meteoritics and Planetary Sci. Suppl., 43, paper id. 5209.
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- Kato, Y., M. Miyoshi, R. Takahashi, H. Negoro, and R. Matsumoto [2010], "Measuring Spin of a Supermassive Black Hole at the Galactic Center - Implications for a Unique Spin," Mon. Not. Roy. Astron. Soc. (Letters,) vol.403, pp.L74-L78.
  - We determine the spin of a supermassive black hole in the context of disc-seismology by

comparing newly detected quasi-periodic oscillations (QPOs) of radio emission in the Galactic centre, Sagittarius A* (Sgr A*), as well as infrared and X-ray emissions with those of the Galactic black holes. We find that the spin parameters of black holes in Sgr A* and in Galactic X-ray sources have a unique value of ≈0.44 which is smaller than the generally accepted value for supermassive black holes, suggesting evidence for the angular momentum extraction of black holes during the growth of supermassive black holes. Our results demonstrate that the spin parameter approaches the equilibrium value where spin-up via accretion is balanced by spin-down via the Blandford-Znajek mechanism regardless of its initial spin. We anticipate that measuring the spin of black holes by using QPOs will open a new window for exploring the evolution of black holes in the Universe.

- Kawaguchi, N. [2008], "eVLBI Technical Development in Japan," Proc. of the 9th European VLBI Network Symposium on The role of VLBI in the Golden Age for Radio Astronomy and EVN Users Meeting, September 23-16, 2008, Bologna, Italy, p.41.
  - Not Available
- Kawaguchi, N. [2009], "HALCA Data Recording and ASTRO-G?," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.18-21.
  - Three different types of a data acquisition terminals were used for VSOP: the K4, the S2 and the Mark-IV, which were developed in Japan, Canada and the U.S.A., respectively. The compatibility was achieved by translating proceedures among the recording media, an IDR cassette of K4, a VHS cassette of S2 and a 14=81h reel tape of Mark-IV. In the next generation of space VLBI for ASTRO-G, the strongly recommended unified interface will be the Vlbi Standard Interface (VSI) established in 2001. Also, the successful accomplishment of the phase transfer from a ground tracking station to the space orbiting telescope is presented in this paper by showing the statistical analysis of the loop phase fluctuations. A similar phase transfer system is suggested to follow for the ASTRO-G project.
- Kawaguchi, T., K. Nakanishi, K. Kohno, K. Ohta, and K. Aoki [2008a], "First Detection of ^{12}CO (1-0) Emission from Two Narrow-Line Seyfert 1 Galaxie," Astrophys. J., vol.676, pp.137-146.
  - In order to investigate how the growth of galactic bulges progresses with the growth of central black holes (BHs), we observed molecular gas (fuel for the coming star formation) in possibly young active galaxies: narrow-line Seyfert 1 galaxies (NLS1s). We present the results of radio observations of ^{12}CO(1→0) using the Nobeyama Millimeter Array (with 2-4 kpc spatial resolution) for two FIR-bright NLS1s, yielding the first detection of their CO emission. Corresponding molecular gas masses M(H_2) of (1-3)x10^9 M_{solar} are the second and fourth largest among NLS1s. By estimating dynamical masses and bulge masses Mbulge for these two NLS1s using CO channel maps and CO line widths, we found that M(H_2) amounted to 13%-35% of these masses. Taking into account the star formation efficiency (~0.1), the increase in M_{bulge} in those NLS1s in the near future (<~$10^{7.5}$ yr) is not expected to be a huge fraction (1%-5% of the preexisting stars). Bulge growth may have finished before BH growth, or bulge-BH coevolution may proceed with many occasionally discrete events, where one coevolution event produces only a small amount of mass growth of BHs and bulges. We also discuss the ratios of star formation rate to gas accretion rate onto BHs, finding that two NLS1s have very small ratios (~1) compared with the M_{bulge}/M_{BH} ratios found in active and inactive galaxies (~700). This huge difference suggests either nonoverlapped coevolution, a long star formation duration, or a temporarily high accretion rate during the NLS1 phase.
- Kawaguchi, T., K. Nakanishi, K. Kohno, K. Ohta, and K. Aoki, [2008b], "^{12}CO Observations on Narrow-Line Seyfert 1 Galaxies," Proc. of the IAU Symp. 245, "Formation and evolution of galaxy buldge", eds. Bureau, M., Athanassoula, E., Barbuy, B., pp.249-250.

- In order to investigate how the growth of galactic bulges is accompanied with the growth of central black holes (BHs), we observed molecular gas (fuel for the coming star formation) in possibly young active galaxies, narrow-line Seyfert 1 galaxies (NLS1s). We present the results of pilot observations of ^{12}CO (1→0) line using the Nobeyama Millimeter Array for two FIR-bright NLS1s, ending in the first detection of their CO emission. Corresponding molecular-gas masses M(H_2) of (1-3) 10^9 M. are the 2nd and 4th largest ones among NLS1s. Together with CO data for other NLS1s (including our sub-kpc observations) and for broad-line Seyfert 1 galaxies (BLS1s), we found that NLS1s and BLS1s contain a similar amount of molecular-gas. We do not see a significant difference in M(H2)/MBH ratios and in M(H_2)/M_{bulge} ratios between NLS1s and BLS1s. The lack of a clear difference in M(H_2) between them indicates either that bulge and BH growth phases are not overlapped or that the duration of star formation is much longer than that of active galaxies.

- Kawaguchi, T., K. Nakanishi, K. Kohno, K. Ohta, and W. Aoki [2008c], "Molecular Gas in Narrow-Line seyfert 1 Galaxy: A Search for Coevolving Massive Black Holes and Galaxies," Proc. of the "Panoramic views of galaxy formation and evolution", eds. T. Kodama, T. Yamada, and K. Aoki, ASP Conf. Ser. vol.399, pp.427-428.

- In order to investigate how the growth of galactic bulges progresses with the growth of central black holes (BHs), we observed molecular gas (fuel for the upcoming star formation) in narrow-line Seyfert 1 galaxies (NLS1s, possibly young active galaxies). We present the results of radio observations of ^{12}CO (1→0) line using the Nobeyama Millimeter Array for two far infrared (FIR)-bright NLS1s, yielding the first detection of their CO emission. Corresponding molecular-gas masses M(H_2) of (1-3) 10^9M. are the 2nd- and 4th-largest among NLS1s. We found that these M(H_2) amounted to 13%-35% of their dynamical or bulge masses.

- Kawakatu, N., H. Nagai, and M. Kino [2008], "The Fate of Young Radio Galaxies: Decelerations Inside Host Galaxies?" Astrophys. J., vol.687, pp.141-155.

- We examine the evolution of variously sized radio galaxies (i.e., compact symmetric objects [CSOs], medium-size symmetric objects [MSOs], Fanaroff-Riley type II (FR II) radio galaxies by comparing the relation between the hot spot size and the projected linear size with a coevolution model of hot spots and a cocoon. We take account of the deceleration effect by the cocoon head growth. We find that the advance speed of hot spots and lobes inevitably show the deceleration phase (CSO-MSO phase) and the acceleration phase (MSO-FR II phase). This is ascribed to the change of the power-law index of ambient density profile in the MSO phase (~1 kpc). It is also found that the cocoon shape becomes nearly spherical or disrupted for MSOs, while an elongated morphology is predicted for CSOs and FR II galaxies. This seems to be consistent with the higher fraction of distorted morphology of MSOs than that of CSOs and FR II galaxies. Finally, we predict that only CSOs whose initial advance speed is higher than about 0.1 c can evolve into FR II galaxies, comparing the hot spot speed with the sound speed of the ambient medium.

- Kawakatu, N., M. Kino, and H. Nagai, [2009], "On the Origin of Fanaroff-Riley Classification of Radio Galaxies: Deceleration of Supersonic Radio Lobes," Astrophys. J. (Letters), vol.697, pp.L173-L176.

- We argue that the origin of "FRI/FRII dichotomy"- the division between Fanaroff-Riley class I (FRI) with subsonic lobes and class II (FRII) radio sources with supersonic lobes is sharp in the radio-optical luminosity plane (Owen-White diagram) can be explained by the deceleration of advancing radio lobes. The deceleration is caused by the growth of the effective cross-sectional area of radio lobes. We derive the condition in which an initially supersonic lobe turns into a subsonic lobe, combining the ram pressure equilibrium between the hot spots and the ambient medium with the relation between "the hot spot radius" and "the linear size of radio sources" obtained from the radio observations. We find that the dividing

line between the supersonic lobes and subsonic ones is determined by the ratio of the jet power Lj to the number density of the ambient matter at the core radius of the host galaxy na. It is also found that the maximal ratio of Lj/na exists and its value resides in (Lj/na)max $\approx 10^{44\text{-}47}$ erg s^{-1} cm^3, taking into account considerable uncertainties. This suggests that the maximal value (L_j/n_a)max separates between FRIs and FRIIs.

- Kawamura, A. [2008], "Molecular Clouds and Star Formation in the Magellanic Clouds and the Milky Way," Astrophys. Sp. Sci., vol.313, pp.145-151.
  - Star formation is a fundamental process that dominates the life-cycle of various matters in galaxies: Stars are formed in molecular clouds, and the formed stars often affect the surrounding materials strongly via their UV photons, stellar winds, and supernova explosions. It is therefore revealing the distribution and properties of molecular gas in a galaxy is crucial to investigate the star formation history and galaxy evolution. Recent progress in developing millimeter and sub-millimeter wave receiver systems has enabled us to rapidly increase our knowledge on molecular clouds. In this proceedings, the recent results from the surveys of the molecular clouds in the Milky Way and the Magellanic Clouds as well as the Galactic center as the most active regions in the Milky Way are presented. The high sensitivity with unrivaled high resolution of ALMA will play a key role in detecting denser gas that is tightly connected to star formation.
- Kikuchi, F., Q. Liu, N. Petrova, K. Matsumoto, Y. Ishihara, S. Goossens, K. Asari, S. Tsuruta, T. Ishikawa, H. Noda, H. Hanada, T. Iwata, N. Namiki, N. Kawano, and S. Sasaki [2008a], "Preliminary Results for VRAD Mission of Kaguya (SELENE)," 39th Lunar and Planetary Science Conference, (Lunar and Planetary Science XXXIX), held March 10-14, 2008 in League City, Texas. LPI Contribution No. 1391, p.1562.
  - The preliminary analysis of VRAD mission of Kaguya has been carried out and the performance of the system is confirmed. The differential phase delay of the signal from two satellites is derived without the cycle ambiguity within an error of 2 pico-seconds.
- Kikchi, F., Q. Liu, K. Matsumoto, H. Hanada, and N. Kawano [2008b], "Simulation Analysis of Differential Phase Delay Estimation by Same Beam VLBI Method," Earth, Planets and Space, vol.60, pp.391-406.
  - The same beam VLBI method (SBV) is newly applied to the multi-frequency VLBI method in the VRAD mission of SELENE (KAGUYA). By simultaneously observing two nearby spacecraft with one antenna, the error sources of VLBI measurement common in two propagation paths can be almost canceled out. In this paper, error estimation and simulation analysis are carried out for a feasibility study to apply the SBV method to the VRAD mission. Differential phase delay can be estimated without cycle ambiguity even if tropospheric fluctuation is large and/or traveling ionospheric disturbance occurs. The sensitivity of the differential phase delay with respect to the average elevation angle and the elongation of two spacecraft is also investigated. Moreover, a method is developed for estimating differential phase delay in switching VLBI observations using the cycle ambiguity derived from SBV observations. This method can be performed in more than 90% of the VRAD mission's total paths. Precise positioning with SBV contributes to accurate estimation of the low degree coefficients of lunar gravity fields by more than one order of magnitude than previous results.
- Kikuchi, F., Q. Liu, N. Petrova, H. Noda, K. Matsumoto, Y. Ishihara, S. Goossens, T. Iwata, N. Namiki, H. Hanada, N. Kawano, and S. Sasaki [2008c], "VLBI Observations in VRAD Mission of KAGUYA (SELENE)," 37th COSPAR Scientific Assembly, held 13-20 July 2008, in Montreal, Canada, p.1508.
  - One of the important questions still remaining about the Moon is the existence and state of a lunar core. The size and density of the lunar core estimated from the moment of inertia of the Moon are important constraints for investigating the origin of the Moon. However, the lack of

accurate gravity field information especially for the far side and the limb region of the Moon restrict the accuracy of the moment of inertia of the Moon. In Japanese lunar exploring program KAGUYA (SELENE), VRAD (the differential VLBI RADio sources) mission is carried out to improve the accuracy of the lunar gravity field. Two VLBI radio sources are loaded on two sub-satellites called Rstar and Vstar. These on-board radio sources transmit four carrier wave signals and the differential VLBI observations between Rstar and Vstar are carried out. The differential phase delay (DPD), which is the measurement of the differential VLBI, is highly sensitive to the relative position and velocity of the two sub-satellites in the direction perpendicular to the line-of-sight (LOS). VRAD is expected to contribute to the improvement of the gravity field over the limb region. After combining with the 2-way and 4-way Doppler observation in the RSAT (the Relay SAtellite Transponder) mission, which is sensitive to the LOS direction, the spacecraft's three-dimensional motion can be determined and precise global lunar gravity field estimation will be possible. Highlight of this work is the application of the same-beam VLBI method for DPD estimation. By simultaneously observing two nearby spacecraft, most of tropospheric and ionospheric delays that are major error sources of VLBI can be canceled out. This makes it possible to derive the cycle ambiguity of the DPD by multi-frequency VLBI (MFV) method. As the result of the data analysis, the DPD can be estimated without the cycle ambiguity. The error of DPD is smaller than 2 ps in 30-second integration interval. The desired accuracy of the VRAD mission is successfully achieved and it is expected that VRAD will contribute to improve the accuracy of the lunar gravity field estimation. In the presentation, the results of the DPD estimation as well as the process of the cycle ambiguity reduction are shown. The details of the dedicated VRAD system, the analysis software, and the same-beam VLBI observation method are also shown.

- Kikuchi, F., Q. Liu, H. Hanada, N. Kawano, K. Matsumoto, T. Iwata, S. Goossens, K. Asari, Y. Ishihara, S. Tsuruta, T. Ishikawa, H. Noda, N. Namiki, N. Petrova, Y. Harada, J. Ping, and S. Sasaki [2009], "Picosecond Accuracy VLBI of the Two Subsatellites of SELENE (KAGUYA) Using Multifrequency and Same Beam Methods," Radio Sci.vol.44, pp.RS2008-1-7.
  - Same beam very long baseline interferometry (VLBI) observations of the two subsatellites of SELENE (KAGUYA) are demonstrated for purpose of the precise gravimetry of the Moon. Same beam VLBI contributes a great deal to cancel out the tropospheric and ionospheric delays and to determine the absolute value of the cycle ambiguity by using the multifrequency VLBI method. As a result, the differential phase delay of the X-band signal is estimated within an error of below 1 ps. This accuracy is more than 1 order of magnitude smaller than former VLBI results. The preliminary results for the orbit determination of the subsatellites show a decrease of the orbit error from a few hundreds of meters to around 10 m when the differential phase delay data are added to the conventional range and Doppler data. These results reveal the possibility of precise gravimetry.
- Kikuchi, F., Q. Liu, N. Petrova, Y. Harada, H. Hanada, T. Iwata, N. Namiki, N. Kawano, and S. Sasaki, [2010], "Differential Phase Delay Estimation in VRAD Mission of SELENE (KAGUYA)," Trans. of Sp. Tech. Japan, vol.7, Ppp.k7-Pk10.
  - In the very long baseline interferometry (VLBI) radio sources mission of selenological and engineering explorer, the differential phase delay between the Rstar and Vstar sub-satellites is obtained by using the multifrequency VLBI method during the switching VLBI observation period. The cycle ambiguity is successfully determined and the differential phase delay is estimated within an error of 7 picoseconds. The RMS error is somewhat larger than that for the case of same-beam VLBI because fluctuations of propagation delays whose periods are shorter than the switching interval cannot be canceled out between Rstar and Vstar. However, the differential phase delay during the switching VLBI period is sufficiently accurate and, together with Doppler and range measurements, can be a useful means for precisely determining

satellite orbits and precisely estimating the lunar gravity field.

- Kim, M. K., T. Hirota, M. Honma, H. Kobayashi, T. Bushimata, Y. K. Choi, H. Imai, K. Iwadate, T. Jike, S. Kameno, O. Kameya, R. Kamohara, Y. Kan-ya, N. Kawaguchi, S. Kuji, T. Kurayama, S. Manabe, M. Matsui, N. Matsumoto, T. Miyaji, T. Nagayama, A. Nakagawa, C. S. Oh, T. Omodaka, T. Oyama, S. Sakai, T. Sasao, K. Sato, M. Sato, K. M. Shibata, Y. Tamara, and K. Yamashita [2008], "SiO Maser Observations toward Orion-KL with VERA," Publ. Astron. Soc. Japan, vol.60, pp.991-999.
  - We present results of phase-referencing VLBI observations of SiO masers in the Orion-KL region made with VERA. Using a strong maser spot in the 43 GHz ν=1-0 emission, we derived the trigonometric parallax of Orion-KL to be 2.39±0.03 mas, corresponding to a distance of 418±6pc, with the highest accuracy among existing parallax measurements of the source. We made a superimposed image of ν=1 J=1-0 and ν=2 J=1-0 maser features in Orion-KL based on absolute positions obtained from the phase-referencing with a common reference source. The maser features of both transitions show similar X-shaped distributions centered at Source I. However, in each of the four arms of the X-shape, the SiO ν=2 features tend to lie closer to Source I than the SiO ν=1 features. The radial velocities of the maser emission decrease with the distance from Source I. The spatial and radial velocities distributions of the SiO masers suggest that the SiO masers lie in the rotating materials associated with a disk around Source I, rather than a decelerating outflow.
- Kim, M. K., T. Hirota, M. Honma, H. Kobayashi, and other VERA members [2009], "SiO Maser Observations toward Orion-KL with VERA," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.469-472.
  - We present results of phase-referencing VLBI observations of SiO masers in the Orion KL region made with VERA. The goal of our study is to investigate the dynamics of the gas surrounding Source I, as well as to determine the distance to Orion-KL. We imaged SiO v=1, J=1-0 and v=2, J=1-0 maser emission in Orion-KL and compared the absolute positions of the maser spots with that of Source I. The maser emission shows an X-shaped distribution centered at Source I, and the SiO v=2 emission lies closer to Source I than the SiO v=1 emission. The radial velocities and proper motions of the maser spots indicate that the gas around Source I is rotating and expanding. In addition, we present the preliminary result of the measurement of the annual parallax using the SiO v=2 emission. The parallax of Orion-KL is 2.39±0.03 mas, corresponding to the distance of 418±6 pc.
- Kimura, K., H. Iwashita, S. Asayama, M. Sugimoto, G. Kikuchi, and H. Ogawa [2008], "Antenna Performance of a Directory Dug Corrugated Feedhorn for the 150-GHz Bnad," Int. J. of IR and MM Waves, vol.29, pp.713-723.
  - We have developed a 150 GHz band corrugated feed horn. These corrugated feed horns have been established by a new machining method, which involves digging corrugations through a metal material. We were able to realize E plane and H plane symmetry, low side lobe level, and low cross-polarization level. Measured co-polarization beam patterns above -35 dB were consistent with the simulated patterns within a designed frequency range. The peak levels of cross-polarization beam patterns were less than -30 dB. And, the performances were uniform in several horns. In the present paper, we describe the corrugated horn produced by this methods.
- Kimura, K., T. Toshikawa, N. Shiroyama, A. Kurozumi, T. K. Ojima, Y. Abe, Y. Yonekura, H. Ogawa, H. Ujihara, Y. Murata, M. Tsuboi, and T. Kasuga [2009], "Simulation of the Optical System for the ASTRO-G Offset Cassegrain Antenna," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.74-76.

- We are developing the satellite (ASTRO-G) for the space VLBI mission, called VSOP-2 (Hirabayashi et al. 2004). This system will have an offset cassegrain antenna, and the three multi-mode feed horns (8, 22, 43 GHz bands) will be chosen by the Cassegrain focus position. We are designing the antenna optics of the three band receivers by using the GRASP physical optics software package on simulated feed configurations. The result of these simulations shows low cross-polarization level, a good radiation pattern, and the antenna efficiencies are 63 ~ 68 percent in these bands, assuming a perfect reflector. In this paper, we present these results of simulation of ASTRO-G antenna optics.
- Kino, M., K. Asada, Y. Hagiwara, P. G. Edwards, and VSOP-2 Science Working Group [2009], "Direct Observations of the Dynamics and Variability at High Energy Emission Regions in TeV Blazars," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.270-273.
- VSOP-2 observations of "blazar" may be part of the VSOP-2 Key Science Program for Active Galactic Nuclei. We propose VSOP-2 observations of nearby blazars together with a multi-frequency campaign observations. For example, in two nearby TeV blazars Mrk 421 and Mrk 501, the 38 micro-arcsec resolution corresponds to about 0.03 pc in linear scale, which is comparable to the size of the high energy emission region in the standard one-zone model. We show the advantages of VSOP-2 observation of these blazars compared with previous VLBI studies, and discuss some relevant unresolved problems.
- Kobayashi, H., N. Kawaguchi, S. Manabe, K. M. Shibata, M. Honma, Y. Tamura, O. Kameya, T. Hirota, T. Jike, H. Imai, and T. Omodaka [2008a], "Phase Referencing VLBI Astrometry Observation System: VERA," Proc. of the IAU Symp. 248, "A Giant Step: from Milli- to Micro-arcsecond Astrometry", eds. Wenjing Jin, Imants Platais, Michael A. C. Perryman, pp.148-155.
- VERA aims at astrometric observations using phase referencing VLBI techniques, whose goal is a 10 micro arc-second accuracy for annual parallax measurements. VERA has four 20-m diameter VLBI radio telescopes in Japanese archipelago with the maximum baseline length of 2,300 km. They have the two-beam observing system, which makes simultaneous observations of two objects possible. This leads to very accurate phase referencing VLBI observations. An important science goal is to make a 3-dimensional map of the Galaxy and reveal its dynamics. In order to achieve this, VERA has the 22GHz and 43GHz bands for H_2O and SiO maser objects, respectively. Maser objects are compact and suitable for astrometry observations. VERA's construction was started in 2000 and the array became operational in 2004. We have already measured annual parallaxes and proper motions of some galactic objects. In the future, VERA will collaborate with Korean and Chinese VLBI stations.
- Kobayashi, H. [2008b], "Recent Activities of VERA and East Asia VLBI Network," Proc. of the 9th European VLBI Network Symposium on The role of VLBI in the Golden Age for Radio Astronomy and EVN Users Meeting, September 23-16, 2008, Bologna, Italy, p.48.
- Not Available
- Kobayashi, M., H. Ohashi, S. Sasaki, T. Iwai, M. Fujii, K. Nogami, H. Kimura, M. Nakamura, and T. Hirai [2010], "Lunar Dust Monitor for the Orbiter of the Next Japanese Lunar Mission SELENE2," LPI Contribution No. 1533, p.1964.
- A dust particle detector is proposed to be onboard the orbiter of SELENE-2 mission. We summarize the significance of circumlunar dust and report an overview of our instrument proposed to accompany the SELENE-2 mission.
- Koda, J., and CARMA team [2007], "CARMA M51 Project: Dynamically-Driven ISM Evolution," American Astron. Soc., AAS meeting #211, #153.04, BAAS, vol.39, p.1005.
- The entire M51 disk is observed in CO(1-0) line with the CARMA interferometer and

Nobeyama 45m telescope. With the unprecedented high image fidelity and spatial resolution, we detect many giant molecular clouds (GMCs) both on spiral arms and in interarm regions. Associations of giant molecular clouds (GMAs) are found only on spiral arms, and thus, they are unbound, short-lived structures. Molecular gas fraction is high even in interarm regions. Therefore, the GMA destruction is not caused by stellar feedback, which is likely to destroy molecules as well as GMAs and GMCs. We will discuss dynamically-driven ISM evolution -- strong shear motions in spiral arms cause GMA destruction and trigger ISM evolution.

- Koda, J. [2008], "Star Formation and Interstellar Medium Evolution in Galaxies," Proc. of the "Formation and evolution of galaxy disks", eds. J. G. Funes, and E. M. Corsini, ASP conf. Ser., vol.396, pp.97-104.
  - I review recent studies of star formation in galaxies, and discuss the underlying structure of the interstellar medium (ISM). Studies of star formation in galaxies have been limited by spatial resolution, and focused mostly on empirical correlations between star formation rate and gas properties averaged over large areas. With recent and upcoming facilities (e.g., Spitzer, GALEX, CARMA, Herschel, and ALMA), studies of star formation are transitioning to the regime in which the star forming regions and their local environment are well-resolved. With this in mind, I re-consider classical arguments for star formation (e.g., Toomre criterion) by taking into account the underlying gas structure. With new CO(1-0) data from CARMA and Nobeyama 45-m telescope, I show the evolution of the ISM in M 51, and argue that the evolution is largely triggered by global galactic dynamics.
- Koda, J., and Nearby Galaxies CO survey Group [2009a], "CARMA & Nobeyama CO Survey of Nearby Galaxies," American Astron. Soc., AAS meeting #213, #485.04.
  - Our observations of M51 in CO(1-0) line with CARMA and Nobeyama 45m telescope has revealed a new picture of ISM evolution in galaxies, namely one driven by galaxy's global dynamics -- the most massive GMCs (Giant Molecular Associations - GMAs) are first assembled and then broken up as the gas flow through the spiral arms. The GMAs and their H2 molecules are not fully dissociated into atomic gas as predicted in stellar feedback scenarios, but are fragmented into smaller GMCs upon leaving the spiral arms. We have initiated a new survey of nearby galaxies in CO(1-0) line with CARMA and Nobeyama 45m telescope, probing the generality of the scenario of dynamically-driven ISM evolution. The sample is selected from that of the Spitzer SINGS survey, and comprises the most famous nearby galaxies with the full range of ancillary data; those data are crucial in our study of ISM evolution (CARMA, Nobeyama ¥& VLA) and star formation (Spitzer, GALEX ¥& Herschel). We will present initial results from this new CO survey.
- Koda, J., N. Scoville, T. Sawada, M. A. La Vigne, S. N. Vogel, A. E. Potts, J. M. Carpenter, S. A. Corder, M. C. Wright, S. M. White, B. A. Zauderer, J. Patience, A. I. Sargent, D. C. J. Bock, D. Hawkins, M. Hodges, A. Kemball, J. W. Lamb, R. L. Plambeck, M. W. Pound, S. L. Scott, P. Teuben, and D. P. Woody [2009b], "Dynamically Driven Evolution of the Interstellar Medium in M51," Astrophys. J. (Letters), vol.700, pp.L132-L136.
  - Massive star formation occurs in giant molecular clouds (GMCs); an understanding of the evolution of GMCs is a prerequisite to develop theories of star formation and galaxy evolution. We report the highest-fidelity observations of the grand-design spiral galaxy M51 in carbon monoxide (CO) emission, revealing the evolution of GMCs vis-a-vis the large-scale galactic structure and dynamics. The most massive GMCs (giant molecular associations (GMAs)) are first assembled and then broken up as the gas flow through the spiral arms. The GMAs and their H_2 molecules are not fully dissociated into atomic gas as predicted in stellar feedback scenarios, but are fragmented into smaller GMCs upon leaving the spiral arms. The remnants of GMAs are detected as the chains of GMCs that emerge from the spiral arms into interarm regions. The kinematic shear within the spiral arms is suf ` cient to unbind the GMAs against

self-gravity. We conclude that the evolution of GMCs is driven by large-scale galactic dynamics-their coagulation into GMAs is due to spiral arm streaming motions upon entering the arms, followed by fragmentation due to shear as they leave the arms on the downstream side. In M51, the majority of the gas remains molecular from arm entry through the interarm region and into the next spiral arm passage.

- Kohno, K., K. Nakanishi, T. Tosaki, K. Muraoka, R. Miura, H. Ezawa, and R. Kawabe [2008a], "Dense Gas in Normal and Active Galaxies," Astrophys. and Sp. Sci., vol.313, pp.279-285.
  - Dense molecular medium plays essential roles in galaxies. As demonstrated by the tight and linear correlation between HCN(1-0) and FIR luminosities among star-forming galaxies, from very nearby to high-z ones, the observation of a dense molecular component is indispensable to understand the star formation laws in galaxies. In order to obtain a general picture of the global distributions of dense molecular medium in normal star-forming galaxies, we have conducted an extragalactic CO(3-2) imaging survey of nearby spiral galaxies using the Atacama Submillimeter Telescope Experiment (ASTE). From the survey (ADIoS; ASTE Dense gas Imaging of Star-forming galaxies), CO(3-2) images of M 83 and NGC 986 are presented. Emphasis is placed on the correlation between the CO(3-2)/CO(1-0) ratio and the star formation efficiency in galaxies. In the central regions of some active galaxies, on the other hand, we often find enhanced or overluminous HCN(1-0) emission. The HCN(1-0)/CO(1-0) and HCN(1-0)/HCO^+(1-0) intensities are often enhanced up to ~0.2-0.3 and ~2-3, respectively. Such elevated ratios have never been observed in the nuclear starburst regions. One possible explanation for these high HCN(1-0)/CO(1-0) and HCN(1-0)/HCO^+(1-0) ratios is X-ray induced chemistry in X-ray dominated regions (XDRs), i.e., the overabundance of the HCN molecule in the X-ray irradiated dense molecular tori. If this view is true, the known tight correlation between HCN(1-0) and the star-formation rate breaks in the vicinity of active nuclei. Although the interpretation of these ratios is still an open question, these ratios have a great potential for a new diagnostic tool for the energy sources of dusty galaxies in the ALMA era because these molecular lines are free from dust extinction.
- Kohno, K. [2008b], "ASTE Surveys of Galactic Star-Forming Regions," Bulletin of American Astronomical Society, vol.40, p.272.
  - We report some recent highlights on the observational studies of Galactic star formation based on surveys using the Atacama Submillimeter Telescope Experiment (ASTE), a new 10 m telescope in the Atacama desert in northern Chile (Kohno et al., 2008, ApSS, 313, 279). The highlights will include (1) a large scale CO(3-2) imaging survey of the Galactic Center, unveiling the presence of numerous compact high velocity clouds with high CO(3-2)/CO(1-0) ratios as a "fossil" of the recent burst of star formation in the Galactic Center region (Oka et al., 2007, PASJ, 59, 15; Nagai et al., 2007, PASJ, 59, 25; Tanaka et al., 2007, PASJ, 59, 323), (2) a large scale CO(3-2) imaging survey of the Sgr arm and inter-am regions, revealing the distinct difference on the morphology and physical property of molecular gas between the arm and inter-arm regions for the first time (Sawada, Koda, et al., in prep.), and (3) a wide area 1.1 mm imaging survey of Southern low mass star-forming regions such as Chamaeleon and Lupus molecular clouds using the bolometer camera AzTEC (Wilson et al., 2008, MNRAS, in press) mounted on ASTE, yielding detections of starless cores with a very low mass detection limist down to 0.1 solar masses (Hiramatsu, Tsukagoshi, Kawabe et al., in prep.). Related topics on the massive star-forming regions in very nearby galaxies such as LMC (Minamidani et al., 2008, ApJS, in press) and M 33 (Tosaki et al., 2007, ApJ, 664, L27; Onodera et al., in prep.; Komugi et al., in prep.) will also be reviewed.
- Kohno, K., T. Tosaki, R. Miura, K. Muraoka, T. Sawada, K. Nakanishi, N. Kuno, T. Sakai, K. Sorai, K. Kamegai, K. Tanaka, T. Okuda, A. Endo, B. Hatsukade, M. Sameshima, H. Ezawa, S. Sakamoto, T. Kamazaki, N. Yamaguchi, J. Cortes, Y. Tamura, M. Fukuhara, D. Iono, and R.

Kawabe [2008c], "ASTE CO(3-2) Observations of the Southern Barred Spiral Galaxy NGC 986: a Large Gaseous Bar Filled with Dense Molecular Medium," Publ. Astron. Soc. Japan, vol.60, pp.457-464.

- We present CO(3-2) emission observations toward the 3'x3' (or 20x20kpc at a distance of 23Mpc) region of the southern barred spiral galaxy NGC 986 using the Atacama Submillimeter Telescope Experiment (ASTE). This effort is a part of our on-going extragalactic CO(3-2) imaging project ADIoS (ASTE Dense gas Imaging of Spiral galaxies). Our CO(3-2) image revealed the presence of a large (the major axis is 14 kpc in total length) gaseous bar filled with dense molecular medium along the dark lanes observed in optical images. This is the largest "dense-gas rich bar" known to date. The dense gas bar discovered in NGC 986 could be a huge reservoir of possible "fuel" for future starbursts in the central region, and we suggest that the star formation in the central region of NGC 986 could still be in a growing phase. We found a good spatial coincidence between the overall distributions of dense molecular gas traced by CO(3-2) and the massive star formation depicted by H . The global CO(3-2) luminosity $L'_{CO(3-2)}$ of NGC 986 was determined to be (5.4 ± 1.1) ×108 K km s^{-1} pc^2. The CO(3-2)/CO(1-0) integrated intensity ratio was found to be 0.60 ± 0.13 at a spatial resolution of 44" or 5 kpc, and a CO(3-2)/CO(2-1) ratio was 0.67 ± 0.14 at a beam size of ~25" or ~2.8 kpc. These line ratios suggest moderate excitation conditions of CO lines (n_{H2} ~ 10^{3-4} cm^{-3}) in the central a few kpc region of NGC 986.

- Kohno, K., K. Muraoka, B. Hatuskade, K. Tanaka, D. Iono, K. Nakanishi, T. Tosaki, T. Sawada, R. Kawabe, H. Ezawa, N. Yamaguchi, Y. Tamura, G. Wilson, M. S. Yun, D. Hughes, S. Matsushita, and P.-Y. Hsieh [2008d], "Tracing Star Formation in Galaxies with Molecular Line and Continuum Observations," EAS Publication Series, vol.31, pp.65-71.

- We report our recent progress on extragalactic spectroscopic and continuum observations, including HCN(J=1-0), HCO^+(J=1-0), and CN(N=1-0) imaging surveys of local Seyfert and starburst galaxies using the Nobeyama Millimeter Array, high-J CO observations (J=3-2 observations using the Atacama Submillimeter Telescope Experiment (ASTE) and J=2-1 observations with the Submillimeter Array) of galaxies, and λ1.1 mm continuum observations of high-z violent starburst galaxies using the bolometer camera AzTEC mounted on ASTE.

- Kohno, K., Y. Tamura, B. Hatsukade, K. Nakanishi, D. Iono, T. Takata, G. W. Wilson, M. S. Yun, T. Perera, J. E. Austermann, K. S. Scott, H. Hughes, I. Aretxaga, K. Tanaka, N. Yamaguchi, H. Matsuo, H. Ezawa, and R. Kawabe [2008e], "AzTEC on ASTE Survey of Submillimeter Galaxies," Proc. of the "Panoramic views of galaxy formation and evolution", eds. T. Kodama, T. Yamada, and K. Aoki, ASP Conf. Ser. vol.399, pp.264-267.

- We have conducted an unprecedented survey of submillimeter galaxies (SMGs) using the 144 pixel bolometer camera AzTEC mounted on the ASTE 10-m dish in Chile. We have already obtained many (>20) wide (typically 12' x 12' or wider) and deep (1 σ sensitivity of 0.5-1.0 mJy) 1.1 mm continuum images of known blank fields and over-density regions/protoclusters across a wide range of redshifts with a spatial resolution of ~30". It has resulted in the numerous (~ a few 100, almost equivalent to the total number of the previously known SMGs) new and secure detections of SMGs. In this paper, we present initial results of two selected fields, SSA 22 and AKARI Deep Field South (ADFS). A significnat clustering of bright SMGs toward the density peak of LAEs is found in SSA 22. We derived the differential and cumulative number counts from the detected sources in ADF-S, which probe the faintest flux densities (down to -1 mJy) among 1-mm blank field surveys to date.

- Komugi, S., Y. Sofue, H. Nakanishi, S. Onodera, F. Egusa, K. Muraoka, and J. S. Young [2008a], "Molecular Gas and Star Formation in Nearby Galaxies," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., pp.231-236.

- The quantitative relationship between molecular gas and star formation, or the Schmidt Law,

was derived for the central kpc of nearby spiral galaxies using ^{12}CO(J=1-0) line data and H alphaimaging. The CO spectra were obtained at the 45m telescope at Nobeyama Radio Observatory (NRO). The derived Schmidt law index is found to be affected significantly depending on galaxy distance, ranging from 0.7 to 1.3. The data covers the densest regions of normal spirals, and overlaps with starburst galaxies. We categorize the Schmidt law according to existence of bars. Barred galaxies are found to display a Schmidt law with higher gas density, but on the same Schmidt law track as non-barred samples.

- Komugi, S., Y. Sofue, S. Onodera, F. Egusa, K. Muraoka, H. Nakanishi, and J. S. Young [2008b], "The Star Formation Law as a Function of Galactic Properties," Proc. of the "Pathways Through an Eclectic Universe", eds. J. H. Knapen, T. J. Mahoney, and A. Vazdekis, ASP Conf. Ser., vol.390, pp.161-165.
  - The relation between molecular gas quantity and star formation rate, known as the Schmidt law, is tested for its dependency on galactic morphology, with an emphasis on the presence of bars. The galaxy sample is based on a survey of the ^{12}CO(J = 1→0) emission in nearby galaxies completed at the Nobeyama Radio Observatory 45m telescope, combined with previous surveys with similar resolution. These data were compared to star formation rates derived using internal extinction corrected Hα. The slope of the Schmidt law is found to vary considerably with sample distance, from 0.7 to 1.4. The Schmidt law is categorized according to the presence of bars. Consequently, we find that barred galaxies occupy the denser regime of the Schmidt law, but with no apparent difference in the star formation efficiency, indicating that bars stimulate central inflow of gas, but that star formation still occurs according to a common star formation law as with non-barred galaxies.
- Komugi, S., Y. Sofue, K. Kohno, H. Nakanishi, S. Onodera, F. Egusa, and K. Muraoka [2008c], "Molecular Gas Distribution in Barred and Non-Barred Galaxies along the Hubble Sequence," Astrophys. J. Suppl, vol.178, pp.225-246.
  - We present results from a survey of ^{12}CO (J=1-0) spectra obtained for the central regions of 68 nearby galaxies at an angular resolution of 16" using the Nobeyama Radio Observatory 45 m telescope, aimed at characterizing the properties of star-forming molecular gas. Combined with observations of similar resolution in the literature, the compiled sample set of 166 galaxies span a wide range of galactic properties. NGC 4380, which was previously undetected in CO, was detected. This initial paper of a series will focus on the data and the gaseous properties of the samples, and particularly on the degree of central concentration of molecular gas in a range of morphological types, from early (S0/Sa) to late (Sd/Sm) galaxies with and without bars. The degree of molecular central concentration in the central kiloparsec, compared with the central several kiloparsecs of galaxies, is found to vary smoothly with Hubble type, so that early-type galaxies show larger central concentration. The comparison of barred and nonbarred galaxies within early- and late-type galaxies suggest that difference in Hubble type, representing the effect of bulges, is the more important factor in concentrating gas into the central regions than bars.
- Kotani, T., S. Fabrika, N. Kawai, K. Kinugasa, K. Kubota, S. Trushkin, and M. Tsuboi [2009], "Multi-Wavelength Observations of the Microquasar SS433," Proc. of "Astrophysics with All-Sky X-Ray Observations", pp.108-113.
  - A radio-IR-optical-X-ray observation campaigns have been performed in 2006 April and 2006 December for SS433, the unique microquasar known for the very stable continuous jet emanating at a quarter of the speed of light. The participating observatories/telescopes include Suzaku, RXTE, BTA, 150-cm Telescope at Gunma, Nayuta at Nishi-Harima, Crimean Observatory, MITSuME, VSOLJ, 1.4-m Telescope at SAAO, RATAN-600, RT-32 at IAA RAS, and Nobeyama Millimeter Array. In the April campaign, five radio flares have been detected and the source seems to be in the active state. In the December campaign, a simple radio flare

has been detected, and we triggered a series of observations with RXTE.

