

Titles and Abstracts for East Asia VLBI Network Workshop

Oral Presentation

Session I: Projects in East Asia

1. Taehyun Jung

Affiliation: KASI

Title: **Status of KVN/KaVA and the E-KVN Project**

Abstract: The status and progress of Korean VLBI Network (KVN) and KaVA (KVN and VERA Array) will be presented including the Extended-KVN project.

2. Zhi-Qiang Shen

Affiliation: SHAO

Title: **Chinese VLBI Network**

Abstract:

3. Kenta Fujisawa

Affiliation: Yamaguchi Univ.

Title: **Status of the JVN**

Abstract: The status and recent progress of the JVN is presented. Fringe-detection (non-imaging) mode observation by Ibaraki-Yamaguchi baseline has been started.

4. Tomoya Hirota

Affiliation: NAOJ

Title: **Status of VERA**

Abstract:

5. Juan Zhang

Affiliation: SHAO

Title: **The Progress of CVN Software Correlator**

Abstract: CVNScorr is a software correlator developed by Shanghai Astronomical Observatory (SHAO) based on MPI. It is mainly used in deep space exploration mission in China, including real-time correlating, PCAL, fast fringe search of detector signal functions. It can also output FIT-IDI format result and MK4 format result.

Session II: International Projects

6. Francisco Colomer

Affiliation: JIVE

Title: **What Can VLBI Do for Your Research?**

Abstract: Very Long Baseline Interferometry (VLBI) is providing key information to the study of processes in the Universe, in star formation regions and circumstellar envelopes around evolved stars, galactic structure and cosmology through precise astrometry, measuring magnetic fields, etc. The European VLBI Network (EVN) offers superb capabilities and, most importantly, support to users through the Joint Institute for VLBI ERIC (JIVE), ensuring that the EVN research infrastructure is fully accessible and that the best science always emerges.

7. Chris Phillips

Affiliation: CSIRO

Title: **The Long Baseline Array**

Abstract: The Long Baseline Array (LBA) is a Southern Hemisphere VLBI network consisting, mostly of antennas from Australia, New Zealand and South Africa. In this talk I will present a summary of the LBA and give an update on the facilities, including the new UltraWideband receiver and backend for the Parkes telescope.

8. Tao An

Affiliation: SHAO

Title: **SKA-VLBI and SKA Regional Center**

Abstract:

9. Richard Dodson, Maria Rioja

Affiliation: ICRAR/UWA

Title: **The Korean VLBI Network as a Pathfinder for the ngVLA**

Abstract: We report on work we have performed to explore calibration methods that will be relevant to the next generation VLA (ngVLA). The ngVLA will have baselines up to 500--1000 km and support frequencies from 1 to 116 GHz. With this instrument the baselines are sufficiently long that the atmospheric conditions for different antennas are essentially independent. Therefore our experience with VLBI becomes relevant. We have explored the application of our innovative calibration schemes: Source/Frequency Phase Referencing (SFPR) methods at very high frequencies (mm and sub-mm wavelengths), where the short coherence times prevent conventional phase referencing; and Multi-View methods (MV) for lower frequencies, where direction dependent effects prevent phase transfer from the calibrator. The SFPR method has allowed unique astrometrically registered measurements up to 130 GHz, using the KVN. The MV method has allowed an order of magnitude improvements in astrometric measurements on OH (1.6 GHz) masers, using VLBA observations. We will discuss these results, and how the Korean VLBI Network, being a 500 km mm-wavelength interferometric array supporting frequencies as high as 130 GHz, provides a perfect pathfinder for many of the design questions currently under consideration by the ngVLA team.

10. Kitiyanee Asanok, Phrudth Jaroenjittichai, et al.

Affiliation: NARIT

Title: **Progress of the Thai National Radio Observatory**

Abstract: Here, I will update status and progress of Radio Astronomy Network and Geodesy for Development (RANGD) project, which includes the constructions of the 40m Thai National Radio Telescope by 2019 in Chiang Mai and a co-locating 13m VGOS geodetic antenna by 2021. Early science case will also be discussed.

Session III: Evolved Stars

11. Hiroshi Imai, Se-Hyung Cho, Youngjoo Yun, Bo Zhang

Affiliation: Kagoshima Univ.