- Kuno, N., A. Hirota, T. Tosaki, and R. Miura [2008a], "Observations of molecular clouds in nearby galaxies with ALMA," Astrophys. and Sp. Sci., vol.313, pp.293-296.
  - We present recent results of the observations of giant molecular clouds in nearby galaxies with the Nobeyama 45 m telescope and Millimeter Array. We give some brief comments about observations of GMCs in nearby galaxies with ALMA.
- Kuno, N., N. Sato, H. Nakanishi, A. Hirota, T. Tosaki, Y. Shioya, K. Sorai, N. Nakai, K. Nishiyama, and B. Vila-Vilaro [2008b], "Nobeyama CO Atlas of Nearby Spiral Galaxies," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., pp.170-177.
  - The results of a CO(1-0) mapping survey of 40 nearby spiral galaxies performed with the Nobeyama 45-m telescope are presented. The maps of CO cover most of the optical disk of the galaxies. We investigated the influence of bar on distribution of molecular gas in spiral galaxies using these data. We confirmed that the degree of central concentration is higher in barred spirals than in non-barred spirals as shown by previous works. Furthermore, we show that bars are efficient in driving molecular gas that lies within their radial scales toward the center, while the role in the accumulation from the larger spatial scales on the disks is small. The transported gas accounts for about half of molecular gas within the central region in barred spiral galaxies. We found a correlation between the degree of central concentration and bar strength. Galaxies with stronger bars tend to have higher central concentration. The correlation implies that stronger bars accumulate molecular gas toward the center more efficiently. These results are consistent with long-lived bars.
- Kuno, N., K. Nakanishi, K. Sorai, and T. Shibatsuka [2008c], "Central Spiral Structure of Molecular Gas in Maffei 2," Publ. Astron. Soc. Japan, vol.60, pp.475-485.
  - The distribution and kinematics of molecular gas in the central region of the barred spiral galaxy Maffei 2 were investigated using a data set of ^{12}CO(1-0), ^{12}CO(2-1), CS(2-1) lines, and 103 GHz continuum. We found that the offset ridges along the kpc-scale bar continue to the central spiral structure embedded in a weak oval structure, which is regarded as $\chi 2$ orbit in the bar potential. The spiral structure continues toward the center, diverging from the oval structure. The size of these structures is less than R ~ 100 pc. The mass concentration within R = 35 pc is estimated to be 2 X 10^8 $M_\odot$. The high mass concentration is consistent with theoretical predictions concerning the creation of such a nuclear spiral structure. A comparison with the tracers of dense gas and star-forming region suggests that the dense molecular gas traced by the CS(2-1) line is formed at the crossing points of the x1 and x2 orbits and the star-forming region appears after 2 X 10^5 yr, which is comparable to the free-fall time of dense gas traced by the CS line (~ 10^5 cm^{-3}).
- Kuno, N., T. Tosaki, S. Onodera, K. Muraoka, H. Kaneko, T. Sawada, K. Nakanishi, S. Komugi, Y. Tamura, K. Kohno, R. Kawabe, N. Arimoto, and S. Okamoto [2010], "NRO Legacy Project: Survey of Giant Molecular Clouds in M33," Highlights of Astronomy, 1vol.5 : XXVIIth IAU General Assembly, August 2009, ed. Ian F. Corbett, pp.416-416.
  - As the Nobeyama Radio Observatory Legacy Project: Survey of Giant Molecular Clouds in M33, we have been mapping M33 in CO(1-0) with the multi-beam receiver BEARS equipped on the 45-m telescope using the OTF mapping technique since 2007. The purpose of this project is to investigate the physical properties of GMCs and understand the evolutionary process from GMC formation to star formation in GMCs by comparing with various data such as CO(3-2), 1.1 mm continuum obtained with ASTE10m telescope at Atacama and the optical data obtained with SUBARU. We identified 87 GMCs using the first year data of CO(1-0) and observed 28 GMCs among them in CO(3-2) with ASTE (Onodera 2009, PhD thesis, University of Tokyo). From the comparison of these lines, it was shown that the

CO(3-2)/CO(1-0) ratio increases with star forming activity in the GMCs. Furthermore, we found that more massive GMCs tend to have higher CO(3-2)/CO(1-0) ratio. Since the ratio is thought to be an indicator of the fraction of warm and dense molecular gas, our results imply that the fraction of warm and dense gas increases with GMC mass. Especially, since the ratio in the GMCs with low star forming activity is in the range where the ratio depends mainly on the density, we speculate that dense gas fraction increases with GMC mass.

- Kurayama, T. [2008], "VERA Observation of the Massive Star Forming Region G34.4+0.23," Proc. of the IAU Symp. 248, "A Giant Step: from Milli- to Micro-arcsecond Astrometry", eds. Wenjing Jin, Imants Platais, Michael A. C. Perryman, pp.202-203.
  - We observed with VERA the massive star forming region G34.4+0.23, to obtain parallaxes and proper motions. Four infrared dark clouds were observed and water maser were found in two dark clouds, MM1 and MM4. In MM1, the distribution of maser spots shows a "V-shaped" structure and most features co-moving with this structure. Phase-referenced images have peaks and their motion is much larger than the expected parallax. Further analysis is needed to correctly interpret our measurement of parallax.
- Kurayama, T. [2009], "VERA Observation of G34.4+0.23 and Matters that Require Attention for VSOP-2 Phase Referencing," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.473-475.
  - We observed the massive star forming region G34.4+0.23 with VERA to determine parallaxes and proper motions. Four infrared dark clouds were observed and water masers are found from two dark clouds, MM1 and MM4. In MM1, the distribution of the maser spots shows a “V-shape” structure and most features move along this structure. The peaks on the phase (position)-referenced images are detected, but their motions indicate a parallax that is larger than expected and with a large scatter. The analysis processes should be checked to confirm the measurement of the parallax.
- Kurono, Y., K.-I. Morita, and T. Kamazaki [2009], "A Study of Combining Technique of Single-Dish and Interferometer Data: Imaging Simulations and Analysis," Publ. Astron. Soc. Japan, vol.61, pp.873-894.
  - We have investigated a technique of combining single-dish data and interferometer data in the spatial frequency domain, using imaging simulations and analytical considerations. Our study shows that there is an optimum of the relative weights between the visibility data of a single-dish and an interferometer The quality of the reconstructed combined image achieves the highest values at relative weights where the mean of the difference between the synthe-sized beam and the CLEAN beam is close to zero. We also examined the (u,v)-range that can be effectively used for the data combining by considering a blurring effect due to a pointing error. The error in single-dish deconvolution caused by the beam approximation is small with a large diameter of the single-dish aperture. The diameter should be at least 1.7-times larger than the minimum baseline of the interferometer for an amplitude accuracy better than 10%. Furthermore, we derived an estimate of the noise variance in the combined image, which agrees with our simulation results. The noise-added simulations demonstrate that there is a threshold of the noise level of the single-dish image, beyond which a large-scale error is emphasized in the combined image. We should take observation times to make at least the same noise level at the border of the spatial frequency between the single-dish and the interferometer. Although our examinations were assumed to use the 45 m telescope and NMA, our results concerning the required conditions for observations and data processes can be used in a general case of heterogeneous array imaging.
- Levshakov, S. A., P. Molaro, M. G. Kozlov, A. V. Lapinov, C. Henkel, D. Reimers, T. Sakai, and I. I. Agafonova [2010], "Search for Chameleon-Like Scalar Fields," JENAM 2010, Joint

European and National Astronomy Meeting held 6-10 September, 2010 in Lisbon Portugal, p.68.

- Using the 32-m Medicina, 45-m Nobeyama, and 100-m Effelsberg telescopes we found a statistically significant velocity offset $\Delta_V \approx 27\pm3$ m s^{-1} between the inversion transition in $NH_3(1,1)$ and low-J rotational transitions in $N_2H^+(1\text{-}0)$ and $HC_3N(2\text{-}1)$ arising in cold and dense molecular cores in the Milky Way. Systematic shifts of the line centers caused by turbulent motions and velocity gradients, possible non-thermal hyperfine structure populations, pressure and optical depth effects are shown to be lower than or about 1 m s^{-1} and thus can be neglected in the total error budget. The reproducibility ofΔ_V at the same facility (Effelsberg telescope) on a year-to-year basis is found to be very good. Since the frequencies of the inversion and rotational transitions have different sensitivities to variations in $\mu = m_e/m_p$, the revealed non-zeroΔ_V may imply that mu changes when measured at high (terrestrial) and low (interstellar) matter densities as predicted by chameleon-like scalar field models - candidates to the dark energy carrier. Thus we are testing whether scalar field models have chameleon-type interactions with ordinary matter. The measured velocity offset corresponds to the ratio $\Delta\mu/\mu = (\mu_{space} - \mu_{lab})/\mu_{lab}$ of $(26\pm3)\times10^{-9}$ (1σ).

- Li, J., Z.-Q. Shen, A. Miyazaki, L. Huang, R. J. Sault, M. Miyoshi, M. Tsuboi, and T. Tsutsumi [2009], "The Variability of Sagittarius A* at 3 Millimeter," Astrophys. J., vol.700, pp.417-425.
- We have performed monitoring observations of the 3 mm flux density toward the Galactic center compact radio source Sagittarius A* (Sgr A*) with the Australia Telescope Compact Array since 2005 October. Careful calibrations of both elevation-dependent and time-dependent gains have enabled us to establish the variability behavior of Sgr A*. Sgr A* appeared to undergo a high and stable state in the 2006 June session, and a low and variable state in the 2006 August session. We report the results, with emphasis on two detected intraday variation events during its low states. One is on 2006 August 12 when Sgr A* exhibited a 33% fractional variation in about 2.5 hr. The other is on 2006 August 13 when two peaks separated by about 4 hr, with a maximum variation of 21% within 2 hr, were seen. The observed short timescale variations are discussed in light of two possible scenarios, i.e., the expanding plasmon model and the sub-Keplerian orbiting hot spot model. The fitting results indicate that for the adiabatically expanding plasmon model, the synchrotron cooling cannot be ignored, and a minimum mass-loss rate of 9.7×10^{-10} $M_\odot yr^{-1}$ is obtained based on parameters derived for this modified expanding plasmon model. Simultaneous multiwavelength observation is crucial to our understanding of the physical origin of rapid radio variability in Sgr A*.

- Li, J., T. An, Z.-Q. Shen, and A. Miyazaki [2010], "ATCA Observations of SiO Masers in the Galactic Center," Astrophys. J. (Letters), vol.720, pp.L56-L61.
- We present the Australia Telescope Compact Array observations of the SiO masers in the Galactic center (GC) in transitions of v = 1, J = 2-1 at 86 GHz and v = 1, J = 1-0 at 43 GHz. Two 86 GHz SiO masers were detected within the central parsec, and they are associated with IRS 10EE and IRS 15NE, respectively. We detected eighteen 43 GHz SiO masers within a projected separation of □2 pc from Sagittarius A*, among which seven masers are newly discovered from our observations. This raises the total number of 43 GHz SiO masers within the central 4 pc of the GC region to 22. Simultaneous observations at 86 and 43 GHz showed that the intensity of 43 GHz SiO maser is ~3 times higher than that of 86 GHz maser in IRS 10EE (an OH/IR star), while the integrated flux of the SiO maser emission at 43 GHz is comparable with that at 86 GHz in IRS 15NE (an ordinary Mira variable). These results are consistent with previous observations of massive late-type stars in the Galaxy in which the 86 GHz SiO maser is in general weaker than the 43 GHz SiO maser in OH/IR stars, while the two transitions are comparably strong in Mira stars.

- Lightfoot, J., G. Kosugi, F. Wyrowski, L. Zapata, D. Muders, F. Boone, T. Tsutsumi, L. Davis,

C. Wilson, and D. Shepherd [2008], "ALMA Pipeline Heuristics," Proc. of the "Astronomical data analysis software and systems", eds. Robert W. Argyle, Peter S. Bunclark, and James R. Lewis, ASP conf. ser., vol.394, p.573.

- The ALMA Pipeline Heuristics system is being developed to reduce automatically data taken with the standard observing modes. The goals are to make ALMA comfortable to use for astronomers who are new to radio interferometry and to provide reduced results of publishable quality. The reduction sequence will continue to develop as experience is gained at the telescope, so it is important that the system has a framework and interface that are flexible and easy to use. Observing modes to be handled include single field interferometry, mosaics, single dish 'on the fly' maps, and combinations of these. The data will be produced by the main ALMA array, the Alma Compact Array, and single dish antennas. The reduction sequence is logged to a collection of html files that can examined using a standard browser for verification of the process. The reduction is performed by a Python script and classes bound to the CASA libraries.

- Lisenfeld, U., D. Espada, S. Leon, L. Lerdes-Montenegro, N. Kuno, and N. Sato [2010], "Molecular Gas Properties in the Most Isolated Galaxies," Proc. of the "Galaxies in Isolation: Exploring Nature Versus Nurture", eds. Verdes-Montenegro, L., del Olmo, A., Sulentic, J. W., ASP Conf. Ser., vol.421, p.262.

- We present results obtained from CO(1-0) data of a velocity-restricted subsample of isolated galaxies from the AMIGA project.

- Liszt, H. S., J. Pety, and K. Tachihara [2009], "Imaging Galactic Diffuse Clouds: CO Emission, Reddening and Turbulent Flow in the Gas aroundζOph,Astron. " Astrophys., vol.499, pp.503-513.

- Context. Most diffuse clouds are only known as kinematic features in absorption spectra, but those with appreciable H_2 content may be visible in the emission of such small molecules as CH, OH, and CO.
  Aims. We interpret in greater detail the extensive observations of ^{12}CO emission from diffuse gas seen around the archetypical line of sight toζOph.
  Methods. The ^{12}CO emission is imaged in position and position-velocity space, analyzed statistically, and then compared with maps of total reddening E^{∞}_{B-V} and with models of the C^+ - CO transition in H2-bearing diffuse clouds.
  Results. AroundζOph, ^{12}CO emission appears in two distinct intervals of reddening centered near $E^{\infty}_{B-V} \approx 0.4$ and 0.65 mag, of which □0.2 mag is background material. Within either interval, the integrated ^{12}CO intensity varies up to 6-12 K km s^{-1}, compared to 1.5 K km s^{-1} toward ζOph. Nearly 80% of the individual profiles have velocity dispersions$\sigma_v < 0.6$ km s-1, which are subsonic at the kinetic temperature derived from H2 towardζOph, 55 K. Partly as a result, ^{12}CO emission exposes the internal, turbulent, supersonic (1-3 km s^{-1}) gas flows with especial clarity in the cores of strong lines. The flows are manifested as resolved velocity gradients in narrow, subsonically-broadened line cores.
  Conclusions. The scatter between N(CO) and E_{B-V} in global, CO absorption line surveys toward bright stars is present in the gas seen aroundζOph, reflecting the extreme sensitivity of N(^{12}CO) to ambient conditions. The two-component nature of the optical absorption towardζOph is coincidental and the star is occulted by a single body of gas with a complex internal structure, not by two distinct clouds. The very bright ^{12}CO lines in diffuse gas arise at $N(H_2) \approx 10^{21}$ cm^{-2} in regions of modest density $n(H) \approx 200\text{-}500$ cm^{-3} and somewhat more complete C^+-CO conversion. Given the variety of structure in the foreground gas, it is apparent that only large surveys of absorption sightlines can hope to capture the intrinsic behavior of diffuse gas.

- Liu, G., D. Calzetti, M. S. Yun, G. W. Wilson, B. T. Draine, K. Scott, J. Austermann, T. Perera,

D. Hughes, I. Aretxaga, K. Kohno, R. Kawabe, and H. Ezawa [2010a], "From Near-Infrared to Millimeter: An Investigation of the Content in the NGC 1512/1510 Pair," American Astron. Soc., AAS Meeting #215, #432.18.

- We combine new ASTE/AzTEC 1.1 mm maps of the galaxy pair NGC1512/1510 with archival Spitzer IRAC and MIPS images covering the wavelength range 3.6-160μm from the SINGS project. The two galaxies form a high-metallicity, large spiral (NGC1512)/low-metallicity compact dwarf (NGC1510) pair. Using the models of Draine & Li (2007), the derived total dust masses are $(2.4\pm0.6)\times10^7$ and $(1.7\pm3.6)\times10^5$ M_{sun} for NGC1512 and NGC1510, respectively. The derived dust/H I ratio is within expectations of low-metallicity galaxies for NGC1510, but it is much lower, by at least a factor of 3, than expected for NGC1512, as previously found by Draine et al. (2007). In contrast, regions within NGC1512, specifically the central region and the arms, do not show such unusually low dust/H I values, suggesting the possibility that some of the H I included in the determination of the dust/H I ratio of NGC1512 is not associated with the star forming disk. Simple two-temperature modified-blackbody fits to the far-infrared/mm data of the two galaxies and the sub-regions of NGC1512 are also performed to derive the dust masses associated with warm and cool dust components. As generally expected, the warm dust temperature of the low-metallicity, low-mass NGC1510 (~36 K) is substantially higher than the corresponding warm temperature of the high-metallicity spiral NGC1512 (~24 K). In both galaxies, our fits indicate that a substantial fraction (>93%) of the total dust mass is in a cool dust component (~14-16 K for NGC1512 and ~15-24 K for NGC1510). This result is similar to what is determined for a few other nearby galaxies. The warm dust component in the sub-galactic regions of NGC1512 represents a much larger fraction of the total dust content (17-40%), in agreement with the fact that all three regions have higher specific star formation rates than the average in the galaxy.

- Liu, G., D. Calzetti, M. S. Yun, G. W. Wilson, B. T. Draine, K. Scott, J. Austerman, T. Perera, D. Hughes, I. Aretxaga, K. Kohno, R. Kawabe, and H. Ezawa [2010b], "An Investigation of the Dust Content in the Galaxy Pair NGC 1512/1510 from Near-Infrared to Millimeter Wavelengths," Astron. J., vol.139, pp.1190-1198.

- We combine new ASTE/AzTEC 1.1 mm maps of the galaxy pair NGC 1512/1510 with archival Spitzer IRAC and MIPS images covering the wavelength range 3.6-160μm from the SINGS project. The availability of the 1.1 mm map enables us to measure the long-wavelength tail of the dust emission in each galaxy, and in sub-galactic regions in NGC 1512, and to derive accurate dust masses. The two galaxies form a pair consisting of a large, high-metallicity spiral (NGC 1512) and a low-metallicity, blue compact dwarf (NGC 1510), which we use to compare similarities and contrast differences. Using the models of Draine and Li, the derived total dust masses are $(2.4 \pm 0.6) \times10^7$ M_{sun} and $(1.7 \pm 3.6) \times 10^5$ M_{sun} for NGC 1512 and NGC 1510, respectively. The derived ratio of dust mass to H I gas mass for the galaxy pair, M_d/M_{HI} ~0.0034, is much lower (by at least a factor of 3) than expected, as previously found by Draine et al. In contrast, regions within NGC 1512, specifically the central region and the arms, do not show such unusually low M_d/M_{HI} ratios; furthermore, the dust-to-gas ratio is within expectations for NGC 1510. These results suggest that a fraction of the HI included in the determination of the M_d/M_{HI} ratio of the NGC 1512/NGC 1510 pair is not associated with the star-forming disks/regions of either galaxy. Using the dust masses derived from the models of Draine & Li as references, we perform simple two-temperature modified blackbody fits to the far-infrared/millimeter data of the two galaxies and the sub-regions of NGC 1512, in order to derive and compare the dust masses associated with warm and cool dust temperature components. As generally expected, the warm dust temperature of the low-metallicity, low-mass NGC 1510 (T_w ~ 36 K) is substantially higher than the corresponding warm temperature of the high-metallicity spiral NGC 1512 (T_w ~ 24 K). In both galaxies (albeit with

a large uncertainty for NGC 1510), our fits indicate that a substantial fraction (>93%) of the total dust mass is in a cool dust component, with temperatures ~14-16 K for NGC 1512 and ~15-24 K for NGC 1510. This result is similar to what is determined for a few other nearby galaxies. In contrast, the warm dust component in the sub-galactic regions of NGC 1512 represents a much larger fraction of the total dust content, in agreement with the fact that all three regions have higher specific star formation rates than the average in the galaxy; in the center, the warm dust represents about 40% of the total, while in the arms the fractions are close to ~20%.

- Liu, Q., X. Shi, F. Kikuchi, Q. Huang, S. Kamata, K. Matsumoto, H. Hanada, X. Hong, A. Yu, J. Ping, Q. Fan, B. Xia, T. An, Z. Qian, W. Yang, H. Zhang, Z. Wang, and N. Wang, [2009], "High-Accuracy Same-Beam VLBI Observations using Shanghai and Urumqi Telescope," Science in China Ser. G: Phys. Mathe. & Astron., vol.52, pp.1858-1866.
  - The same-beam VLBI observations of Rstar and Vstar, which were two small satellites of Japanese lunar mission, SELENE, were successfully performed by using Shanghai and Urumqi 25-m telescopes. When the separation angle between Rstar and Vstar was less than 0.1 deg, the differential phase delay of the X-band signals between Rstar and Vstar on Shanghai-Urumqi baseline was obtained with a very small error of 0.15 mm rms, which was reduced by 1-2 order compared with the former VLBI results. When the separation angle was less than 0.56 deg, the differential phase delay of the S-band signals was also obtained with a very small error of several mm rms. The orbit determination for Rstar and Vstar was performed, and the accuracy was improved to a level of several meters by using VLBI and Doppler data. The high-accuracy same-beam differential VLBI technique is very useful in orbit determination for a spacecraft, and will be used in orbit determination for Mars missions of China Yinghuo-1 and Russia Phobos-grunt.
- Liu, Q., F. Kukuchi, K. Matsumoto, S. Goossens, H. Hanada, Y. Harada, X. Shi, Q. Huang, T. Ishikawa, S. Tsuruta, K. Asari, Y. Ishihara, N. Kawano, S. Kamata, T. Iwata, H. Noda, N. Namiki, S. Sasaki, S. Elingsen, K. Sato, K. Shibata, Y. Tamura, T. Jike, K. Iwadate, O. Kameya, J. Ping, B. Xia, T. An, Q. Fan, X. Hong, W. Yang, H. Zhang, Y. Aili, B. Reid, W. Hankey, J. McCallum, G. Kronschnabl, and W. Schluter [2010], "Same-Beam VLBI Observations of SELENE for Improving Lunar Gravity Field Model," Radio Sci., 45, CitelID RS2004(1-16).
  - The Japanese lunar mission, Selenological and Engineering Explorer (Kaguya), which was successfully launched on 14 September 2007, consists of a main satellite and two small satellites, Rstar and Vstar. Same-beam very long baseline interferometry (VLBI) observations of Rstar and Vstar were performed for 15.4 months from November 2007 to February 2009 using eight VLBI stations. In 2008, S band same-beam VLBI observations totaling 476 h on 179 days were undertaken. The differential phase delays were successfully estimated for most (about 85%) of the same-beam VLBI observation periods. The high success rate was mainly due to the continuous data series measuring the differential correlation phase between Rstar and Vstar. The intrinsic measurement error in the differential phase delay was less than 1 mm RMS for small separation angles and increased to approximately 2.5 mm RMS for the largest separation angles (up to 0.56 deg). The long-term atmospheric and ionospheric delays along the line of sight were reduced to a low level (several tens of milimeters) using the same-beam VLBI observations, and further improved through application of GPS techniques. Combining the eight-station (four Japanese telescopes of VLBI Exploration of Radio Astrometry and four international telescopes) S band same-beam VLBI data with Doppler and range data, the accuracy of the orbit determination was improved from a level of several tens of meters when only using Doppler and range data to a level of 10 m. As a preliminary test of the technique, the coefficient sigma degree variance of the lunar gravity field was compared with and without 4 months of VLBI data included. A significant reduction below around 10 deg (especially for

the second degree) was observed when the VLBI data were included. These observations confirm that the VLBI data contribute to improvements in the accuracy of the orbit determination and through this to the lunar gravity field model.

- Maeda, T., H. Imai, T. Omodaka, H. Kobayashi, K. M. Shibata, T. Bushimata, Y. K. Choi, T. Hirota, M. Honma, K. Horiai, N. Inomata, K. Iwadate, T. Jike, S. Kameno, O. Kameya, R. Kamohara, Y. Kan-ya, N. Kawaguchi, S. Kuji, T. Kurayama, S. Manabe, T. Miyaji, T. Nagayama, A. Nakagawa, K. Nakashima, C. S. Oh, T. Oyama, S. Sakai, S. Sakakibara, K. Sato, R. Shimizu, M. Shintani, K. Sora, H. Suda, Y. Tamura, and K. Yamashita [2008], "A Bipolar Outflow of the M-Type Giant IRC 10414 Traced by H_2O Maser Emission," Publ. Astron. Soc. Japan, vol.60, pp.1057-1067.

  - We report on results of five-epoch VLBI observations of H_2O maser emission in the M-type star IRC - 10414, carried out with the VLBI Exploration of Radio Astrometry (VERA). The maser distribution extends over an area of 70 mas x 260 mas and exhibits a bipolar structure. The relative proper motions of 17 maser features were measured during the monitoring observations spanning nine months. The distance to IRC - 10414 was re-estimated on the basis of the statistical treatment of parallax and the model-fitting method, yielding D = 3.1±0.4 kpc and D = 2.0±0.2 kpc, respectively. The estimated distance, D = 2-3 kpc, is much larger than that previously adopted. The stellar luminosity of IRC - 10414 is also re-estimated to be $L_* \sim 9$ x 104 $(D/2\ \mathrm{kpc})^2$ L , much brighter by a factor of 10-20 than previously adopted (L* ~ 10000 L). The maser motions exhibit not only a spherically expanding flow with a velocity of ~ 10(D/2 kpc) km s^{-1}, but also a faster bipolar outflow with a major axis in the north-south direction and at a small inclination angle with respect to the celestial sphere. These characteristics of the star and the circumstellar envelope seen in IRC - 10414 are very similar to those in some supergiants exhibiting bipolar stellar mass loss.

- Mamyoda, K., N. Nakai, A. Yamauchi, P. Diamond, and J.-M. Huré [2009], "Detection of a Sub-Keplerian Water Maser Disk at the Active Galactic Nuclear of the Galaxy IC 481," Publ. Astron. Soc. Japan, vol.61, pp.1143-1151.

  - We present a study of H_2O maser emission from the LINER, IC 1481, based on single-dish and highly sensitive VLBI observations. The Nobeyama 45-m telescope detected new maser features near the systemic velocity and blue-shifted by 124-205 km s^{-1}. In addition, the known features red-shifted by ≈97-155 km s^{-1} were monitored. VLBI observations with the High Sensitivity Array (HSA) revealed that the maser features are distributed along a line, with a velocity gradient, strongly suggesting a nearly edge-on molecular gas disk. The radius and thickness of the disk are r = 2.8-14.0 pc and 2H = 1.5-4.2 pc, respectively, which are the largest among the maser disks detected in active galactic nuclei. The disk is rotating at V_{rot} = 124-168 km s^{-1}, having a large velocity dispersion of $\Delta V \approx 31$ km s^{-1}. The rotation curve of the disk is sub-Keplerian ($V_{rot} \propto r^{-0.19\pm0.04}$), indicating a massive disk. The disk mass is estimated to be (4.3±0.3) $\times 10^7$ M. and the mass of a putative central black hole is $<10^7$ M. The massive disk is gravitationally unstable. A radio continuum source was also detected to be offset from the maser disk by 1.6 pc.

- Marsher, A., S. Jorstad, D. Murphy, D. Meier, R. Preston, S. Unwin, K. Kellermann, J. Wrobel, J. Romney, D. Homan, M. Lister, G. Piner, L. Greenhill, M. Reid, G. Taylor, A. Weshrle, D. Roberts, A. Readhead, M. Böttcher, M. Georganopoulos, S. Bloom, K. Johnston, C. C. Cheung, T. Krichbaum, M. Tsuboi, M. Inoue, and S. Kameno [2009], "Exploring the Most Compact Regions of Relativistic Jets with the Ultra-High Angular Resolution of Space VLBI," Astro2010: The Astronomy and Astrophysics Decadal Survey, Science White Papers, no. 193-1-8.

  - Without abstract

- Maruta, H., F. Nakamura, R. Nishi, N. Ikeda, and Y. Kitamura [2010], "Physical Properties of

Dense Cores in the Ophiuchi Main Cloud and A Significant Role of External Pressures in Clustered Star Formation," Astrophys. J., vol.714, pp.680-698.

- Using the archive data of the $H^{13}CO^+$ (J = 1-0) line emission taken with the Nobeyama 45 m radio telescope with a spatial resolution of ~ 0.01 pc, we have identified 68 dense cores in the central dense region of theρOphiuchi main cloud. The $H^{13}CO^+$ data also indicate that the fractional abundance of $H^{13}CO^+$ relative to H_2 is roughly inversely proportional to the square root of the H_2 column density with a mean of 1.72×10^{-11}. The mean radius, FWHM line width, and LTE mass of the identified cores are estimated to be 0.045 ± 0.011 pc, 0.49 ± 0.14 km s^{-1}, and 3.4 ± 3.6 M sun, respectively. The majority of the identified cores have subsonic internal motions. The virial ratio, the ratio of the virial mass to the LTE mass, tends to decrease with increasing LTE mass and about 60% of the cores have virial ratios smaller than 2, indicating that these cores are not transient structures but self-gravitating. The detailed virial analysis suggests that the surface pressure often dominates over the self-gravity and thus plays a crucial role in regulating core formation and evolution. By comparing theρOph cores with those in the Orion A molecular cloud observed with the same telescope, we found that the statistical properties of the core physical quantities are similar between the two clouds if the effect of the different spatial resolutions is corrected. The line widths of theρOph cores appear to be nearly independent of the core radii over the range of 0.01-0.1 pc and deviate upward from the Heyer & Brunt relation. This may be evidence that turbulent motions are driven by protostellar outflows in the cluster environment.

- Matsumoto, K., S. Goossens, Q. Liu, T. Iwata, N. Namiki, H. Noda, H. Hanada, F. Kikuchi, Y. Ishihara, N. Kawano, S. Tsuruta, K. Asari, T. Ishikawa, and S. Sasaki [2008a], "Current Status of Acquisition and Processing of Tracking Data from SELENE (Kaguya) Satellites for Lunar Gravity Field Estimation," 39th Lunar and Planetary Science Conference, (Lunar and Planetary Science XXXIX), held March 10-14, 2008 in League City, Texas. LPI Contribution No. 1391, p.1541.

- This presentation summarizes the current status of acquisition and processing of tracking data from Kaguya. A special emphasis will be on the four-way Doppler data coverage over the lunar far-side and its impact on lunar gravity field estimation.

- Matsumoto, K., H. Hanada, N. Namiki, T. Iwata,S. Goossens, S. Tsuruta, N. Kawano, and D. D. Rowlands [2008b], "A Simulation Study for Anticipated Accuracy of Lunar Gravity Field Model by SELENE Tracking Data," Adv. Sp. Res., vol.42, pp.331-336.

- Results of numerical simulations are presented to examine the global gravity field recovery capability of the Japanese lunar exploration project SELENE (SELenological and ENgineering Explorer) which will be launched in 2007. New characteristics of the SELENE lunar gravimetry include 4-way satellite-to-satellite Doppler tracking of main orbiter and differential VLBI tracking of two small free-flier satellites. It is shown that the proposed satellite constellation will provide the first truly global satellite tracking data coverage. The expected results from these data are; (1) drastic reduction in far-side gravity error, (2) estimation of many gravity coefficients by the observation, not by a priori information, and (3) one order of magnitude improvement over existing gravity models for low-degree field.

- Matsumoto, K., S. Goossens, Y. Ishihara, Q. Liu, T. Iwata, N. Namiki, H. Noda, H. Hanada, F. Kikuchi, N. Kawano, S. Tsuruta, K. Asari, T. Ishikawa, and S. Sasaki [2008c], "Initial Results of Global Lunar Gravity Field Recovery from SELENE Tracking Data," 37th COSPAR Scientific Assembly, held 13-20 July 2008, in Montreal, Canada, p.1953.

- Two small spin-stabilized sub-satellites, Rstar (OKINA) and Vstar (OUNA), have successfully been separated from Main satellite of SELENE (KAGUYA) and inserted into planned elliptical orbits on October 9 and 12, 2007, respectively. These spacecraft are dedicated to improving our knowledge of the global lunar gravity field with the mission instruments on-board, i.e.,

RSAT (a satellite-to-satellite Doppler tracking sub-system) and VRAD (artificial radio sources for VLBI). We have started collecting new types of tracking data for the lunar-orbiting satellites, i.e., 4-way Doppler tracking between the Main satellite and Rstar (i.e., a direct far-side gravity observation), and multi-frequency differential VLBI tracking between Rstar and Vstar. A global lunar gravity field with unprecedented accuracy is expected to be estimated through precision orbit determination by using these tracking data. A preliminary global lunar gravity field model (degree and order up to 60) was developed from about 3-month of SELENE tracking data which include 2-way Doppler, 2-way range, and 4-way Doppler data. Although the current far-side data coverage is incomplete and a Kaula-type a priori constraint is necessary for meaningful inversion, some of ring-shaped gravity anomalies are more clearly resolved in the far-side compared with existing lunar gravity models. We will present concept of tracking data acquisition scheduling, current status of tracking data acquisition, and preliminary results of global lunar gravity filed recovery.

- Matsumoto, K., S. Goossens, Y. Ishihara, Q. Liu, F. Kikuchi, T. Iwata, H. Noda, H. Hanada, N. Kawano, F. G. Lemoine, and D. D. Rowlands [2010], "An Improved Lunar Gravity Field Model from SELENE and Historical Tracking Data: Revealing the Farside Gravity Features,J" . Geophys. Res., vol.115, pp.E06007(1-20).
  - A new spherical harmonic solution of the lunar gravity field to degree and order 100, called SGM100h, has been developed using historical tracking data and 14.2 months of SELENE tracking data (from 20 October 2007 to 26 December 2008 plus 30 January 2009). The latter includes all usable 4-way Doppler data collected which allowed direct observations of the farside gravity field for the first time. The new model successfully reveals farside features in free-air gravity anomalies which are characterized by ring-shaped structures for large impact basins and negative spots for large craters. SGM100h produces a correlation with SELENE-derived topography as high as about 0.9, through degree 70. Comparison between SGM100h and LP100K (one of the pre-SELENE models) shows that the large gravity errors which existed in LP100K are drastically reduced and the asymmetric error distribution between the nearside and the farside almost disappears. The gravity anomaly errors predicted from the error covariance, through degree and order 100, are 26 mGal and 35 mGal for the nearside and the farside, respectively. Owing to the 4-way Doppler measurements the gravity coefficients below degree and order 70 are now determined by real observations with contribution factors larger than 80 percent. With the SELENE farside data coverage, it is possible to estimate the gravity field to degree and order 70 without applying any a priori constraint or regularization. SGM100h can be used for global geophysical interpretation through degree and order 70.
- Matsumoto, N., T. Omodaka, H. Imai, R. Shimizu, T. Bushimata, Y. K. Choi, T. Hirota, M. Honma, N. Inomata, K. Iwadate, T. Jike, S. Kameno, O. Kameya, R. Kamohara, Y. Kan-ya, N. Kawaguchi, H. Kobayashi, S. Kuji, T. Kurayama, T. Maeda, S. Manabe, T. Miyaji, A. Nakagawa, T. Nagayama, K. Nakashima, K., C. S. Oh, T. Oyama, S. Sakai, S. Sakakibara, T. Sasao, K. Sato, K. M. Shibata, M. Shintani, Y. Sofue, K. Sora, H. Suda, Y. Tamura, M. Tsushima, and K. Yamashita [2008], "Variable Asymmetry of the Circumstellar Envelope in IK Tauri Traced by SiO Maser Emission," Publ. Astron. Soc. Japan, vol.60, pp.1039-1050.
  - We observed the SiO (v=1 and$v$=2, J=1-0) maser emissions toward the Mira variable IK Tauri (IK Tau, NML Tau, IRC+10050) over nine epochs from 2002 November to 2005 April using the VLBI Exploration of Radio Astrometry (VERA) telescope array. We found that the SiO maser distributions around IK Tau are highly variable, depending on the stellar pulsation phase. The velocity structures were complex and also time-variable, and are inconsistent with a simply rotating shell that was suggested by previous observations. Based on fittings of the SiO maser distributions to elliptical ring models, we found that the ring size seems to vary in

correlation with the pulsation phase, as previously found for TX Cam. Comparisons of thev=1 andv=2 maser distributions reveal that 42-50% of the maser pairs have a positional offset less than 0.5 mas, suggesting that the maser pumping in these spots is likely to be dominated by line overlapping or collisional pumping, rather than pure radiative pumping. In order to model the velocity structure of the spoke-like features observed in IK Tau, we propose a ballistic-orbit model, in which a gas clump ejected from the stellar surface moves radially outward with a gravitational deceleration, and argue that the stellar mass can be deduced from that model.

- Matsushita, S., A. L. Tsai, R. Kawabe, K. Nakanishi, B. Vola-Vilaro, K. Kohno, T. Inui, H. Matsumoto, T. G. Tsuru, and A. B. Peck [2008], "Molecular Bubbles and Outflows in the Edge-on Starburst Galaxies M82 and NGC 2146," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., p.352.
  - Without abstract
- Matsushita, S., R. Kawabe, K. Kohno, T. Tosaki, and B. Vila-Vilaro [2010], "Dense and Warm Molecular Gas and Warm Dust in Nearby Galaxies," Publ. Astron. Soc. Japan, vol.62, pp.409-421.
  - We performed ^{12}CO(1-0), ^{13}CO(1-0), and HCN(1-0) single-dish observations (beam size ~14" -18") toward nearby starburst and non-starburst galaxies using the Nobeyama 45 m telescope. The ^{13}CO(1-0) and HCN(1-0) emissions were detected from all the seven starburst galaxies, with the intensities of both lines being similar (i.e., the ratios are around unity). On the other hand, for case of the non-starburst galaxies, the ^{13}CO(1-0) emission was detected from all three galaxies, while the HCN(1-0) emission was weakly or not detected in past observations. This result indicates that the HCN/^{13}CO intensity ratios are significantly larger (~1.15±0.32) in the starburst galaxy samples than the non-starburst galaxy samples (< 0.31 ± 0.14). The large-velocity-gradient model suggests that the molecular gas in the starburst galaxies have warmer and denser conditions than that in the non-starburst galaxies, and the photon-dominated-region model suggests that the denser molecular gas is irradiated by stronger interstellar radiation field in the starburst galaxies than that in the non-starburst galaxies. In addition, HCN/^{13}CO in our sample galaxies exhibit strong correlations with the IRAS 25μm flux ratios. It is a well established fact that there exists a strong correlation between dense molecular gas and star formation activities, but our results suggest that molecular gas temperature is also an important parameter.
- Migita, E., H. Araki, H. Noda, S. Tazawa, Y. Ishihara, and T. Iwata [2009], "Laser Altimeter Lunar Crater Measurement by SELENE (Kaguya)," 40th Lunar and Planetary Science Conference, (Lunar and Planetary Science XL), held March 23-27, 2009 in The Woodlands, Texas, id.1981.
  - Laser Altimeter (LALT) on board SELENE (Kaguya) can determine anew crater diameter. LALT data is accurate as compared with Clementine LIDAR data. Especially, central peaks seen in LALT data are clearer than those seen in LIDAR data.
- Minamidani, T., N. Mizuno, Y. Mizuno, A. Kawamura, T. Onishi, T. Hasegawa, K. Tatematsu, M. Ikeda, Y. Moriguchi, N. Yamaguchi, J. Ott, T. Wong, E. Muller, J. L. Pineda, A. Hughes, L. Staveley-Smith, U. Klein, A. Mizuno, S. Nikolic, R. S. Booth, A. Heikkila, L. A. Nyman, M. Lerner, G. Garay, S. Kim, M. Rubio, and Y. Fukui [2008a], "An Observational Study of the GMCs in the Magellanic Clouds in Millimeter and Submillimeter Wavelengths," Proc. of the "Galaxies in the Local Volume", eds. B. S. Koribalski and H. Jerjen, Astrophys. Sp. Sci. Proc., pp.311-312.
  - Not Available
- Minamidani, T., N. Mizuno, Y. Mizuno, A. Kawamura, T. Onishi, T. Hasegawa, K. Tatematsu, M. Ikeda, Y. Moriguchi, N. Yamaguchi, J. Ott, T. Wong, E. Muller, J. L. Pineda, A. Hughes, L.

Staveley-Smith, U. Klein, A. Mizuno, S. Nikolic, R. S. Booth, A. Heikkilä, L.-A. Nyman, M. Lerner, G. Garay, S. Kim, M. Fujishita, T. Kawase, M. Rubio, and Y. Fukui,]2008b], "Sub-millimeter Observations of Giant Molecular Clouds in the Large Magellanic Cloud: Temperature and Density as Determined from J=3-2 and J=1-0 transitions of CO," Astrophys. J. Suppl. Ser., vol.175, pp.485-508.

- We have carried out submillimeter ^{12}CO(J=3-2) observations of six giant molecular clouds (GMCs) in the Large Magellanic Cloud (LMC) with the ASTE 10 m submillimeter telescope at a spatial resolution of 5 pc and very high sensitivity. We have identified 32 molecular clumps in the GMCs and revealed significant details of the warm and dense molecular gas with $n(H_2)\sim10^3$-10^5 cm^{-3} and K. These data are combined with ^{12}CO(J=1-0) and ^{13}CO(J=1-0) results and compared with LVG calculations. The results indicate that clumps that we detected are distributed continuously from cool (~10-30 K) to warm (30-200 K), and warm clumps are distributed from less dense (10^3 cm^{-3}) to dense ($10^{3.5}$-10^5 cm^{-3}). We found that the ratio of ^{12}CO(J=3-2) to ^{12}CO(J=1-0) emission is sensitive to and is well correlated with the local Hα flux. We infer that differences of clump properties represent an evolutionary sequence of GMCs in terms of density increase leading to star formation. Type I and II GMCs (starless GMCs and GMCs with Hii regions only, respectively) are at the young phase of star formation where density does not yet become high enough to show active star formation, and Type III GMCs (GMCs with Hii regions and young star clusters) represent the later phase where the average density is increased and the GMCs are forming massive stars. The high kinetic temperature correlated with Hα flux suggests that FUV heating is dominant in the molecular gas of the LMC.

- Minamidani, T., N. Mizuno, Y. Mizuno, A. Kawamura, T. Onishi, K. Tatematsu, T. Hasegawa, M. Ikeda, and Y. Fukui [2009], "An Observational Study of GMCs in the Magellanic Clouds with the ASTE Telescope," Proc. of the IAU Symp. 256, "The Magellanic System: Stars, Gas, and Galaxies", eds. Van Loon. Borin, Joana M. Oliveira, pp.256-260.

- We report the results of the submillimeter observations with the ASTE 10 m telescope toward the giant molecular clouds (GMCs) in the Magellanic Clouds to reveal the physical properties of dense molecular gas, the principle sites of star and cluster formation. Six GMCs in the Large Magellanic Cloud have been mapped in the ^{12}CO(J = 3-2) transition and 32 clumps are identified in these GMCs at a resolution of 5 pc. These data are combined with ^{12}CO(J = 1-0) and ^{13}CO(J = 1-0) results and compared with LVG calculations to derive the density and temperature of clumps. The derived density and temperature are distributed in wide ranges. We have made small mapping observations in the ^{13}CO(J = 3-2) transition toward 9 representative peak positions of clumps to determine the density and temperature of clumps. These physical properties are constrained well and there are differences in density and temperature among clumps. We suggest that these differences of clump properties represent an evolutionary sequence of GMCs in terms of density increase leading to star formation.

- Miura, R., Y. Tamura, S. K. Okumura, R. Kawabe, T. Tosaki, N. Kuno, K. Nakanishi, S. Sakamoto, and T. Hasegawa [2008], "Dense Clouds and Star Formation on Spiral Arm in M33 -deep CO and HCN Observation in NGC604-," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., p.354.

- Without abstract

- Miyawaki, R., M. Hayashi, and T. Hasegawa [2009], "A Large-Scale ^{13}CO Mapping of the W49A molecular Cloud Complex," Publ. Astron. Soc. Japan, vol.61, pp.39-49.

- We present ^{13}CO (J = 1-0) and C^{18}O (J = 1-0) maps of the W 49 A molecular cloud complex observed at a resolution of 1700 (HPBW). Fourteen features (MHH-1 to MHH-14) were identified in the ^{13}CO velocity channel maps, most of them distributed within an area of 60 (20 pc) in diameter with their total mass amounting to 1.7x 10^6 M . The features have a

three-dimensional velocity dispersion of 8 km s^{-1}, which leads to a mean free time per feature of 10^6 yr. This suggests that they are interacting one another in a region of ~20 pc in diameter. The feature MHH-1, which corresponds to W 49 N, is unique in that it exhibits a large velocity width (15 km s^{-1} FWHM) and is compact in size (2.3 pc x 3.0 pc FWHM), while containing a large mass of 2.4 x105 M . This indicates that the free-fall time of MHH-1 is on the order of 10^5 yr, an order of magnitude smaller than that of the entire complex. It has turned out that MHH-1 has a smaller spatial width at V_{LSR} □ 8 km s^{-1} than at □ 8 km s^{-1}. This result, together with the line-pro ˃ le characteristics of various optically thin lines, suggests that at least two massive clouds with different radial velocities exist toward MHH-1. The massive compact feature may have been produced by the interaction of the two different velocity clouds.

- Miyazaki, A., Z.-Q. Shen, M. Miyoshi, M. Tsuboi, and T. Tsutsumi [2008], "Flux variability of Sgr A* at Short Millimeter Wavelengths," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., p.355.
  - Without abstract
- Miyazaki, A., Z.-Q. Shen, J. Li, M. Miyoshi, M. Tsuboi, and T. Tsutsumi [2009], "Flux Variability of Sagittarius A* at Short mm-wavelengths," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.376-379.
  - We performed the monitoring observations of the flux density toward Sgr A*, which is a compact radio source associated with a super-massive black hole located at the dynamical center of the Galaxy, using the Nobeyama Millimeter Array (NMA) and the Australia Telescope Compact Array (ATCA) at mm-wavelengths. Since 1996, the flux monitoring observations using the NMA were carried out in the 3- and 2-mm bands. Then we detected several flares of Sgr A* with typical durations of a few weeks. We also found some intraday variations (IDVs) of Sgr A* in both observing bands. The 3-mm flux observations of Sgr A* using the ATCA in the southern hemisphere were also carried out to detect IDVs with a longer observing window. In the ATCA observations, we detected IDVs of Sgr A* with timescale of a few hour. In these IDVs, the short flux-doubling timescale was estimated to be a few hours, constraining the physical size of flare-emitting region within about a few tens of AU.
- Miyoshi, M., S. Kameno, J. K. Ishitsuka, Z.-Q. Shen, R. Takahashi, and S. Horiuchi [2007], "An Approach Detecting the Event Horizon of Sgr A*," Publ. Natl. Obs. Japan, vol.10, pp.15-23.
  - Imaging the vicinity of a black hole is one of the ultimate goals of VLBI astronomy. The closest massive black hole, Sgr A*, located at the Galactic center, is the leading candidate for such observations. Combined with recent VLBI recording technique and submillimeter radio engineering, we now have sufficient sensitivity for the observations. Here we show performance simulations simulations of submilllimeter VLBI arrays for imaging Sgr A*. Good images are obtained from submillimeter VLBI arrays in the southern hemisphere composed of more than 10 stations. We also note that even with a small array, we can estimate the shadow size and then the mass of the black hole from visibility analysis. Now, all we need is to construct a submillimeter VLBI array in the southern hemisphere if we wish unveil the black hole environment of Agr A*.
- Miyoshi, M. [2008], "Slit-Modulation Imaging Method for Detecting Any Periodic Structure Change in Interferometric Data," Publ. Astron. Soc. Japan, vol.60, pp.1371-1386.
  - We propose a slit-modulation imaging (SMI) method, a new imaging technique for detecting shorter periodic structural changes of interferometric data. Using simulations with artificial visibility data, we show that the SMI method is highly effective in detecting periodic change patterns, of which period is shorter than the observing time span, of interferometric data.
- Miyoshi, M. [2009a], "Re-Analysis of the First Fringe with 2-Beam in the VERA System from

the Archive Data," Publ. Natl. Astron. Obs. Japan, vol.12, pp.1-9.

- We report results from re-analysis of the visibility data of the first 2-beam observations with VERA (VLBI Exploration of Radio Astrometry), previously reported by Honma et al., 2003 (hereafter A2003). Independently we checked the archival data and found the features noted in A2003 were not from the effect of phase referencing by simultaneous differential VLBI but mainly from a removal of large phase change by subtracting an arbitrary fitted curve to the phase variations. The differential phase of the observed H2O masers between W49 North (W49N) and OH~43.8-0.1 did not show a sinusoidal variation with a period of one sidereal day due to a positional offset from the real celestial positions. We therefore could not reproduce the results in A2003 by a normal positional correction estimated from all time data, but could reproduce almost the same phases only for the first hour by adjusting parameters. Using the parameters, we could not suppress the large amount of phase variations for the successive time data that A2003 did not show in their paper. It is appropriate to regard the analysis in A2003 as not being proper for showing the performance of the instrument for phase referencing, which should be demonstrated by other experiments observing several pairs of continuum sources.

- Miyoshi, M., S. Kameno, J. K. Ishitsuka, Z.-Q. Shen, R. Takahashi, and S. Horiuchi [2009b], "An Approach to Detect the Event Horizon in SgrA* Using Ground Based Submillimeter VLBI Array," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.380-383.

- We present here ground-based array simulations for detecting the black hole shadow in Sgr A*. With modest super resolutions, it is easy to obtain the detection and imaging the black hole shadow. Also it is noteworthy that the visibilities from short baselines ranging from 1000 to 2000 km are quite important to the detection. Miyoshi et al. (2007) show the details.

- Mizuno, N. [2009], "The Properties of Molecular Clouds Across the Magellanic System," Proc. of the IAU Symp. 256, "The Magellanic System: Stars, Gas, and Galaxies", eds. Van Loon. Borin, Joana M. Oliveira, pp.203-214.

- Most stars form in Giant Molecular Clouds (GMCs) and regulate the evolution of galaxies in various respects. The formed stars affect the surrounding materials strongly via their UV photons, stellar winds, and supernova explosions, which lead to trigger the formation of next-generations of stars in the GMCs. It is therefore crucial to reveal the distribution and properties of GMCs in a galaxy. The Magellanic System is a unique target to make such detailed comprehensive study of GMCs. This is because it is nearby and the LMC is nearly face-on, making it feasible to unambiguously identify associated young objects within GMCs. Recent millimeter and sub-millimeter observations in the Magellanic System have started to reveal the distribution and properties of the individual GMCs in detail and their relation to star formation activities. From the NANTEN CO surveys, three types of GMCs can be classified in terms of star formation activities; Type I is starless, Type II is with H ii regions only, and Type III is associated with active star formation indicated by huge H ii regions and young star clusters. The further observations to obtain detailed structure of the GMCs by Mopra and SEST and to search for the dense cores by ASTE and NANTEN2 in higher tansition lines of CO have been carried out with an angular resolution of about 5 to 10 pc. These observations revealed that the differences of the physical properties represent an evolutionary sequence of GMCs in terms of density increase leading to star formation. Type I and II GMCs are at the early phase of star formation where density does not yet become high enough to show active star formation, and Type III GMCs represent the later phase where the average density is increased and the GMCs are forming massive stars.

- Mizuno, Y., A. Kawamura, T. Onishi, T. Minamidani, E. Muller, H. Yamamoto, T. Hayakawa,

N. Mizuno, A. Mizuno, J. Stutzki, J. L. Pineda, U. Klein, F. Bertoldi, B.-C. Koo, M. Rubin, M. Burton, A. Benz, H. Ezawa, N. Yamaguchi, K. Kohno, T. Hasegawa, K. Tatematsu, M. Ikeda, J. Ott, T. Wong, A. Hughes, M. Meixner, R. Indebetouw, K. D. Gordon, B. Whitney, J.-P. Bernard, and Y. Fukui [2010], "Warm and dense Molecular Gas in the N159 Region: ^{12}CO J=4-3 and ^{13}CO J=3-2 Observations with NANTEN2 and ASTE," Publ. Astron. Soc. Japan, vol.62, pp.51-67.

- New ^{12}CO J = 4-3 and ^{13}CO J = 3-2 observations of the N 159 region, an active site of massive star formation in the Large Magellanic Cloud, have been made with the NANTEN2 and ASTE submillimeter telescopes, respectively. The ^{12}CO J = 4-3 distribution is separated into three clumps, each associated with N 159 W, N 159 E, and N 159 S. These new measurements toward the three clumps are used in coupled calculations of molecular rotational excitation and line radiation transfer, along with other transitions of the ^{12}CO J = 1-0, J = 2-1, J = 3-2, and J = 7-6 as well as the isotope transitions of ^{13}CO J = 1-0, J = 2-1, J = 3-2, and J = 4-3. The ^{13}CO J = 3-2 data were newly taken for the present work. The temperatures and densities were found to be ~70-80 K and ~3 x 10^3 cm^{-3} in N 159 W and N 159 E, and ~30 K and ~1.6 x 10^3 cm^{-3} in N 159 S. These results were compared with the star-formation activity based on data of young stellar clusters and H II regions as well as midinfrared emission obtained with the Spitzer MIPS. The N 159 E clump is associated with cluster(s) embedded, as observed at 24 μm by the Spitzer MIPS, and the derived high temperature, 80 K, is interpreted as being heated by these sources. The N 159 E clump is likely to be responsible for a dark lane in a large H II region by dust extinction. On the other hand, the N 159 W clump is associated with clusters embedded mainly toward the eastern edge of the clump only. These clusters show offsets of 20" -40" from the ^{12}CO J = 4-3 peak, and are probably responsible for heating indicated by the derived high temperature, 70 K. The N 159 W clump exhibits no sign of star formation toward the ^{12}CO J = 4-3
  peak position and its western region that shows enhanced $R_{4-3/1-0}$ and $R_{3-2/1-0}$ ratios. We therefore suggest that the N 159 W peak represents a pre-star-cluster core of
  ~10^5 M. which deserves further detailed studies. The N 159 S clump shows little sign of star formation, as is consistent with the lower temperature, 30 K, and has a somewhat lower density than N 159 W and N 159 E. The N 159 S clump is also a candidate for future star formation.

- Mochizuki, N., K. Hachisuka, and T. Umemoto [2009], "Survey of Outer Galaxy Molecular Lines Associated with Water Masers," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.384-387.

- H_2O masers in Young stellar objects (YSOs) in our Galaxy are one of the targets of the VSOP-2 science. The advantage of VSOP-2 observation is the highest angular resolution which can detect a proper motion of H_2O masers for distant objects over short time intervals. To find candidate sources, we observed H_2O maser sources in the outer Galaxy using the VLA, and we surveyed the molecular lines toward these sources to understand the environment of YSOs. Higher H_2 column densities of YSOs were found for objects with active H2O masers.

- Momose, M., M. Hiramatsu, T. Tsukagoshi, Y. Shimajiri, N. Ikeda, Y. Kitamura, K. Kamegai, H. Ezawa, R. Kawabe, and M. Saito, [2009], "Wide-field Imaging Survey of Dust Continuum Emissions atλ= 1.1 mm toward the Chamaeleon and Lupus Regions with AzTEC on ASTE," Proc. of the "Exoplanets and disks: their formation and diversity", eds. Usuda, T., Tamura, M., and Ishii, M., AIP Conf. Proc., vol.1158, pp.141-142.

- We carried out an imaging survey of dust continuum emissions toward the Chamaeleon and Lupus regions. Observations were made with the 144-element bolometer array camera AzTEC mounted on the 10-meter sub-millimeter telescope ASTE during 2007-2008. The preliminary

results of disk search and the cloud structure of Lupus III are presented.

- Momose, R., S. K. Okumura, J. Koda, and T. Sawada [2010], "Star Formation Efficiency in the Barred Spiral Galaxy NGC 4303," Astrophys. J., vol.721, pp.383-394.
  - We present new ^{12}CO (J = 1 - 0) observations of the barred galaxy NGC 4303 using the Nobeyama 45 m telescope (NRO45) and the Combined Array for Research in Millimeter-wave Astronomy (CARMA). The Hα images of barred spiral galaxies often show active star formation in spiral arms, but less so in bars. We quantify the difference by measuring star formation rate (SFR) and star formation efficiency (SFE) at a scale where local star formation is spatially resolved. Our CO map covers the central 2'3 region of the galaxy; the combination of NRO45 and CARMA provides a high fidelity image, enabling accurate measurements of molecular gas surface density. We find that SFR and SFE are twice as high in the spiral arms as in the bar. We discuss this difference in the context of the Kennicutt-Schmidt (KS) law, which indicates a constant SFR at a given gas surface density. The KS law breaks down at our native resolution (~250 pc), and substantial smoothing (to 500 pc) is necessary to reproduce the KS law, although with greater scatter.
- Morita, K.-I., and M. A. Holdaway [2008], "The Array Configuration Design of the Atacama Compact Array," Proc. of the SPIE, vol.7012, pp.701200-1-12.
  - The Atacama Compact Array (ACA) is an array composed of twelve 7-m dishes and four 12-m dishes. The ACA is designed for use as a part of the ALMA (Atacama Large Millimeter / Submillimeter Array) to provide high fidelity imaging capability for large extended objects. Basic parameters of the array configuration of the ACA were selected based on the analysis of the sensitivity in uv plane for mosaicing observations with the ACA and the ALMA. For detailed design of the sub-array with 7-m dishes (7-m Array), we adopted the compact spiral concept, which realizes higher uv response at the short uv spacings and better sidelobe performance. To satisfy the sky coverage requirement, the north-south elongation is needed. The 7-m Array was designed to have two configurations, one (Inner Array) is a compact spiral array with small north-south elongation (×1.1) and the other (NS Array) is a dedicated configuration with large north-south elongation (×1.7). In actual design, inner 6 antenna pads are shared by both configurations because of construction constraints.
- Morota, T., J. Haruyama, C. Honda, M. Ohtake, Y. Yokota, J. Kimura, T. Matsunaga, Y. Ogawa, N. Hirata, H. Demura, A. Iwasaki, H. Miyamoto, R. Nakamura, Y. Ishihara, and S. Sasaki [2009a], "Ages and Thicknesses of Mare Basalts in Mare Moscoviense: Results from SELENE (KAGUYA) Terrain Camera Data," 40th Lunar and Planetary Science Conference, (Lunar and Planetary Science XL), held March 23-27, 2009 in The Woodlands, Texas, id.1280. We investigate ages and thicknesses of mare basalts in Mare Moscoviense, which is in the northern hemisphere of the lunar farside, using high-resolution images and digital terrain models (DTMs) obtained by SELENE Terrain Camera (TC).
- Morota, T., J. Haruyama, C. Honda, M. Ohtake, Y. Yokota, J. Kimura, T. Matsunaga, Y. Ogawa, N. Hirata, H. Demura, A. Iwasaki, H. Miyamoto, R. Nakamura, H. Takeda, Y. Ishihara, and S. Sasaki [2009b], "Mare Volcanism in the Lunar Farside Moscoviense Region: Implication for Lateral Variation in Magma Production of the Moon," Geophys. Res. Letters, vol.36, CiteID L21202-1-5.
  - Accurate estimates of the duration and volume of extrusive volcanism of the Moon are essential for understanding the lunar thermal evolution. Here, using new high-resolution images obtained by the SELENE Terrain Camera, we determined the thicknesses and ages of basalts in Mare Moscoviense, one of the most prominent mare deposits on the farside. Mare volcanism in Mare Moscoviense was active for at least ~1.5 Ga following the formation of the Moscoviense basin. Mare basalts are estimated to be at least 600 m thick, corresponding to a total volume of 9,500-16,000 km^3. The long duration and large volume of extrusive volcanism

are plausibly attributed to the thinner crust of the Moscoviense basin relative to those of other farside basins. From a comparison with mare volume within a same-sized nearside basin, we concluded that a magma production in the farside mantle was 3-10 times less than that of the nearside.

- Morota, T., J. Haruyama, M. Ohtake, T. Matsunaga, Y. Yokota, C. Honda, T. Sugihara, J. Kimura, Y. Ishihara, T. Kawamura, A. Iwasaki, K. Saiki, and H. Takeda [2010], "Mare Volcanism on the Farside and in the Oriental Region of the Moon," LPI Contribution No. 1533, p.1309.
  - Dating of lunar mare basalts is necessary for understanding the volcanic history of the Moon. Here we performed new crater counts in mare deposits on the farside and in the Orientale region, using new images obtained by SELENE Terrain Camera.
- Motogi, K., Y. Watanabe, K. Sorai, M. Honma, H. Imai, A. Yamauchi, H. Kobayashi, K. Fujisawa, T. Omodaka, H. Takaba, K. M. Shibata, T. Minamidani, K. Wakamatsu, H. Sudou, E. Kawai, and Y. Koyama [2008], "Microstructure and Kinematics of H_2O Masers in the Massive Star Forming Region IRAS 06061+2151," Mon. Not. Roy. Astron. Soc., vol.390, pp.523-234.
  - We have made multi-epoch very long baseline interferometer (VLBI) observations of H_2O maser emission in the massive star-forming region IRAS 06061+2151 with the Japanese VLBI network (JVN) from 2005 May to 2007 October. The detected maser features are distributed within a 1 x 1 arcsec^2 area (2000 x 2000 au^2 at the source position) around the ultracompact Hii region seen in radio continuum emission. The bipolar morphology and expanding motion traced through their relative proper motions indicate that they are excited by an energetic bipolar outflow. Our three-dimensional model fitting has shown that the maser kinematical structure in IRAS 06061+2151 can be explained by a biconical outflow with a large opening angle (>50°). The position angle of the flow major axis coincides very well with that of the large-scale jet seen in 2.1μm hydrogen emission. This maser geometry indicates the existence of dual structures composed of a collimated jet and a less collimated massive molecular flow. We have also detected a large velocity gradient in the southern maser group. This can be explained by a very small (on a scale of several tens of astronomical units) and clumpy (the density contrast by an order of magnitude or more) structure of the parental cloud. Such a structure may be formed by strong instability of the shock front or splitting of the high density core.
- Muller, E., J. Ott, A. Hughes, J. Pineda, T. Wong, N. Mizuno, A. Kawamura, Y. Mizuno, Y. Fukui, T. Onishi, and M. Rubio [2010], "Characterizing the Low-Mass Molecular Component in the Northern Small Magellanic Cloud," Astrophys. J., vol.712, pp.1248-1258.
  - We present here the first results from a high-resolution survey of the ^{12}CO(J=1-0) emission across the northern part of the poorly enriched Small Magellanic Cloud (SMC), made with the ATNF Mopra telescope. Three molecular complexes detected in the lower resolution NANTEN survey are mapped with a beam FWHM of ~42", to sensitivities of approximately 210 mK per 0.9 km s^{-1} channel, resolving each complex into 4-7 small clouds of masses in the range of $M_{vir} \sim 10^3$-10^4 M_{sun} and with radii no larger than 16 pc. The northern SMC CO clouds follow similar empirical relationships to the southern SMC population, yet they appear relatively under-luminous for their size, suggesting that the star-forming environment in the SMC is not homogeneous. Our data also suggests that the CO cloud population has little or no extended CO envelope on scales gsim30 pc, further evidence that the weak CO component in the north SMC is being disassociated by penetrating UV radiation. The new high-resolution data provide evidence for a variable correlation of the CO integrated brightness with integrated H I and 160 μm emission; in particular CO is often, but not always, found coincident with peaks of 160 μm emission, verifying the need for matching-resolution 160 μm and H I data for a complete assessment of the SMC H_2 mass.

- Muraoka, K., K. Kohno, T. Tosaki, N. Kuno, K. Nakanishi, K. Sorai, and S. Sakamoto [2008], "CO(3-2) Wide Area Imaging of M83 with ASTE: Correlation between CO(3-2)/CO(1-0) Ratios and Star Formation Efficiencies," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., p.357.
  - Without abstract
- Muraoka, K., K. Kohno, T. Tosaki, N. Kuno, K. Nakanishi, K. Sorai, S. Ishizuki, T. Handa, and T. Okuda, [2009a], "Nobeyama Millimeter Array Observations of the Nuclear Starburst of M83: A GMA Scale Correlation between Dense Gas Fraction and Star Formation Efficiency," Publ. Astron. Soc. Japan, vol.61, pp.163-176.
  - We present aperture synthesis high-resolution (~7"x3") observations in CO (J = 1-0), HCN (J = 1-0), and 95 GHz continuum emission toward the central (~1.5 kpc) region of the nearby barred spiral galaxy M 83 with the Nobeyama Millimeter Array. Our high-resolution CO (J = 1-0) mosaic map depicts the presence of molecular ridges along the leading sides of the stellar bar and a nuclear twin peak structure, whereas the distributions of the HCN (J = 1-0) emission that traces dense molecular gas (nH_2 > a few x 10^4 cm^{-3}) and the 95 GHz continuum emission that traces massive starburst show nuclear single-peak structures. The HCN (J = 1-0) and the 95 GHz continuum peaks are not spatially coincident with the optical starburst regions traced by the HST V -band image, suggesting the existence of deeply buried ongoing starburst due to strong extinction (A_V ~ 5 mag) near these peaks. We found that the HCN (J = 1-0)/CO (J = 1-0) intensity ratio, RHCN/CO correlates well with the extinction-corrected star formation efficiency (SFE) in the central region of M 83 at a resolution of 7".5 (~160 pc). This suggests that SFE is controlled by a dense gas fraction traced by $R_{HCN/CO}$, even on a Giant Molecular cloud Association (GMA) scale. Moreover, the correlation between $R_{HCN/CO}$ and SFE in M 83 seems to be almost coincident with that among the Gao and Solomon (2004a, ApJ, 606, 271) sample. This suggests that the correlation between $R_{HCN/CO}$ and the SFE on a GMA (~160 pc) scale found in M 83 is the origin of the global correlation on a few kpc scale shown by Gao and Solomon (2004a).
- Muraoka, K., K. Kohno, T. Tosaki, N. Kuno, K. Nakanishi, K. Sorai, T. Sawada, K. Tanaka, T. Handa, M. Fukuhara, H. Ezawa, and R. Kawabe, [2009b], "ASTE CO(3-2) Mapping toward the Whole Optical Disk of M 83: Properties of Inter-arm Giant Molecular-Cloud Associations," Astrophys. J., vol.706, pp.1213-1225.
  - We present a new on-the-fly mapping of CO (J = 3-2) line emission with the Atacama Submillimeter Telescope Experiment toward the 8'x8' (or 10.5x10.5 kpc at the distance of 4.5 Mpc) region of the nearby barred spiral galaxy M 83 at an effective resolution of 25". Due to its very high sensitivity, our CO (J = 3 - 2) map can depict not only spiral arm structures but also spur-like substructures extended in inter-arm regions. This spur-like substructures in CO (J = 3-2) emission are well coincident with the distribution of massive star-forming regions traced by Hα luminosity and Spitzer/Infrared Array Camera 8 m emission. We have identified 54 CO (J = 3-2) clumps as Giant Molecular-cloud Associations (GMAs) employing the CLUMPFIND algorithm, and have obtained their sizes, velocity dispersions, virial masses, and CO luminosity masses. We found that the virial parameter α, which is defined as the ratio of the virial mass to the CO luminosity mass, is almost unity for GMAs in spiral arms, whereas there exist some GMAs whose are 3-10 in the inter-arm region. We found that GMAs with higher α tend not to be associated with massive star-forming regions, while other virialized GMAs are. Since α mainly depends on velocity dispersion of the GMA, we suppose that the onset of star formation in these unvirialized GMAs with higher α are suppressed by an increase in internal velocity dispersions of giant molecular clouds within these GMAs due to shear motion.
- Murata, Y., N. Mochizuki, H. Saito, H. Hirabayashi, M. Inoue, H. Kobayashi, P. D. Edwards,

and the Next Generation Space VLBI Working Group [2008], "The Next Generation Space VLBI Project, VSOP-2," Proc. of the IAU Symp. 242, "Astrophysical Masers and their Environments", eds. Jessica Chapman and Willem Baan, pp.517-521.

- The first dedicated space-VLBI project, the VLBI Space Observatory Programme (VSOP), commenced with the successful launch of radio-astronomical satellite HALCA in 1997. Plans for a second generation space-VLBI project have been made by a working group over a number of years. This project, VSOP-2, has now been approved by Japan's space agency, JAXA, as the ASTRO-G project. It is planned for the spacecraft to observe in the 8, 22 and 43 GHz bands with cooled receivers for the two higher bands, which include important maser lines. It will have a maximum angular resolution at 43 GHz (7 mm) of about 40 micro-arcseconds. Although the VSOP project mainly observed continuum emission from active galactic nuclei (AGN), VSOP-2/ASTRO-G is expected to enable a variety of high angular resolution maser line observations.

- Nagai, H., M. Inoue, K. Asada, S. Kameno, and A. Doi [2008], "Kinematic Aging and Spectral Aging in Young Radio Galaxies," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., p.358.

- Without abstract

- Nagai, H., K. Asada, A. Doi, M. Kino, S. Kameno, and VSOP-2 Science Working Group [2009], "Disk-Jet Connection in the Nearby Low Luminosity AGN M 81: A Proposal for VSOP-2 Key Science Program," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.110-111.

- We propose a monitoring observation to probe the disk-jet connection in the nearby low luminosity AGN M 81 with VSOP-2 and an X-ray telescope. M 81 is the nearest Active Galactic Nuclei and VSOP-2 can resolve the region near the central black hole and jet-launching region. This proposal is one of the Key Science Programs.

- Nagai, H., K. Suzuki, K. Asada, M. Kino, S. Kameno, A. Doi, M. Inoue, J. Kataoka, U. Bach, T. Hirota, N. Matsumoto, M. Honma, H. Kobayashi, and K. Fujisawa [2010], "VLBI Monitoring of 3C 84 (NGC 1275) in Early Phase of the 2005 Outburst," Publ. Astron. Soc. Japan, vol.62, pp.L11-L15.

- Multi-epoch Very Long Baseline Interferometry (VLBI) study of a sub-pc scale jet of 3C 84 is presented. We carried out 14-epoch VLBI observations during 2006-2009 with the Japanese VLBI Network and the VLBI Exploration of Radio Astrometry, immediately following a radio outburst that began in 2005. We confirmed that the outburst was associated with the central ~1 pc core accompanying the emergence of a new component. This is striking evidence of the recurrence of jet activity. The new component became brighter during 2008, in contrast to constant γ-ray emission that was observed with the Fermi Gamma-ray Space Telescope during the same time. We found that the projected speed of the new component was 0.23 c from 2007/297 (2007 October 24) to 2009/114 (2009 April 24). The direction of movement of this component differs from that of the pre-existing component by ~40°. This was the first measurement of the kinematics of a sub-pc jet in a γ-ray active phase. A possible detection of jet deceleration and the jet kinematics in connection with theγ-ray emission is discussed.

- Nagai, M., T. Oka, S. Yamamoto, Y. Moriguchi, Y. Fukui, and Y. Sekimoto [2008], " High-Velocity [CI] Wing Emission Toward the M71 Molecular Cloud," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., 359.

- Without Abstract

- Nagayama, T., T. Omodaka, T. Handa, T. Sawada, H. B. Iahak, and N. Matsuyama [2008a], "A Wide Survey in NH3 Lines of the Central 200 pc Around the Galactic Center with Kagoshima 6 Meter Radio Telescope," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada,

K., and Combes, F., p.361.

- Without abstract

- Nagayama, T., A. Nakagawa, H. Imai, T. Omodaka, and Y. Sofue [2008b], "VLBI Observations of Water Masers in Onsala1: Massive Binary Star-Forming Site?," Publ. Astron. Soc. Japan, vol.60, pp.183-190.

- We present the proper motions of water masers toward the Onsala 1 star-forming region, observed with the Japanese VLBI network at three epochs spanning 290 days. We found that there are two-water maser clusters (WMC1 and WMC2) separated from each other by 1".6 (2900 AU at a distance of 1.8 kpc). A proper-motion measurement reveals that WMC1 is associated with a bipolar outflow elongated in the east-west direction with an expansion velocity of 69±11 km s^{-1}. WMC1 and WMC2 are associated with two 345 GHz continuum dust emission sources, which were located 2" (3600 AU) east from the core of an ultracompact HII region traced by 8.4 GHz radio continuum emission. This indicates that the star-formation activity of Onsala 1 could move from the west side of the ultracompact HII region to the east side of two young stellar objects associated with the water masers. We have also find that WMC1 and UC HII regions could be gravitationally bound. Their relative velocity along the line of sight is ~3 km s^{-1}, and total mass is ~37 Mo. Onsala 1 seems to harbor a binary star at a different evolutionary stage.

- Nagayama, T., K. Takeda, T. Omodaka, H. Imai, S. Kameno, Y. Sofue, A. Doi, K. Fujisawa, A. Habe, M. Honma, N. Kawaguchi, E. Kawai, H. Kobayashi, Y. Koyama, Y. Murata, K. Sorai, H. Sudou, H. Takaba, S. Tamura, and K. Wakamatsu [2008c], "H_2O Maser Outflow from the Red Supergiant Star NML Cygni Observed with Japanese VLBI Network," Publ. Astron. Soc. Japan, vol.60, pp.1069-1075.

- We present the proper motions of H_20 masers in NML Cygni, observed with the Japanese VLB Network at three epoch spanning 455 d. We detected about 15 maser features at each epoch. Overall, 13 features that were detected at least twice were tracked by their radial velocities and proper motions. The three-dimensional kinematics of the maser features indicate the presence of an expanding outflow. The major axis of the outflow is estimated to be at a position angle of ~ 108°, and an inclination angle of ~ 8° with respect to the line of sight. The H_2O masers are located between an apparent minimum radius of ~ 9.6 x 10^{12} m (64 AU) and a maximum radius of ~ 3.0 x 10^{13} m (202 AU), where the expansion velocity increases from 12 to 27 km s^{-1}. A comparison with the distributions of SiO, H_2O, and OH masers suggests that the outflow of NML Cygni is expanding outside a radius of ~ 1.5 x 10^{13} m (100 AU). This radius corresponds to 6 stellar radii, and is consistent with the radius of the inner boundary for the dust shell.

- Nagayama, T., S. Sato, S. Nishiyama, Y. Murai, T. Nagata, H. Hatano, M. Kurita, M. Tamura, Y. Nakajima, K. Sugitani, T. OKa, and Y. Sofue [2009a], "A Chain of Dark Clouds in Projection Against the Galactic Center," Publ. Astron. Soc. Japan, vol.61, pp.283-290.

- In a J, H, and KS band survey of the Galactic center region over an area of 2°
  x 5°, we have found many dark clouds, among which a distinguished chain of dark clouds can be identified with a quiescent CO cloud. The distances of the clouds are estimated to be 3.2-4.2kpc, corresponding to the Norma arm, by our new method for determining the distances to dark clouds using the cumulative number of stars against the J - KS color. By adopting these estimated distances, the size and total mass of the cloud are estimated to be ~70 pc in length and 6 x 10^4 $M_\odot$,
  respectively. Three compact H II regions exist in the cloud, indicating that star forming activities are going on at the cores of the quiescent CO cloud on the spiral arm.

- Nagayama, T., T. Omodaka, T. Handa, H. Toujima, Y. Sofue, T. Sawada, H. Kobayashi, and Y. Koyama [2009b], "NH3 in the Galactic Center is formed Cool Contributions," Publ. Astron. Soc. Japan, vol.61, pp.1023-1037.

- It is an open question as to why the temperature of molecular gas in the Galactic center region is higher than that of dust. To address this problem, we made simultaneous observations in the NH_3 (J,K) = (1, 1), (2, 2), and (3, 3) lines of the central molecular zone (CMZ) using the Kagoshima 6-m telescope. The ortho-to-para ratio of NH_3 molecules in the CMZ is 1.5-3.5 at most in the observed area. This ratio is higher than the statistical equilibrium value, and suggests that the formation temperature of NH_3 is 11-20 K. This temperature is similar to the dust temperature estimated from the submillimeter and infrared continuum. This result suggests that the NH3 molecules in the CMZ were produced on dust grains with the currently observed temperature (11-20 K), and they were released into the gas phase by supernova shocks or collisions of dust particles. The discrepancy between warm molecular gas and cold dust can be explained by transient heating of the interstellar media in the CMZ approximately 10^5 yr ago when NH3 molecules were released from the dust.

- Nakagawa, A., T. Omodaka, K. M. Shibata, T. Kurayama, H. Imai, S. Kameno, M. Tsushima, M. Shintani, N. Matsumoto, M. Matsui, S. Oizumi, T. Yasuda, and Y. Arao [2008a], "VLBI Monitoring of Mira Variables with VERA," Proc. of the IAU Symp. 242, "Astrophysical Masers and their Environments", eds. Jessica Chapman and Willem Baan, pp.326-327.

- We have started a VLBI monitoring program for Asymptotic Giant Branch (AGB) stars at 22 and 43 GHz as part of a project of the VLBI Exploration of Radio Astrometry (VERA) for precisely obtaining the period-luminosity (PL) relation of Galactic Mira variables. Using accurate distances measured with VERA, we reveal PL relation in the Galaxy based on the absolute magnitudes of the sources. We selected the sources for VLBI monitoring so that they have a good coverage of various pulsation periods. Photometry in the infrared J, H, and K bands for over 600 AGB stars has also started since 2003 with the 1m telescope of Kagoshima University to obtain the pulsation periods and magnitudes. Current analysis of the phase referencing VLBI observations of S Crt shows that the parallax of 2.3±0.2 milliarcsec (mas) corresponds to a distance of 435^{+41}_{-35} pc. From the infrared monitoring data, pulsation periods and magnitudes in K band for 248 sources were obtained.

- Nakagawa, A., T. Omodaka, K. M. Shibata, T. Kurayama, H. Imai, S. Kameno, M. Tsushima, N. Matsumoto, and M. Matsui [2008b], "Parallax Measurement of the Galactic Mira Variables with VERA," Proc. of the IAU Symp. 248, "A Giant Step: from Milli- to Micro-arcsecond Astrometry", eds. Wenjing Jin, Imants Platais, Michael A. C. Perryman, pp.206-207.

- Parallax measurements of the Galactic Mira variables with VERA have started since 2004 to establish their Period-Luminosity (PL) relationship in the Galaxy. Multi-epoch VLBI observations of a semiregular variable S Crt yielded an accurate parallax of 2.27±0.14 mas corresponding to the distance of 441^{+29}_{-24} pc. In addition to the distance, we obtained physical properties of S Crt. Temperature of the photosphere was found to be ~3000 K by fitting the infrared spectrum with a blackbody radiation. The stellar radius was obtained based on the distance, apparent magnitude, and the temperature. Internal proper motions of circularly-arranged maser spots in S Crt were detected for the first time. Observations of the other Mira variables, such as R UMa, SY Scl, AP Lyn, and WX Psc are in progress.

- Nakagawa, A., M. Tsushima, K. Ando, T. Bushimata, Y. K. Choi, T. Hirota, M. Honma, H. Imai, K. Iwadate, T. Jike, S. Kameno, O. Kameya, R. Kamohara, Y. Kan-Ya, N. Kawaguchi, M. Kijima, M. K. Kim, H. Kobayashi, S. Kuji, T. Kurayama, T. Maeda, S. Manabe, K. Maruyama, M. Matsui, N. Matsumoto, T. Miyaji, T. Nagayama, K. Nakamura, D. Nyu, C. S. Oh, T. Omodaka, T. Oyama, N. Pradel, S. Sakai, T. Sasao, K. Sato, M. Sato, K. M. Shibata, H. Suda, Y. Tamura, K. Ueda, Y. Ueno, and K. Yamashita [2008c], "VLBI Astrometry of AGB Variables with VERA - A Semiregular Variable S Crateris -," Publ. Astron. Soc. Japan, vol.60, pp.1013-1021.

- We present a distance measurement for the semiregular variable S Crateris (S Crt) based on its

annual parallax. With the unique dual beam system of the VLBI Exploration for Radio Astrometry (VERA) telescopes, we measured the absolute proper motion of a water maser spot associated with S Crt, referred to the quasar J1147-0724 located at an angular separation of 1.°23. In observations spanning nearly two years, we detected the maser spot at an LSR velocity of 34.7 km s-1, for which we measured an annual parallax of 2.33±0.13 mas, corresponding to a distance of 430^{+25}_{-23} pc. This measurement has an accuracy one order of magnitude better than the parallax measurements of HIPPARCOS. The angular distribution and three-dimensional velocity field of maser spots indicate a bipolar outflow with the flow axis along the northeast-southwest direction. Using the distance and photospheric temperature, we estimate the stellar radius of S Crt and compare it with those of Mira variables.

- Nakagawa, H., Y. Kasaba, H. Maezawa, A. Hashimoto, H. Sagawa, I. Murata, S. Okano, S. Aoki, N. Moribe, A. Mizuno, M. Momose, T. Ohnishi, N. Mizuno, and T. Nagahama [2009], "Search of SO2 in the Martian Atmosphere by Ground-Based Submillimeter Observation," Planetary and Sp. Sci., vol.57, pp.2123-2127.

  - We searched sulfur oxide (SO2 and SO) in the Martian atmosphere by the Atacama Submillimeter Telescope Experiment (ASTE). Sulfur oxide is one of the most evident species in terrestrial volcanic gases. Although it has not yet been detected at Mars, this detection can constraint the Martian crustal and volcanic activities. We observed northern winter of Mars on 26 December 2007 (Ls=8.1°) in 346 GHz range with ~1h integration. We get the upper limit of the SO_2 mixing ratio, 2 ppb. This is mostly equivalent to the value observed in northern summer (Ls=205°) (Krasnopolsky, 2005). We concluded that the crustal or volcanic gas produced into the atmosphere is tenuous in northern winter. Even at Mars, it can be expected that the crustal or volcanic gas includes non-negligible amount of SO_2 produced as degasification from the magma. Our result and recent detections of CH_4 suggest a possibility of some kind of carbon hydride sources under the ground reservoir, independent of usual crustal and volcanic activities.