Title: **Status Reports on EAVN Evolved Stars Science Working Group and ESTEMA**

Abstract: The current progresses of the EAVN commissioning works in the Science Working Group, KaVA ESTEMA (Expanded Study on Stellar Masers) and the new ESTEMA (EAVN Synthesis of Stellar Maser Animations) will be reported. The scientific feasibility of the EAVN imaging of circumstellar water and silicon-monoxide masers will be discussed. The present status of HINOTORI (Hybrid Project in Nobeyama, Triple-band Oriented) also will be briefly presented. The ESTEMA monitoring program has launched since 2018 May, focusing on two out of six stars, BX Cam and NML Cyg which will be monitored tri-weekly and bi-monthly over 2--3 stellar pulsation periods to elucidate the periodic change in maser pumping conditions and propagation of the pulsation-driven shock waves.

12. Jaehoon Kim

Affiliation: SHAO

Title: **Calabash Nebula: Time Variation of SiO and H₂O Masers**

Abstract: We present the results of simultaneous monitoring observations of H₂O (22 GHz) maser and several vibrationally excited lines of SiO $J = 1-0$, $2-1$, $3-2$ masers (43, 86, 129 GHz) associated with the bipolar proto-planetary nebula OH231.8+4.2, a.k.a. Calabash nebula, using the KVN single dish telescopes. We detect H₂O, SiO $v = 0$, $J = 1-0$, $2-1$ maser lines, SiO $v = 1$, $J = 2-1$ maser lines, SiO $v = 0$, $J = 1-0$ and $2-1$ thermal lines, depending on the epochs. A periodic flux variability of both H₂O and SiO masers are noted, correlating well with the optical light curve. The phase delay between the peak flux variations and the light curve is 0.0–0.15 periods. These characteristics are consistent with that of typical thermally pulsing AGB star. From analyses of the peak/integrated flux densities and the peak/mean velocity patterns of all detected maser emission, we find that the intensity of both masers presents a general trend to decrease with the time. An overall H₂O maser clump of this source is gradually decelerating, although the individual maser features corresponding to the peaked lines may be periodically accelerated and decelerated. SiO maser-emitting region undergoes rotation and simultaneously experiences expanding motion. These show a long-term stellar evolution that the central star is leaving the AGB phase now.

13. Haneul Yang, Se-Hyung Cho, Youngjoo Yun, Dong-Hwan Yoon, Dongjin Kim, Hyosun Kim, Sungchul Yoon

Affiliation: SNU

Title: **Asymmetric Distribution of H₂O and SiO Masers toward V627 Cas**

Abstract: Symbiotic stars are interacting binary systems composed of a cool giant star and a hot white dwarf. The symbiotic stars are important sources for finding a clue to the dynamical evolution from AGB to post-AGB stars because of the complex phenomena (e.g., accretion of the stellar material around the hot component, mass loss from a giant star, bipolar photoionized planetary nebulae, and jet-like feature). We can trace these phenomena by observing H₂O and SiO masers emitted from symbiotic stars. By using Korean VLBI Network (KVN), we have observed V627 Cas, one of the D-type symbiotic stars emitting strong H₂O and SiO masers. The H₂O and SiO maser in V627 Cas are distributed asymmetrically, and the intensities of the masers at west side of the giant star are larger than that for the maser at east-side. We suppose that the reason of asymmetry is effect of the hot dwarf in V627 Cas (e.g., UV photons from accretion disk around the hot dwarf, wind interaction zone located from wind colliding region).

14. Dong-Hwan Yoon

Affiliation: KASI/SNU

Title: **Simultaneous VLBI Monitoring Observations of H₂O and SiO Masers toward VX Sgr**

Abstract: The red supergiant VX Sagittarii is a strong emitter of both H₂O and SiO masers which trace a dynamic of the circumstellar envelope. The H₂O masers detected above the dust-forming layers have an asymmetric distribution. On the other hand the SiO masers are nearly circular ring, suggesting spherically symmetric wind within a few stellar radii. However, previous VLBI observations of H₂O and SiO masers have been performed separately, which make it difficult to spatially trace the outward transfer of the material consecutively from the SiO to H₂O maser regions. To overcome these limitations, we performed simultaneous VLBI and single-dish monitoring observations of 22.2 GHz H₂O and 43.1/42.8/86.2/129.3 GHz SiO masers toward VX Sgr using the KVN. Also, simultaneous observations provide a clue to the formation of ring to asymmetric structures in a complex mass loss field. Our VLBI observations are performed for 25 epochs from Nov. 2014 to Apr. 2018. In addition, from May. 2013 to May. 2018, 27 epochs single-dish observations are also performed in parallel. Here, we present the broken point at which the periodicity and homogeneity of distribution toward each maser maser transition in contrast to the optical light curve. We think there is a correlation between the broken periodicity of SiO maser and the sudden disappearance of the SiO maser ring structure. At the same time, the blue-shifted central spots of the H₂O maser appear to separate significantly in shape. In the case of SiO maser, we verify accelerating SiO maser spots through the tracing of the maser feature spectra. On the other hand, the H₂O maser are found to be the proper motion expanding from the center to the outside at almost constant velocity. These results provide the clear evidence that the asymmetry in the accelerated outflow is enhanced after the smaller molecular gas clump transform into the inhomogeneous dust layers.

15. Youngjoo Yun, Se-Hyung Cho, Dong-Hwan Yoon, Haneul Yang, Richard Dodson, María J. Rioja

Affiliation: KASI

Title: **KVN Observations toward the Evolved Stars at Four Frequency-Bands**

Abstract: We present the astrometrically registered maps of the H₂O and SiO masers emitted from the circumstellar envelopes (CSEs) of the evolved stars, which have been observed at four frequency-bands (K, Q, W and D bands) of KVN since 2014. The relative spatial distributions between the H₂O and SiO masers are precisely determined from the source frequency phase referencing (SFPR) method, which show the physical links between the inner and outer parts of the CSEs. The relative spatial distributions between the different SiO maser transitions are also precisely measured from the KVN simultaneous observations, and they give the crucial evidences for the SiO maser pumping mechanisms affected by the physical environments of CSEs. The temporal variabilities of not only the spatial distribution but also the intensity of the individual maser emission are also obtained from our multi-epoch observations, which enable us to study the physical evolution of the CSEs of the evolved stars along the stellar phase. From our results, the KVN multi-band observations are proved to be powerful to investigate the evolution of the late-type stars, which are closely related to the maser pumping mechanism and the mass-loss processes.

16. Bo Zhang

Affiliation: SHAO

Title: **Geometry and Kinematics of Colliding-Wind Binary WR 146**

Abstract:

Session IV: Stars and Star-Forming Regions

17. Tomoya Hirota, Kee-Tae Kim and KaVA SFRs WG

Affiliation: NAOJ

Title: **Status of KaVA SFRs WG**

Abstract: I will present current status of the KaVA SFRs WG activities and future plan of the SFRs LP.

18. Jungha Kim, Hirota Tomoya, Kee-Tae Kim and KaVA Science Working Group for Star Forming Regions

Affiliation: SOKENDAI/NAOJ

Title: **Disk+outflow system in G25.82-0.17**

Abstract: We have started survey observations of the 22 GHz water maser sources associated with high-mass young stellar objects (HM-YSOs) as a part of the KaVA (KVN and VERA Array) large program (LP). The aim of our LP is to determine physical parameters of jets/outflows from HM-YSOs by analyzing 3D velocity structures of water maser features. In the first year (2016-2017), an imaging survey toward 25 HM-YSOs at 22 GHz has been conducted to check detectability and variability of the water masers. To complement physical properties in the vicinity of HM-YSOs, we have also carried out ALMA cycle 3 observations of thermal molecular lines and continuum emissions toward 11 selected samples. In this talk, I will report summary of the KaVA first year observations and the results from the ALMA and KaVA data toward one of the observed HM-YSOs, G25.82-0.17. We identified 1.3 mm dust continuum source powering water maser with high angular resolution (0.2''-0.3''). High velocity (~ 10 km s⁻¹) of SiO J=5-4 emission was detected indicating the presence of outflowing gas from the source. In addition, the velocity gradients within the compact thermal methanol line emission which are possible signature of rotating disk were shown. In the future, we are going to investigate dynamical structure of jets/outflows and mass loss/accretion processes by combining ALMA results with measured proper motion of water maser by KaVA observations.