- Nakagawa, H., Y. Kasaba, S. Aoki, I. Murata, H. Maezawa, S. Okano, H. Sagawa, and Y. Kasai [2010], "High Spectral Resolution Observations of Martin Atmosphere in Infrared - Submillimeter Rang from Ground-Based Instruments," Geophys. Res. Abstracts, vol.12, pp.EGU2010-2010-1.

  - With increased knowledge on our “neighbor” planets Mars and Venus, based on recent aggressive explorations by the US and Europe, our image on them is changing significantly. In particular, Mars is called ‘a frozen water planet’. It is almost certain that Mars once had duration with warm and wet climate [Head et al., 1999; Donahue, 1995; Parker et al., 1993]. It still conserves a large amount of water ice under the surface [Boynton et al., 2002; Mitrofanov et al., 2002; Feldman et al., 2002]. The question “Why and when did they diverge?” is essential for their environments which potentially could create and keep the life or not. Many molecules in planetary atmospheres show transitions in the mid infrared - submillimeter region. Thus, high-resolution spectroscopy in this region is significantly indispensable to study planetary atmospheres.

    We searched sulfur oxide (SO2 and SO) in the Martian atmosphere by the Atacama Submillimeter Telescope Experiment (ASTE). Sulfur oxide is one of the most evident species in terrestrial volcanic gases. Although it has not yet been detected at Mars, this detection can constraint the Martian crustal and volcanic activities. We observed northern winter of Mars on 26/Dec./2007 (Ls=8.1) in 346 GHz range with ~1h integration, and got the upper limit of the SO2 mixing ratio, 2 ppb. We concluded that the crustal or volcanic gas produced into the atmosphere is tenuous in northern winter [Nakagawa et al., 2009].

    Infrared heterodyne spectroscopy has proven to be a powerful tool for astrophysical studies. To achieve highest spectral resolution and sensitivity as well as compact instrumentation

heterodyne systems are advantageous over direct-detection methods. Our group in Tohoku University has developed own heterodyne system for infrared spectrometer for Earth's atmosphere over the past 20 years. The failure of earlier attempts to build tunable systems using tunable diode lasers was due mostly to insufficient laser power. Recently, quantum cascade lasers (QCLs) offer sufficient optical output power of several milliwatts to guarantee an efficient heterodyning process and high system sensitivity. The use of QCLs in our system led to a breakthrough giving the heterodyne infrared spectrometer for planetary atmosphere. We report experiments evaluating the feasibility of QCLs at mid-infrared wavelengths for use as local oscillator (LO) in a heterodyne receiver. Performance tests with the QCL provided by Hamamatsu Photonics (operating at 7.7 um), and QCL provided by Maxion Technologies(operating at 10.6 um in room temperature) were evaluated.

- Nakajima, T., T. Sakai, S. Asayama, K. Kimura, M. Kawamura, Y. Yonekura, H. Ogawa, N. Kuno, T. Noguchi, M. Tsuboi, and R. Kawabe [2008a], "Development of a Waveguide-Type Dual-Polarization Sideband-Separating SIS Receiver System in 100 GHz Band for the NRO 45-m Radio Telescope," Proc. of the 19th International Symposium on Space THz Technology, ed. Wolfgang Wild, pp.286-291.
  - We developed a waveguide-type dual-polarization sideband-separating SIS receiver system of the 100-GHz band for the 45-m radio telescope at the Nobeyama Radio Observatory, Japan. This receiver is composed of an ortho-mode transducer and two sideband-separating SIS mixers, which are both based on the waveguide technique. The receiver has four intermediate frequency (IF) bands of 4.0-8.0 GHz. Over the radio frequency range of 80-120 GHz, the single-sideband receiver noise temperatures are 50-100 K and the image rejection ratios are greater than 10 dB. The new receiver system was installed in the telescope, and we successfully observed the ^{12}CO, ^{13}CO, $C^{18}O$ and the other emission lines simultaneously toward the Sagittarius B2 region to confirm the performance of the receiver system.
- Nakajima, T., T. Sakai, S. Asayama, K. Kimura, M. Kawamura, Y. Yonekura, H. Ogawa, N. Kuno, T. Noguchi, M. Tsuboi, and R. Kawabe [2008b], "A New 100-GHz Band Front-End System with a Waveguide-Type Dual-Polarization Sideband-Separating SIS Receiver for the NRO 45-m Radio Telescope," Publ. Astron. Soc. Japan, vol.60, pp.435-443.
  - We developed a waveguide-type dual-polarization sideband-separating SIS receiver system of the 100-GHz band for the 45-m radio telescope at the Nobeyama Radio Observatory, Japan. This receiver is composed of an ortho-mode transducer and two sideband-separating SIS mixers, which are both based on the waveguide technique. The receiver has four intermediate frequency bands of 4.0-8.0 GHz. Over the radio frequency range of 80-120 GHz, the single-sideband receiver noise temperatures are 50-100 K and the image rejection ratios are greater than 10 dB. We developed new matching optics for the telescope beam as well as new IF chains for the four IF signals. The new receiver system was installed in the telescope, and we successfully observed the ^{12}CO, ^{13}CO and $C^{18}O$ emission lines simultaneously toward the Sagittarius B2 region to confirm the performance of the receiver system. The SSB noise temperature of the system, including the atmosphere, became approximately half of that of the previous receiver system. The Image Rejection Ratios (IRRs) of the two 2SB mixers were calculated from the ^{12}CO and HCO^+ spectra from the W51 giant molecular cloud, resulting in > 20 dB for one polarization and > 12 dB for the other polarization.
- Nakajima, T., T. Sakai, N. Kuno, and H. Ogawa [2010], "Development of the Measurement System of Image Rejection Ratio for the Sideband-Separating Receiver," J. Infrared Milli. Terahz. Waves, vol.31, pp.143-150.
  - We developed a measurement system of image rejection ratio for the sideband-separating receiver. This system comprises a horn moved by a motor slider, a harmonic mixer and a signal generator. We have installed the system on the Nobeyama 45-m millimeter telescope and

compared the image rejection ratio measured by this system with that obtained from molecular line observations of celestial objects. We confirmed that we can measure image rejection ratio with an accuracy of ±10% with our system. By using the system, we can tune the applied bias voltage of mixer chips to the best performance of image rejection ratio and accurate calibration of the intensity of molecular line observations becomes possible. This is the first IRR measurement system developed for practical use with the 2SB receiver system.

- Nakanishi, K., N. Sato, N. Kuno, S. K. Okumura, R. Kawabe, K. Kohno, A. Yamauchi, and N.Nakai [2008], "Radio Continuum and Water Vapor Maser Monitoring Toward the Luminous Infrared Galaxy NGC 6240," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., p.364.
  - Without abstract
- Nakashima, J., and S. Deguchi [2007], "Correlation between Infrared Colors and Intensity Ratos of SiO Maser Lines," Astrophys. J., vol.669, pp.446-458.
  - We present the results of SiO millimeter line observations of a sample of known SiO maser sources covering a wide dust temperature range. A cold part of the sample was selected from the SiO maser sources found in our recent SiO maser survey of cold dusty objects. The aim of the present research is to investigate the causes of the correlation between infrared colors and SiO maser intensity ratios among different transition lines. In particular, the correlation between infrared colors and SiO maser intensity ratio among the J=1-0 v=1, 2, and 3 lines are our main concern in this paper. We observed in total 75 SiO maser sources with the Nobeyama 45 m telescope quasi-simultaneously in the SiO J=1-0 v=0, 1, 2, 3, 4 and J=2-1 v=1, 2 lines. We also observed the sample in the ^{29}SiO J=1-0 v=0 and J=2-1 v=0 lines, ^{30}SiO J=1-0 v=0 line, and the H_2O $6_{1,6}$-$5_{2,3}$ line. As reported in previous papers, we confirmed that the intensity ratios of the SiO J=1-0 v=2 to v=1 lines clearly correlate with infrared colors. In addition, we found possible correlation between infrared colors and the intensity ratios of the SiO J=1-0 v=3 to v=1 and 2 lines. Two overlap lines of H_2O (i.e., $11_{6,6}$ ν_2=1→$12_{7,5}$ ν2=0 and $5_{0,5}$ ν_2=2→$6_{3,4}$ ν2=1) might explain this correlation if these overlap lines become stronger with an increase of infrared colors, although the phenomena also might be explained in more fundamental ways if we take into account the variation of opacity from object to object.
- Nakashima, J., and S. Deguchi [2008a], "SiO Maser Observations of a Wide Dust-Temperature Range Sample," Proc. of the IAU Symp. 242, "Astrophysical Masers and their Environments", eds. Jessica Chapman and Willem Baan, pp.266-270.
  - We present the results of SiO line observations of a sample of known SiO maser sources covering a wide dust-temperature range. The aim of the present research is to investigate the causes of the correlation between infrared colors and SiO maser intensity ratios among different transition lines. We observed in total 75 SiO maser sources with the Nobeyama 45m telescope quasi-simultaneously in the SiO J = 1-0 v = 0, 1, 2, 3, 4 and J = 2-1 v = 1, 2 lines. We also observed the sample in the ^{29}SiO J = 1-0 v = 0 and J = 2-1 v = 0, and ^{30}SiO J = 1-0 v = 0 lines, and the H_2O $6_{1,6}$-$5_{2,3}$ line. As reported in previous papers, we confirmed that the intensity ratios of the SiO J = 1-0 v = 2 to v = 1 lines clearly correlate with infrared colors. In addition, we found possible correlation between infrared colors and the intensity ratios of the SiO J = 1-0 v = 3 to v = 1&2 lines.
- Nakashima, J., S. Deguchi, H. Imai, and A. Kembell [2008b], "Molecular Line Observations of the SiO Maser Source IRAS 19312+1950," Proc. of the IAU Symp. 251, "Organic Matter in Space", eds. S. Kwok, and S. Sandford, pp.165-166.
  - IRAS 19312+1950 is a unique SiO maser source, exhibiting a rich set of molecular radio lines, although SiO maser sources are usually identified as oxygen-rich evolved stars, in which chemistry is relatively simple comparing with carbon-rich environments. The rich chemistry of IRAS 19312+1950 has raised a problem in circumstellar chemistry if this object is really an

oxygen-rich evolved star, but its evolutional status is still controversial. In this paper, we briefly review the previous observations of IRAS 19312+1950, as well as presenting preliminary results of recent VLBI observations in maser lines. PDF file of the poster is available from http://www.geocities.jp/nakashima_junichi/

- Namiki, N., T. Iwata, K. Matsumoto, H. Hanada, H. Noda, M. Ogawa, N. Kawano, K. Asari, S. Tsuruta, S. Goossens, Q. Liu, F. Kikuchi, Y. Ishihara, T. Ishikawa, S. Sasaki, and C. Aoshima [2008a], "Initial Results of Gravity Experiment by Four-Way Doppler Measurement of Kaguya (SELENE)," 39th Lunar and Planetary Science Conference, (Lunar and Planetary Science XXXIX), held March 10-14, 2008 in League City, Texas. LPI Contribution No. 1391, p.1596.
  - Current lunar gravity field models include large uncertainties on the far side of the Moon. We developed a satellite-to-satellite Doppler tracking sub-system on Kaguya. New results of direct tracking data on the far side will be discussed.
- Namiki, N., H. Hanada, T. Iwata, Rsat Team, Vrad Team, and Lalt Team [2008b], "Lunar Far Side Gravity from the Kaguya (SELENE) Mission and Dichotomy of the Moon," Meteoritics and Planetary Sci. Suppl., 43, paper id. 5193, 2008.
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- Namiki, N., H. Hanada, T. Iwata, R. Team, V. Team, and L. Team [2008c], "Lunar Far Side Gravity From SELENE Mission And Dichotomy of the Moon," American Geophysical Union, Fall Meeting 2008, abstract #P13E-02.
  - Current lunar gravity field models include large uncertainties on the far side of the Moon. We developed a satellite-to-satellite Doppler tracking sub-system (RSAT) on SELENE (KAGUYA). Main function of RSAT is to relay Doppler tracking signals between the main orbiter (MAIN) over the far side and ground-based antenna. When MAIN is orbiting over the far side of the Moon, tracking signal in S band is relayed by Rstar to MAIN. Then MAIN returns the tracking signal to Rstar to downlink a coherent Doppler signal to the antenna. RSAT realizes the first direct observation of the gravity field over the far side of the moon. The most recent lunar gravity models from SELENE enable global gravity anomaly mapping of the Moon up to degrees as high as 100. Gravity anomaly of our new models on the near side is almost identical with that of Lunar Prospector, however, gravity anomaly map on the far side reveals dramatic improvement. Gravity signatures over far-side basins that used to be recognized as linear features are now identified as circular anomaly. New gravity model reveals a marked difference of gravity signatures between the near side and the far side. It has been well known that near-side gravity anomaly is dominated by mascons, that is, positive gravity anomaly indicating mantle uplift beneath basins. In contrast, far-side gravity field is characterized by rings of negative free-air anomaly over basins and large craters. Bouguer gravity anomaly map shows that such negative anomaly can be mostly attributed to topographic depression of basin, and that contribution of Moho variation is minor. Our new models suggest that elastic thickness of lithosphere was thin on the near side while was thick on the far side, and propose an important constraint on the origin of dichotomy.
- Namiki, N., T. Iwata, K. Matsumoto, H. Hanada, H. Noda, S. Goossens, M. Ogawa, N. Kawano, K. Asari, S. Tsuruta, Y. Ishihara, Q. Liu, F. Kikuchi, T. Ishikawa, S. Sasaki, C. Aoshima, K. Kurosawa, S. Sugita, and T. Takano [2009a], "Farside Gravity Field of the Moon from Four-Way Doppler Measurements of SELENE (Kaguya)," Science, vol.323, pp.900-905.
  - The farside gravity field of the Moon is improved from the tracking data of the Selenological and Engineering Explorer (SELENE) via a relay subsatellite. The new gravity field model reveals that the farside has negative anomaly rings unlike positive anomalies on the nearside. Several basins have large central gravity highs, likely due to super-isostatic, dynamic uplift of the mantle. Other basins with highs are associated with mare fill, implying basalt eruption facilitated by developed faults. Basin topography and mantle uplift on the farside are supported

by a rigid lithosphere, whereas basins on the nearside deformed substantially with eruption. Variable styles of compensation on the near- and farsides suggest that reheating and weakening of the lithosphere on the nearside was more extensive than previously considered.

- Namiki, N., S. Sugita, K. Matsumoto, S. Goossens, Y. Ishihara, H. Noda, S. Sasaki, T. Iwata, H. Hanada, H. Araki, K. Kurosawa, M. Matsumura, M. Yokoyama, S. Kamata, N. Kubo, A. Mori, and M. Sato [2009b], "Comparative Study of Compensation Mechanism of Lunar Impact Basins from New Gravity Field Model of SELENE (Kaguya)," 40th Lunar and Planetary Science Conference, (Lunar and Planetary Science XL), held March 23-27, 2009 in The Woodlands, Texas, id.1519.
  - Based on the gravity model of the Moon by SELENE, we propose new classification and compensation mechanism of lunar impact basins. Impact basins on lunar far side are classified into two types depending on free-air and Bouguer gravity anomalies.
- Namiki, N., T. Iwata, H. Hanada, K. Matsumoto, S. Goossens, Y. Ishihara, S. Sugita, H. Noda, S. Sasaki, and H. Araki [2009c], "Study of Compensation Mechanism of Lunar Impact Basins from New Gravity and Topographic Data of Kaguya," American Astronomical Society, DPS meeting #41, #26.03.
  - On the basis of the gravity model of the Moon developed by SELENE (Kaguya), we propose new classification and compensation mechanism of lunar impact basins. Impact basins on lunar far side and limb are classified into Type I and II basins depending on the magnitude of central gravity high in free-air and Bouguer gravity anomalies. Among previously known gravity anomalies, most typical mascons are referred as primary mascon basins. Topographic depression and rim of both Type I and II basins show good correlation between topography and free-air gravity anomaly suggesting elastic support of lunar lithosphere. Central gravity high of Type I basin is inferred to be a result of mantle uplift at the time of basin formation, and is elastically supported, too. On the other hand, free-air anomalies at the center of Type II basins are lower than Bouguer anomalies indicating brittle deformation of the basins. Topographic depression and rim of primary mascon basins on near side of the Moon show little to no free-air gravity anomalies. This indicates a result of elastic relaxation that occurred probably after eruption of mare basalts. Plateau-like signature of gravity anomalies of primary mascon basins implies viscous relaxation at crust-mantle boundary beneath the basins and significant heat (or volatile) transport by basaltic magma.
- Naruse, M., T. Ito, Y. Sekimoto, H. Toba, N. Satou, M. Sugimoto, W. Shan, Y. Iizuka, T. Kamba, M. Kamikura, and Y. Serizawa [2009], "Near-Field Beam Pattern Measurement of Qualification Model of ALMA Band 8 (385-500 GHz) Cartridge Receiver," Experimental Astron., vol.24, pp.89-107.
  - We have developed a near-field vector beam measurement system covering the range of frequencies from 385 to 500 GHz. The measurement set-up is capable of measurements with dynamic range exceeding 50 dB and amplitude and phase stability respectively of 0.1 dB/h and 1 degree/5 min at room temperature. Beam patterns of the ALMA band 8 corrugated horns and receiver optics block were measured at room temperature and lately compared with physical optics calculations obtained in the far-field. Both co-polar and cross-polar beam patterns of a qualification model of the ALMA band 8 cartridge cooled in a cartridge-test cryostat have also been measured in the near-field as a detector of a submillimeter vector network analyzer. The measurements presented in this work refer to the lowest, middle and upper frequencies of band 8. The comparisons between software model and experimental measurements at these frequencies show good agreement down to -30 dB for the main polarization component. The cross polarization level of the beam propagating through the receiver optics block was also characterized. We found that a cross-polarization level better than -28 dB can be achieved at all measured frequencies. The measured beam pattern of this receiver corresponds to efficiency of

greater than 92% at the sub reflector(diameter of 750 mm) of the ALMA 12 m optics.

- Niinuma, K., T. Daishido, N. Matsumura, K. Takefuji, M. Kuniyoshi, K. Asuma, S. Kida, T. Tanaka, T. Aoki, S. Ishikawa, K. Hirano, H. Uehara, and S. Nakagawa, [2009], "Discovery of Two Radio Transients at a High Galactic Latitude in A 1.4 GHz Drift-Scan Survey," Astrophys. J., vol.704, pp.652-660.
  - We report two new radio transients at high Galactic latitude, WJN J0951+3300 ($\alpha = 09^h51^m22^s \pm 10^s$, $\delta = 33°00' \pm 0°.4$, b = 50°54.'2) and WJN J1039+3300 ($\alpha = 10^h39^m26^s \pm 10s$, $\delta = 33°00' \pm 0°.4$, b = 60°58.'5), which were detected by interferometric drift-scan observations at 1.4 GHz at the Waseda Nasu Pulsar Observatory. WJN J0951+3300 was detected at 16:49:32 UT on 2006 January 12 with the flux density of approximately 1760.5 ± 265.9 mJy, and WJN J1039+3300 was detected at 17:13:32 UT on 2006 January 18 with the flux density of approximately 2242.5 ± 228.7 mJy. Both of them lasted for a short duration (≤2 days). The possibility that the distribution of the WJN radio transients is isotropic was suggested in a previous study. Having re-evaluated the log N-log S relation with the addition of the two new objects reported in this paper, we find that the slope is consistent with a slope of -1.5 and the previous result. Additionally, although there are several counterparts to WJN radio transients, we found that one of the quasar counterparts within the positional error of WJN J0951+3300 could be a radio-loud quasar. We have discussed whether or not WJN J0951+3300 could be of this quasar origin.
- Nishizuka, N., H. Takasaki, A. Asai, and K. Shibata [2010], "Multiple Plasmoid Ejections and Associated Hard X-Ray Bursts in the 2000 November 24 Flare," Astrophys. J., vol.711, pp.1062-1072.
  - The Soft X-ray Telescope (SXT) on board Yohkoh revealed that the ejection of X-ray emitting plasmoid is sometimes observed in a solar flare. It was found that the ejected plasmoid is strongly accelerated during a peak in the hard X-ray (HXR) emission of the flare. In this paper, we present an examination of the GOES X 2.3 class flare that occurred at 14:51 UT on 2000 November 24. In the SXT images, we found "multiple" plasmoid ejections with velocities in the range of 250-1500 km s^{-1}, which showed blob-like or loop-like structures. Furthermore, we also found that each plasmoid ejection is associated with an impulsive burst of HXR emission. Although some correlation between plasmoid ejection and HXR emission has been discussed previously, our observation shows similar behavior for multiple plasmoid ejection such that each plasmoid ejection occurs during the strong energy release of the solar flare. As a result of temperature-emission measure analysis of such plasmoids, it was revealed that the apparent velocities and kinetic energies of the plasmoid ejections show a correlation with the peak intensities in the HXR emissions.
- Niwa, T., K. Tachihara, Y. Itoh, Y. Oasa, K. Sunada, K. Sugitani, and T. Mukai [2009], "Millimeter-Wave Survey of Molecular Clouds around the W5-East Triggered Star-Forming Region," Astron. Astrophys., vol.500, pp.1119-1129.
  - Aims. We examined the physical properties of molecular clouds (morphology, column density, number density, mass) to investigate the mechanism of triggered star formation by UV radiation from a massive star.

    Methods. We made extensive, high-resolution maps of molecular clouds associated and interacting with the W5-East H II region using the 45-m telescope at the Nobeyama Radio Observatory (HPBW= 15".)) in ^{13}CO (J=1-0) and $C^{18}O$ (J=1-0) to reveal details in the high-density regions of the molecular clouds. In addition, to investigate the spatial distributions of young stellar objects (YSOs) in the W5-East H II region, we mapped the spatial distributions of Class I and II candidates.

    Results. We identified eight ^{13}CO molecular clouds (three of them are known bright-rimmed clouds) and nine $C^{18}O$ clumps. The masses of the clouds and clumps range from 460 to 36 000

M. and from 55 to 740 M, respectively. The peak ^{13}CO column densities of the clouds facing the H II region are twice as large as the others. They have steep density gradients toward the H II region, indicating interactions with the H II region. We selected 55 Class I candidates and 778 Class II candidates associated with the W5-East H II region from the previous Spitzer IRAC/MIPS survey. Most Class I candidates are located around integrated intensity peaks of ^{13}CO, whereas most Class II candidates are distributed along the front sides of the BRC arcs close to the exciting star.

Conclusions. The alignments of the YSO candidates and the molecular clouds in order of age indicate that triggered star formation occurs in the W5-East H II region as a result of gas compression by strong UV radiation. Based on the column densities of ^{13}CO and the spatial distribution of YSO candidates, we identified a new bright-rimmed cloud candidate on the west side of the W5-East H II region.

- Noda, H., H. Araki, S. Tazawa, Y. Ishihara, Laser Altimeter (Lalt) in Migita, E. Kaguya, N. Kawano, T. Tsubokawa, I. Kamiya, S. Sasaki, and J. Oberst [2008a], "The First Global Lunar Topography Mapping by KAGUYA (SELENE) Laser Altimeter (LALT)," 37th COSPAR Scientific Assembly, held 13-20 July 2008, in Montreal, Canada, p.2245.
  - The Laser ALTimeter(LALT) aboard Japanese lunar explorer KAGUYA(SELENE) is a ranging instrument which measures the distance between the satellite and the lunar surface with accuracy of 1 m by detecting the timing delay of the reflected laser light. As KAGUYA is in a polar circular orbit, the first global and precise topographic map will be produced. Especially, data at high latitude regions above 75 degree are collected for the first time. LALT data are useful to determine the lunar global figure, especially center-of-mass and center-of-figure offset, and to estimate the thickness of the lunar crust in combination with gravity field data obtained by RSAT/VRAD gravity field measurement. It also provides basic information for the exploration of the lunar polar area. Also, intensity of the returned pulses contains information concerning inclination and roughness of the footprints, which contributes to the study of the lunar surface maturity and age. The LALT started normal operation on 30th, December 2007 after two months' commissioning phase. Measurements have been done with repetition rate of 1 Hz except the period of unloading of the momentum wheels. As of the middle of Februrary 2008, a first topographic grid has been accomplished for all areas which currently has a grid spacing of 0.05 degrees (=1.5 km) alongtrack and 0.5 degrees across-track near the equator. Especially, data density at high latitude regions is sufficient to produce detailed elevation map, which is useful to study the illumination condition of the polar regions. In our talk, the status of the LALT and initial results of the data analysis will be presented.
- Noda, H., H. Araki, S. Goossens, Y. Ishihara, K. Matsumoto, S. Tazawa, N. Kawano, and S. Sasaki [2008b], "Illumination Conditions at the Lunar Polar Regions by KAGUYA(SELENE) Laser Altimeter," Geophys. Res. Letters, vol.35, pp.L24203 (1 of 5).
  - The sunlit conditions of the lunar polar regions were estimated by using a digital elevation model made by the laser altimeter data onboard the Japanese lunar orbiter KAGUYA (SELENE). The result shows that i) there are no peaks of eternal light in either north or south polar regions, ii) most continuously lit surfaces are 89% for north and 86% for south, iii) there are permanently shadowed regions. These information will be useful for the long-durable landing experiments on the Moon and possibly for the human activity on the Moon in the near future.
- Noda, H., H. Arakai, Y. Ishihara, S. Tazawa, S. Sasaki, and N. Kawano [2009], "Lunar Surface Reflectance by LALT aboard Kaguya," American Geophysical Union, Fall Meeting 2009, abstract #P23C-1283.
  - The Laser Altimeter (LALT) aboard Japanese lunar explorer KAGUYA (SELENE) is a ranging instrument which measures the distance between the satellite and the lunar surface with

accuracy of 1 m by detecting the timing delay of the reflected laser light. The main science goal of the LALT is to obtain the lunar global topographic data including polar regions for the study of the origin and the evolution of the Moon [1]. Besides, the LALT is equipped with an intensity monitor of the returned pulses. The intensity of the returned pulses contains information concerning surface roughness and reflectance of the footprints, which will contribute to the study of the lunar surface maturity and age. The reflectance at LALT wavelength (1064nm) is sensitive to the surface maturity and composition. The data should be particularly important at lunar polar regions where camera instruments should suffer from phase angle effects in the surface reflectance and moreover cannot obtain reflectance data at the permanently shadowed area. The normal operation of the LALT began on 30th, December 2007 after two months ㄴ commissioning phase. Before the end of the normal operation phase in October 2008, the LALT measured more than 10 million range data. Unfortunately, due to the laser power decrease and also possible smaller surface reflectance than the expected value before launch (15 % at 1 micro meter), the return pulse intensity during the nominal mission phase is so small that they are not reliable enough to discuss the surface property. During the extended mission phase, which started November 2008, the satellite altitude decreased to 50 km. Due to the malfunction of the reaction wheel and high-voltage instruments were shutdown, the observation was suspended until 11th of February, 2009. LALT successfully resumed observation on 12th February and continued observation until the controlled crash of KAGUYA onto the Moon on 10th of June, 2009. Thanks to the lower orbit during this phase, the return pulse intensity is high enough to be used for the study of the surface property. Especially, it is of interest whether water ice exists or not on the bottom of the eternal shaded regions in the polar region. If we assume that the surface roughness within the size of the footprint is the same inside and the vicinity of a crater, the change of the intensity is due to the variety of the reflectance. It can be used for possible detection of the water ice if exists. We will report the initial results of the analysis of derived reflectance, especially of the lunar polar regions. references [1] H. Araki et. al., Science, 323, 897-900 (2009).

- Nyman, L.-Å., P. Andreani, J. Hibbard, and S. K. Okumura [2010], "ALMA Science Operations,Observatory Operations: Strategies, Processes, and Systems III." Edited by Silva, David R.; Peck, Alison B.; Soifer, B. Thomas. Proceedings of the SPIE, vol.7737, pp.77370G-77370G-7.
  - The ALMA (Atacama Large Millimeter/submillimeter Array) project is an international collaboration between Europe, East Asia and North America in cooperation with the Republic of Chile. The ALMA Array Operations Site (AOS) is located at Chajnantor, a plateau at an altitude of 5000 m in the Atacama desert in Chile, and the ALMA Operations Support Facility (OSF) is located near the AOS at an altitude of 2900 m. ALMA will consist of an array of 66 antennas, with baselines up to 16 km and state-of-the-art receivers that cover all the atmospheric windows up to 1 THz. An important component of ALMA is the compact array of twelwe 7-m and four 12-m antennas (the Atacama Compact Array, ACA), which will greatly enhance ALMA's ability to image extended sources. Construction of ALMA started in 2003 and will be completed in 2013. Commissioning started in January 2010 and Early Science Operations is expected to start during the second half of 2011. ALMA science operations is provided by the Joint ALMA Observatory (JAO) in Chile, and the three ALMA Regional Centers (ARCs) located in each ALMA region - Europe, North America and East Asia. ALMA observations will take place 24h per day, interrupted by maintenance periods, and will be done in service observing mode with flexible (dynamic) scheduling. The observations are executed in the form of scheduling blocks (SBs), each of which contains all information necessary to schedule and execute the observations. The default output to the astronomer will be pipeline-reduced images calibrated according to the calibration plan. The JAO is responsible

for the data product quality. All science and calibration raw data are captured and archived in the ALMA archive, a distributed system with nodes at the OSF, the Santiago central office and the ARCs. Observation preparation will follow a Phase 1/Phase 2 process. During Phase 1, observation proposals will be created using software tools provided by the JAO and submitted for scientific and technical review. Approved Phase 1 proposals will be admitted to Phase 2 where all observations will be specified as SBs using software tools provided by the JAO. User support will be done at the ARCs through a helpdesk system as well as face-to-face support.

- Oasa, Y., M. Tamura, K. Sunada, and K. Sugita [2008], "Luminosity and Mass Functions at the Very Low Mass Side in NGC 1333," Astron. J., vol.136, pp.1372-1387.
  - We present the results of a deep near-infrared (NIR) imaging survey searching for very low mass young stellar objects (YSOs) in the embedded cluster associated with the Perseus molecular cloud. Our observations cover an area of ~5'x 5' in the NGC 1333-S region at J-, H-, and Ks-bands. The 10 limiting magnitudes exceed 18 mag in all three bands. Based on NIR color-color diagrams, embedded YSO candidates were identified using NIR excesses. The derived frequency of these YSO candidates with NIR excess emission among all the detected sources is 58^{+10}_{-13}%. The higher frequency of YSOs with NIR excesses implies that NGC 1333 is an active and young star-forming region. Approximately half of the YSO candidates exhibit extremely low luminosity, indicating very low mass. Combining the reddening-corrected luminosity with theoretical evolutionary models, the low-luminosity YSO candidates are considered to be young substellar-mass objects. Furthermore, some sources could have planetary masses. In addition, we carried out CO molecular-line observations of the same cloud region. The results suggested that the YSO candidates are likely formed on the side of the parent molecular cloud and star-formation activity could be high. The K-band luminosity function of all the detected sources revealed a significant population of extremely low-luminosity sources in NGC 1333. The reddening-corrected J-band luminosity function of the YSO candidates does not clearly decline to the completeness limit and seems to be bimodal. We also argue that the fraction of substellar objects is larger than those in other young clusters and the mass function of the YSO candidates appears to be increasing toward the substellar-mass regime, similar to that of dust clumps. It implies that substellar-mass distributions may depend on the initial conditions of the molecular cloud.
- Oh, C. S., H. Kobayashi, M. Honma, T. Hirota, K. Sato, and Y. Ueno [2010], "VERA Observations of H_2O Maser Sources in Three Massive Star-Forming Regions and Galactic Rotation Measurements," Publ. Astron. Soc. Japan, vol.62, pp.101-114.
  - We present the results of VLBI observations of three H_2O maser sources in massive star-forming regions: IRAS 06058+2138, IRAS 19213+1723, and AFGL 2789. We determined the annual parallaxes and proper motions for these sources by a phase-referencing method. The estimated distances to IRAS 06058+2138 and AFGL 2789 are 1.76±0.11 kpc and 3.07±0.30 kpc, which are located in the Perseus spiral arm. The distance to IRAS 19213+1723 is 3.98±0.57 kpc, placing it in the Carina-Sagittarius arm. With estimated 3-dimensional velocity components, we have shown that the galactic rotation curve is flat in the range of 6.4 kpc $\leq R \leq$13 kpc as combining with S 269, which was observed with VERA. We have also found that the overall rotation curve of the Galaxy do not depend on Θ_0 . The maser sources also show deviations from flat rotation curves by a few kilometers per second. We discuss possible reasons for these peculiar motions.
- Ohama, A., J. R. Dawson, N. Furukawa, A. Kawamura, N. Moribe, H. Yamamoto, T. Okuda, N. Mizuno, T. Onishi, H. Maezawa, T. Minamidani, A. Mizuno, and Y. Fukui [2010], "Temperature and Density Distribution in the Molecular Gas Toward Westerlund 2: Further Evidence for Physical Association," Astrophys. J., vol.709, pp.975-982.
  - Furukawa et al. reported the existence of a large mass of molecular gas associated with the

super star cluster Westerlund 2 and the surrounding HII region RCW49, based on a strong morphological correspondence between NANTEN2 ^{12}CO(J = 2-1) emission and Spitzer IRAC images of the HII region. We here present temperature and density distributions in the associated molecular gas at ~3.5 pc resolution, as derived from a large velocity gradient analysis of the ^{12}CO(J = 2-1), ^{12}CO(J = 1-0), and ^{13}CO(J = 2-1) transitions. The kinetic temperature is as high as ~60-150 K within a projected distance of ~5-10 pc from Westerlund 2 and decreases to as low as ~10 K away from the cluster. The high temperature provides robust verification that the molecular gas is indeed physically associated with the HII region, supporting Furukawa et al.'s conclusion. The derived temperature is also roughly consistent with theoretical calculations of photodissociation regions (PDRs), while the low spatial resolution of the present study does not warrant a more detailed comparison with PDR models. We suggest that the molecular clouds presented here will serve as an ideal laboratory to test theories on PDRs in future higher resolution studies.

- Ohishi, M. [2008], "Molecular Spectral Line Syrveys and the Organic Molecules in the Interstellar Molecular Clouds," Proc. of the IAU Symp. 251, "Organic Matter in Space", eds. S. Kwok, and S. Sandford, pp.17-26.

➢ It is known that more than 140 interstellar and circumstellar molecules have so far been detected, mainly by means of the radio astronomy observations. Many organic molecules are also detected, including alcohols, ketons, ethers, aldehydes, and others, that are distributed from dark clouds and hot cores in the giant molecular clouds. It is believed that most of the organic molecules in space are synthesized through the grain surface reactions, and are evaporated from the grain surface when they are heated up by the UV radiation from adjacent stars.

On the other hand the recent claim on the detection of glycine have raised an important issue how difficult it is to confirm secure detection of weak spectra from less abundant organic molecules in the interstellar molecular cloud.

I will review recent survey observations of organic molecules in the interstellar molecular clouds, including independent observations of glycine by the 45 m radio telescope in Japan, and will discuss the procedure to securely identify weak spectral lines from organic molecules and the importance of laboratory measurement of organic species.

- Ohta, K., S. Sakamoto, N. Kawai, J. R. Cortes, K. Nakanishi, T. Okuda, K. Muraoka, T. Sakai, H. Ezawa, N. Yamaguchi, K. Kamegai, R. Kawabe, B. Hatsukade, K. Kohno, A. Endo, and T. Tosaki [2008], "A Possible Detection of CO(J=3-2) Emission from the Host Galaxy of GRB980425 with the Atacama Submillimeter Telescope Experiment," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., p.331.

➢ Without abstract

- Ohtake, M., T. Matsunaga, J. Haruyama, Y. Yokota, T. Morota, C. Honda, Y. Ogawa, M. Torii, H. Miyamoto, T. Arai, N. Hirata, A. Iwasaki, R. Nakamura, T. Hiroi, T. Sugihara, H. Takeda, H. Otake, C. M. Pieters, K. Saiki, K. Kitazato, M. Abe, N. Asada, H. Demura, Y. Yamaguchi, S. Sasaki, S. Kodama, J. Terazono, M. Shirao, A. Yamaji, S. Minami, H. Akiyama, and J.-L. Josset, [2009], "The Global Distribution of Pure Anothosite of the Moon," Nature, vol.461, pp.236-240.

➢ It has been thought that the lunar highland crust was formed by the crystallization and floatation of plagioclase from a global magma ocean, although the actual generation mechanisms are still debated. The composition of the lunar highland crust is therefore important for understanding the formation of such a magma ocean and the subsequent evolution of the Moon. The Multiband Imager on the Selenological and Engineering Explorer (SELENE) has a high spatial resolution of optimized spectral coverage, which should allow a clear view of the composition of the lunar crust. Here we report the global distribution of rocks

of high plagioclase abundance (approaching 100vol.%), using an unambiguous plagioclase absorption band recorded by the SELENE Multiband Imager. If the upper crust indeed consists of nearly 100vol.% plagioclase, this is significantly higher than previous estimates of 82-92vol.% (refs 2, 6, 7), providing a valuable constraint on models of lunar magma ocean evolution.

- Oka, T., T. Hasegawa, G. J. White, F. Sato, M. Tsuboi, and A. Miyazaki [2008], "Aperture Synthesis Imaging of a High-Velocity Compact Cloud near the Valactic Center," Publ. Astron. Soc. Japan, vol.60, pp.429-434.
  - We observed CO J=1-0 and HCN J=1-0 line emission toward a high-velocity, compact molecular cloud, CO 0.02-0.02, near the center of our Galaxy, using the Nobeyama Millimeter Array (NMA). A CO velocity-intergrated map with a resolution of 4".3 x 2".4 shows two oval clumps with sizes of 0.8pc. These clumps are separated by 1.2pc. being located at the eastern and southwestern peripheries of the CO0.02-0.02 cloud. The overall distribution of HCN emission coincides with that taken with the Nobeyama 45m telescope. The HCN velocity-integrated map with a resolution of 6".1 x 3".4 shows two prominent peaks in the cloud center. Both NMA maps at V_{LSR} ~ 110 km s^{-1} show an arc-shaped edge in the southeast, which may correspond to the edge of the "emission cavity" found in the CO J=3-2 integrated-intesity map. We also noticed a faint radio continuum "arc" that encircles the bulk of the CO 0.02-0.02 cloud. These results support the notion that CO 0.02-0.02 has been accelerated, heated, and compressed in a series of supernova shocks that occurred within the last (3-5) x 10^4 yr. We suggest that a massive compact cluster with an age of 10-30 Myr is responsible for the formation of the CO 0.02-0.02 cloud.
- Okuda, T., J. Koda, K. Nakanishi, K. Kohno, S. Ishizuki, N. Kuno, and S. K. Okumura [2008a], "Nuclear Molecular Gas and Star Formation in Nearby Early-Type Spiral Galaxies," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., p.368.
  - Without abstract
- Okuda, T., and S. Iguchi [2008b], "Performance Measurements of 8-Gsps 1-bit ADCs Developed for Wideband Radio Astronomical Observations," Publ. Astron. Soc. Japan, vol.60, pp.315-325.
  - 8-Gsps 1-bit Analog-to-Digital Converters (ADCs) were newly developed toward the realization of the wideband observation. The development of the wideband ADCs is one of the most essential developments for the radio interferometer. To evaluate its performance in interferometric observations, the time (phase) stability and frequency response were measured with a noise source and a signal generator. The results of these measurements show that the developed ADCs can achieve the jitter time less than 0.05 ps at a time interval of 1 second, a passband frequency response with a slope less than 0.73 dB/GHz^{-1} and the ripple less than 1.8 dB, and an aperture time of less than 20 ps. The details of the developed ADC design, the measurement methods, and the results of these measurements are presented in this paper.
- Onodera, S., N. Kuno, T. Tosaki, K. Kohno, K. Nakanishi, T. Sawada, K. Muraoka, S. Komugi, R. Miura, H. Kaneko, A. Hirota, and R. Kawabe [2010], "Breakdown of Kennicutt-Schmidt Lawa at GMC Scales in M33," Astrophys. J. (Letters), vol.722, pp.L127-L131.
  - We have mapped the northern area (30'x20') of a Local Group spiral galaxy M33 in ^{12}CO(J = 1-0) line with the 45 m telescope at the Nobeyama Radio Observatory. Along with Hα and Spitzer 24μm data, we have investigated the relationship between the surface density of molecular gas mass and that of star formation rate (SFR) in an external galaxy (Kennicutt-Schmidt law) with the highest spatial resolution (~80 pc) to date, which is comparable to scales of giant molecular clouds (GMCs). At positions where CO is significantly detected, the SFR surface density exhibits a wide range of over four orders of magnitude, from Σ_{SFR} □ 10^{-10} to ~10^{-6} $M_{\odot}$ yr^{-1} pc^{-2}, whereas the Σ_{H2} values are mostly within

10-40 $M_{\odot}$ pc^{-2}. The surface density of gas and that of SFR correlate well at an ~1 kpc resolution, but the correlation becomes looser with higher resolution and breaks down at GMC scales. The scatter of the Σ_{SFR}-Σ_{H2} relationship in the ~80 pc resolution results from the variety of star-forming activity among GMCs, which is attributed to the various evolutionary stages of GMCs and to the drift of young clusters from their parent GMCs. This result shows that the Kennicutt-Schmidt law is valid only in scales larger than that of GMCs, when we average the spatial offset between GMCs and star-forming regions, and their various evolutionary stages.