19. Koichiro Sugiyama, Tomoya Hirota, Kee-Tae Kim, Jungha Kim, Mikyoung Kim, Do-Young Byun, Kazuhito Motogi, James O. Chibueze, and KaVA SF SWG members

Affiliation: NAOJ

Title: **KaVA Imaging Survey of 44.1 GHz CH₃OH Masers in the Large Program of Star Formation**

Abstract: A four-year large program with KaVA for a systematic study toward 22.2 GHz H₂O and 44.1 GHz CH₃OH masers in high-mass star-forming regions has been initiated since 2016. Target sample consists of 87 high-mass young stellar objects in various evolutionary phases (see a talk by T. Hirota et al.). Here, we focus on a talk about 44.1 GHz CH₃OH masers, which are known to be a tracer of low-velocity outflows. In this talk, we will present the initial results in the first year that conducted a snap-shot VLBI imaging survey toward 19 sources, 16 of which were succeeded in the imaging. These VLBI images were obtained for the first time except G 18.34+1.78SW (Matsumoto et al. 2014). In 12 of 16 imaged sources, only single spectral feature was detected on each VLBI image, while 2-4 features were detected in remaining four sources. In the latter case, individual features in each source were spatially separated by ~ 1 Arcsec at the widest. These VLBI data provided the sizes of individual CH₃OH maser spots 1.1-3.6 milliarcsecond. On the basis of the relation between the sizes and source distances, an intrinsic size of the 44.1 GHz CH₃OH maser spots might be constant. We will also show the progress of the second year observations, which have been initiated since Mar 2018 to measure 3D velocity fields.

20. Jeong-Sook Kim, Soon-Wook Kim, Taehyun Jung and Do-Young Byun

Affiliation: KASI

Title: **The KVN Observation of Peculiar**

Abstract: The TeV-emitting gamma-ray binary LSI 61° 303 is a peculiar microquasar in which the compact object of unknown nature orbits its massive Be star, every 26.496 days with high eccentricity. Based on the single dish observations at 2-9 GHz, LSI 61° 303 has large radio flares around the orbital phases of 0.5-0.8, unlike typical eccentric Neutron star-Be star binaries in which the radio flare occur only at the perihelion. There also are numerous flares through the entire orbit. The VLBI observation of LSI 61° 303 has been performed mainly at 5 GHz or lower frequencies due to its low flux density at high frequency. With recently improved multi-Gbps facility of KVN, we carried out the VLBI observation. We present the first simultaneous VLBI observation at 22 and 43 GHz with the KVN wide band recording system, around ~0.6 orbital phase.

21. Sujin Lee, Toshio Terasawa, Mareki Honma

Affiliation: NAOJ/Univ. of Tokyo

Title: **High-Frequency Radio Observation of Magnetars with EAVN**

Abstract: Magnetars are thought as young and highly magnetized neutron stars but their fundamental physics including the origin and the emission mechanism still remains a mystery. To date, only four sources among known 29 magnetars have been identified to emit the radio radiation, and their flat spectra enable them to be observable at higher radio frequencies than ordinary pulsars. GHz-observations of radio-emitting magnetars hold the key to distinguish between them and ordinary radio pulsars and to explain the variety of emission mechanism within the magnetar population. One radio-loud magnetar located in the vicinity of the galactic center especially could provide unique laboratories. Therefore, we are working with K- and Q-band data of Galactic center magnetar observed by Japanese radio telescopes including the 45-m radio telescope of Nobeyama Radio Observatory (NRO), one of the stations of East Asia VLBI Network (EAVN), to detect its radio pulses. This work could be a stepping stone to high-frequency VLBI observations of pulsars in East Asia. We will present our trial of radio pulse detection from NRO 45-m telescope and others in Japan and suggest possible sciences for future EAVN pulsar/magnetar observations.

22. Wu Jiang

Affiliation: SHAO

Title: **Magnetar with EAVN**

Abstract:

Session V: Sgr A* and Polarimetry with KVN

23. Motoki Kino

Affiliation: Kogakuin Univ.

Title: **Summary of KaVA-EAVN AGN Science WG Activity**

Abstract: On behalf of KaVA-EAVN AGN Science WG, I will summarize recent activities of the AGN SWG.

24. Ilje Cho, B.W.Sohn, T.Jung (UST/KASI), M.Kino (Kogakuin Univ., NAOJ), G.-Y.Zhao (KASI), I.Agudo (IAA-CSIC), M.Rioja, R.Dodson (ICRAR), K.Hada (Mizusawa VLBI Observatory)

Affiliation: KASI/UST

Title: **Measuring the Core Shift of Sgr A***

Abstract: The Galactic center, Sagittarius A* (Sgr A*), is the closest supermassive black hole (SMBH) and provides a great opportunity to study the origin of mm/sub-mm emission. Currently, two competing models have been suggested: the base of the jet and a radiatively inefficient accretion flow (RIAF). Measuring the frequency dependent core shift which the radio core moves toward the central SMBH with increasing frequency when the structure is elongated (e.g., conical jet) is an important tool to test this. The Korean VLBI Network (KVN) is one of the best VLBI arrays to study the core shift, thanks to its quasi-optics system at four frequencies (i.e., 22, 43, 86 and 129 GHz) so that it enables to correct the phase of target source at higher frequency using the calibrator's phase at lower frequency, so called source frequency phase referencing (SFPR; Rioja & Dodson, 2011). Then the relative astrometric measurements can be recovered. We have conducted several observations for Sgr A* using KVN, and found not only the positional shift of its center at different frequencies but also an unexpected systematic phase slope which has not been clearly shown in the higher declination sources. We present our efforts to remove the residual phase trend and to constrain the other positional uncertainties so that we can obtain the intrinsic core shift of Sgr A*. In addition, we conducted VLBA observations closely scheduled to the event horizon telescope (EHT) observations at 1 mm in April 2018. It aims to measure the core shift in parallel with KVN and compare it with the asymmetric structure of Sgr A* which may be resolved through EHT observations.

25. Zhao, G.-Y.; Kino, M.; Akiyama, K.; Sohn, B. W.; Jung, T.; Cho, I.-J.; Jiang, W.; Shen, Z.-Q.; and the KaVA/EAVN AGN working group

Affiliation: KASI

Title: **Sgr A* Observations with KaVA and EAVN**

Abstract: In this presentation, we will summarize recent observational results of Sgr A* obtained with KaVA Long-term monitoring at 7 mm which is part of the KaVA/EAVN AGN large program. The KaVA array provides an excellent (u,v)-coverage for Sgr A* observations, especially along the minor axis direction. The source is in a relatively quiescent status during our KaVA monitoring. No sign of G2 encounter has been detected so far, which supports the predictions of delayed or no activity from the close encounter. We found the sizes of Sgr A* is very stable during the several years of monitoring, which enables us to put tight constraints on the physical parameters of the scattering screen. We also show that joint observations at 13 and 7 mm with more stations in the East Asia region and the KaVA array (EAVN) can further enhance the image quality (uv-coverage, sensitivity) and more explorations could be possible.

26. Rusen Lu, et al.

Affiliation: SHAO

Title: **The Event-Horizon-Scale Structure of Sgr A* at a Resolution of $\sim 3 R_s$**

Abstract: We report results from VLBI observations of the supermassive black hole in the Galactic center, Sgr A*, at 1.3 mm. The observations were performed in 2013 March using six VLBI stations in Hawaii, California, Arizona, and Chile. Compared to earlier observations, the addition of the APEX telescope in Chile almost doubles the longest baseline length in the array, provides additional uv coverage in the N–S direction, and leads to a spatial resolution of $\sim 30\mu\text{as}$ (~ 3 Schwarzschild radii) for Sgr A*. The source is detected even at the longest baselines with visibility amplitudes of $\sim 4\text{--}13\%$ of the total flux density. We argue that such flux densities cannot result from interstellar refractive scattering alone, but indicate the presence of compact intrinsic source structure on scales of ~ 3 Schwarzschild radii. The measured nonzero closure phases rule out point-symmetric emission. We discuss our results in the context of simple geometric models that capture the basic characteristics and brightness distributions of disk- and jet-dominated models and show that both can reproduce the observed data. Common to these models are the brightness asymmetry, the orientation, and characteristic sizes, which are comparable to the expected size of the black hole shadow. Future 1.3 mm VLBI observations with an expanded array and better sensitivity will allow a more detailed imaging of the horizon-scale structure and bear the potential for a deep insight into the physical processes at the black hole boundary

27. Sang-Sung Lee and the iMOGABA team

Affiliation: KASI

Title: **An Interesting Story of Gamma-Ray Bright AGNs by the iMOGABA**

Abstract: A Korean VLBI Network key science program, the Interferometric Monitoring of Gamma-ray Bright AGNs (iMOGABA) program continues to reveal the nature of the gamma-ray flares in active galactic nuclei (AGNs). Here in this presentation, we would like to introduce an interesting story about gamma-ray bright AGNs based on the recent results of the iMOGABA.