- Reid, M. J., K. M. Menten, X. W. Zheng, A. Brunthaler, L. Moscadelli, Y. Xu, B. Zhang, M. Sato, M. Honma, T. Hirota, K. Hachisuka, Y. K. Choi, G. A. Moellenbrock, and A. Bartkiewicz [2009], "Trigonometric Parallaxes of Massive Star Forming Regions: VI. Galactic Structure, Fundamental Parameters and Non-Circular Motions," Astrophys. J., vol.700, pp.137-148.
  - We are using the Very Long Baseline Array and the Japanese VLBI Exploration of Radio Astronomy project to measure trigonometric parallaxes and proper motions of masers found in high-mass star-forming regions across the Milky Way. Early results from 18 sources locate several spiral arms. The Perseus spiral arm has a pitch angle of 16° ± 3°, which favors four rather than two spiral arms for the Galaxy. Combining positions, distances, proper motions, and radial velocities yields complete three-dimensional kinematic information. We find that star-forming regions on average are orbiting the Galaxy ≈15 km s^{-1} slower than expected for circular orbits. By fitting the measurements to a model of the Galaxy, we estimate the distance to the Galactic center R_0 = 8.4 ± 0.6 kpc and a circular rotation speed Θ_0 = 254 ± 16 km s^{-1}. The ratio Θ_0/R_0 can be determined to higher accuracy than either parameter individually, and we find it to be 30.3 ± 0.9 km s^{-1} kpc^{-1}, in good agreement with the angular rotation rate determined from the proper motion of Sgr A*. The data favor a rotation curve for the Galaxy that is nearly flat or slightly rising with Galactocentric distance. Kinematic distances are generally too large, sometimes by factors greater than 2; they can be brought into better agreement with the trigonometric parallaxes by increasing Θ_0/R_0 from the IAU recommended value of 25.9 km s^{-1} kpc^{-1} to a value near 30 km s^{-1} kpc^{-1}. We offer a "revised" prescription for calculating kinematic distances and their uncertainties, as well as a new approach for defining Galactic coordinates. Finally, our estimates of Θ_0 and Θ_0/R_0, when coupled with direct estimates of R0, provide evidence that the rotation curve of the Milky Way is similar to that of the Andromeda galaxy, suggesting that the dark matter halos of these two dominant Local Group galaxy are comparably massive.
- Reznikova, V. E., V. F. Melnikov, K. Shibasaki, S. P. Gorbikov, N. P. Pyatakov, I. N. Myagkova, and H. Ji [2009a], "Dynamics of Microwave Brightness Distribution in the Giant 24 August 2002 Flare Loop," Proc. of the IAU Symp. 257, "Universal Heliophysical Processes", eds. N. Gopalswamy and David F. Webb, pp.345-347.
  - We have found a similar tendency of the spatial dynamics at 34 GHz for all major temporal sub-peaks of the burst with the re-distribution of the brightness from the footpoints (on the rising phase of each peak) to the upper part of the loop (on the decay phase). Observed dynamics is interpreted by the re-distribution of accelerated electrons number density with their relative enhancement in the loop top. Results of diagnostics show that the ratio of non-thermal electron number density in the loop top and in the footpoint changes 7 times from the peak to decay phase. Model simulations by solving the Fokker-Planck equation allowed to determine an injection type which is able to result in necessary dynamics of energetic electrons.
- Reznikova, V. E., V. F. Melnikov, K. Shibasaki, S. P. Gorbikov, N. P. Pyatakov, I. N. Myagkova, and H. Ji [2009b], "2002 August 24 Limb Flare Loop: Dynamics of Microwave Brightness Distribution," Astrophys. J., vol.697, pp.735-745.
  - High-resolution radio observation of Nobeyama Radioheliograph at 17 and 34 GHz allowed

studying the dynamics of microwave brightness distribution along the giant limb flaring loop in the event of 2002 August 24. It is found that on the rising phase of the radio burst the brightness distribution was highly asymmetric, with a strong maximum near the southern footpoint (SFP) and much weaker brightness enhancements near the loop top (LT) and northern footpoint. On the decay phase, the LT gradually became most bright. The similar dynamics of brightness distribution are shown to happen for all major temporal subpeaks of the burst. Results of our diagnostics show two important properties: (1) the number density of mildly relativistic electrons in the LT is much higher than near the footpoints (FPs) during rise, maximum and decay of each major peak; and (2) the ratio of the electron number densities in the LT and an FP increases from the maximum to decay phase. Model simulations with making use of the nonstationary Fokker-Planck equation have allowed us to find the model explaining the major properties of the microwave brightness distribution and dynamics. The model is characterized by a compact source of electrons located near the center of an asymmetric magnetic loop; the source is nonstationary, long lasting, and injecting high-energy electrons with the pitch-angle distribution mostly directed toward the SFP but also having a very weak isotropic component.

This easily explains the observed brightness asymmetry. The observed dynamics comes due to two reasons: faster precipitation of electrons having their mirror points near the ends of the magnetic trap, and relatively faster decay of the lower energy electrons responsible for the gyrosynchrotron emission near the FPs with higher magnetic ˚ eld.

- Reznikova, V. E., V. Melnikov, H. Ji, and K. Shibasaki [2010], "Topology Dynamics of the Flaring Loop System on 2005 August 22 Observed in Microwaves and Hard X-Rays," 38th COSPAR Scientific Assembly, 18-25 July 2010, p.5.
  - Microwaves generated by mildly relativistic electrons allow us to trace magnetic flaring loops in their full length including their upper parts. We take advantage of this property and study the spatial dynamics of the system of flaring loops in the 2005 August 22 flare using high res-olution microwave observations of Nobeyama Radioheliograph (NoRH) along with hard X-ray observations of RHESSI. As complimentary data, magnetograms from SOHO/MDI, Hα images from SMART at Hida Observatory, as well as EUV images from SOHO/EIT and TRACE were analyzed. The flare consisted of six temporal emission peaks. During all the emission peaks, the evolution of sizes, footpoint positions and orientations of the observed microwave loop(s) were analyzed. We have found that the Northern footpoint of the apparent bright loop moves along the magnetic neutral line, and the position of Southern footpoint is almost invariable so that the shear angle of the loop steadily decreases during the flare process. The corresponding contraction of the distance between the footpoints parallel to the magnetic neutral line is from 25 Mm to 13 Mm. After the first emission peak, the length and altitude of the loop are growing continuously. During the fifth emission peak we observe a jump in the loop height which re-lates to the formation of a new loop at higher altitude. The microwave loops characteristics are compared with corresponding properties of the hard X-ray emission for the period of RHESSI observations (after the first microwave peak). Diagnostics of parameters of accelerated electrons and other flare parameters are fulfilled. Possible theoretical models explaining the behavior of the observed flaring loop system are considered.
- Rhee, M.-H., Y.-I. Byun, H. R. Kim, J. W. Choi, J. W. Yoon, J. E. An, H. J. Kim, K. H. Lee, and Y. Kan-Ya [2010], "Project SETI KOREA, Astrobiology Science Conference 2010: Evolution and Life: Surving Catastrophes and Extremes on Earth and Beyond, LPI Contribution No. 1538, p.5191.
  - We have recently launched a new SETI project in Korea. It would be one of the first SETI project using VLBI raw data to investigate short time scale radio events. We will report current status of the Project SETI KOREA.

- Rioja, M. J., R. Dodson, F. Colomer, V. Bujarrabal, R. Kamohara, and H. Kobayashi [2008], "VERA Astrometric Observations of 43-GHz SiO Maser towards R Leonis Minoris," Proc. of the 9th European VLBI Network Symposium on The role of VLBI in the Golden Age for Radio Astronomy and EVN Users Meeting, September 23-16, 2008, Bologna, Italy, pp.88-90.
  - Oxygen-rich Asymptotic Giant Branch (AGB)stars are intense emitters of SiO maser lines at 43 GHz(J=1→0, v=1and2). The masers appear at a distance of a few stellar radii occupying a more or less circular structure. The relative position of the spots of both the v=1 and v=2 SiO transitions is an important result in order to elucidate the nature of the pumping mechanism, and hence a unique interpretation of the observations in terms of physical underlying conditions. VLBI observations of the SiO maser emission has been a unique tool to sample the innermost layers of the circumstellar envelopes in AGB stars, despite the difficulties to achieve astrometrically aligned v=1 and v=2 SiO maser maps. We present such maps, at multiple epochs, towards R LMi, and discuss the analysis.
- Romney, J. D., R. T. Schilizzi, S. T. Garrington, L. I. Gurvits, X. Hong, X., D. L. Jauncey, H. Kobayashi, R. Porcas, R. A. Preston, C. J. Salter, A. Szomoru, M. Tsuboi, J. S. Ulvestad, and A. R. Whitney [2008], "Division / Commission 40 / Working Global Very Long Baseline Interferometry," Transactions IAU, vol. 4, Issue 27A, pp.342-343.
  - This triennium began with an action to re-create the Terms of Reference for the Working Group Global VLBI (WG-GV). These had been lost over the years since the Group was established in 1990. Fortunately, the personal archive of one long-term member yielded a copy of the original memorandum by R. D. Ekers, which was found to coincide quite well with current practice and areas of interest. New Terms of Reference, based on modern conditions, were drafted and accepted by both IAU and URSI.
- Saito, H., M. Saito, Y. Yonekura, and F. Nakamura [2008], "High-Resolution Studies of the Multiple-Core Systems toward Cluster-Forming Regions Including Massive Stars," Astrophys. J. Suppl., vol.178, pp.302-329.
  - We present the results of $C^{18}O$ observations by the Nobeyama Millimeter Array toward dense clumps with radii of 0.3 pc in six cluster-forming regions including massive (proto) stars. We identified 171 cores, whose radius, line width, and molecular mass range from 0.01 to 0.09 pc, 0.43 to 3.33 km s^{-1}, and 0.5 to 54.1 Msolar, respectively. Many cores with various line widths exist in one clump, and the index of the line width-radius relationship of the cores and the parental clump differs from core to core in the clump. This indicates that the degree of dissipation of the turbulent motion varies for each core in one clump. Although the mass of the cores increases with the line width, most cores are gravitationally bound by the external pressure. In addition, the line width and the external pressure of the cores tend to decrease with the distance from the center of the clump, and these dependencies may be caused by the inner H2 density structure of the clump that affects the physical properties of the cores. Moreover, the number density of the cores and the number density of young (proto) stars have a similar relationship to the average H2 density of the clumps. Thus, our findings suggest that the cluster is formed in the clump through the formation of such multiple cores, whose physical properties would have been strongly related to the H 2 density structure and the turbulent motion of the clump.
- Sakai, N., T. Sakai, and S. Yamamoto [2008a], "Tentative Detection of C_4H^- toward the Low-Mass Protostar IRAS 04368+2557 in L1527," Astrophys. J. (Letters), vol.673, pp.L71-L74.
  - The millimeter-wave rotational emission line (J=9-8) of the negative ion, C_4H^-, has tentatively been detected toward the low-mass Class 0 protostar IRAS 04368+2557 in L1527 with the IRAM 30 m telescope. The column density of C_4H^- is determined to be $1.1x10^{10}$ cm^{-2}. The $[C_4H^-]/[C_4H]$ ratio is found to be $6.8x10^{-5}$, which is much lower than the $[C_6H^-]/[C_6H]$ ratio

(0.093). From this result, the rate coefficient for the radiative attachment reaction between C_4H and electron is estimated to be as small as $3x10^{-11}$ cm^3 s^{-1} on the basis of the simplified chemical model. The present observation has demonstrated the uniqueness and importance of L1527 in searching for a new carbon-chain molecule in a star-forming region.

- Sakai, N., T. Sakai, T. Hirota, and S. Yamamoto [2008b], "Abundant Carbon-Chain Molecules toward the Low-Mass Protostar IRAS 04368+2557 in L1527," Astrophys. J., vol.672, pp.371-381.

➢ We have detected the high-excitation lines of carbon-chain molecules such as C_4H_2 ($J=10_{0,10}$-$9_{0,9}$), C_4H (N=9-8, F_1, F_2), l-C_3H_2 ($4_{1,3}$-$3_{1,2}$), and CH_3CCH (J=5-4, K=2) toward a low-mass star-forming region, L1527. In particular, the F1 line of C_4H is as strong as 1.7 K (T_{MB}). The rotational temperature of C_4H_2 is determined to be 12.3±0.8 K, which is higher than that in TMC-1 (3.8 K). Furthermore, the column density of C_4H_2 is derived to be about 1/4 of that in TMC-1, indicating that carbon-chain molecules are abundant in L1527 for a star-forming region. Small mapping observations show that the C_4H, C_4H_2, and c-C_3H_2 emissions are distributed from the infalling envelope to the inner part. Furthermore, we have detected the lines of C_5H, HC_7N, and HC_9N in the 20 GHz region. Since the carbon-chain molecules are generally deficient in star-forming cores, the above results cannot simply be explained by the existing chemical models. The following hypothesis is proposed. If the timescale of the prestellar collapse in L1527 were shorter than those of the other star-forming cores, the carbon-chain molecules could survive in the central part of the core. In addition, regeneration processes of the carbon-chain molecules due to star formation activities would play an important role. Evaporation of CH_4 from the grain mantles would drive the regeneration processes. The present observations show new chemistry in a warm and dense region near the protostars, which is named "warm carbon-chain chemistry (WCCC)."

- Sakai, N., T. Sakai, and S. Yamamoto [2008c], "Complex Organic Molecules in an Early Stage of Protostellar Evolution," Astrophys. and Sp. Sci., vol.313, pp.153-157.

➢ We have detected the rotational lines of $HCOOCH_3$ toward a Class 0 low-mass protostar, NGC1333 IRAS4B, which is reported to be extremely young according to the dynamical age of the molecular outflow (a few 100 yr). This suggests that the complex organic molecules appear from the very early stage of protostellar evolution. On the other hand, the complex organic molecules are not detected in a more evolved protostar, L1527. We have also found a similar trend in a massive star forming region, NGC2264. The $HCOOCH_3$ emission is almost absent toward IRS1, whereas it is concentrated near MMS3, which is younger than IRS1. In addition, the $HCOOCH_3$ intensity peak is slightly shifted from the dust emission peak, as is seen in the Orion KL Compact Ridge, giving an important clue to solve its origin.

- Sakai, N., T. Sakai, Y. Aikawa, and S. Yamamoto [2008d], "Detection of HCO^+_2 toward the Low-Mass Protostar IRAS 04368+2557 in L1527," Astrophys. J. (Letters), vol.675, pp.L89-L92.

➢ The millimeter-wave rotational emission lines (4_{04}-3_{03} and 5_{05}-4_{04}) of protonated carbon dioxide, $HCO^+_2(HOCO^+)$, have been detected toward the low-mass Class 0 protostar IRAS 04368+2557 in L1527 with the IRAM 30 m telescope. This is the first detection of HCO^+_2 except for the Galactic center clouds. The column density of HCO^+_2 averaged over the beam size (29") is determined to be $7.6x10^{10}$ cm, assuming a rotational temperature of 12.3 K. The fractional abundance of gaseous CO_2 relative to H_2 is estimated from the column density of HCO^+_2 with the aid of a simplified chemical model. If the HCO^+_2 emission only comes from the evaporation region of CO_2 near the protostar (T >/~ 50 K), the fractional abundance of CO_2 is estimated to be higher than $6.6x10^{-4}$. This is comparable to the elemental abundance of carbon in interstellar clouds, and hence, the direct evaporation of CO_2 from dust grain is unrealistic as a source of gaseous CO_2 in L1527. A narrow line width of HCO^+_2 also supports

this. On the other hand, the fractional abundance of CO_2 is estimated to be 2.9×10^{-7}, if the source size is comparable to the beam size. These results indicate that gaseous CO_2 is abundant even in the low-mass star-forming region. Possible production mechanisms of gaseous CO_2 are discussed.

- Sakai, N., T. Sakai, T. Hirota, M. Burton, and S. Yamamoto [2009], "Discovery of the Second Warm Carbon-Chain-Chemistry Source, IRAS15398-3359 in Lupus," Astrophys. J., vol.697, pp.769-786.
  - We have conducted a search for carbon-chain molecules toward 16 protostars with the Mopra 22 m and Nobeyama 45 m telescopes, and have detected high excitation lines from several species, such as C_4H (N = 9-8), C_4H_2(J = $10_{0,10}$-$9_{0,9}$), CH_3CCH(J = 5-4, K = 2), and HC_5N(J = 32-31), toward the low-mass protostar, IRAS15398 - 3359 in Lupus. The C_4H line is as bright as 2.4 K measured with the Nobeyama 45 m telescope. The kinetic temperature is derived to be 12.6 ± 1.5 K from the K = 1 and K = 2 lines of CH_3CCH. These results indicate that the carbon-chain molecules exist in a region of warm and dense gas near the protostar. The observed features are similar to those found toward IRAS04368+2557 in L1527, which shows warm carbon-chain chemistry (WCCC). In WCCC, carbon-chain molecules are produced efficiently by the evaporation of CH_4 from the grain mantles in a lukewarm region near the protostar. Our data clearly indicate that WCCC is no longer specific to L1527, but occurs in IRAS15398 - 3359. In addition, we draw attention to a remarkable contrast between WCCC and hot corino chemistry in low-mass star-forming regions. Carbon-chain molecules are deficient in hot corino sources like NGC1333 IRAS4B, whereas complex organic molecules seem to be less abundant in the WCCC sources. A possible origin for such source-to-source chemical variations is suggested to arise from the timescale of the starless-core phase in each source. If this is the case, the chemical composition provides an important clue to explore the variation of star formation processes between sources and/or molecular clouds.
- Sakai, N., O. Saruwatari, T. Sakai, S. Takano, and S. Yamamoto [2010a], "Abundance Anomaly of the ^{13}C Species of CCH," Astron. Astrophys., vol.512, pp.A31(1-10).
  - Aims. We have observed the N = 1-0 lines of CCH and its ^{13}C isotopic species toward a cold dark cloud, TMC-1 and a star-forming region, L1527, to investigate the ^{13}C abundances and formation pathways of CCH.
    Methods. The observations have been carried out with the IRAM 30 m telescope.
    Results. We have successfully detected the lines of ^{13}CCH and $C^{13}CH$ toward the both sources and found a significant intensity difference between the two 13C isotopic species. The [$C^{13}CH$] /[^{13}CCH] abundance ratios are 1.6 ± 0.4 (3σ) and 1.6 ± 0.1 (3σ) for TMC-1 and L1527, respectively. The abundance difference between $C^{13}CH$ and ^{13}CCH means that the two carbon atoms of CCH are not equivalent in the formation pathway. On the other hand, the [CCH]/[$C^{13}CH$] and [CCH]/[^{13}CCH] ratios are evaluated to be larger than 170 and 250 toward TMC-1, and to be larger than 80 and 135 toward L1527, respectively. Therefore, both of the ^{13}C species are significantly diluted in comparison with the interstellar $^{12}C/^{13}C$ ratio of 60. The dilution is discussed in terms of a behavior of ^{13}C in molecular clouds.
- Sakai, N., T. Shiino, T. Hirota, T. Sakai, and S. Yamamoto [2010b], "Long Carbon-Chain Molecules and Their Anions in the Starless Core, Lupus-1A," Astrophys. J. (Letters), vol.718, pp.L49-L52.
  - We have recently discovered a new starless core with bright radio emissions of long carbon-chain molecules in the Lupus molecular cloud, which we have named as Lupus-1A. Toward this source, the peak intensities of the C_6H and C_8H lines are found to be higher than toward TMC-1 by a factor of 2-3. Even the lines of their anions, C_6H^- and C_8H^-, are also brighter than in TMC-1. Moreover, the line of C_4H^- has been detected for the first time in a starless core. The column densities of these long carbon-chain molecules are almost

comparable to those in TMC-1, and hence, this source can be regarded as the second "TMC-1 like cloud." TMC-1 has long been an outstanding molecular cloud with rich carbon-chain molecules since its discovery in 1976. In spite of extensive efforts, no comparable sources have been found so far. Lupus-1A will be used for hunting of new interstellar molecules as well as understanding of carbon-chain chemistry through critical comparison of physical and chemical properties with TMC-1. This source is important not only for astronomy but also for molecular science as an ideal spectroscopic laboratory because of narrow line shapes and bright intensities.

- Sakai, T., N. Sakai, K. Kamegai, T. Hirota, N. Yamaguchi, S. Shiba, and S. Yamamoto [2008], "A Molecular Line Observation toward Massive Clumps Associated with Infrared Dark Clouds," Astrophys. J., vol.678, pp.1049-1069.
  - We have surveyed the N_2H^+ J=1-0, HC_3N J=5-4, CCS $J_N=4_3$-3_2, NH_3 (J, K) = (1, 1), (2, 2), (3, 3), and CH_3OH J=7-6 lines toward the 55 massive clumps associated with infrared dark clouds by using the Nobeyama Radio Observatory 45 m telescope and the Atacama Submillimeter Telescope Experiment 10 m telescope. The N_2H^+, HC_3N, and NH_3 lines are detected toward most of the objects. On the other hand, the CCS emission is detected toward none of the objects. The [CCS]/[N_2H^+] ratios are found to be mostly lower than unity even in the Spitzer 24μm dark objects. This suggests that most of the massive clumps are chemically more evolved than the low-mass starless cores. The CH_3OH emission is detected toward 18 out of 55 objects. All the CH_3OH-detected objects are associated with the Spitzer 24μm sources, suggesting that star formation has already started in all the CH_3OH-detected objects. The velocity widths of the CH_3OH $J_K=7_0$-6_0 A^+ and 7_{-1}-6_{-1} E lines are broader than those of N_2H^+ J=1-0. The CH_3OH $J_K=7_0$-6_0 A^+ and 7_{-1}-6_{-1} E lines tend to have broader line width in the MSX dark objects than in the others, the former being younger or less luminous than the latter. The origin of the broad emission is discussed in terms of the interaction between an outflow and an ambient cloud.
- Sakai, T., N. Sakai, T. Hirota, and S. Yamamoto [2010], "A Survey of Molecular Lines Toward Massive Clumps in Early Evolutionary Stages of High-Mass Star Formation," Astrophys, J., vol.714, pp.1658-1671.
  - We have observed the CH_3OH J = 2-1, SiO J = 2-1, $C^{34}S$ J = 2-1, $H^{13}CO^+$ J = 1-0, $HN^{13}C$ J = 1-0, CCH N = 1-0, OCS J = 8-7, and SO $J_N = 2_2$-1_1 lines toward 20 massive clumps, including Midcourse Space Experiment (MSX) 8μm dark sources (infrared dark clouds) and MSX 8μm sources, by using the Nobeyama Radio Observatory 45 m telescope. We have found that the velocity widths of the CH_3OH and $C^{34}S$ lines are broader than those of the $H^{13}CO^+$ line in the MSX dark sources. On the other hand, they are comparable to the velocity width of the $H^{13}CO^+$ line in the MSX sources. In addition, the [SiO]/[$H^{13}CO^+$] abundance ratio is found to be enhanced in the MSX dark sources in comparison with the MSX sources. These results suggest that shocks caused by interaction between an outflow and an ambient dense gas would have substantial impact on the chemical composition of the MSX dark sources. The velocity widths of the CH_3OH and $C^{34}S$ lines relative to that of the $H^{13}CO^+$ line as well as the [SiO]/[$H^{13}CO^+$] abundance ratio could be used as good tools for investigating evolutionary stages of massive clumps. On the basis of the results, we discuss the chemical and physical evolution of massive clumps.
- Sakao, T., S. Tsuneta, M. Shimojo, N. Narukage, R. Kano, T. Obara, S. Watari, and Hinode Team [2009], "A New View of the Sun with Hinode Mission," Trans. JSASS Space Tech. Japan, vol.7, pp.Tr.2-15-Tr.2-19.
  - We present highlights of observations of the Sun with Japanese Hinode mission launched by JAXA in September 2006. The scientific objective of Hinode mission is to observe, in an unprecedented detail, a wide variety of plasma activities in the Sun's corona together with

magnetic activities on the photosphere and in the chromosphere, utilizing a suite of three state-of-the-art telescopes; Solar Optical Telescope (SOT), X-Ray Telescope (XRT), and EUV Imaging Spectrometer (EIS). Since the beginning of the observations late in October 2006, Hinode has been providing ample information on activities of magnetized plasmas in the solar atmosphere some of which are totally new to us. In this article, we present an overview of the Hinode mission as well as some highlights of the observations.

- Sako, N., M. Shimojo, and T. Kitabayashi [2010[, "Statistical Study of the Polar X-Ray Jets," 38th COSPAR Scientific Assembly, 18-25 July 2010, p.4.
  - The X-Ray Telescope(XRT) abroad Hinode had revealed that X-ray jets in the polar region occur at the high frequency. Savcheva et al. (2007) studied 104 X-ray jets occurred around the south pole and reported the parameters of the jets. However, their study included only the X-ray jets that occurred in the coronal hole. In order to reveal the properties of the polar X-ray jets in not only the coronal hole but also the quiet region, we detected 870 polar X-ray jets occurred around the north pole, and investigated the jets statistically. The 470 jets in the 848 events occurred in the coronal hole. The occurrence rate of the jets in the coronal hole and the quiet sun is 5.04×10^{-12} jets/hr/km^2 and 7.66×10^{-12} jets/hr/km^2, respectively. It shows that the quiet region is more productive of X-ray jets than the coronal hole. We derived five parameters of the polar X-ray jets, and the average of the parameters are 2.91×10^4 km for the maximum length, 4.42×10^3 km for the width, and 180 km/sec for the apparent velocity. The lifetime and length scale of the jets in this result is smaller than that in Savcheva et al. (2007). The reason for these differences is that we could detect smaller jets than the previous work because we used not only X-ray intensity images but also the running difference images for detecting the jets. We derived also the frequency distributions of the parameters and found thatthe frequency distributions of the lifetime and the X-ray intensity of the footpoint flare show the power-raw distribution. The power-law index of the lifetime is -4.22±0.36, and it is smaller than the index(-1.2) derived from the jets that occurred near the active regions(Shimojo et al. 1996). The difference indicates that the occurrence rate of the polar X-ray jets with short lifetime is larger than that of the X-ray jets that occurred near active regions.On the other hand, the power-raw index of the X-ray intensity of the footpoint flare is -2.04±0.27. The index is smaller than that of the X-ray jets near the active regions(Shimojo et al. 1996).
- Sanhueza, P., G. Garay, L. Bronfman, D. Mardones, J. May, and M. Saito [2010], "Molecular Outflows Within the Filamentary Infrared Dark Cloud G34.43+0.24," Astrophys. J., vol.715, pp.18-32.
  - We present molecular line observations, made with angular resolutions of ~20", toward the filamentary infrared dark cloud G34.43+0.24 using the APEX [CO(3→2), ^{13}CO(3→2), C^{18}O(3→2), and CS(7→6) transitions], Nobeyama 45 m [CS(2→1), SiO(2→1), C^{34}S(2→1), HCO$^+$(1→0), H^{13}CO$^+$(1→0), and CH_3OH(2→1) transitions], and SEST [CS(2→1) and C^{18}O(2→1) transitions] telescopes. We find that the spatial distribution of the molecular emission is similar to that of the dust continuum emission observed with 11" resolution showing a filamentary structure and four cores. The cores have local thermodynamic equilibrium masses ranging from 3.3×10^2 to 1.5×10^3 Msun and virial masses from 1.1×10^3 to 1.5×10^3 Msun, molecular hydrogen densities between 1.8×10^4 and 3.9×10^5 cm^{-3}, and column densities $>2.0 \times 10^{22}$ cm^{-2}, values characteristic of massive star-forming cores. The ^{13}CO(3→2) profile observed toward the most massive core reveals a blue profile indicating that the core is undergoing large-scale inward motion with an average infall velocity of 1.3 km s^{-1} and a mass infall rate of 1.8×10^{-3} Msun yr^{-1}. We report the discovery of a molecular outflow toward the northernmost core thought to be in a very early stage of evolution. We also detect the presence of high-velocity gas toward each of the other three cores, giving support to the hypothesis that the excess 4.5μm emission ("green fuzzies") detected toward these cores is due to shocked gas.

The molecular outflows are massive and energetic, with masses ranging from 25 to 80 Msun, momentum 2.3-6.9×10^2 Msun km s^{-1}, and kinetic energies 1.1-3.6×10^3 Msun km^2 s^{-2}, indicating that they are driven by luminous, high-mass young stellar objects.

- Sasaki, S., and T. Hiroi [2008a], "How Does Space Weathering Depend on the Surface Condition of Airless Bodies (Asteroids, the Moon, and Mercury)?," 39th Lunar and Planetary Science Conference, (Lunar and Planetary Science XXXIX), held March 10-14, 2008 in League City, Texas. LPI Contribution No. 1391., p.1625.
  - Itokawa suggested that the rocky small asteroids should be weathered although they lack regolith. On Mercury, surface mixing probably caused by impacts would have weakened the weathering although it is covered with regolith.
- Sasaki, S., T. Iwai, K.-I. Nogami, R. Srama, E. Gruen, H. Ohashi, T. Hirai, T. Yamamoto, M. Fujii, and H. Shibata [2008b], "Development of Plane Parallel Impact-Ionization Dust/Debris Detector," 37th COSPAR Scientific Assembly, held 13-20 July 2008, in Montreal, Canada, p.2740.
  - In-situ measurement of dust and small debris particles in space is important to study the origin or those particles. Especially to examine the time variation of dust/debris flux, relatively large sensor aperture (> 500cm2) is necessary for dust/debris measurement at LEO. We have been developing light-weight large-area dust detectors for space. Impact-ionization dust detectors on board HITEN and NOZOMI had a box-shape where volume/mass of a detector should be larger as increasing the target area. We have developed plane-parallel type detectors with a target plate and entrance grids. So far we tested three models with different target diameters: 5cm, 15cm, 30cm. In these types, volume/mass of a detector is basically proportional to its sensor area. A detector consists of a target plate and two grids. Electrons from impact-generated plasma are collected by the target and positive ions from the plasma are attracted by the inner grids. Detected charge signals at the target and grids are amplified and stored. Using the total charge and rise time of plasma signals, we can obtain information on mass and velocity of impacted particles. Using van de Graff dust accelerators at Univ. Tokyo and Max-Planck Institute Kernphysik, we have done experiments of irradiation of micron size dust particles. Typical speed of impact velocity is 4-20km/s. A few of faster particles were also measured. Particles of Ag, Fe, C, and latex polymer have been irradiated. We have confirmed relationships between the total charge and dust mass, and between the charge rise time and impact velocity. The detector can measure mass and velocity of micron-size dust particles in space. Currently we are planning to measure dust and debris particles at LEO using the surface unit on board the Space Station.
- Sasaki, S., Y. Ishihara, H. Noda, H. Araki, Laser Altimeter (Lalt) in Emiko Migita, Kaguya, and S. Tazawa [2008c], "KAGUYA Laser Altimeter (LALT) Initial Results on Lunar Impact Structures," 37th COSPAR Scientific Assembly, held 13-20 July 2008, in Montreal, Canada, p.2739.
  - The main orbiter of Japanese lunar explorer KAGUYA(SELENE) has laser altimeter (LALT) which measures the distance between the orbiter and the lunar surface. Detecting the delay time of reflecting laser pulse from the surface, LALT can determine the lunar topography with the accuracy better than 5m. After the initial checkout of the instrument, LALT started the nominal continuous observation on 30 December 2007 and it scanned the whole lunar surface once by mid January 2008. KAGUYA LALT can detect reflected signals day and night. Therefore LALT can scan the lunar globe in a half month. By late June, we will have 12 times scans of the lunar surface. At that time, the spatial resolution will be 2.4km at the equator in the longitudinal direction. Since pulse frequency is 1 second, the resolution in the latitudinal direction is 1.5km. The spatial resolution will be one order of magnitude better than that of Clementine altimeter. Also LALT covers high-latitude and polar regions where Clementine

LIDAR did not obtain data. LALT can clarify the presence and shape of craters as well as large impact structure. Previously unresolved heights of central peaks of large craters are obtained. Within the farside highland, several large impact structures show multi-ring morphologies some of which are obscure. The farside impact structures would be corresponding to gravity patterns, which will be also obtained by KAGUYA gravity instruments. In the nearside, LALT preliminary data would suggest hidden impact structures within the mare region.

- Sasaki, S., and T. Hiroi [2008d], "Difference of Space Weathering Degree on Asteroids of Various Sizes," Meteoritics and Planetary Sci. Suppl., 43, paper id. 5245.
  - Not Available
- Sasaki, S., H. Araki, H. Hanada, N. Namiki, T. Iwata, K. Asari, S. Goossens, Y. Ishihara, T. Ishikawa, N. Kawano, F. Kikuchi, Q. Liu, K. Matsumoto, H. Noda, S. Tazawa, S. Tsuruta, Y. Harada, N. Petrova, K. Kurosawa, and S. Sugita [2008e], "Global Topography and Gravity of the Moon Revealed by KAGUYA Mission," American Astronomical Society, DPS meeting #40, #9.01.
  - The Japanese lunar explorer KAGUYA (SELENE) was launched successfully on September 14th, 2007. KAGUYA has two small spin-stabilized subsatellites, Rstar (OKINA) and Vstar (OUNA) for gravity measurement. We can track the three satellites by new methods: 4-way Doppler tracking between the main satellite and Rstar for the far-side gravity and multi-frequency differential VLBI tracking between Rstar and Vstar. The global lunar gravity field with unprecedented accuracy can be obtained. Through more than 6 months, precise gravity field including most of farside was obtained. The farside gravity field shows significant improvement from the previous model. Many circular features corresponding to impact structures are clearly identified. Some of the circular gravity anomalies in the free-air gravity apparently disappear in Bouguer anomaly map; the surface topography is a dominant source of free-air gravity anomalies and large impact structures are supported by lithosphere, which would lead to the difference of thermal history between nearside and farside. A possible cryptomare candidate (a circular gravity anomaly without topographic signature) was also found.

    KAGUYA has a laser altimeter (LALT). The first precise global topography data with range accuracy 5m have been produced by LALT. In the polar regions where CLEMENTINE did not cover, topographic features in the shadowed area are newly discovered. Solar illumination condition was calculated: the region whose solar illumination rate is higher than 90% is very limited. Lunar mean radius is 1737.15±0.01 km and the COM-COF offset is 1.94 km. The amplitude of the power spectrum of topography spherical harmonics is larger than that of the previous model at L>30.

    From the gravity and topography data, we obtain the distribution of the crustal thickness on the Moon. We also estimate the correlation between gravity and topography and localized admittance values. Gravity and topography observation of KAGUYA will continue until early 2009.
- Sasaki, S., Y. Ishihara, H. Araki, H. Noda, S. Goossens, N. Namiki, T. Iwata, H. Hanada, K. Matsumoto, N. Kawano, F. Kikuchi, Q. Liu, Y. Harada, SELENE Gravity/Topography Group [2009a], "Lunar Topography and Crustal Thickness by KAGUYA (SELENE) Selenodesy Observation," American Astronomical Society, DPS meeting #41, #26.02.
  - The Japanese lunar explorer KAGUYA (SELENE) was launched on September 14th, 2007 and continued its operation by June 11th, 2009. Laser altimeter(LALT) on board KAGUYA obtained the first precise global topography data with range accuracy of 5m [1]. In the polar regions where CLEMENTINE LIDAR could not obtain data, KAGUYA clarified topographic features including permanently shadowed areas. Distribution of solar illumination rates was also estimated at elevated areas [2]. The amplitude of the power spectrum of topography

spherical harmonics is larger than that of the previous model at L>30. Using 4-way Doppler tracking with relay satellite OKINA(Rstar), KAGUYA obtained the first precise gravity field of the lunar far-side [3]. Multi-frequency VLBI observation using subsatellites OKINA and OUNA(Vstar) improved the accuracy of gravity. Combined with topography data, we estimate the crustal thickness variation of the Moon [4]. Gravity signatures of far-side impact basins are mostly explained by topography except for the central high. We have better correlation of spherical harmonics coefficients between gravity and topography than the previous model [3]. On the far-side, obtained Bouguer anomaly distribution is relatively smooth both within South Pole-Aitken basin (SPA) and within far-side highland terrain (FHT). This would imply relatively smooth crust-mantle boundary there. The shape of the central SPA basin with thinner crust is rather circular. SPA is also characterized by the admittance spectra. Although the crustal thickness of SPA is much thinner than that FHT, the elastic thicknesses of both zones are not so different on the basis of the admittance. SPA area would be elastically supported by a part of upper mantle.

[1] Araki, H. et al.(2009) Science 323, 892. [2] Noda et al.(2008) GRL, doi:10.1029/2008GL035692 [3] Namiki, N. et al.(2009) Science 323, 900, [4] Ishihara, Y. et al.(2009) GRL, submitted.

- Sasaki, S., N. Namiki, H. Hanada, H. Araki, T. Iwata, Y. Ishihara, K. Matsumoto, H. Noda, S. Goossens, and Kaguya Topography/Gravity Team [2009b], "Global Topography and Gravity of the Moon Observed by KAGUYA," EPSC(European Planetary Science Congress) abstracts, vol.4, pp.EPSC2009-547(1-2).
  - Not Available
- Sasaki, S., Y. Ishihara, H. Araki, H. Noda, H. Hanada, K. Matsumoto, S. Goossens, N. Namiki, T. Iwata, and M. Ohtake [2010], "Structure of the Lunar South Pole-Aitken Basin from Kaguya (SELENE) Gravity/Topography," LPI Contribution No. 1533, p.1691.
  - KAGUYA gravity and topography data are used to characterize the structure of South Pole-Aitken basin. Previously proposed elliptic basin shape was confirmed by crustal thickness. The thinner region with 30km crust is offset from the basin center.
- Sato, M., T. Hirota, M. Honma, and H. Kobayashi [2008a], "Absolute Proper Motions of Water Masers in NGC 281 Measured with VERA," Proc. of the IAU Symp. 242, "Astrophysical Masers and their Environments", eds. Jessica Chapman and Willem Baan, pp.170-171.
  - We report on absolute proper-motion measurements of H_2O maser features in the NGC 281 West molecular cloud, located ~320 pc above the Galactic plane and associated with an HI loop extending from the Galactic plane. We conducted six-epoch phase-referencing observations of the maser source with VERA (VLBI Exploration of Radio Astrometry) over six months since May 2006. The H_2O maser features are found to be systematically moving toward the southwest and further away from the Galactic plane with a vertical velocity of ~20-30 km s^{-1} at its estimated distance of 2.2-3.5 kpc. Our new results provide the most direct evidence that the gas in the NGC 281 region was blown out from the Galactic plane, most likely in a superbubble driven by multiple or sequential supernova explosions in the Galactic plane.
- Sato, M., T. Hirota, M. Honma, H. Kobayashi, T. Sasao, T. Bushimata, Y. K. Choi, H. Imai, K. Iwadate, T. Jike, S. Kameno, O. Kameya, R. Kamohara, Y. Kan-ya, N. Kawaguchi, M. K. Kim, S. Kuji, T. Kurayama, S. Manabe, M. Matsui, N. Matsumoto, T. Miyaji, T. Nagayama, A. Nakagawa, K. Nakamura, C. S. Oh, T. Omodaka, T. Oyama, S. Sakai, K. Sato, K. M. Shibata, Y. Tamura, and K. Yamashita [2008b], "Distance to NGC 281 in a Galactic Fragmenting Superbubble: Parallax Measurements with VERA," Publ. Astron. Soc. Japan, vol.60, pp.975-989.
  - We have used the Japanese VLBI array VERA to perform high-precision astrometry of an H_2O

maser source in the Galactic star-forming region NGC 281 West, which has been considered to be part of a 300-pc superbubble. We successfully detected a trigonometric parallax of 0.355±0.030 mas, corresponding to a source distance of 2.82±0.24 kpc. Our direct distance determination of NGC 281 has resolved a large distance discrepancy between previous photometric and kinematic studies; likely NGC 281 is in the far side of the Perseus spiral arm. The source distance as well as the absolute proper motions were used to demonstrate the 3D structure and expansion of the NGC 281 superbubble, ~650 pc in size parallel to the Galactic disk and with a shape slightly elongated along the disk or spherical, but not vertically elongated, indicating that the superbubble expansion may be confined to the disk. We estimate the expansion velocity of the superbubble as being ~20 km/s^{-1}, both perpendicular to and parallel to the Galactic disk with a consistent timescale of ~20 Myr.