28. S. Trippe, J. Park, M. Kam

Affiliation: SNU

Title: **PAGaN : The Nature of Blazar Radio Cores from KVN Polarimetry**

Abstract: We study the linear polarization of the radio cores of eight blazars simultaneously at 22, 43, and 86 GHz with observations obtained by the Korean VLBI Network (KVN) in three epochs between late 2016 and early 2017 in the frame of the Plasma-physics of Active Galactic Nuclei (PAGaN) project. We investigate the Faraday rotation measure (RM) of the cores. We find a systematic increase of RMs at higher observing frequencies in our targets. The RM– ν relations follow power laws with indices distributed around 2, indicating conically expanding outflows serving as Faraday rotating media. Comparing our KVN data with contemporaneous optical polarization data from the Steward Observatory for a few sources, we find indications that the increase of RM with frequency saturates at frequencies of a few hundred gigahertz. This suggests that blazar cores are physical structures rather than simple $\tau = 1$ surfaces. A single region, e.g., a recollimation shock, might dominate the jet emission downstream of the jet-launching region.

Session VI: Millimeter/Sub-Millimeter VLBI

29. Geoffrey Bower, Keiichi Asada, Ming-Tang Chen, Paul Ho, Makoto Inoue, Satoki Matsushita, and the Event Horizon Telescope Collaboration

Affiliation: ASIAA

Title: **The Event Horizon Telescope**

Abstract: The EHT is a global network of mm/submm telescopes with the goal of imaging event horizon scale structure in supermassive black holes. Images and analyses from the EHT will be capable of probing general relativistic effects on the strong-field limit, including strong lensing and tests of the no-hair theorem. Successful imaging of the shadow will provide the strongest constraint on the existence of black holes. I will review the technology, techniques, status and goals of the EHT.

30. Keiichi Asada on behalf of GLT project

Affiliation: ASIAA

Title: **Status of Greenland Telescope**

Abstract: Construction of the Greenland Telescope has finally finished in last year. Following that, we got first light, first fringe in last winter season, and participated GMVA/EHT observations in last April. I will report on the status of Greenland Telescope

31. Per Friberg

Affiliation: EAO/JCMT

Title: **VLBI Development at the JCMT**

Abstract: The VLBI was one of the three telescope participating in the first detection of the SgrA* with mm VLBI - the start of the Event Horizon Telescope. After a short recap of history I will be describing the technical development at the JCMT to support mm and sub-mm VLBI in the future.

32. Alexey Rudnitskiy, Likhachev S. F., Andrianov A. S., Smirnov A. V.

Affiliation: LPI

Title: **Millimetron Space Mission: Current Status and Future Prospects**

Abstract: Millimetron is the next space observatory led by Astro Space Center to be addressed for the far infrared, sub-millimeter and millimeter wavelength ranges. The unprecedented sensitivity and angular resolution of the cooled 10-m telescope, placed in a L2 orbit, will provide the astronomical community an opportunity to solve key scientific problems in astronomy and astrophysics. Millimetron will be launched at an ambient temperature and then cooled down in orbit with a combination of passive and active cooling systems using onboard mechanical coolers. Such combination will cool down the telescope to temperatures less than 10K. The observatory will operate in two modes: as a Space-Earth VLBI element and as single dish telescope.

33. Keiichi Asada

Affiliation: ASIAA

Title: **Future of EAVN High Frequency Side**

Abstract: mm/submm VLBI is one of the directions for future expansion for EA VLBI community. We have already participated to Event Horizon Telescope, which is an international collaboration on mm/submm VLBI. Its primary objective is to image the shadow of SMBHs associated to M87 and Sgr A*. In meantime, numbers of mm/submm telescopes those can be used for mm/submm VLBI is increasing in EA region, and nearly ready to start independent observations. Based on this idea, we summarized EA mm/submm VLBI white paper. I will discuss on those aspects in the talk.