- Sato, M. T., and M. Tsuboi, [2009a], "SiO and $H^{13}CO^{+}$ Emission Lines Observations Toward the Infalling Gas onto the CND at the Galactic Center," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.388-391.
  - The central region of our Galaxy (Sgr A*) is the nearest galactic center harboring a massive black hole. The environment around Sgr A* is a topic of interest in diverse fields. We have studied the gas feeding from giant molecular clouds (GMC) within 10 pc of the Galactic center to the Circumnuclear Ring (CND), which is presumable is infalling gas toward Sgr A*. In order to study the mechanism, we observed SiO (J=2-1 v=0) and $H^{13}CO^{+}$ (J=1-0) lines using the Nobeyama Millimeter Array (NMA). We detected the CND clearly in SiO line. The molecular gas in the CND rotates interactively. We observed two molecular streamers within CND in SiO line. One is a new detection. The line intensity ratios at overlapping points of the streamers in the CND are significantly higher ($I(SiO)/I(H^{13}CO^{+}) > 8$) than the average of other lines in the CND (about 2-4). This is a strong evidence indicating these streamers are associated with the CND.
  - Sato, M., T. Hirota, M. Honma, H. Kobayashi, and VERA Project Team [2009b], "Superbubble Motion Away from the Galactic Plane: Astrometry of Water Masers in NGC 281 with VERA," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.476-479. We report on results of our parallax measurements of an H2O maser source in the NGC 281 West molecular cloud, associated with a 300-pc fragmenting superbubble above the Galactic plane. We have conducted multi-epoch phase-referencing observations of the maser source with VERA (VLBI Exploration of Radio Astrometry) over 18 months year since May 2006. The parallax measurement yields a direct distance estimate of 2.82 ± 0.24 kpc, which agrees well with the photometric distance of 2.94 ± 0.15 kpc derived by Guetter and Turner (1997) and resolves the large distance discrepancy of NGC 281 in previous studies. We find that the H2O maser features in NGC 281 West are systematically moving toward the southwest and further away from the Galactic plane with a vertical velocity of 20 km s 1. Our new results provide the most direct evidence for the NGC 281 superbubble expansion is most likely driven by multiple or sequential supernova explosions in the Galactic plane.
- Sato, M., T. Hirota, M. J. Reid, M. Honma, H. Kobayashi, K. Iwadate, T. Miyaji, and SK. M. hibata [2010], "Distance to G14.33-0.64 in the Sagittarius Spiral Arm: H_2O Maser Trigonometric Parallax with VERA," Publ. Astron. Soc. Japan, vol.62, pp.287-299.
  - We report on trigonometric parallax measurements for the Galactic star-forming region G14.33-0.64 toward the Sagittarius spiral arm. We conducted multi-epoch phase-referencing observations of an H_2O maser source in G14.33-0.64 with the Japanese VLBI array VERA. We successfully detected a parallax of π=0.893±0.101 mas, corresponding to a source distance of d

= 1.12±0.13 kpc, which is less than half of the kinematic distance for G14.33-0.64. Our new distance measurement demonstrates that the Sagittarius arm lies at a closer distance of ~1 kpc, instead of the previously assumed ~2-3 kpc from the kinematic distances. The previously suggested deviation of the Sagittarius arm toward the Galactic center from the symmetrically fitted model (Taylor & Cordes 1993, ApJ, 411, 674) is likely due to large errors of the kinematic distances at low galactic longitudes. G14.33-0.64 most likely traces the near side of the Sagittarius arm. We attempted to fit the pitch angle of the arm with other parallax measurements along the arm, which yielded two possible pitch angles of i = 34°.7±2°.7 and i = 11°.2±10。.5. Our

proper-motion measurements suggest that G14.33-0.64 has no significant peculiar motion relative to the differential rotation of the Galaxy (assumed to be in a circular orbit), indicating that the source motion is in good agreement with the Galactic rotation.

- Sato, M. T., and M. Tsuboi [2008a], "Infallng Gas onto the Galactic Center Circumnuclear Ring," Proc. of the "Observational Evidence for Black Holes in the Universe", AIP Conf. Proc., vol.1053, pp.95-98.

➢ The central region of our Galaxy (Sgr A*) is the nearest galactic center harboring a massive black hole. The environment around Sgr A* is a topic of interest to diverse fields. We are interested in gas feeding from giant molecular clouds (GMC) within 10 pc of the Galactic center to the Circumnuclear Ring (CND), which is presumable Ą glay-down bay Ąh of infalling gas toward Sgr A*. In order to reveal the mechanism, we observed SiO J = 2-1 ν= 0 and $H^{13}CO^{+}$ J = 1-0 lines using the Nobeyama Millimeter Array (NMA). We depicted the CND clearly in SiO line. Molecular gas in CND rotates interacting each other. We observed two molecular streamers to CND in SiO line. One is a new detection. The line intensity ratios at overlapping points of streamers with CND are significantly higher ($I(SiO)/I(H^{13}CO^{+})>8$) than the average of CND (about 2-4). This is a strong evidence indicating these streamers are connecting to the CND.

- Sato, M. T., and M. Tsuboi [2008b], "Infallng Gas onto the Galactic Center Circumnuclear Ring," J. of Phys., Conf. Ser., vol.131, pp.012033(1-7).

➢ The central region of our Galaxy (Sgr A*) is the nearest galactic center harboring a massive black hole. The environment around Sgr A* is a topic of interest to diverse fields. We are interested in gas feeding from giant molecular clouds (GMC) within 10 pc of the Galactic center to the Circumnuclear Ring/Disk (CND), which is presumable 'lay-down bay' of infalling gas toward Sgr A*. In order to reveal the mechanism, we observed the CND and its surroundings in SiO and $H^{13}CO^{+}$ lines using Nobeyama Millimeter Array (NMA). We depict the CND clearly in both lines and some molecular streamers to the CND in only SiO line including one new detection. The line intensity ratios at overlapping points of streamers with the CND are higher ($I(SiO)/I(H^{13}CO^{+}) > 6$) than the average of CND (2-4). This is a strong evidence indicating these streamers are connecting to the CND. Some components at the outer region of the CND are also detected in both lines. We also estimate the rotation velocity of the CND as 110±10 km s^{-1} and of just a bit outside from the CND as 93±14 km s^{-1}. The estimation of the rotation velocity in the distance range of 5-10 pc from the Sgr A* has a great meaning since there have been few report about the kinematic parameters at just outside of the CND.

- Satou, N., Y. Sekimoto, Y. Iizuka, T. Ito, W.-I. Shan, T. Kambe, K. Kumagai, M. Kamikura, Y. Tomimura, Y. Serizawa, S. Asayama, and M. Sugimoto [2008], "A Submillimeter Cartridge-Type Receiver: ALMA Band 8 (385-500GHz) Qualification Model," Publ. Astron. Soc. Japan, vol.60, pp.1199-1207.

➢ We have developed a cartridge-type receiver covering the frequency band of 385-500 GHz as a qualification model of Atacama Large Millimeter/submillimeter Array (ALMA) band 8. It receives two orthogonal polarizations and down-converts the sideband-separated signals to

intermediate frequencies (IF) of between 4 and 8 GHz. The cartridge-type receiver consists of cold optics, two feed horns, a wire grid, mirrors, two sideband-separating SIS mixers, cryogenic multipliers of a local oscillator (LO), cryogenic and warm IF ampliflers, a cartridge body, and sensors/wirings. These components were individually tested, and then the cartridge was integrated and tested as a complete assembly. We have also developed equipment for efficiency tests of both the components and the inte-

grated receiver. The single sideband (SSB) noise temperature of this receiver is 100 K at the band center and 300 K at the band edges. The beam pattern and cross-polarization pattern are consistent with a physical optical calculation.

The amplitude stability is around $3x10^{-4}$ in 1 s. The phase stability is less than 2.°0 on a time scale of 0.1 s to 10 min. These results are promising for a receiver in the ALMA.

- Sawada, T., J. Koda, T. Handa, M. Sugimoto, and T. Hasegawa [2008a], "NRO/CSO/ASTE Galactic Plane CO Survey," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., p.374.

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- Sawada, T., N. Ikeda, K. Sunada, N. Kuno, T. Kamazaki, K.-I. Morita, Y. Kurono, N. Koura, K. Abe, S. Kawase, J. Maekawa, O. Horigome, and K. Yanagisawa [2008b], "On-The-Fly Observing System of the Nobeyama 45-m and ASTE 10-m Telescopes," Publ. Astron. Soc. Japan, vol.60, pp.445-455.

➢ We have developed a spectral line On-The-Fly (OTF) observing mode for the Nobeyama Radio Observatory 45-m and the Atacama Submillimeter Telescope Experiment 10-m telescopes. Sets of digital autocorrelation spectrometers are available for OTF with heterodyne receivers mounted on the telescopes, including the focal-plane 5x5 array receiver, BEARS, on the 45-m. During OTF observations, the antenna is continuously driven to cover the mapped region rapidly, resulting in high observing efficiency and accuracy. Pointing of the antenna and readouts from the spectrometer are recorded as fast as 0.1 s. In this paper we report improvements made to the software and instruments, requirements and optimization of observing parameters, data-reduction process, and verification of the system. It is confirmed that, using optimal parameters, the OTF is about twice as the conventional position-switch observing method.

- Scott, K. S., M. S. Yun, G. W. Wilson, J. E. Austermann, I. Aretxaga, H. Ezawa, D. Ferrusca, B. Hatsukade, D. H. Hughes, D. Iono, M. Giavalisco, R. Kawabe, K. Kohno, P. D. Mauskopf, T. Oshima, T. A. Perera, J. Rand, Y. Tamura, T. Tosaki, M. Velazquez, and C. C. Williams [2010], "Deep 1.1 mm-Wavelength Imaging of the GOODS-S Field by AzTEC/ASTE - I. Source Catalogue and Number Counts," Mon. Not. Roy. Astron. Soc., vol.405, pp.2260-2278.

➢ We present the first results from a 1.1mm confusion-limited map of the Great Observatories Origins Deep Survey-South (GOODS-S) taken with the AzTEC camera on the Atacama Submillimeter Telescope Experiment. We imaged a 270 $arcmin^2$ field to a 1σdepth of 0.48-0.73 mJy $beam^{-1}$, making this one of the deepest blank-field surveys at mm-wavelengths ever achieved. Although by traditional standards our GOODS-S map is extremely confused due to a sea of faint underlying sources, we demonstrate through simulations that our source identification and number counts analyses are robust, and the techniques discussed in this paper are relevant for other deeply confused surveys. We find a total of 41 dusty starburst galaxies with signal-to-noise ratios S/N ≥ 3.5 within this uniformly covered region, where only two are expected to be false detections, and an additional seven robust source candidates located in the noisier ($1\sigma \approx$ 1mJy beam 1) outer region of the map. We derive the 1.1mm number counts from this field using two different methods: a fluctuation or "P(d)" analysis and a semi-Bayesian technique and find that both methods give consistent results. Our data are well fit by a Schechter function model with $(S', N_{3mJy}, \alpha) = (1.30^{+0.19}_{-0.25}$ mJy, 160^{+27}_{-28} mJy^{-1}

deg^{-2}, -2.0). Given the depth of this survey, we put the first tight constraints on the 1.1mm number counts at $S_{1.1mm}$ = 0.5 mJy, and we find evidence that the faint end of the number counts at $S_{850\mu m}$ □2.0 mJy from various SCUBA surveys towards lensing clusters are biased high. In contrast to the 870μm survey of this field with the LABOCA camera, we find no apparent underdensity of sources compared to previous surveys at 1.1 mm; the estimates of the number counts of SMGs at flux densities > 1 mJy determined here are consistent with those measured from the AzTEC/SHADES survey. Additionally, we find a significant number of SMGs not identified in the LABOCA catalogue. We find that in contrast to observations at λ≤500μm, MIPS 24μm sources do not resolve the total energy density in the cosmic infrared background at 1.1mm, demonstrating that a population of z □3 dust-obscured galaxies that are unaccounted for at these shorter wavelengths potentially contribute to a large fraction (~2/3) of the infrared background at 1.1mm.

- Sekido, M., N. Kawaguchi, Y. Koyama, M. Kimura, T. Kondo, H. Takiguchi, T. Hobiger, K. Takefuji, H. Harai, T. Ikeda, S. Shimojo, T. Oyama, T. Hara, Y. Kono, S. Kurihara, K. Kokado, D. Tanimoto, K. Nozawa, H. Takechi, H. Uose, K. Fujisawa, and H. Takaba [2009], "e-VLBI Activities in Japan," Proc. of the 8th International e-VLBI Workshop "Science and Technology of Long Baseline Real-Time Interfrometry", pp.24-29.

➢ Recent Japanese e-VLBI activities are reported in this paper. Of ° ine data transfer though the network has been regularly performed for geodetic VLBI experiments. Besides these offline transfers, real-time eVLBI experiments for ultra-rapid UT1 measurements have been performed among Onsala, Mets 撹 ovi, Tsukuba, and Kashima stations in a pilot project. In the field of astronomy, a real-time e-VLBI demonstration session organized by the ATNF in 2008 was the first occasion for Kashima to transmit VLBI data obtained by the K5 system to a foreign correlator
in real-time. The global e-VLBI observation session organized by JIVE for the opening event of International Year of Astronomy in January 2009 was the first participation for a Japanese station in a global real-time e-VLBI session. Overview of the K5 DAS systems (K5/VSSP, and K5/VSI) used for the e-VLBI is described.
Optically linked e-VLBI observations with domestic VLBI stations have been conducted by the NAOJ. Also the NAOJ has developed a high speed VLBI data sender/reciver equipment named VOA-200 and a high speed hardware correlator (2Gbps x 6 baselines). A test observation of 8 Gbps real-time VLBI was successfully achieved by using the VOA-200 and the hardware corre-lator in 2008.

- Seta, H., M. Tashiro, N. Isobe, Y. Yaji, M. Hayashida, K. Nakanishi, T. Tosaki, K. Kohno, Y. Shimajiri, M. Fukuhara, M. Sasada, A. Arai, and M. Umemura [2008], "Suzaku Observation of the OJ 287, Quiescence and Predicted Flare in 2007," Proc. of the Workshop on Blazar variability across the electromagnetic spectrum, published online, PoS063-1-6.

➢ Suzaku observations are reported of the BL Lacertae object OJ 287, performed on 2007 April 10-13 during the optical quiescent phase and on 2007 November 7 9 during the optical flaring phase. We organized the simultaneous the radio and optical observations with the Nobeyama Millimeter Array and optical KANATA telescope at Hiroshima University, respectively. The X-ray spectrum obtained in the quiescent phase was described by a single power-low model with a photon index of $\Gamma = 1.65 \pm 0.02$ and the flux density was measured to be 216 ± 6 nJy at 1 keV. In the flare phase, the X-ray spectrum became harder ($\Gamma = 1.50 \pm 0.01$), and the flux density has doubled to be 398 ± 7 nJy at 1 keV. Our multi-wavelength spectrum exhibited the SR and IC components, and the X-ray spectra cannot be explained as an extension from the SR components, but suggest that the X-rays are dominated by the IC component. We suggested electron spectrum indices are variable for each phase. Thus, for the 2nd-flare, SR and IC components increased without extending energy band.

- Seta, H., N. Isobe, M. S. Tashiro, Y. Yaji, A. Arai, M. Fukuhara, K. Kohno, K. Nakanishi, M. Sasada, Y. Shimajiri, T. Tosaki, M. Uemura, H. Anderhub, L. A. Antonelli, P. Antoranz, M. Backes, C. Baixeras, S. Balestra, J. A. Barrio, D. Bastieri, J. Becerra Gonzalez, J. K. Becker, W. Bednarek, K. Berger, E. Bernardini, A. Biland, R. K. Bock, G. Bonnoli, P. Bordas, D. Borla Tridon, V. Bosch-Ramon, D. Bose, I. Braun, T. Bretz, I. Britvitch, M. Camara, E. Carmona, S. Commichau, J. L. Contreras, J. Cortina, M. T. Costado, S. Covino, V. Curtef, F. Dazzi, A. De Angelis, E. De CeadelPozo, R. de los Reyes, B. DeLotto, M. De Maria, F. De Sabata, C. Delgado Mendez, A. Dominguez, D. Dorner, M. Doro, D. Elsaesser, M. Errando, D. Ferenc, E. Fernandez, R. Firpo, M. V. Fonseca, L. Font, N. Galante, R. J. Garc□ Lopez, M. Garczarczyk, M. Gaug, F. Goebel, D. Hadasch, M. Hayashida, A. Herrero, D. Hildebrand, D. Hohne-Monch, J. Hose, C. C. Hsu, T. Jogler, D. Kranich, A. La Barbera, A. Laille, E. Leonardo, E. Lindfors, S. Lombardi, F. Longo, M. Lopez, E. Lorenz, P. Majumdar, G. Maneva, N. Mankuzhiyil, K. Mannheim, L. Maraschi, M. Mariotti, M. Martınez, D. Mazin, M. Meucci, M. Meyer, J. M. Miranda, R. Mirzoyan, H. Miyamoto, J. Moldon, M. Moles, A. Moralejo, D. Nieto, K. Nilsson, J. Ninkovic, N. Otte, I. Oya, R. Paoletti, J. M. Paredes, M. Pasanen, D. Pascoli, F. Pauss, R. G. Pegna, M. A. Perez-Torres, M. Persic, L. Peruzzo, F. Prada, E. Prandini, N. Puchades, I. Reichardt, W. Rhode, M. Ribo, J. Rico, M. Rissi, A. Robert, S. Rugamer, A. Saggion, T. Y. Saito, M. Salvati, M. Sanchez-Conde, K.Satalecka, V. Scalzotto, V. Scapin, T. Schweizer, M. Shayduk, S. N. Shore, N. Sidro, A. Sierpowska-Bartosik, A. Sillanpaa, J. Sitarek, D. Sobczynska, F. Spanier, A. Stamerra, L. S. Stark, L. Takalo, F. Tavecchio, P. Temnikov, D. Tescaro, M. Teshima, M. Tluczykont, D. F. Torres, N. Turini, H. Vankov, R. M. Wagner, W. Wittek, V. Zabalza, F. Zandanel, R. Zanin, J. Zapatero [2009]. "Suzaku and Multi-Wavelength Observations of OJ287 During the Periodic Optical Outburst in 2007," Publ. Astron. Soc. Japan, vol.61, pp.1011-1022.
  - Suzaku observations of the blazar OJ 287 were performed in 2007 April 10-13 and November 7-9. They correspond to a quiescent and a flaring state, respectively. The X-ray spectra of the source can be well-described with single power-law models in both exposures. The derived X-ray photon index and the flux density at 1 keV were found to be $\Gamma=1.65\pm0.02$ and $S_{1keV}=215\pm5$ nJy in the quiescent state. In the flaring state, the source exhibited a harder X-ray spectrum ($\Gamma=1.50\pm0.01$) with a nearly doubled X-ray flux density of $S_{1keV}=404^{+6}_{-5}$ nJy. Moreover, significant hard X-ray signals were detected up to ~27 keV. In cooperation with Suzaku, simultaneous radio, optical, and very-high-energy γ-ray observations of OJ 287 were performed with the Nobeyama Millimeter Array, the KANATA telescope, and the MAGIC telescope, respectively. The radio and optical fluxes in the flaring state (3.04±0.46 Jy and 8.93±0.05 mJy at 86.75 Hz and in the V-band, respectively) were found to be higher by a factor of 2-3 than those in the quiescent state (1.73±0.26 Jy and 3.03±0.01 mJy at 86.75 Hz and in the V-band, respectively). No notable γ-ray events were detected in either observation. The spectral energy distribution of OJ 287 indicated that the X-ray spectrum was dominated by inverse Compton radiation in both observations, while synchrotron radiation exhibited a spectral cutoff at around the optical frequency. Furthermore, no significant difference in the synchrotron cutoff frequency was found between the quiescent and flaring states. According to a simple synchrotron self-Compton model, the change of the spectral energy distribution is due to an increase in the energy density of electrons with small changes of both the magnetic field strength and the maximum Lorentz factor of electrons.
- Shibasaki, K. [2008a], "Multi-Wavelength Imaging of Solar Plasma: High-Beta Disruption Model of Solar Flares," Plasma and Fusion Res., vol.2, pp.S1012-1-S1012-4.
  - Solar atmosphere is filled with plasma and magnetic field. Activities in the atmosphere are due to plasma instabilities in the magnetic field. To understand the physical mechanisms of activities / instabilities, it is necessary to know the physical conditions of magnetized plasma,

such as temperature, density, magnetic field, and their spatial structures and temporal developments. Multi-wavelength imaging is essential for this purpose. Imaging observations of the Sun at microwave, X-ray, ENV and optical ranges are routinely going on. Due to free exchange of original data among solar physics and related field communities, we can easily combine images covering wide range of spectrum. Even under such circumstances, we still do not understand the cause of activities in the solar atmosphere well. The current standard model of solar activities is based on magnetic reconnection: release of stored magnetic energy by reconnection is the cause of solar activities on the Sun such as solar flares. However, recent X-ray, ENV and microwave observations with high spatial and temporal resolution show that dense plasma is involved in activities from the beginning. Based on these observations, I propose a high-beta model of solar activities, which is very similar to high-beta disruptions in magnetically confined fusion experiments.

- Shibasaki, K. [2008b], "Leakage of Sub-Photospheric Hot Plasma through Magnetic Flux Tube," American Geophysical Union, Fall Meeting 2008, abstract #SH41A-1614.
  - The solar corona has million degree temperature even though it is located above the cooler chromosphere and the photosphere. Also, coronal plasma is constantly flowing out as the solar wind. So the mechanism of coronal heating needs to include a mechanism of constant plasma supply. Most of the proposed coronal heating mechanisms are by waves or nano-flares. Both mechanisms are to carry energy of photospheric convection motion into the corona and dissipate there. Plasma supply is assumed to be through evaporation (or ablation) from the lower atmosphere due to steep temperature gradient. In these mechanisms, tenuous coronal plasma receives large amount of energy to heat and evaporate low temperature plasma into the corona. Hence the temperature of the initially heated plasma should be much higher than the million degree corona. Charged particles with such high temperature in the tenuous corona cannot reach the lower atmosphere due to their strong diamagnetic moment. They will be pushed upwards where magnetic field is weak rather than downwards where magnetic field is strong. Hence, the evaporation mechanism will not work. I will propose a quite different mechanism of million-degree plasma supply in more direct manner. The solar corona is filled with magnetic fields. They are generated at the base of the convection zone and lifted by the convection motion. The standard model of the Sun shows that the temperature at the base of the convection zone is about 2 million degree. So the plasmas trapped in the magnetic flux tube must have temperature there. Plasma particles have diamagnetic moments and they will be pushed along the flux tube toward weaker magnetic field region. As the result, the solar atmosphere which is filled with magnetic field, generated at the base of the convection zone, must have million degree temperature.
- Shibasaki, K. [2009], "Nonlinear and Diamagnetic Nature of Plasma and Activities in the Solar Atmosphere," American Astronomical Society, SPD meeting #40, #30.01; Bulletin of the American Astronomical Society, vol.41, p.864.
  - Plasma is a nonlinear and diamagnetic media. Magnetic moment of each charged particle in thermal plasma is $\mu=-kT/B$, where k is the Boltzmann constant, T is the plasma temperature and B is the magnetic flux density. It does not depend on mass or charge. Negative value means that the magnetic moment is anti-parallel to B, or diamagnetic.

    This nonlinear and diamagnetic nature of plasma is often not explicitly treated due to low plasma beta assumption. The plasma beta is the ratio between magnetic moment per unit volume and the magnetic flux density. However, if the plasma beta exceeds several percent, nonlinear nature becomes important. This is one of the reasons why nuclear fusion experiment in magnetically confined plasmas is difficult. This condition should be the same in the solar atmosphere.

    Particles with magnetic moment anti-parallel to B are pushed toward weak field region along

the field. This force (mirror force, f =μdB/dr = -kT/L) is proportional to the plasma temperature and is inversely proportional to the magnetic scale length L (=1/ (1/B dB/dr)). Generally, magnetic field strength decreases upwards, hence the force is directed upwards. At higher temperature, this force exceeds the gravity force and generates temperature dependent up-flows. If the magnetic field is closed, plasma will be accumulated around the top where magnetic field is the weakest and they suppress B further due to their diamagnetism, hence a high beta region spontaneously appears around the loop top. High-beta plasma around the loop top is unstable against the interchange mode or the ballooning mode due to convex outward curvature (or bad curvature) of B. High-beta disruption will be expected from the outer surface of the loop top.

- Shimajiri, Y., S. Takahashi, S. Takakuwa, M. Saito, and R. Kawabe [2008], "Millimeter- and Submillimeter-Wave Observations of the OMC-2/3 Region. II. Observational Evidence for Outflow-Triggered Star Formation in the OMC-2 FIR 3/4 Region," Atrophys. J., vol.683, pp.255-266.

➢ We have observed the Orion Molecular Cloud-2 FIR 3/4 region in the $H^{13}CO^+$ (J-1-0), ^{12}CO (J=1-0), SiO (v=0, J=2-1), and CS (J=2-1) lines and the 3.3 mm continuum emission with the Nobeyama Millimeter Array (NMA) and in the CO (J=3-2) and CH_3OH ($J_K=7_K$-6_K) lines with Atacama Submillimeter Telescope Experiment (ASTE). Our NMA observations in the $H^{13}CO^+$ emission have revealed 0.07 pc scale dense gas associated with FIR 4 (FIR 4 clump). The ^{12}CO (J=3-2,1-0) emission shows high-velocity blue- and redshifted components to both the northeast and southwest of FIR 3, suggesting an outflow from FIR 3 along the plane of the sky. The SiO and CH_3OH emission, known as shock tracers, are detected around the interface between the outflow and FIR 4 clump. Furthermore, the ^{12}CO (J=1-0) emission shows an L-shaped structure in the PV diagram. These results suggest the presence of an interaction between the outflow and FIR 4 clump. Moreover, our interferometric 3.3 mm continuum observations have first found that FIR 4 consists of 11 dusty cores at a scale of ~2000 AU. The separation among these cores (~5×10^3 AU) is on the same order of the Jeans length (~13×10^3 AU), and the estimated time scale of the fragmentation (~3.8×10^4 yr) is similar to the time scale of the outflow interaction (~1.4×10^4 yr). We suggest that the interaction triggered the fragmentation into these dusty cores, and hence the next generation of the cluster formation in FIR 4.

- Shimajiri, Y., S. Takahashi, S. Takakuwa, M. Saito, and R. Kawabe [2009], "Millimeter- and Submillimeter-Wave Observations of the OMC-2/3 Region. IV Interaction between the Outflow and the Dense Gas in the Cluster Forming Region of OMC-2 FIR 6," Publ. Astron. Soc. Japan, vol.61, pp.1055-1063.

➢ We have conducted millimeter interferometric observations of the Orion Molecular Cloud-2 (OMC-2) FIR 6 region at an angular resolution of ~4"-7" with the Nobeyama Millimeter Array (NMA). In the 3.3-mm continuum emission we detected dusty core counterparts of previously identified FIR sources (FIR 6a, 6b, 6c, and 6d), and moreover resolved FIR 6a into three dusty cores. The size and mass of these cores are estimated to be 1100-5900 AU and 0.19-5.5$M_\odot$, respectively. We found that in the ^{12}CO (J=1-0) emission FIR 6b, 6c, and 6d eject molecular outflow, and that the FIR 6c outflow also exhibits at least two collimated jet-like components in SiO (J=2-1) emission. At the tip of one of the SiO components there appears an abrupt increase in the SiO line width (~15 km s^{-1}), where the three resolved cores in FIR 6a seem to delineate the tip. These results imply the presence of the interaction and a bowshock front between the FIR 6c molecular outflow and FIR 6a. If the interaction occurred after the formation of the FIR 6a cores, the influence of the FIR 6c outflow on the FIR 6a cores would be minimal, since the total gravitational force in the FIR 6a cores (1.0-7.7×10^{-4} $M_\odot$ km $s^{-1}yr^{-1}$) is much larger than the outflow momentum flux (2.4×10^{-5} $M_\odot$ km $s^{-1}yr^{-1}$). On the other hand, it

is also possible that the interaction caused the gravitational instability in FIR 6a, and triggered the fragmentation into three cores, since the separation among these cores (~2.0×10^3 AU) is on the same order of the Jeans length (~$5.0\text{-}8.4 \times 10^3$ AU). In either case, FIR 6a cores, with a mass of 0.18-1.6 M.and a density of $0.2\text{-}5.8 \times 10^7$ cm^{-3}, might be potential formation sites of the next generation of cluster members.

- Shimojo, M., and S. Tsuneta [2009], "The Relation Between Magnetic Fields and Coronal Activities in the Polar Coronal Hole," Astrophys. J. (Letters), vol.706, pp.L145-L149.
  - We investigated the relation between polar magnetic fields and polar coronal activities based on Stokes maps of photospheric and chromospheric lines, simultaneous X-ray and EUV images. These images are taken with Hinode and Solar and Heliospheric Observatory. With careful co-alignment between these images, we found that the X-ray jets, the X-ray bright points, and the coronal loops in the polar coronal hole appear around the relatively large magnetic concentrations near the kG-patches with minority polarity. The magnetic concentrations have magnetic polarity opposite to that of kG-patches, and they are clearly identified in the Stokes-V maps of the Na I line. We also found that such minority magnetic concentrations emerge from below the photosphere in the polar region. Our results suggest that the coronal activities and structures in the polar coronal hole can be used as a tracer of the appearance of the minority polarities in the polar region.
- Shimojo, M. [2010[, "The Variations of Prominence Activities During Solar Cycle," 38th COSPAR Scientific Assembly, 18-25 July 2010, p.2.
  - The prominence activities (prominence eruption/disappearance) in the solar atmosphere closely relate with the CMEs that cause great influences on heliosphere and magnetosphere. Gopal-swarmy et al. (2003) reported that 72 The Nobeyama Radioheliograph (NoRH) is observing Sun in microwave (17 GHz) since 1992. At a flare, the main component of the microwave from Sun is emitted from non-thermal electrons that are accelerated by flare. On the other hand, the main component of the microwave is thermal emission when Sun is quiet, and a prominence is clearly observed in microwave because there is the prominence on the limb. We developed the automatic prominence activity detection program based on 17 GHz images observed by NoRH, and investigated the variation of the properties of the prominence activities that oc-curred from 1992 to the end of 2009. We found the following results. 1. The variation in the number of prominence activities is similar to that of sunspots during one solar cycle but there are differences between the peak times of prominence activities and sunspots. 2. The frequency distribution as a function of the magnitude of the prominence activities the size of activated prominences at each phase shows a power-law distribution. The power-law index of the distribution does not change except around the solar minimum. 3. The number of promi-nence activities has a dependence on the latitude On the other hand the average magnitude is independent of the latitude. In the paper, we will also discuss the relationship the other properties of prominence eruptions, solar cycle and the photospheric magnetic field.
- Shintani, M., H. Imai, K. Ando, K. Nakashima, T. Hirota, N. Inomata, T. Kai, S. Kameno, M. Kijima, H. Kobayashi, M. Kuroki, T. Maeda, K. Maruyama, N. Matsumoto, T. Miyaji, T. Nagayama, R. Nagayoshi, K. Nakamura, A. Nakagawa, D. Namikawa, T. Omodaka, T. Oyama, S. Sakakibara, R. Shimizu, K. Sora, M. Tsushima, K. Ueda, Y. Ueda, and K. Yamashita [2008], "Statistical Properties of Stellar H_2O Masers - Results of Three-Year Single-Dish Observations with the VERA Iriki Telescope," Publ. Astron. Soc. Japan, vol.60, pp.1077-1131.
  - We report on the results of monitoring observations of 242 stellar H_2O masers, which have been made with the Iriki 20 m telescope of the VLBI Exploration of Radio Astrometry (VERA) from 2003 July to 2006 November. The present paper mainly focuses on 85 stellar H_2O masers that have been tightly observed with a time spacing of typically 1-2 months. In particular, 46 masers out of them have been recognized concerning their periodic flux variation

and have light-curve data of stellar visual light. Thus, the present paper shows some statistical views of the observed time variability properties of stellar H_2O masers. We found a good correlation between a time delay of the variation in the H_2O maser flux with respect to that in the stellar visual light and the stellar pulsation period. The corresponding phase lags are mildly scattered, but are mainly concentrated in the range, $0.7 \leq \Delta \square \leq 1.5$. We also measured line-of-sight velocity drifts of the individual spectral peaks of H_2O maser emission, which indicate radial acceleration of mass-loss outflows from the evolved stars. We discuss possible pulsation-driven shock waves that are enhanced near the stellar surface, and are propagating outwards in the circumstellar envelope.

- Shitov, S. V., J. Inatani, W.-L. Shan, M. Takeda, Z. Wang, A. V. Uvarov, A. B. Ermakov, and Y. Uzawa [2008], "Mesurement of Emissivity of the ALMA Antenna Panel at 840 GHz Using NbN-Based Heterodyne SIS Receiver," Proc. of the 19th International Symposium on Space THz Technology, ed. Wolfgang Wild, pp.263-266.

  - We measured emissivity of sample presenting panel of ALMA antenna using Band-10 heterodyne SIS receiver as antenna switching balanced radiometer with 8 GHz instantaneous bandwidth. Receiver noise temperature measured with 80 K/300 K antenna loads was ≈560 K (DSB). Emissivity of the surface is detected at LO frequency about 840 GHz via the imbalance of the antenna switch due to extra reflection from sample of panel; absorption 0.25±0.10 % is calculated from measured emissivity. To confirm measured value, samples made of phosphor bronze and stainless steel are tested using the same technique. The values of 0.30±0.10 % and 1.10±0.10 % are obtained for these samples correspondingly that is consistent with previous data obtained using direct detector radiometers.

- Sofue, Y. [2008a], "CO-Line Rotation Curves, Deep Potential of Massive Cores, and High-Density Molecular Nuclei," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., pp.178-185.

  - We review observational studies of central rotation curves of spiral galaxies using the Nobeyama mm-wave interferometer in the CO 2.6-mm line emission. The observed high-accuracy rotation curves show universal characteristics: RCs rise steeply in the nuclei, or they start at finite speed, and are flat toward the galaxy edges. Calculated mass distributions are similar to each other: spiral galaxies generally have a massive core of $\sim 10^9 M_\odot$ in the central 100 pc, bulge, disk and a dark halo. We found extremely high-density, single-peaked molecular gas nuclei in many galaxies, which are embedded in deep gravitational potential of the massive core. Although the molecular nuclei is as that of a giant molecular cloud, the gas is kept gravitationally stable because of the high-velocity rotation.

- Sofue, Y. [2008b], "Central Rotation Curves by CO Lines," Proc. of the "Formation and evolution of galaxy disks", eds. J. G. Funes, and E. M. Corsini, ASP conf. Ser., vol.396, pp.27-36.

  - Central rotation curves are fundamental to understand the mass distribution inside galactic bulges and central disks, which may be physically linked to central massive objects. We review observational studies of central rotation curves using mm-wave interferometers in the CO 2.6mm line emission. Observed high-accuracy rotation curves show steep rise in the nuclei, or more likely, they start at finite speed from the center. Mass distributions show that spiral galaxies generally nest a massive core of $\sim 10^9 M_\odot$ in the central 100 pc, which is supposed to link the black hole and bulge. Massive cores are often associated with high-density molecular gas nuclei, and the core mass and gas density are proportional. The molecular nuclei are gravitationally stabilized by high velocity differential rotation in the deep gravitational potential.

- Sofue, Y., M. Honma, and T. Omodaka, [2009], "Unified Rotation Curve of the Galaxy - Decomposition into de Vaucouleurs Bulge, Disk, Dark Halo, and the 9-kpc Rotation Dip -,"

Publ. Astron. Soc. Japan, vol.61, pp.227-236.

- We present a uni ˇ ed rotation curve of the Galaxy re-constructed from existing data by re-calculating the distances and velocities for a set of Galactic constants, R_0 = 8 kpc and V_0 = 200 km s_{-1}. We decomposed it into a bulge with de Vaucouleurs-law profile of half-mass scale radius 0.5 kpc and mass 1.8 x 10^{10} M , an exponential disk of scale radius 3.5 kpc and 6.5 x 10^{10} M , and an isothermal dark halo of terminal velocity 200 km s^{-1}. A r 1=4 -law fit was obtained for the first time for the Milky Way's rotation curve. After fitting by these fundamental structures, two local minima, or dips, of the rotation velocity are prominent at radii 3 and 9 kpc. The 3-kpc dip is consistent with the observed bar. It is alternatively explained by a massive ring with the density maximum at a radius of 4 kpc. The 9-kpc dip is clearly exhibited as the most peculiar feature in the Galactic rotation curve. We explain it by a massive ring of amplitude as large as 0.3 to 0.4-times the disk density with the density peak at a radius of 11 kpc. This great ring may be related to the Perseus arm, while no peculiar feature of HI-gas is associated.

- Sorai, K., N. Kuno, N. Nakai, H. Matsui, and A. Habe [2008a], "Kinematics of Molecular Gas in the Bar of Maffei 2," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., p.380.

- Without abstract

- Sorai, K., A. Habe, H. Nishitani, K. Hosaka, Y. Watanabe, S. Miwa, Y. Ohishi, K. Motogi, T. Minamidani, J. Awano, S. Sumida, Y. Fukuya, R. Uchida, N. Kaneko, M. Y. Fujimoto, Y. Koyama, M. Kimura, and N. Nakai [2008b], "Large-Scale NH_3 Observations toward the Galactic Star-Forming Regions I. W51 Molecular Cloud Complex," Publ. Astron. Soc. Japan, vol.60, pp.1285-1296.

- Large-area observations of dense molecular gas were made in NH_3 (J, K) = (1, 1), (2, 2), and (3, 3) inversion lines with 4.'5 resolution toward the molecular cloud complex of the W 51 region. The observations were a part of a NH_3 survey of the Galactic star-forming regions using the Tomakomai 11-m radio telescope. NH_3 (J, K) = (1, 1) and (2, 2) emission was detected in the W 51 A and B complexes, while the detection of (J, K) = (2, 2) emission was marginal in W 51 B. The rotation temperature was ~40 K in the central part of the W 51 A complex, while being ~20 K in the other positions. A weak correlation is found that the ortho-to-para ratio decreases with increasing the rotation temperature, the far-infrared luminosity and the index of the star-formation ef ˇ ciency. This tendency is explained if star formation has continued for more than the time scale of the transformation between ortho- and para-NH_3 : active star formation on a large scale, such as the interaction of molecular clouds with a spiral arm, has made the molecular gas warmer, even in a scale of ~10 pc, and the proceeding transformation has made the ortho-to-para ratio lower.

- Sugimoto, M., G. Kosugi, S. Iguchi, H. Iwashita, M. Saito, J. Inatani, M. Tasaki, T. Takahashi, K. Nakanishi, J. P. McMullin, J. P. Puga, B. Hoff, J. Notambuena, T. Kamazaki, B. Vila-Volaro, B. Ikenoue, K.-I. Morita, S. Asayama, M. Yamada, and H. Kiuchi [2009a], "Beam Pattern Measurements and Observational Evaluations of the ALMA/ACA 12-m Antenna," Publ. Astron. Soc. Japan, vol.61, pp.451-459.

- We have evaluated the beam pattern of the ALMA/ACA 12-m antenna with total power observations of Jupiter and the Moon. Models of the expected beam pattern as it passes across Jupiter and the Moon were derived in consideration of the radiation pattern of the actual receiving system and the surface error of the main reflector. Since the profiles of the measured beam patterns were consistent with those of the models within the range from the peak to -20 dB, we confirmed that the antenna achieved the beam pattern expected from its optical design. After this confirmation, we performed astronomical observations. In addition to the detection of the CS J = 3-2 (146.969026 GHz) spectrum toward Orion KL, the change in the Moon

intensity was successfully detected during the total lunar eclipse during 2008 February 20-21. A time lag longer than 10 min in the millimeter-wave eclipse relative to the corresponding optical eclipse ephemeris was detected. Mapping observations of the Sun revealed the structure of the chromospheric networks at 147 GHz. These astronomical observations confirmed that the ACA 12-m antenna could be successfully operated under various operating conditions.