Session VII: Present and Future of EAVN

34. Hideyuki Kobayashi

Affiliation: NAOJ

Title: **EAVN Status and Future Perspective**

Abstract:

35. Kiyooki Wajima

Affiliation: KASI

Title: **Launch of the East Asian VLBI Network: Open-Use Program and Future Prospects**

Abstract: The East Asian VLBI Network (EAVN) starts the open-use program from the second half of 2018 (2018B semester). EAVN consists of 20 radio telescopes and two correlator sites located in China, Korea, and Japan, while 10 telescopes (KVN 3 x 21 m, VERA 4 x 20 m, Nobeyama 45 m, Tianma 65 m, and Nanshan 26 m) and one correlator (Daejeon Hardware Correlator at KASI) participate in the first-term EAVN open-use program and provide the total observing time of 100 hours in 2018B semester. As a first step, EAVN serves a basic observing mode for simple imaging with single circular polarization at 22 and 43 GHz. We have conducted a series of EAVN observations called 'the EAVN AGN Campaign' in 2017 and 2018, and obtained high-fidelity images with the maximum baseline length of greater than 5,000 km. We confirmed a basic array performance of EAVN through observations of the campaign. As a short-term (within the next two years) agenda, we will start an open-use operation at 6.7 GHz involving other potential telescopes, and focus on test observations of dual-polarization and wide-band backend system. As a mid- and long-term agenda, EAVN will investigate the possibility of conducting observations at lower frequencies (< 5 GHz) as a pathfinder of the Square Kilometre Array (SKA) since there are many potential telescopes having a large effective aperture at these frequencies including FAST 500-m telescope in China. We have already succeeded with VLBI observations with some of LBA and EVN telescopes, thus worldwide collaboration in VLBI observations with Thai VLBI Network (TVN), LBA, as well as EVN and VLBA, will also be an important mid- and long-term agenda. Launch of EAVN open-use program is an extension of achievements and efforts of all predecessors in VLBI in East Asia, such as various astronomical researches with VLBI, technical developments in VLBI, and stable operation of each VLBI array. I would like to express my sincere appreciation to all predecessors involved in VLBI-related works and researches in East Asia.

36. Se-Jin Oh, Jae-Hwan Yeom, Duk-Gyoo Roh, Dong-Kyu Jung, Chungsik Oh, Hyo-Ryoung Kim, Ju-Yeon Hwang

Affiliation: KASI

Title: **Recent Status of KJCC for EAVN**

Abstract: In this presentation, the recent KJCC status for KaVA and EAVN will be given and development for wideband recording system of KVN will be introduced.

37. Zhen Zhao, Tao An

Affiliation: SHAO

Title: **The East Asia VLBI Network SIMulator: An Integrated Simulation Tool**

Abstract: The East Asia Very Long Baseline Interferometry (VLBI) Network SIMulator is an auxiliary tool for radio astronomers to design the VLBI experiments and evaluate the network performance. The tool not only integrates the functionalities commonly used in the SCHED and Difmap, but also further extends these functions and involves new features such as sensitivity calculations and space VLBI simulations. In addition, the tool provides friendly interactions on both command line and graphical user interfaces and offers good supports for log reports and database operations, as well as real-time result updating. All the functions are packaged in different Python modules for independently invoking and testing, which could facilitate the future developments and extensions. Though EAVNSIM is initially designed for the East Asia VLBI Network, it can also be expandable to other VLBI networks and interferometers.

Session VIII: Up-Close View of M87 and High-/Low-Luminosity AGNs

38. Kazuhiro Hada, KaVA/EAVN AGN SWG, EAVN Tiger Team

Affiliation: NAOJ

Title: **Current Status of EAVN-EHT Campaign 2017-2018**

Abstract: I will overview the current status (data analysis, preliminary results) of the EAVN campaign that were performed along with the EHT observations 2017 and 2018.

39. Yuzhu Cui, Kazuhiro Hada, Mareki Honma on behalf of AGN Working Group

Affiliation: NAOJ

Title: **EAVN Observations Near-in-Time with EHT for M87 in 2017**

Abstract: The radio galaxy M87 offers an privileged opportunity to probe the jet launching and formation scales thanks to the proximity and large mass of the central black hole. This makes M87 a prime target for the Event Horizon Telescope (EHT) along with SgrA*. In April 2017, M87 was for the first time observed by EHT+ALMA. This may allow the first imaging of the black hole shadow and jet-launching regions at scales of a few Schwarzschild radii. However, due to the sparse uv-coverage of the EHT, a proper interpretation of the EHT image (emission features surrounding the shadow) may require contemporaneous complementary observations at the lower frequencies that provides the higher fidelity jet images. Here we report results from detailed EAVN 22/43GHz monitoring observations of M87 that were performed from January to May 2017 (so-called the "EAVN campaign 2017"), covering well the EHT-2017 observing window. We obtained data for a total of >15 epochs, and for each session 7-15 telescopes joined from East Asia, boosting the sensitivity and imaging capability compared to KaVA. These data will uniquely monitor the detailed structural evolution of the jet, velocity fields and possible component ejections near in time to the EHT period.