- Sugimoto, M., M. Carter, J. Inatani, Y. Sekimoto, and S. Iguchi [2009b], "Design of Corrective Beam Waveguide System for the ALMA/ACA 7-m Antenna," Publ. Astron. Soc. Japan, vol.61, pp.1065-1080.
  - A beam waveguide system for connecting the ALMA front-end, which has been designed for the Cassegrain focus of the ALMA 12-m antenna, with the ALMA/ACA 7-m antenna was designed. The beam waveguide system, covering 30-950 GHz, consists of flat mirrors or prisms to modify the boresight tilt angle from the front-end, and recovers more than the half of the sensitivity loss caused by a misalignment between the front-end optics and the 7-m antenna. No mechanical alignment procedure is needed for installation of the beam waveguide system, and thus it does not impact on the maintenance/operation scheme of the front-end system. Beam-pattern measurements in the frequency ranges of ALMA bands 4 (144 GHz), 6 (252 GHz), and 8 (385 GHz) have confirmed that directions of the radiation patterns transmitted to the subreflector are successfully shifted by the beam waveguide system without any serious deformation of the beam. The aperture efficiencies calculated from the measured radiation patterns were determined to be 84.6% at 144 GHz, 86.1% at 252 GHz, and 84.8% at 385 GHz, which are consistent with those of a simulated radiation pattern.
- Sugimoto, M., S. Iguchi, J. Inatani, Y. Sekimoto, and S. Asayama [2010], "Sensitivity Analysis of optical Systems in Radio Telescope," Publ. Astron. Soc. Japan, vol.62, pp.39-50.
  - We have demonstrated an approach to predict the overall efficiency and system noise regarding optical systems in radio telescopes, based on a systematic evaluation of both the optical propagation efficiency through all optical components, from the receiver horn to the main reflector, and of their noise contributions. The analysis employs several conventional techniques, including the principle of multimode Gaussian optics and calculations of losses associated with optical components. A detailed analysis was performed for cases of ALMA band 4 (125-163 GHz) and 8 (385-500 GHz). The analysis predicts a reasonable efficiency of 0.75-0.76 (0.57-0.62) and a system noise of ~70 K (300-400 K) for band 4 (band 8). The calculated efficiency of the band 4 optics was found to be consistent with the efficiency measured by astronomical observations with the ALMA/ACA 12-m antenna. In addition to a confirmation that the bands 4 and 8 optics were designed to maximize the overall efficiency, the analysis for the bands 4 and 8 frequency ranges also confirmed that there is no difference in the optimum edge levels at the subreflector between the two different ways of maximization, i.e., toward the overall efficiency or the sensitivity, which is defined by the ratio of the overall efficiency over the sum of noises generated from all possible sources. We also applied a sensitivity analysis to the band 1 frequency case, and revealed a slight, but clear, difference in the optimum edge levels between the sensitivity and the efficiency (difference is 1 ~ 2 dB). This corresponds to a sensitivity loss of 1% if we optimize the optics to maximize the efficiency.
- Sugiyama, K., K. Fujisawa, A. Doi, M. Honma, H. Kobayashi, T. Bushimata, N. Mochizuki, and Y. Murata [2008a], "Mapping Observations of 6.7 GHz Methanol Masers with Japanese VLBI Network," Publ. Astron. Soc. Japan, vol.60, pp.23-35.
  - We have observed 13 methanol maser sources associated with massive star-forming regions: W 3(OH), Mon R2, S 255, W 33A, IRAS 18151-1208, G 24.78+0.08, G 29.95-0.02, IRAS 18556+0136, W 48, OH 43.8-0.1, ON 1, Cep A, and NGC 7538 at 6.7GHz using the Japanese VLBI Network (JVN). Twelve of the thirteen sources were detected at our longest baseline of

~50Mλ, and their images are presented. Seven of them are the first VLBI images at 6.7GHz. The high detection rate and the small fringe spacing of ~4 mas suggest that most of the methanol maser sources have compact structures. Given this compactness as well as the known properties of long life and small internal motion, the methanol maser line is suitable for astrometry with VLBI.

- Sugiyama, K., K. Fujisawa, M. Honma, A. Doi, N. Mochizuki, Y. Murata, and Y. Isono [2008b], "Japanese VLBI Network Observations of 6.7-GHz Methanol Masers II. Results," Proc. of the IAU Symp. 242, "Astrophysical Masers and their Environments", eds. Jessica Chapman and Willem Baan, pp.176-177.

  - We are using a Japanese VLBI network (JVN) for VLBI observations of 6.7-GHz methanol masers associated with massive star-forming regions. Here we present results for Cepheus A (Cep A) from observations taken on September 9, 2006. The distribution of the maser spots indicates either a spherical bubble or a disk having an inclination of several tens degree. We construct a disk model with an inclination of ~70° and a radius of ~700 AU. From a luminosity of 1.7 x 10^4 Lsolar for a source observed in this region, the excitation of the maser is probably radiative.

- Sugiyama, K., K. Fujisawa, A. Doi, M. Honma, Y. Isono, H. Kobayashi, N. Mochizuki, and Y. Murata [2008c], "A Synchronized Variation to the 6.7 GHz Methanol Maser in Cepheus A," Publ. Astron. Soc. Japan, vol.60, pp.1001-1006.

  - We present the results of monitoring observations of a 6.7 GHz methanol maser in Cepheus A (Cep A) using the Yamaguchi 32m radio telescope and of imaging observations conducted with the JVN (Japanese VLBI Network). We indentified five spectral features, which are grouped into two groupes: redshifted (-1.9 and -2.7 km s^{-1}) and blueshifted (-3.8, -4.2, and -4.9 km s^{-1}). We detected rapid variabilities in these maser features within a monitoring period of 81 d. The redshifted features decreased in flux density to 50% of the initial value, while the blueshifted ones rapidly increased within 30 d. The time variation in these maser features had two remarkable properties: synchronization and negative correlation between the redshifted and the blueshifted. Based on the JVN observations,we found that the maser spots were associated with the Cep A HW2 object and had an arched structure with a scale of ~1400AU; also, separations of the five maser features were found to be larger than 100AU. These properties of the masers, namely, the synchronization of the flux variation and the spectral and spatial isolations of the features, suggest that the collisional excitation by a shock wave from a common exciting source is unlikely to happen. Instead, the synchronized time variation of the masers can be explained if all the maser features are excited by infrared radiation from the dust that is heated by a common exciting source with a rapid variability.

- Sugiyama, K., K. Fujisawa, A. Doi, M. Honma, Y. Isono, N. Mochizuki, Y. Murata, S. Sawada-Satoh, and K. Wajima [2008d], "Associating Sites of Methanol Maser Emissions at 6.7 GHz," Proc. of the 9th European VLBI Network Symposium on The role of VLBI in the Golden Age for Radio Astronomy and EVN Users Meeting, September 23-16, 2008, Bologna, Italy, p.99.

  - We have carried out VLBI observations of some methanol maser sources at 6.7 GHz with the Japanese VLBI Network (JVN) using phase-referencingt echniques. We superposed the methanol masers on water, hydroxyl masers, radio continuum,and various molecular line emissions with an accuracy of a milliarcsecond (mas) scale, which is enough for investigating a positional relation with a central or exciting star. In this paper, were port results of the superposition in massive star-forming regions(SFRs) Cepheus A (CepA) and Onsala 1 (ON1). The methanol maser spots of Cep A showed an arched structure with a scale of 1400 AU. This structure was roughly per-pendicular to a radio continuum jet, having an exciting star near the center of the arch, and was coincident with the CH_3CN, NH_3 disks. It is easy to explain that the

Cep A methanol masers are associated with a circumstellar disk around a massive young stellar object (YSO). The methanol maser spots of ON 1 formed two main clusters isolated 1800 AU from each other, which corre-sponded to a red- and ablue-shifted spectral feature, respectively. The direction of the elongation of the isolated clusters coincided with the $H^{13}CO^+$, SiO molecular outflows, although each spatial size is quite different. Also, the position-velocity diagram along the direction of the molecular outflows roughly coincided. The ON 1 methanol masers may trace an outflow ejected from a massive YSO, while it is also thought to be possible that the masers of this source may trace an expansion of an Ultra-compact (UC) HII region by superposing on the hydroxyl masers.

- Sugiyama, K., K. Fujisawa, K. Wajima, S. Sawada-Satoh, Y. Isono, M. Honma, Y. Murata, N. Mochizuki, and A. Doi [2009], "The Kinematics of the Methanol Maser at 6.7 GHz in Cepheus A," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.392-395.

➢ We have conducted VLBI observations of methanol masers at 6.7 GHz with JVN and water maser at 22.2 GHz with VERA in the massive star-forming region Cepheus A (Cep A). The distribution of methanol maser spots showed an arc-like structure. Comparing the distributions of CH_3CN line emission and continuum emission at 8, 22, and 43 GHz obtained from other observations, we inferred that the 6.7-GHz methanol masers in Cep A originates from a rotating disk with a radius of 690 AU, a PA of 110°, and an inclination of 73°. Also, some of the water masers in this region may be associated with the rotating disk.

- Sunada, K., T. Nakazato, N. Ikeda, S. Hongo, Y. Kitamura, and J. Yang [2007], "Water Maser and Ammonia Survey toward IRAS Sources in the Galaxy I. H_2O Maser Data," Publ. Astron. Soc. Japan, vol.59, pp.1185-1219.

➢ We present H2O maser data from a survey toward IRAS sources in the Galaxy with the Nobeyama 45m telescope. This survey had a 1σ noise as small as 0.24Jy, resulting in one of the most sensitive water-maser surveys. The maximum distance of the masers to be detected by our survey is estimated to be 3 kpc for sources with $F_{v,\,1\,kpc} < 10$Jy and 10 kpc for those with 10 Jy $\leq F_{v,\,1\,kpc} < 100$Jy, where $F_{v,\,1\,kpc}$ is the maser flux density converted at a distance of 1 kpc/ For strong masers with $F_{v,\,1\,kpc} \geq 100$Jy,our survey cloud detect all sources in the Galaxy. We carried out a total of 2229 observations toward 1536 sources and detected water-maser emission toward 222 sources. Our survey newly found masers from 75 of the 222 sources. The maser spectra of the new sources are shown in addition to the line parameters of all the detected sources. Furthermore, we discovered an extremely high-velocity component with $V_{LSR} = -146$ km s^{-1} toward a well-known source, NGC 7538 IRS 11. For the three sources of NGC 1333 IRAS 4A/B, IRAS 05329-0512, and 06053-0622, we succeeded to spatially separate multiple-velocity components.

- Sunada, K., N. Ikeda, Y. Kitamura, T. Nakazato, and J. Yang [2010], "Class 0 Protostellar Candidates in the AKARI-FIS Bright Source Catalogue," Proc. of the "AKARI, a light to illuminate the misty universe", eds. T. Onaka, G. J. White, T. Nakagawa, and I. Yamamura, ASP Conf. Ser. vol.418, pp.73-78.

➢ It is expected that the FIS Bright Source Catalogue contains many Class 0 protostellar candidates. In particular, the identification of high-mass protostellar candidates is expected. To search new protostellar candidates systematically in the FIS Bright Source Catalogue, we characterized the far-infrared properties of various known objects. We carried out the identification of the FIS point sources for our 1563 survey sources. As a result, we could find the region occupied by the sources associated with the water maser emission on the FIS $\log(F_{140\mu m})$ - $\log(F_{90\mu m}/F_{65\mu m})$ diagram. Comparing the core properties with the far-infrared properties, we also found the spread of the region occupied by the H_2O maser sources meant

the mass difference and the evolution sequence. Finally, we examined the far-infrared properties of all the point sources in the catalogue. Considering the above results, we were able to confirm the new protostellar candidates from low- to high-mass in the FIS Bright Source Catalogue.

- Tachihara, K., R. Neuhauser, and Y. Fukui, [2009], "Search for Remnant Clouds Associated with the TW Hya Association," Publ. Astron. Soc. Japan, vol.61, pp.585-591.

➢ We report on a search for the parental molecular clouds of the TW Hya association (TWA), using CO emission and Na I absorption lines. TWA is the nearest young (~50 pc; ~10 Myr) stellar association; yet in spite of its youth there has been no detection of any associated natal molecular gas, as is the case with other typical young clusters. Using infrared maps as a guide, we conducted a CO cloud survey toward a region with a dust extinction of $E(B - V) > 0.2$ mag, or $A_V > 0.6$ mag. CO emission was detected in the direction of three IR dust clouds, and we rejected one cloud out of the TWA, because no interstellar Na absorption was detected in the nearby Hipparcos stars, implying that it is too distant to relate to the TWA. The two other clouds exhibit only faint and small-scale CO emission. Interstellar Na I absorptions of Hipparcos targets (HIP 57809, HIP 64837, and HIP 64925, at distances of 133, 81, and 101 pc, respectively) by these clouds were also detected. We conclude that only a small fraction of the interstellar matter (ISM) toward the infrared (IR) dust cloud is located at a distance less than 100 pc, which may be all that is left out of the remnant clouds of TWA; the remaining remnant cloud dissipated within the last ~1 Myr. Such a short-dissipation timescale may be due to an external perturbation or kinematic segregation that has a large stellar proper motion relative to the natal cloud.

- Takahashi, H., H. Matsuo, and K. Nakanishi [2010], "Spectroscopic Imaging Study of Nearby Spiral Galaxies: Introduction of Observations with AKARI, NRO and ASTE," Proc. of the "AKARI, a light to illuminate the misty universe", eds. T. Onaka, G. J. White, T. Nakagawa, and I. Yamamura, ASP Conf. Ser. vol.418, pp.491-494.

➢ The aim of this research is to reveal the spatial distribution of the star formation activity toward nearby galaxies by comparing CO molecular emission lines with the large area observation in FIR lines. We report the imaging observations of far-Infrared (FIR) forbidden lines via FIS-FTS and CO molecular lines from low to high excitation levels with ASTE, which are good tracer of star forming regions or photo-dissociation regions, especially spiral galaxies, in order to derive the information of the physical conditions of the ambient interstellar radiation fields. The information tells us not only the difference of current star forming activity between the arm and the interarm of these galaxies but also star forming history and evolution of spiral galaxies with systematic and statistical study. Furthermore the dust properties can be referred by combining far-infrared photometric data and submillimeter observation. This observation program is a proposal which presents a tool for investigation of physical properties of nearby galaxies.

- Takahashi, S., M. Saito, S. Takakuwa, and R. Kawabe [2008a], "A New Evolutionary Scenario of Intermediate-Mass Star-Formation Revealed by Multi-Wavelength Observations of OMC-2/3," Astrophys. and Sp. Sci., vol.313, pp.165-168.

➢ We have performed millimeter- and submilli- meter-wave survey observations using the Nobeyama millimeter array (NMA) and the Atacama Submillimeter Telescope Experiment (ASTE) in one of the nearest intermediate-mass (IM) star forming regions: Orion Molecular Cloud-2/3 (OMC-2/3). Using the high-resolution capabilities offered by the NMA ("several arcsec), we observed dust continuum and $H^{13}CO^+$(1-0) emission in 12 pre- and proto-stellar candidates identified previously in single-dish millimeter observations. We unveiled the evolutionary change with variations of the morphology and velocity structure of the dense envelopes traced by the $H^{13}CO^+$(1-0) emission. Furthermore, using the high-sensitivity

capabilities offered by the ASTE, we searched for large-scale molecular outflows associated with these pre- and proto-stellar candidates observed with the NMA. As a result of the CO(3-2) observations, we detected six molecular outflows associated with the dense gas envelopes traced by $H^{13}CO^{+}$(1-0) and 3.3 mm continuum emission. The estimated CO outflow momentum increases with the evolutionary sequence from early to late type of the protostellar cores. We also found that the 24 mum flux increases as the dense gas evolutionary sequence. We propose that the enhancement of the 24 mum flux is caused by the growth of the cavity (i.e. the CO outflow destroys the envelope) as the evolutionary sequence. Our results show that the dissipation of the dense gas envelope plays an essential role in the evolution of the IM protostars. The extremely high-sensitivity and high-angular resolution offered by ALMA will reveal unprecedented details of the inner "50 AU of these protostars, which will provide us a break through in the classic scenario of IM star/disk formation.

- Takahashi, S., M. Saito, N. Ohashi, N. Kusakabe, S. Takakuwa, Y. Shimajiri, M. Tamura, and R. Kawabe [2008b], "Millimeter- and Submillimeter-Wave Observations of the OMC-2/3 Region. III. An Extensive Survey for Molecular Outflows," Astrophys. J., vol.688, pp.344-361.

➢ Using the ASTE 10 m submillimeter telescope and the 1.4 m Infrared Survey Facility (IRSF), we performed an extensive outflow survey in the Orion Molecular Cloud 2 and 3 region. Our survey, which includes 41 potential star-forming sites, has been newly compiled using multiwavelength data based on millimeter- and submillimeter-continuum observations, as well as radio continuum observations. From the CO(3-2) observations performed with the Atacama Submillimeter Telescope Experiment (ASTE) 10 m telescope, we detected 14 CO molecular outflows, seven of which were newly identified. This higher detection rate, as compared to previous CO(1-0) results in the same region, suggests that CO(3-2) may be a better outflow tracer. Physical properties of these outflows and their possible driving sources were derived. Derived parameters were compared with those of CO outflows in low- and high-mass star-forming regions. We show that the CO outflow momentum correlates with the bolometric luminosity of the driving source and with the envelope mass, regardless of the mass of the driving sources. In addition to these CO outflows, seven sources having near-IR features suggestive of outflows were also identified.

- Takahashi, S., P. T. P. Ho, T.-W. Tang, R. Kawabe, and M. Saito [2009], "Evolutionary Status of Brightest and Youngest Sources in the Orion Molecular Cloud -3 Region," Astrophys. J., vol.704, pp.1459-1470.

➢ The brightest continuum source in the Orion molecular cloud-3 region (OMC-3), MMS 6, was observed with the Very Large Array (VLA), the Nobeyama Millimeter Array (NMA), and the Submillimeter Array (SMA). Our data were supplemented by near- to mid-infrared archival data taken by Spitzer Space Telescope. The compact continuum source, MMS 6-main, was detected with an H_2 mass of 3.0 Msun with a size of 510 AU. Despite its compact and well-condensed appearance, neither clear CO outflow, radio jet, nor infrared sources (at a wavelength shorter than 8μm) were detected at MMS 6-main even with the present high angular resolution and high-sensitivity observations. The derived H_2 column density, 2.6 10^{25} cm^{-2}, corresponds to a visual extinction of Av ~ 15, 000 mag, and the derived number density is at least two orders of magnitude higher than for the other OMC-2/3 continuum sources. The volume density profile of the source was estimated to have a power-law index of 2 or steeper down to a radius of ~450 AU. The timescale to form a protostar at the center or the timescale elapsed after its formation is estimated to be 830 to 7600 yr. This is much shorter than the typical lifetime of the Class 0/I protostars, which is ~10^4-10^5 yr, suggesting that MMS 6-main is probably in either the earliest stage of the protostellar core or in the latest stage of the prestellar phase.

- Takahashi, S., S. Deguchi, N. Kuno, T. Shimoikura, and F. Yoshida [2010], "A Search for

Water Masers in the Saturnian System," Publ. Astron. Soc. Japan, vol.62, pp.L17-L21.

- We searched for H_2O 6(1,6)-5(2,3) maser emission at 22.235 GHz from several Saturnian satellites with the Nobeyama 45m radio telescope in May 2009. Observations were made for Titan, Hyperion, Enceladus and Atlas, for which Pogrebenko et al. (2009) had reported detections of water masers at 22.235 GHz, and in addition for Iapetus and other inner satellites. We detected no emission of the water maser line for all the satellites observed, although sensitivities of our observations were comparable or even better than those of Pogrebenko et al.. We infer that the water maser emission from the Saturnian system is extremely weak, or sporadic in nature. Monitoring over a long period and obtaining statistical results must be made for the further understanding of the water maser emission in the Saturnian system.

- Takakuwa, S., D. Iono, B. Vila-Vilaro, T. Sekiguchi, and R. Kawabe [2008], "Scientific Role of ACA for Low-Mass Star-Formation Study," Astrophys. and Sp. Sci., vol.313, pp.169-173.
  - We discuss the scientific role of the Atacama Compact Array (ACA), the Japanese contribution to the ALMA project, for low-mass star-formation study. Our recent observations of several low-mass protostellar envelopes in the submillimeter CS (J=7-6) and HCN (J=4-3) lines with the SMA and ASTE have revealed that these submillimeter emissions are more extended than ~2000 AU and show different velocity structures from those traced by millimeter lines. These results suggest the importance of taking short-spacing informations the ACA can offer. Our comprehensive imaging simulations of these protostellar envelopes, as well as prestellar cores and debris disks, unprecedentedly demonstrate the scientific importance of ACA.
- Takeuchi, T., H. Yamamoto, K. Torii, N. Kudo, T. Hayakawa, A. Kawamura, N. Mizuno, T. Onishi, A. Mizuno, H. Ogawa, and Y. Fukui [2010], "NANTEN Survey of Molecular Clouds toward the Galactic Centre; Association of Compact Astronomical Objects," Publ. Astron. Soc. Japan, vol.62, pp.557-612.
  - In order to better understand molecular clouds and their properties toward the Galactic center region, we have analyzed the NANTEN database of ^{12}CO (J = 1-0) and ^{13}CO (J = 1-0) to search for associations with candidates for young high-mass star-forming regions, such as IRAS point sources, radio continuum sources recombination line sources, maser line sources, and other molecular line sources. We have also compared the data with TeV γ-ray sources. The analyzed region covers $-12° \leq l \leq 12°$ and $-1°.5 \leq b \leq 1°.5$ for ^{12}CO, and $-6° \leq l \leq 8°$ and $-1° \leq b \leq 1°$ for ^{13}CO. As a result, we identified 167 IRAS point sources, 73 recombination line sources, 58 maser sources, 107 radio continuum sources, and 77 molecular line sources associated with 169 positions with the CO emission. The associations among the objects with known velocity are fairly certain (68%), while those with only positional coincidence are less reliable (32%). We present a catalog of these CO clouds in a form useful for future follow-up studies. As specific examples of usage of the catalog, we highlight three outstanding regions of active star formation: W 28, W 30, and W 31. In particular, we have discovered that the W 30 region shows a striking correlation between the extended TeV γ-ray source and the molecular gas. This is a second case of such a good correlation identified from the NANTEN dataset subsequent to W 28 (Aharonian et al. 2008, A&A, 481, 401). We suggest that the pulsar PSR J1803 2137 near the molecular features may play a role in γ-ray production. The W 31 region exhibits another active star formation, while noγ-ray source is yet known.
- Takita, S., Y. Kitamura, H. Kataza, D. Ishihara, M. Ueno, H. Fujiwara, N. Ikeda, A. Kawamura, H. Murakami, Y. K. Okamoto, T. Onaka, S. Oyabu, I. Sakon, and H. Takahashi [2009], "Diffuse 18 m Emission around TYC 3159-691 Discovered by the AKARI MIR All-Sky Survey," Publ. Astron. Soc. Japan, vol.61, pp.291-299.
  - We report on observations of the mysterious object TYC 3159-6-1 located toward the Cygnus X region. It shows interesting characteristics in the AKARI mid-infrared All-Sky Survey. The central star is clearly detected as a point source at 9μm, while no point-like source, but a large

shell-like structure is seen around the source at 18μm. The optical spectrum indicates the presence of the weak Hαemission on the red smooth continuum, where as the mid-infrared N-band spectrum shows neither excess emission nor significant silicate absorption Interferometric continuum observations at 104 GHz do not show any appreciable peak at the position of the star. On the basis of these observations, we investigate three possibilities of concerning the nature of TYC 3159-6-1: a nearby young stellar object, a heavily extincted high-mass star, and an asymptotic giant branch(AGB) star with a detached shell. We conclude that none of these cases can account for the observations consistently, and the nature of TYC 3159-6-1 remains a mystery.

- Tamura, Y., K. Nakanishi, K. Kohno, R. Kawabe, and S. K. Okumura [2008], "HCN and HCO^+ Imaging of the Antenna Galaxies: Distribution and Evolution of Dense Molecular Gas in a Colliding Galaxy System," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., p.379.

➢ Without abstract

- Tamura, Y., K. Kohno, K. Nakanishi, B. Hatsukade, D. Iono, G. W. Wilson, M. S. Yun, T. Takada, Y. Matsuda, T. Tosaki, H. Ezawa, T. A. Perera, K. S. Acott, J. E. Austermann, D. H. Hughes, I. Aretxaga, A. Chung, T. Oshima, N. Yamaguchi, K. Tanaka, and R. Kawabe [2009], "Spatial Correlation between Submillimeter and Lyman-Alpha Galaxies in the SSA 22 Protocluster," Nature, vol.459, pp.61-63.

➢ Lyman-α emitters are thought to be young, low-mass galaxies with ages of ~10^8yr (refs 1, 2). An overdensity of them in one region of the sky (the SSA22 field) traces out a filamentary structure in the early Universe at a redshift of z~3.1 (equivalent to 15 per cent of the age of the Universe) and is believed to mark a forming protocluster. Galaxies that are bright at (sub)millimetre wavelengths are undergoing violent episodes of star formation, and there is evidence that they are preferentially associated with high-redshift radio galaxies, so the question of whether they are also associated with the most significant large-scale structure growing at high redshift (as outlined by Lyman-α emitters) naturally arises. Here we report an imaging survey of 1,100-μm emission in the SSA22 region. We find an enhancement of submillimetre galaxies near the core of the protocluster, and a large-scale correlation between the submillimetre galaxies and the low-mass Lyman-α emitters, suggesting synchronous formation of the two very different types of star-forming galaxy within the same structure at high redshift. These results are in general agreement with our understanding of the formation of cosmic structure.

- Tanaka, K., T. Oka, M. Nagai, and K. Kamegai [2009], "A Large Expanding Molecular Arc in the Sagittarius B1 Complex," Publ. Astron. Soc. Japan, vol.61, pp.461-469.

➢ Results of molecular line observations toward the Sagittarius B1 complex are reported. Maps of the HCN, HCO^+ and SiO J = 1-0 emissions were taken with the NRO 45-m telescope. With these data, combined with the ASTE CO J = 3-2 survey data, we have investigated the spatial structure, kinematics and physical conditions of two peculiar molecular features: CO0.55+0.07 and SiO0.56-0.01. The CO arc, CO0.55+0.07, shows clear expanding motion with sizes of 8.5x6.8 pc^2 and an expansion velocity of 40 km s^{-1}. The SiO shell, SiO0.56-0.01, has a size of 3.0 x 3.4 pc^2, and surrounds an X-ray Fe line source, G0.570-0.018. The mass and the kinetic energy of CO0.55+0.07 are estimated to be $10^{5.5}$ M. and $10^{51.5}$ erg, respectively. The kinetic energy of SiO0.56-0.01 is ~1050.4 erg. An LVG analysis shows that the typical density and kinetic temperature are $10^{3.8}$ cm^{-3} and 28 K, respectively. High-density clumps with a density of $10^{4.0\text{-}4.5}$ cm^{-3} associated with CO0.55+0.07 and SiO0.56-0.01 have been found, supporting the idea that they consist of swept-up material. The huge kinetic energy of CO0.55+0.07 is considered to be injected by a series of supernova explosions that took place within ~2 x 10^5 yr, which would suggest that it is a ‘bubble’ created by a massive stellar cluster, whose mass is

estimated to be $10^{3.5\text{-}4.5}$ M. The origin of SiO0.5-0.01 is rather unclear, but we suggest that it could be related to the X-ray source G0.570-0.018.

- Tatematsu, K., R. Kandori, T. Umemoto, and Y. Sekimoto [2007], "Orion A Giant Molecular Cloud in N_2H^+, HC_3N, and CCS, American Astronomical Society, AAS Meeting #211, #139.13.
  - The "integral-shaped filament" of the Orion A giant molecular cloud was mapped in N_2H^+ J = 1-0 (93 GHz), and its northern end, OMC-2/3 region was observed also in HC_3N J =5-4 (45 GHz) and CCS (45 and 82 GHz). The observations were carried out with Nobeyama 45-m Radio Telescope. Their distribution was compared with our previous $H^{13}CO^+$ map (Aso et al. 2000) and with the dust map in the literature. N2H+ distribution is similar to the dust distribution, except for the central part of the Orion Nebula, where gas temperature is high. We identified 34 cloud cores from N_2H^+ data, and carried out hyperfine fitting to spectra. Their average physical parameters are N_2H^+ excitation temperature T_{ex} = 9.3±4.3 K, linewidth Deltav = 0.92±0.52 km/s, core radius R = 0.086±0.018 pc, column density N (H_2) = 4.2±1.6 10^{22} cm $^{-2}$, average density n (H_2)=7±3; 10^4 cm^{-3}, and core mass M = 30.3±20.5 Mo. The excitation temperature is twice as high as that in Taurus cores (Tatematsu et al. 2004). The masses of cores identified both in N_2H^+ and in $H^{13}CO^+$ in OMC-2/3 are very consistent. We found one peculiar $H^{13}CO^+$ core which is not prominent in either N_2H^+, HC_3N or dust. This core overlaps with the lobe of the intense outflow, which might cause $H^{13}CO^+$ intensity enhancement. In OMC-2/3, we detected no CCS emission. In general N_2H^+ and HC_3N distribution is quite similar in OMC-2/3, but we observed displacement between N_2H^+ and HC_3N over 2 arcmin scale along the OMC-3 ridge, which has a chain of Class 0-I protostars (and candidates) including X-ray protostars.
- Tatematsu, K., R. Kandori, T. Umemoto, and Y. Sekimoto [2008], "N_2H^+ and HC_3N Observations of the Orion A Cloud," Publ. Astron. Soc. Japan, vol.60, pp.407-419.
  - The "∫-shaped filament" of the Orion A giant molecular cloud was mapped in N_2H^+, and its northern end, the OMC-2/3 region, was also observed in HC_3N and CCS. The results were compared with map s of other molecular lines and the dust continuum emission. The N_2H^+ distribution is similar to the dust continuum distribution, except for the central part of the Orion Nebula. The distribution of $H^{13}CO^+$ hold a resemblance to that of the dust continuum, but the N_2H^+ distribution looks more similar to the dust continuum distribution. The N-bearing molecules, N_2H^+ and NH_3, seem to be more intense in OMC-2, compared with the $H^{13}CO^+$ and CS distribution. This suggests that OMC-2 has a higher abundance of N-bearing molecules, or a higher filling factor of the quiescent gas. We identified 34 cloud cores from N_2H^+ data. Over the Orion Nebula region, the N_2H^+ linewidth is large (1.1-2.1 km s^{-1}). In the OMC-2/3 region, it becomes moderate (0.5-1.3 km s^{-1}), and it is smaller (0.3-1.1 km s^{-1}) in the south of the Orion Nebula. On the other hand, the gas kinetic temperature of the quiescent cores observed in N_2H^+ is rather constant (~ 20 K) over the∫-shaped filament. We detected no CCS emission in the OMC-2/3 region. In general, N_2H^+ and HC_3N distribution is quite similar in the OMC-2/3 region, but we observed displacement between N_2H^+ and HC_3N over a 2' scale in OMC-3, which has a chain of Class 0-I protostars (candidates).
- Torii, K., N. Kudo, M. Fujishita, T. Kawase, T. Okuda, H. Yamamoto, A. Kawamura, N. Mizuno, T. Onishi, M. Machida, K. Takahashi, S. Nozawa, R. Matsumoto, J. Ott, K. Tanaka, N. Yamaguchi, H. Ezawa, J. Stutzki, U. Klein, F. Bertoldi, K. Bon-Chul, L. Bronfman, M. Burton, A. Benz, H. Ogawa, and Y. Fukui [2010], "Temperature and Density in the Foot Points of the Molecular Loops in the Galactic Center; Analysis of Multi-J Transitions of ^{12}CO(J=1-0, 3-2, 4-3, 7-6), ^{13}CO(J=1-0) and $C^{18}O$(J=1-0)," Publ. Astron. Soc. Japan, vol.62, pp.675-695.
  - Fukui et al. (2006) discovered two molecular loops in the Galactic center and argued that the foot points of the molecular loops, two bright spots at both loops ends, represent the gas

accumulated by the falling motion along the loops, subsequent to magnetic flotation by the Parker instability. We have carried out sensitive CO observations of the foot points toward l=356° at a few pc resolution in the six rotational transitions of CO; ^{12}CO(J=1-0, 3-2, 4-3, 7-6), ^{13}CO(J=1-0) and C^{18}O(J=1-0). The high resolution image of ^{12}CO (J=3-2) has revealed the detailed distribution of the high excitation gas including U shapes, the outer boundary of which shows sharp intensity jumps accompanying strong velocity gradients. An analysis of the multi-J CO transitions shows that the temperature is in a range from 30-100 K and density is around 10^3-10^4 cm^{-3}, confirming that the foot points have high temperature and density although there is no prominent radiative heating source such as high mass stars in or around the loops. We argue that the high temperature is likely due to the shock heating under C-shock condition caused by the magnetic flotation. We made a comparison of the gas distribution with theoretical numerical simulations and note that the U shape is consistent with numerical simulations. We also find that the region of highest temperature of ~100 K or higher inside the U shape corresponds to the spur having an upward flow, additionally heated up either by magnetic reconnection or bouncing in the interaction with the narrow neck at the bottom of the U shape. We note these new findings further reinforce the magnetic floatation interpretation.

- Tosaki, T., Y. Shioya, N. Kuno, T. Hasegawa, K. Nakanishi, S. Matsushita, and K. Kohno [2008a], "Giant Molecular Association in Spiral Arms of M31 : Evidence for Dense Gas Formation via Spiral Shock Associated with Density Waves?," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., p.382.
  - Without abstract
- Tosaki, T., R. Miura, T. Sawada, N. Kuno, K. Nakanishi, K. Kohno, S. K. Okumura, S. Komugi, Y. Tamura, and R. Kawabe [2008b], "NRO 45 M and ASTE 10 M Observations of Dense Gas in Giant HII Regions of M 33," EAS Publication Series, vol.31, pp.211-212.
  - We present ^{12}CO(J=3-2) and ^{12}CO(J=1-0) observations of the supergiant HII region NGC 604 in the nearest face-on piral galaxy M 33 using the Atacama Submillimeter Telescope Experiment (ASTE) 10-m and the Nobeyama Radio Observatory (NRO) 45-m telescopes. We found high ^{12}CO(J=3-2)/^{12}CO(J=1-0) ratio gas with an arc-like distribution ("high-ratio gas arc") surrounding the central star cluster of NGC 604. Our results suggest that dense gas formation and second-generation star formation occur in the surrounding gas compressed by the stellar wind and/or supernova of the first-generation stars of NGC 604, i.e., the central star cluster of NGC 604. Thus, NGC 604 is an example of large-scale sequential star formation.
- Trushkin, S. A., N. N. Bursov, T. Kotani, N. A. Nizhelskij, M. Namiki, M. Tsuboi, and P. A. Voitsik, [2007], "Recent Radio Monitoring of Microquasars with RATAN-600 Radio Telescope," Proceedings of the 6th INTEGRAL workshop "The Obscured Universe", 2-8 July 2006, Moscow, ESA SP-622.
  - We report about the multi-frequency (1-30 GHz) daily monitoring of the radio flux variability of the three microquasars: SS433, GRS1915+105 and Cyg X-3 during the period from September 2005 to May 2006. 1. We detected clear correlation of the flaring radio fluxes and X-rays 'spikes' at 2-12 keV emission detected in RXTE ASM from GRS1915+105 during eight relatively bright (200-600 mJy) radio flares in October 2005. The 1-22 GHz spectra of these flares in maximum were optically thick at frequencies lower 2.3 GHz and optically thin at the higher frequencies. During the radio flares the spectra of the X-ray spikes become softer than those of the quiescent phase. Thus these data indicated the transitions from very high/hard states to high/soft ones during which massive ejections are probably happened. These ejections are visible as the detected radio flares. 2. After of the quiescent radio emission we have detected a drop down of the fluxes (~20 mJy) from Cyg X-3. That is a sign of the following bright flare. Indeed such a 1Jy-flare was detected on 3 February 2006 after 18 days of the quenched radio emission. The daily spectra of the flare in the maximum was flat from 1 to 100

GHz, using the quasi-simultaneous observations at 109 GHz with RT45m telescope and millimeter array (NMA) of Nobeyama Radio Observatory in Japan. The several bright radio flaring events (1-10 Jy) followed during this state of very variable and intensive 1-12 keV X-ray emission (~0.5 Crab), which being monitored in RXTE ASM program.

- Trushkin, S., N. Nizhelskij, T. Kotani, N. Kawai, M. Tsuboi, and M. Namiki [2009], "Active Flaring States of GRS 1915+105 and Cyg X-3 in Radio/X-Ray Monitoring," Proc. of "Astrophysics with All-Sky X-Ray Observations", pp.88-93.

➢ In multi-wavelength collaboration we studied the variability of the microquasars GRS1915+105 and Cyg X-3 during 2005 to May 2008 with the RATAN-600 radio telescope of SAO RAS. We detected clear correlation of the flaring radio fluxes and X-rays 'spikes' at 2-12 keV emission redundant in RXTE ASM from GRS1915+105 during eight relatively bright (200-600 mJy) radio flares in October 2005. Spectra of these flares at maximum are optically thick at frequencies lower than 2.3 GHz and optically thin at the higher frequencies. During the radio flares the spectra of the X-ray spiked become softer than the those of the quiescent phase. Thus these data indicate the transitions from the very high/hard state to high/soft state during which massive ejections probably occur. These ejections are detected as radio flares. such X-ray/radio events correlation detected later in 2006-2008. In December 2005 after of the 4-year quiescent radio state (100-200 mJy) Cyg X-3 entered the softer X-ray with low level of hard (15-50 keV) X-ray and high (~0.5 crab) in the soft band (1-10 keV). In the following 500 days we have detected more 10 bright (> 1Jy) flaring events correlated with rising phases of ASM-Swift-BAT intensity of Cyg X-3. A first 1 Jy-flare was detected on 3 February 2006 after 18 days of the quenched radio emission (< 20mJy). The spectrum of the flare at the maximum id flat from 1 to 100 GHz, obtained the quasi-simultaneous observations with RT45m telescope and millimeter array (NMA) of Nobeyama Radio Observatory.

- Tsai, A. L., S. Matsushita, K. Nakanishi, K. Kohno, R. Kawabe, T. Inui, H. Matsumoto, T. G. Tsuru, A. B. Peck, and A. Tarchi [2009], "Molecular Superbubbles and Outflows from the Starburst Galaxy NGC 2146," Publ. Astron. Soc. Japan, vol.61, pp.237-250.

➢ We present results from a deep (1σ = 5.7 mJy beam-1 per 20.8 km s^{-1} velocity channel) $^{12}CO(1-0)$ interferometric observation of the central 60" region of the nearby edge-on starburst galaxy NGC 2146, observed with the Nobeyama Millimeter Array. Two diffuse expanding molecular superbubbles and one molecular outflow were successfully detected. One molecular superbubble, with a size of ~1 kpc and an expansion velocity of ~50 km s^{-1}, is located below the galactic disk; a second molecular superbubble, with a size of ~700 pc and an expansion velocity of ~35 km s^{-1}, is also seen in the position ≀ velocity diagram; the molecular outflow is located above the galactic disk with an extent of ~2 kpc expanding with a velocity of up to ~200 km s^{-1}. The molecular outflow has an arc-like structure, and is located at the front edge of the soft X-ray outflow. In addition, the kinetic energy (~3 x 10^{55} erg) and the pressure (~1 x $10^{-12\pm1}$ dyn cm^{-2}) of the molecular outflow are comparable to, or smaller than, that of the hot thermal plasma, suggesting that the hot plasma pushes the molecular gas out from the galactic disk. Inside the ~1 kpc size molecular superbubble, diffuse soft X-ray emission seems to exist. However, since the superbubble lies behind the inclined galactic disk, it is largely absorbed by the molecular gas.

- Tsap, Y. T., Y. G. Kopylova, A. V. Stepanov, V. E. Melnikov, and K. Shibasaki [2008], "Ballooning Instability in Coronal Flare Loops," Solar Phys., vol.253, pp.161-172.

➢ Within the framework of ideal magnetohydrodynamics the excitation of the ballooning instability in a toroidal coronal loop with a radius of cross section a and a radius of curvature R is analyzed by using the energy method. Kink oscillations are able to excite the ballooning instability when the plasma beta parameter $\beta>2a/R$. It has been suggested that this can result in the formation of cusp-shaped coronal loops. Modulation of gyrosynchrotron emission

caused by kink oscillations is considered. The intensity of gyrosynchrotron emission for optically thin sources is the most sensitive to Alfvén disturbances. The obtained theoretical results are discussed in the light of Yohkoh, SOHO, TRACE, RHESSI, and Nobeyama observations.

- Tsuboi, M., A. Miyazaki, and T. Handa [2008a], "The Synchrotron Cut-Off Frequency of Relativistic Electrons in the Radio Arc and Their Acceleration Area," Proc. of the "Mapping the Galaxy and Nearby Galaxies", eds. Wada, K., and Combes, F., pp.133-138.

➢ The Galactic Center region is a nearest central region of spiral galaxy. Unique structures which may relate intrinsic activities in the central region have been found. "gRadio Arc" is a most outstanding one of such features. This consists of two parts with different properties. These are non-thermal "Vertical filament" and thermal "Arched filament" [1]. Although the intensity is abruptly decreased at the both ends of Vertical filament, the positive galactic latitude extension corresponds to the base of a famous off-plane feature, "Galactic Center ㄟ-shaped lobe", which was identified by Sofue and Handa (1986) [2]. The lobe also consists of two parts with different properties. The positive longitude part is highly linear polarized up to 50% at 10 GHz, which is non-thermal, and the negative longitude part is non-polarized, which is presumably thermal [3]. It is controversial that the lobe is a real combined structure or an apparent feature by chance superposition in the line of sight. On the other hand, the negative galactic latitude extension is distinctive only in linear polarization map. Two polarized extensions is called "Polarized Lobe" [3]. Radio Arc and Polarized Lobe are presumably a part of large scale poloidal magnetic field through the Galactic center region. It is, however, an open question how much is the strength of the magnetic field. In addition, several vertical continuum features identified in lower frequency map are also a part of such magnetic field [4]. It is also an open question that such magnetic field exists anywhere in the region or is restricted in smaller region. The synchrotron cut-off frequency in the Radio Arc and its distribution presumably provide the informations of the acceleration area of relativistic electrons and the acceleration mechanism.

- Tsuboi, M., T. Tosaki, N. Kuno, K. Nakanishi, T. Sawada, T. Umemoto, S. A. Trushkin, T. Kotani, N. Kawai, Y. Kurono, T. Handa, K. Kohno, T. Tsukagoshi, O. Kameya, H. Kobayashi, K. Fujisawa, A. Doi, T. Omodaka, H. Takaba. H. Sudou, K. Wakamatsu, Y. Koyama, E. Kawai, N. Mochizuki, and Y. Murata [2008b], "The 2006 Radio Outburst of a Microquasar Cyg X-3: Observation and Data," Publ. Astron. Soc. Japan, vol.60, pp.465-473.

➢ We present the results of the multi-frequency observations of radio outburst of the microquasar Cyg X-3 in 2006 February and March with the Nobeyama 45-m telescope, the Nobeyama Millimeter Array, and the Yamaguchi 32-m telescope. Since the prediction of a flare by RATAN-600, the source was monitored from January 27 (UT) with these radio telescopes. At the eighteenth day after the quench of the activity, successive flares exceeding 1 Jy were successfully observed. The time scale of the variability in the active phase is presumably shorter in higher frequency bands. We also present the result of a follow-up VLBI observation at 8.4 GHz with the Japanese VLBI Network 2.6 days after the first rise. A VLBI image exhibits a single core with a size of <8 mas (80 AU). The observed image is almost stable, although the core showed a rapid variation in the flux density. No jet structure can be seen at a sensitivity of T_b (brughtness temperature)= 7.5×10^5 K.

- Tsuboi, M., A. Miyazaki, and S. K. Okumura [2009a], "The Galactic Center 50-km s^{-1} Molecular Cloud with an Expanding Shell," Publ. Astron. Soc. Japan, vol.61, pp.29-37.

➢ We performed high-resolution observations of a Galactic Center 50-km s^{-1} molecular cloud in the CS J = 1-0 line using the Nobeyama Millimeter Array (NMA). The molecular cloud mainly has three different spatial components with large velocity widths of up to 60 km s^{-1}. The northwest component is located at an apparent contact point to the Sgr A east shell, and

elongated along the boundary of the shell. The large velocity width of the component is responsible for interaction with the Sgr A east shell. The molecular gas distribution in CS line emission is dissimilar to that observed previously in NH_3 line emissions. The appearance shows presumably the area of CS line emission enhanced by shock. The central and southwest components are located just out of the Sgr A east shell and far from it, respectively. However, these components have large velocity widths. We found a well-shaped circular molecular shell with expanding motion in the 50-km s^{-1} molecular cloud. This is responsible for the large velocity width. The continuum source in the expanding molecular shell has a steep spectrum in mm-wavelengths, although this was not identified in a previous 5-GHz map. This source may be an SNR with an ionized sheath. From the aspect ratio of an expanding molecular shell of 1.1, the magnetic field in/around the shell is estimated to be smaller than 100μ Gauss. This weak magnetic field is consistent with on-going active star formation in the 50-km s^{-1} molecular cloud. A comparison among CS line emission, low-frequency continuum, and millimeter
continuum toward the 50-km s^{-1} molecular cloud suggests a face-on view of the Sgr A region. The molecular cloud is located in the Sgr A halo region.

- Tsuboi, M., A. Miyazaki, K. Nakanishi, K. Kamegai, and T. Kotani [2009b], "A MM-Wave Flare from Cyg X-3," The Astronomer's Telegram, #2053.
  - We report that the microquasar Cyg X-3 (20:32:25.77, 40:57:27.97, J2000) is currently undergoing a mm-wave flare. A peak activity exceeding 0.4 Jy at 43 GHz has been detected with the 45-m telescope of the Nobeyama Radio Observatory at 2009/05/20 20:40 (UT), followed by a decay with an e-folding time of 150 min. At 86 GHz, the peak is higher than 0.3 Jy, and the rise and decay profile shows a more complicated structure.
- Tsuboi, M., and T. Handa [2010], "Highly Polarized Counterpart of the Double Helix Nebula," Astrophys. J. (Letters), vol.719, pp.L177-L180.
  - We identified the double helix nebula (DHN) found by the Spitzer Space Telescopein the Galactic center region as a highly polarized feature at 10 GHz with the Nobeyama 45 m telescope. The DHN is located near the north end of the polarized plumes. The position angles of Faraday rotation corrected B vectors in the DHN are presumably along the twisting IR filaments. The linear polarization degree of the DHN is as large as p = 10%, and reaches p = 15% ± 2% at the radio polarization peak of the DHN. This means that the DHN has highly ordered magnetic field with synchrotron-emitting relativistic electrons.
- Ueda, K., H. Imai, S. Deguchi, R. Kamohara, T. Maeda, N. Matsumoto, and T. Omodaka [2008], "Japanese VLBI Network Observations of SiO Masers in the M-Type Giant IRC 10414," Publ. Astron. Soc. Japan, vol.60, pp.1051-1056.
  - We present two-epoch maps of SiO masers (v=1 and v=2, J=1-0) associated with the M-type star IRC-10414, which were obtained with the Japanese VLBI Network (JVN). The spatial an Doppler velocity distributions, and the intensity ratio of the v=1 to v=2 (J=1-0) lines have significantly changed for eight years since our previous Very Long Baseline Array (VLBA) observation, The maser proper motions revealed by these two-epoch observations with an interval of one month are quite random and too fast to be explained by ballistic motions of the maser clumps. The maser distributions seen in the present observations cannot be explained by a rotating-infalling ring model implied in the previous work. We discuss the kinematical relation between the SiO and H_2O masers in IRC-10414. In the present observations, the scale sizes of SiO v=1 and v=2 masers in IRC-10414 were roughly equal, as observed in typical Mira variables.
- Ujihara, H., and T. Bushimata [2009a], "Measurement of the Antenna Mesh: Characteristics for VSOP-2/ASTRO-G," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and

Murata, Y., ASP Conf. Ser. vol.402, pp.66-69.

- The surface of the main reflector antenna of the VSOP-2 satellite is made of metal wire that is woven into a tense mesh. Numerical simulations are required to determine the reflectivity characteristics of the mesh which are functions of the reflecting angle, polarization and frequency of the incident radio wave and the tension of the mesh. These characteristics were measured with the tension of 200g/m, 350g/m, 500g/m.

- Ujihara, H. [2009b], "Designs and Development of Multimode Horns for ASTRO-G/VSOP-2 Satellite," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.70-73.

- The antenna optics of VSOP-2 satellite require low cross polarization, and the volume of the receiver box is limited. Thus, instead of conventional corrugated horns, multimode horns were proposed and designed in order to reduce the axial length and weight of the horns but still compatible with a low cross polarization. These multimode horns were designed for three observational bands of VSOP-2 at 8GHz, 22GHz, 43GHz, all with about the same antenna illumination size. However, the ratio of waveguide and wavelength are slightly different. The 22GHz-horn was designed at first, and the other horns were arranged around it. The properties of the horns were improved by controlling the complex amplitude of higher modes and by fitting the beam width to the antenna optics. The BBM models of horns were tested, and their measured beam patterns agree well with numerical simulations.

- Ukita, N., H. Ezawa, B. Ikenoue, and M. Saito [2007], "Thermal and Wind Effects on the Azimuth Axis Tilt of the ASTE 10-m Antenna," Publ. Natl. Obs. Japan, vol.10, pp.25-33.

- The azimuth axis title of the ASTE 10-m antenna induced by thermal and wind loading was investigated with a dual-axis inclinometer on the azimuth axis, along with thermometers on the pedestal and yoke structures and an ultrasonic anemometer on a nearby station. The dependence of the inclinometer zero-point offsets against temperature of the device, temperature gradients in the pedestal and yoke structure were obtained for the measurements over 11 months during the antenna being parked at its home position (azimuth angles = ±180 degrees, an elevation angle = 60 degrees) under wind velocities < 8 m s^{-1}. The temperature dependences of the zero-point offsets were found to be 1.24 and -0.46 arcseconds/degree, and were close to those obtained with an independent method. The azimuth axis tilts due to the temperature difference between the two opposite sides of pedestal walls were found to be about 1.1 and 1.7 arcseconds/degree, and consistent with 1.5 arcseconds/degree estimated with a simple model. The residual axis tilt of the whole samples after removal of the temperature dependences shows dependence against overturning moment estimated from the wind data. The stiffness of the antenna structures between the yoke base section and the ground was estimated to be 5.3 and 3.4 GNm/rad using the observed tilts in two directions; and were smaller than 6/0 GNm/rad from a mechanical model prediction. Based on these field experiments, we discuss the improvements and limitations of pointing performance with the inclinometer metrology system.

- Ukita, N., B. Ikenoue, and M. Saito [2008a], "Optical Seeing Measurements with an Optical Telescope on a Radio Antenna," Publ. Natl. Astron. Obs. Japan, vol.11, pp.1-11.

- Individual images of a video CCD camera with a 10-cm objective lens recorded for pointing performance tests of a prototype 12-m antenna for the ALMA project have been analyzed to evaluate both antenna tracking accuracy and optical seeing at the NRAO VLA site. Data of star image centroid motion have been compared with readouts of angle encoders and inclinomters on the azimuth axis in the yoke structure of the antenna. Under good tracking conditions, a power spectral density (PSD) of image motion during tracking over about 5 minutes had a Kolmogorov power index of -2/3. At frequencies > 4 Hz, the PSD showed a steeper decline

due to a finite exposure time of the video camera (1/30 seconds) than -2/3, which suggests a wind speed of about 3 m s^{-1} at the level where the main turbulence occurs. At lower frequencies, a flattening of the PSD was observed with a turnover frequency of about 0.05 Hz, which in turn suggests an "outer scale" of about 60 m, a length of large-scale disturbances in Kolmogorov's model. The image centroid fluctuations observed during all-sky pointing tests showed a dependence on air mass A as A0.5 and were 0.5 to 0.9 arcseconds rms at the zenith. These measurements suggest that observations for 2-3 seconds can determine a star position with a typical error of 0.3 to 0.6 arcseconds.

- Ukita, N. [2008b], "Wind Induced Surface Deformation of the Nobeyama 45-m Radio Telescope," Proc. of the SPIE, vol.7012, pp.70120V-1-11.
  - Reflector surface deformation due to wind loading on the Nobeyama 45-m antenna has been measured with four LED lamps on the surface at r = 20 m and two CCD cameras on the central hub as it rotates in azimuth with elevation angles of 90 and 11 degrees. The side-wind loading of 8.4 m s^{-1} caused a tilt of 12 arcseconds and an astigmatic deformation of 0.8 mm. The front- and back-wind loading of 9.9 m s^{-1} induced a vertical displacement variation of 2.3 mm. These largescale surface deformation profiles have been compared with those of finite element calculations and coefficients of axial force and yaw moment predicted by a JPL wind tunnel data excerpt.
- Ukita, N., H. Ezawa, S. Onodera, and M. Saito [2010], "Wind-Induced Pointing Errors and Surface Deformation of a 10-m Submillimeter Antenna," J. Proc. of the SPIE, vol.7733, pp.77331D-77331D-11.
  - Two types of field measurements on the Atacama Submillimeter Telescope Experiment 10-m antenna have been made to diagnose antenna oscillations in strong wind gusts and to reduce pointing errors due to static/quasi-static wind loadings. The measurements with seismic accelerometers on the reflector have been compared with those from axis angle encoders. Our results have confirmed that the dominant wind effects are at low frequencies, and have found that twist and pitching motion of yoke arms are the dominant source of pointing jitters and decrease with frequency along the Kolmogorov slope of -5/3. In the range from about 1 to 10 Hz, the servo-loop excites and dominates pointing error oscillations. For azimuth oscillations, the frontal wind has the largest effects, compared with side- or tail-wind. To improve pointing performance against static/quasi-static wind effects, we have implemented and tested an auxiliary auto-pointingcorrection system with a lookup table compiled from all-sky pointing measurements under strong winds, invoking the Taylor's "frozen turbulence" hypothesis. We have successfully demonstrated that use of upwind data from a nearby anemometer helps to reduce the pointing errors of static wind effects from 2.4 " rms (correction OFF) to 1.2 " rms (correction ON) under a mean wind speed of 9.3 m s^{-1}.
- Umemoto, T., N. Mochizuki, K. M. Shibata, D.-G. Roh, and H.-S. Chung [2008], "Millimetre Wavelength Methanol Masers Survey towards Massive Star Forming Regions," Proc. of the IAU Symp. 242, "Astrophysical Masers and their Environments", eds. Jessica Chapman and Willem Baan, pp.234-235.
  - We present the results of a mm wavelength methanol maser survey towards massive star forming regions. We have carried out Class II methanol maser observations at 86.6 GHz, 86.9 GHz and 107.0 GHz, simultaneously, using the Nobeyama 45 m telescope. We selected 108 6.7 GHz methanol maser sources with declinations above -25 degrees and fluxes above 20 Jy. The detection limit of maser observations was ~3 Jy. Of the 93 sources surveyed so far, we detected methanol emission in 25 sources (27%) and "maser" emission in nine sources (10%), of which thre "maser" sources are new detections. The detection rate for maser emission is about half that of a survey of the southern sky (Caswell et al. 2000). There is a correlation between the maser flux of 107 GHz and 6.7 GHz/12 GHz emission, but no correlation with the

"thermal" (non maser) emission. From results of other molecular line observations, we found that the sources with methanol emission show higher gas temperatures and twice the detection rate of SiO emission. This may suggest that dust evaporation and destruction by shock are responsible for the high abundance of methanol molecules, one of the required physical conditions for maser emission.

- Umemoto, T., M. Saito, K. Nakanishi, N. Kuno, and M. Tsuboi [2009], "Detection of a Radio Flare at Millimeter-Wavelengths from the X-Ray T Tauri Star V773 Tau," Proc. of the "Approaching Micro-Arcsecond Resolution with VSOP-2: Astrophysics and Technologies", eds. Hagiwara, Y., Fomalont, Ed., Tsuboi, M., and Murata, Y., ASP Conf. Ser. vol.402, pp.400-403.
  - We present the results of multi-frequency observations of a radio flare in the young stellar object (YSO) V773 Tau, which is probably a weak-line T Tauri star. We carried out radio continuum observations at 22 GHz, 43 GHz and 86 GHz, using the Nobeyama 45 m telescope, and detected a radio flare at all frequencies. The radio flare occurred near periastron passage, and the flux density became 4 to 10 times higher, then rapidly decreased at 43 and 86 GHz within a few hours. The radio spectrum was rising (brighter at higher frequency) during the flare. On the other hand, the radio continuum at 22 GHz was detected even 28 hours later at more than 2 mJy. Thus, the active phase is surprisingly long at 22 GHz. V773 Tau is the most promising target for detailed imaging of the magnetosphere with the next space VLBI project VSOP-2.
- Uralov, A. M., V. V. Grechnev, I. G. Rudenko, and H. Nakajima [2008], "Microwave Neutral Line Associated Source and a Current Sheet," Solar Phys., vol.249, pp.315-335.
  - Neutral Line associated Sources (NLSs) are quasi-stationary microwave sources projected onto vicinities of the neutral line of the photospheric magnetic field. NLSs are often precursors of powerful flares, but their nature is unclear. We endeavor to reveal the structure of an NLS and to analyze a physical connection between such a source with a site of energy release in the corona above NOAA 10488 (October/November 2003). Evolution of this AR includes emergence and collision of two bipolar magnetic structures, rise of the main magnetic separator, and the appearance of an NLS underneath. The NLS appears at a contact site of colliding sunspots, whose relative motion goes on, resulting in a large shear along a tangent. Then the nascent NLS becomes the main source of microwave fluctuations in the AR. The NLS emission at 17 GHz is dominated by either footpoints or the top of a loop-like structure, an NLS loop, which connects two colliding sunspots. During a considerable amount of time, the emission dominates over that footpoint of the NLS loop, where the magnetic field is stronger. At that time, the NLS resembles a usual sunspot-associated radio source, whose brightness center is displaced towards the periphery of a sunspot. Microwave emission of an X2.7 flare is mainly concentrated in an ascending flare loop, initially coinciding with the NLS loop. The top of this loop is located at the base of a non-uniform bar-like structure visible in soft X-rays and at 34 GHz at the flare onset. We reveal i) upward lengthening of this bar before the flare onset, ii) the motion of the top of an apparently ascending flare loop along the axis of this bar, and iii) a non-thermal microwave source, whose descent along the bar was associated with the launching of a coronal ejection. We connect the bar with a probable position of a nearly vertical diffusion region, a site of maximal energy release inside an extended pre-flare current sheet. The top of the NLS loop is located at the bottom of this region. A combination of the NLS loop and diffusion region constitutes the skeleton of a quasi-stationary microwave NLS.
- Vila-Vilaro, B. [2008], "Rare CO Isotope Observations of M51a (NGC5194)," Publ. Astron. Soc. Japan, vol.60, pp.1231-1248.
  - We present observations of the central regions of M 51a (NGC 5194) in the J = 1-0 rotational

transitions of ^{13}CO, $C^{18}O$, and $C^{17}O$. The last two are the ˋ rst detections reported for this object. We have combined these data with published HCN and CO(J = 1-0) observations with the same telescope to carry out some LVG modeling (single-cloud and two-cloud mixtures) of the line ratios. The results are compatible with the presence of a region emitting most of the HCN and another component at lower temperatures and densities emitting most of the rest of the molecular emission. The observed high $C^{18}O/C^{17}O$ ratio, together with our models, suggest that this is caused by an underabundance of $[C^{17}O]$ (compared with Galactic values). This can be explained by different evolutionary histories. The $C^{18}O$ emission line has a clearly asymmetric profile, implying the presence of significant excitation differences within the observed region. Finally, there is an indication that the CO(1-0) is overestimating the molecular gas mass in the central kpc of this galaxy. This is similar to what is found in the Milky Way at similar spatial scales, and possibly associated with a change in the conversion factor due to the average cloud properties in the central regions of this object.

- Wajima, K., N. Kawaguchi, Y. Murata, and H. Hirabayashi [2007], "Radiation Testing of Consumer High-Speed LSI Chips for the Next Space VLBI Mission," Publ. Astron. Soc. Japan, vol.59, pp.1221-1226.
  - We performed two types of radiation testing on high-speed LSI chips to test their suitability for use in wideband observations by the Japanese next space VLBI mission, VSOP-2. In the total ionization dose experiment we monitored autocorrelation spectra which were taken with irradiated LSI chips and the source current at intervals up to 1,000 hours from the ionization dose, but we could not see any change of these features for the chips irradiated with dose rates expected in the VSOP-2 mission. In the single event effect experiment, we monitored the cross correlation phase and power spectra between the data from radiated and non-radiated devices, and the source current during the irradiation of heavy-ions. We observed a few tens of single event upsets as discrete delay jumps for each LSI. We estimated the occurrence rate of single events in space as between once a few days to once a month. No single event latch-up was seen in any of the LSIs. These results show that the tested LSIs have sufficient tolerance to the environment for space VLBI observations.
- Wilson, G. W., I. Aretxaga, D. Hughes, H. Ezawa, J. E. Austermann, S. Doyle, I. Hernandez-Curiel, R. Kawabe, T. Kitayama, K. Kohno, A. Kuboi, H. Matsuo, P. D. Mauskopf, Y. Murakoshi, A. Montana, P. Natarjan, T. Oshima, N. Ota, T. Perera, J. Rand, K. S. Scott, K. Tanaka, M. Tsuboi, C. C. Williams, and M. S. Yun [2008], "A Bright, Dust-Obscure, Millimeter-Selected Galaxy Beyond the Bullet Cluster (1E0657-56)," Mon. Not. Roy. Astron. Soc., vol.390, pp.1061-1070.
  - Deep 1.1 mm continuum observations of 1E0657-56 (the 'Bullet Cluster') taken with the millimeter-wavelength camera AzTEC on the 10-m Atacama Submillimeter Telescope Experiment (ASTE), have revealed an extremely bright ($S_{1.1}$ mm= 15.9 mJy) unresolved source. This source, MMJ065837-5557.0, lies close to a maximum in the density of underlying mass distribution, towards the larger of the two interacting clusters as traced by the weak-lensing analysis of Clowe et al. Using optical-infrared (IR) colours, we argue that MMJ065837-5557.0 lies at a redshift of z= 2.7 ± 0.2. A lensing-derived mass model for the Bullet Cluster shows a critical line (caustic) of magnification within a few arcsec of the AzTEC source, sufficient to amplify the intrinsic millimetre-wavelength flux of the AzTEC galaxy by a factor of □20. After subtraction of the foreground cluster emission at 1.1mm due to the Sunyaev-Zel'dovich effect, and correcting for the magnification, the rest-frame far-IR luminosity of MMJ065837-5557.0 is $\leq 10^{12}$ Lsolar, characteristic of a luminous infrared galaxy (LIRG). We explore various scenarios to explain the colours, morphologies and positional offsets between the potential optical and IR counterparts, and their relationship with MMJ065837-5557.0. Until higher resolution and more sensitive (sub)millimetre observations

are available, the detection of background galaxies close to the caustics of massive lensing clusters offers the only opportunity to study this intrinsically faint millimetre-galaxy population.

- Winnberg, A., S. Deguchi, M. J. Reid, J. Nakashima, H. Olofsson, and H. H. J. Habing [2009], "CO in OH/IR Stars to the Galactic Centre," Astron. Astrophys., vol.497, pp.177-181.
  - Most stars form in Giant Molecular Clouds (GMCs) and regulate the evolution of galaxies in various respects. The formed stars affect the surrounding materials strongly via their UV photons, stellar winds, and supernova explosions, which lead to trigger the formation of next-generations of stars in the GMCs. It is therefore crucial to reveal the distribution and properties of GMCs in a galaxy. The Magellanic System is a unique target to make such detailed comprehensive study of GMCs. This is because it is nearby and the LMC is nearly face-on, making it feasible to unambiguously identify associated young objects within GMCs. Recent millimeter and sub-millimeter observations in the Magellanic System have started to reveal the distribution and properties of the individual GMCs in detail and their relation to star formation activities. From the NANTEN CO surveys, three types of GMCs can be classified in terms of star formation activities; Type I is starless, Type II is with H ii regions only, and Type III is associated with active star formation indicated by huge H ii regions and young star clusters. The further observations to obtain detailed structure of the GMCs by Mopra and SEST and to search for the dense cores by ASTE and NANTEN2 in higher tansition lines of CO have been carried out with an angular resolution of about 5 to 10 pc. These observations revealed that the differences of the physical properties represent an evolutionary sequence of GMCs in terms of density increase leading to star formation. Type I and II GMCs are at the early phase of star formation where density does not yet become high enough to show active star formation, and Type III GMCs represent the later phase where the average density is increased and the GMCs are forming massive stars.
- Wong, T., A. Hughes, Y. Fukui, A. Kawamura, N. Mizuno, J. Ott, E. Muller, J. L. Pineda, D. E. Welty, S. Kim, Y. Mizuno, M. Murai, and T. Onishi [2009], "Molecular and Atomic Gas in the Large Magellanic Cloud. I. Conditions for CO Detection," Astrophys. J., vol.696, pp.370-384.
  - We analyze the conditions for detection of CO(1-0) emission in the Large Magellanic Cloud, using the recently completed second NANTEN CO survey. In particular, we investigate correlations between CO integrated intensity and H I integrated intensity, peak brightness temperature, and line width at a resolution of 2.'6 (~40 pc). We find that significant H I column density (exceeding $\sim 10^{21}$ cm^{-2}) and peak brightness temperature (exceeding ~20 K) are necessary but not sufficient conditions for CO detection, with many regions of strong H I emission not associated with molecular clouds. The large scatter in CO intensities for a given H I intensity persists even when averaging on scales of >200 pc, indicating that the scatter is not solely due to local conversion of H I into H_2 near GMCs. We focus on two possibilities to account for this scatter: either there exist spatial variations in the I(CO) to N(H_2) conversion factor, or a significant fraction of the atomic gas is not involved in molecular cloud formation. A weak tendency for CO emission to be suppressed for large H I linewidths supports the second hypothesis, insofar as large linewidths may be indicative of warm H I, and calls into question the likelihood of forming molecular clouds from colliding H I flows. We also find that the ratio of molecular to atomic gas shows no significant correlation (or anticorrelation) with the stellar surface density, though a correlation with midplane hydrostatic pressure Ph is found when the data are binned in P_h. The latter correlation largely reflects the increasing likelihood of CO detection at high H I column density.
- Yamada, M., K. Wada, and K. Tomisaka [2009], "Three dimensional Line Transfer Study of Energy Sources in Compact Molecular Gas in Active Galaxies - AGN/Starburst Connection-," Proc. of the "The starburst-AGN connection", eds. Weimin Wang, Zhaoqing Yang, Zhijian Luo,

and Zhu Chen, ASP Conf. Ser., vol.408, pp.254-258.

- Recent observations suggest molecular line ratios in millimeter and submillimeter bands may be a good tool to reveal the long-standing question on the origin of energy sources in obscured active galaxies ; AGN and/or starburst. Observations of actual molecular medium show in general inhomogeneous structures as well as high-resolution hydrodynamic simulations do. In order for precise interpretation of emergent line emission from the inhomogeneous molecular gas to probe the dominant energy source of active galaxies, we study characteristic features of emergent intensities via three-dimensional non-LTE (non-local thermodynamic equilibrium) line transfer simulations. Our results succeeded in making clear 1) the necessary conditions for HCN/HCO^+-dichotomy, and 2) importance of clumpiness on intensity ratio and its interpretation. These results are obtained for the first time by our realistic three-dimensional simulations, and line transfer simulations will be a powerful tool to comprehensive studies of extragalactic interstellar medium (ISM) in forthcoming ALMA (Atacama Large Millimeter/submillimeter Array) era.

- Yamamoto, S., R. Nakamura, T. Matsunaga, Y. Ogawa, Y. Ishihara, T. Morota, N. Hirata, M. Ohtake, T. Hiroi, Y. Yokota, and J. Haruyama [2010a], "Global Distribution of Olivine Exposures on the Moon Revealed by SELENE Spectral Profile," LPI Contribution No. 1533, p.1646.
  - Here, we report the global distribution of olivine exposures, possibly originating from the lunar mantle as discovered by Spectral Profiler onboard the Japanese lunar explorer SELENE (Kaguya).
- Yamamoto, S., F. Nakamura, T. Matsunaga, Y. Ogawa, Y. Ishihara, T. Morota, N. Hirata, M. Ohtake, T. Hiroi, Y. Yokota, and J. Haruyama [2010b], "Possible Mantle Origin of Olivine Lunar Impact Basins Detected by SELENE," Nature Geosci., vol.3, pp.533-536.
  - The composition, structure and evolution of the Moon's mantle is poorly constrained. The mineral olivine, one of the main constituents of Earth's mantle, has been identified by Earth-based telescopic observations at two craters on the near side of the Moon, Aristarchus and Copernicus. Global reflectance spectra in five discrete spectral bands produced by the spacecraft Clementine suggested several possible olivine-bearing sites, but one of the candidate occurrences of olivine was later re-classified, on the basis of continuous reflectance spectra over the entire 1 m band, as a mixture of plagioclase and pyroxene. Here we present a global survey of the lunar surface using the Spectral Profiler onboard the lunar explorer SELENE/Kaguya. We found many exposures of olivine on the Moon, located in concentric regions around the South Pole-Aitken, Imbrium and Moscoviense impact basins where the crust is relatively thin. We propose that these exposures of olivine can be attributed either to an excavation of the lunar mantle at the time of the impacts that formed the basins, or to magnesium-rich pluton in the Moon's lower crust. On the basis of radiative transfer modelling, we suggest that at least some of the olivine detected near impact basins originates from upper mantle of the Moon.
- Yan, J., J. Ping, K. Matsumoto, and F. Li [2008], "The Simulation of Lunar Gravity Field Recovery from D-VLBI of Chang'E-1 and SELENE Lunar Orbiters," Adv. Sp. Res., vol.42, pp.337-340.
  - The lunar gravity field is a foundation to study the lunar interior structure, and to recover the evolution history of the Moon. It is still an open and key topic for lunar science. For above mentioned reasons, it becomes one of the important scientific objectives of recent lunar missions, such as KAGUYA (SELENE) the Japanese lunar mission and Chang'E-1, the Chinese lunar mission. The Chang'E-1 and the SELENE were successfully launched in 2007. It is estimated that these two missions can fly around the Moon longer than 6 months simultaneously. In these two missions, the Chinese new VLBI (Very Long Baseline

Interferometry) network will be applied for precise orbit determination (POD) by using a differential VLBI (D-VLBI) method during the mission period. The same-beam D-VLBI technique will contribute to recover the lunar gravity field together with other conventional observables, i.e. R&RR (Range and Range Rate) and multi-way Doppler. Taking VLBI tracking conditions into consideration and using the GEODYNII/SOVLE software of GSFC/NASA/USA [[Rowlands et al., 1997] and [Ullman, 1994]], we simulated the lunar gravity field recovering ability with and without D-VLBI between the Chang'E-1 and SELENE main satellite. The cases of overlapped flying and tracking period of 30 days, 60 days and 90 days have been analyzed, respectively. The results show that D-VLBI tracking between two lunar satellites can improve the gravity field recovery remarkably. The results and methods introduced in this paper will benefit the actual missions.

- Yasui, C., N. Kobayashi, A. T. Tokunaga, and M. Saito [2008], "Extreme Outer Galaxy: A Laboratory of Star Formation in an Early Epoch of the Galaxy's Formation," Proc. of the "Panoramic views of galaxy formation and evolution", eds. T. Kodama, T. Yamada, and K. Aoki, ASP Conf. Ser. vol.399, pp.481-482.
  - The extreme outer Galaxy (EOG) has a very different environment from that in the solar neighborhood, and is an excellent laboratory for the study of the star formation processes that happened during the formation period of the Galaxy. In particular, the study of the EOG may shed light on the origin and role of the thick disk, whose metallicity range matches well with that of the EOG. Through a detailed near-infrared (NIR) study of Cloud 2, one of the most distant star-forming regions in the EOG, we show that key star-formation items, such as the initial mass function (IMF) and star-formation efficiency, in such a potentially "primordial" environment can be studied in detail. We are continuing a detailed study of a number of star-forming regions in the EOG, mostly with wide-field NIR imaging using Subaru Telescope. It turns out that NIR imaging is the most efficient way to find star formation activity in such distant regions.
- Yasui, C., N. Kobayashi, A. T. Tokunaga, M. Saito, and C. Tokoku [2009], "Disk Fraction in a Low-Metallicity Environment," Proc. of the "Exoplanets and disks: their formation and diversity", eds. Usuda, T., Tamura, M., and Ishii, M., AIP Conf. Proc., vol.1158, pp.171-172.
  - The extreme outer galaxy (EOG), at a galactic radius of more than 18 kpc, is known to have very low metallicity. We find that in two very young (~0.5 Myr) star-forming clusters in the EOG the fraction of stars with near-infrared excess is significantly lower than for those in the solar neighborhood. Our results suggest that most stars forming in the low-metallicity environment experience disk dispersal at an earlier stage (<1 Myr) than those forming in the solar metallicity environment (as much as ~5-6 Myr).
- Yoda, T., T. Handa, K. Kohno, T. Nakajima, M. Kaiden, Y. Yonekura, H. Ogawa, and J.-I. Morino, [2010], "The AMANOGAWA-2SB Galactic Plane Syrvey I. Data on Galactic Equator," Publ. Astron. Soc. Japan, vol.62, pp.1277-1289.
  - Using a waveguide-type sideband-separating receiver (2SB receiver) on the Tokyo-NRO 60-cm telescope (renamed the AMANOGAWA telescope), we carried out simultaneous observations in the ^{12}CO (J=2-1) and ^{13}CO (J=2-1) lines over the galactic plane l=0°-245。 along b=0° with a 3'.75 grid. Using the ^{12}CO (J=1-0) data of Dame et al. (2001, ApJ, 547, 792), who used a beam size almost the same as ours, we show ^{12}CO (J=2-1)^{12}CO (J=1-0) and ^{13}CO (J=2-1)^{12}CO (J=2-1) intensity ratios on the l-v map and the intensity correlations among the ^{12}CO (J=2-1), ^{13}CO (J=2-1), and ^{12}CO (J=1-0) lines. As a result, a linear correlation between ^{12}CO (J=2-1) and ^{12}CO (J=110) and a curved correlation between ^{12}CO (J=2-1) and ^{13}CO (J=2-1), as produced by most of the data, have been found. We investigated these correlations with simple radiative transfer equations to ascertain a number of restrictions on the physical quantities of molecular gas on a galactic scale.

- Yokota, Y., T. Matsunaga, M. Ohtake, J. Haruyama, R. Nakamura, S. Yamamoto, Y. Ogawa, T. Morota, T. Honda, K. Saiki, K. Nagasawa, K. Kitazato, S. Sasaki, A. Iwasaki, H. Demura, and N. Hirata [2010], "Pefinement of Lunar Vis/NIR Phase Curve Acquired by SELENE Spectral Profiler," LPI Contribution No. 1533, p.2532.
  - The SELENE Spectral Profiler (SP) acquired lunar visible to NIR spectral data at a spatial resolution of 500 m. we report refined results of the phase curves derived from SP data.
- Yoshida, A., Y. Kitamura, Y. Shimajiri, and R. Kawabe [2010], "Dependence of the Turbulent Velocity Field on Gas Density in L1551," Astrophys. J., vol.718, pp.1019-1035.
  - We have carried out mapping observations of the entire L1551 molecular cloud with about 2 pc x 2 pc size in the ^{12}CO(1-0) line with the Nobeyama 45 m radio telescope at the high effective resolution of 22" (corresponding to 0.017 pc at the distance of 160 pc), and analyzed the ^{12}CO data together with the ^{13}CO(1-0) and C^{18}O(1-0) data from the Nobeyama Radio Observatory database. We derived the new non-thermal line width-size relations, σ_{NT} vprop L^{v}, for the three molecular lines, corrected for the effect of optical depth and the line-of-sight integration. To investigate the characteristic of the intrinsic turbulence, the effects of the outflows were removed. The derived relations are $(\sigma_{NT}/\mathrm{km\ s^{-1}}) = (0.18 \pm 0.010)(L/pc)^{0.45 \pm 0.095}$, $(0.20 \pm 0.020)(L/pc)^{0.48 \pm 0.091}$, and $(0.22 \pm 0.050)\ (L/pc)^{0.54 \pm 0.21}$ for the ^{12}CO, ^{13}CO, and C^{18}O lines, respectively, suggesting that the line width-size relation of the turbulence very weakly depends on our observed molecular lines, i.e., the relation does not change between the density ranges of 10^2-10^3 and 10^3-10^4 cm^{-3}. In addition, the relations indicate that incompressible turbulence is dominant at the scales smaller than 0.6 pc in L1551. The power spectrum indices converted from the relations, however, seem to be larger than that of the Kolmogorov spectrum for incompressible flow. The disagreement could be explained by the anisotropy in the turbulent velocity field in L1551, as expected in MHD turbulence. Actually, the autocorrelation functions of the centroid velocity fluctuations show larger correlation along the direction of the magnetic field measured for the whole Taurus cloud, which is consistent with the results of numerical simulations for incompressible MHD flow.
- Yusef-Zadeh, F., H. Bushouse, M. Wardle, C. Heinke, D. A. Roberts, C. D. Dowell, A. Brunthaler, M. J. Reid, C. L. Martin, D. P. Marrone, D. Porquet, N. Grosso, K. Dodds-Eden, G. C. Bower, H. Wiesemeyer, A. Miyazaki, S. Pal, S. Gillessen, A. Goldwurm, G. Trap, and H. Maness [2009], "Simultaneous Multi-Wavelength Observations of Sgr A* during 2007 April 1-11," Astrophys. J., vol.706, pp.348-375.
  - We report the detection of variable emission from Sgr A* in almost all wavelength bands (i.e., centimeter, millimeter, submillimeter, near-IR, and X-rays) during a multi-wavelength observing campaign. Three new moderate flares are detected simultaneously in both near-IR and X-ray bands. The ratio of X-ray to near-IR flux in the flares is consistent with inverse Compton scattering of near-IR photons by submillimeter emitting relativistic particles which follow scaling relations obtained from size measurements of Sgr A*. We also find that the flare statistics in near-IR wavelengths is consistent with the probability of flare emission being inversely proportional to the flux. At millimeter wavelengths, the presence of flare emission at 43 GHz (7 mm) using the Very Long Baseline Array with milliarcsecond spatial resolution indicates the first direct evidence that hourly timescale flares are localized within the inner 30x70 Schwarzschild radii of Sgr A*. We also show several cross-correlation plots between near-IR, millimeter, and submillimeter light curves that collectively demonstrate the presence of time delays between the peaks of emission up to 5 hr. The evidence for time delays at millimeter and submillimeter wavelengths are consistent with the source of emission initially being optically thick followed by a transition to an optically thin regime. In particular, there is an intriguing correlation between the optically thin near-IR and X-ray flare and optically thick radio flare at 43 GHz that occurred on 2007 April 4. This would be the first evidence of a radio

flare emission at 43 GHz delayed with respect to the near-IR and X-ray flare emission. The time delay measurements support the expansion of hot self-absorbed synchrotron plasma blob and weaken the hot spot model of flare emission. In addition, a simultaneous fit to 43 and 84 GHz light curves, using an adiabatic expansion model of hot plasma, appears to support a power law rather than a relativistic Maxwellian distribution of particles.

- Zhu, M., P. P. Papadopoulos, M. Xilouris, N. Kuno, and U. Lisenfeld [2009], "Is the Gas and Dust Mass Over-Estimated in the Starburst Galaxy NGC 3310?," Proc. of the "The starburst-AGN connection", eds. Weimin Wang, Zhaoqing Yang, Zhijian Luo, and Zhu Chen, ASP Conf. Ser., vol.408, pp.76-79.
  - We present a new observational study of the gas and dust properties in the starburst galaxy NGC 3310.
- Zhu, M., P. P. Papadopoulos, E. M. Xilouris, N. Kuno, and U. Lisenfeld [2009], "Tracing Molecular Gas Mass in Extreme Extragalactic Environments: An Observational Study," Astrophys. J., vol.706, pp.941-959.
  - We present a new observational study of the ^{12}CO(1-0) line emission as an H_2 gas mass tracer under extreme conditions in extragalactic environments. Our approach is to study the full neutral interstellar medium (H2, HI, and dust) of two galaxies whose bulk interstellar medium (ISM) resides in environments that mark (and bracket) the excitation extremes of the ISM conditions found in infrared luminous galaxies, the starburst NGC 3310, and the quiescent spiral NGC 157. Our study maintains a robust statistical notion of the so-called $X = N(H_2)/I_{CO}$ factor (i.e., a large ensemble of clouds is involved) while exploring its dependence on the very different average ISM conditions prevailing within these two systems. These are constrained by fully sampled ^{12}CO(3-2) and ^{12}CO(1-0) observations, at a matched beam resolution of half-power beam width ~15", obtained with the James Clerk Maxwell Telescope (JCMT) on Mauna Kea (Hawaii) and the 45 m telescope of the Nobeyama Radio Observatory in Japan, combined with sensitive 850μm and 450μm dust emission and H I interferometric images which allow a complete view of all the neutral ISM components. Complementary ^{12}CO(2-1) observations were obtained with the JCMT toward the center of the two galaxies. We found an X factor varying by a factor of 5 within the spiral galaxy NGC 157 and about two times lower than the Galactic value in NGC 3310. In addition, the dust emission spectrum in NGC 3310 shows a pronounced submillimeter "excess." We tried to fit this excess by a cold dust component but very low temperatures were required (T_C ~ 5-11 K) with a correspondingly low gas-to-dust mass ratio of ~5-43. We furthermore show that it is not possible to maintain the large quantities of dust required at these low temperatures in this starburst galaxy. Instead, we conclude that the dust properties need to be different from Galactic dust in order to fit the submillimeter "excess." We show that the dust spectral energy distribution can be fitted by an enhanced abundance of very small grains and discuss different alternatives.