40. Masanori Nakamura

Affiliation: ASIAA

Title: **Theory Does Meet (or not?) VLBI Observations in M87**

Abstract: We present the origin of superluminal motions and limb-brightened feature in the M87 Jet by utilizing numerical simulations. Our results can be testable with future VLBI observations led by EA and other facilities. Possible topics for exploring AGN jets will be also discussed.

41. Fumie Tazaki, Kazunori Akiyama, Kotaro Moriyama, Ilje Cho, Kazuhiro Hada, Shiro Ikeda, Kazuki Kuramochi, Shuichiro Tsuda, Hiroki Okino, Mahito Sasada, and Mareki Honma

Affiliation: NAOJ

Title: **Development of New Imaging Technique with Sparse Modeling**

Abstract: We have developed a new imaging technique for VLBI, by applying a statistic method of sparse modeling. Our imaging library, named as Sparse Modeling Imaging Library for Interferometry (Smili; Akiyama et al. in prep.), has been rapidly advanced by including full-closure imaging and movie reconstruction. Achievement of full-closure imaging gives a great advantage to reconstruct a reasonable image without self-calibration, since closure quantities (closure phase and closure amplitude) are independent from station-base errors. For movie reconstruction, we assume the sparsity also along the time axis, namely the continuous image variation. We will present the overview of the imaging technique and the results from application of the technique to EAVN observational data.

42. **Juan Carlos Algaba, Jeffrey Hodgson, Sin-Cheol Kang, Dae-won Kim, Jae-Young Kim, Jee Won Lee, Sang-Sung Lee, Sascha Trippe**

Affiliation: SNU

Title: **Core-Jet Blending Effects in Active Galactic Nuclei Under the Korean VLBI Network View**

Abstract: A long standing problem in the study of Active Galactic Nuclei (AGNs) is that the observed VLBI core is in fact a blending of the actual AGN core (classically defined by the $\tau=1$ surface) and the upstream regions of the jet or optically thin emitting region flows. This blending may cause some biases towards the observables of the core, such as its flux density, size or brightness temperature, which may lead to misleading interpretation of the derived quantities and physics. We study the effects of such blending under the view of the Korean VLBI Network (KVN) for a sample of AGNs at 43 GHz by comparing their observed properties with observations with the Very Large Baseline Array (VLBA). Our results suggest that the observed core sizes are a factor ~ 11 larger than these of VLBA, which is different than the factor ~ 18 expected by purely considering the different resolution of the two facilities. We investigate possible dependencies with source compactness, viewing angle or redshift, finding no signs of correlations. We suggest the use of a common factor, albeit a large scatter may be used, to consider blending effects in KVN measurements.

43. **Wen-Ping Lo, Keiichi Asada, Satoki Matsushita, Masanori Nakamura, Kevin Jun Yi Koay, Shoko Koyama**

Affiliation: ASIAA

Title: **mm/submm Flux Survey towards Nearby Low-Luminosity AGNs**

Abstract: Low-luminosity AGNs (LLAGNs), a subclass of AGN, are thought to host the radiatively-inefficient accretion flow which has a relatively lower mass accretion rate. To constrain the mass accretion rate of nearby LLAGNs via spectral energy distributions, we conducted the flux survey with the Submillimeter Array (SMA). Meanwhile, the LLAGNs are critical for the future Event-Horizon Telescope (EHT) observations since its optically thin nature in mm/sub-mm is relevant for observing the black hole shadow. Thus, the flux survey of LLAGNs also serves to search the future candidate for EHT. To efficiently survey the possible candidates, the single-baseline VLBI observation utilizing the James Clerk Maxwell Telescope (JCMT) and the Greenland Telescope (GLT) is crucial for selecting the sources which are detectable with long-baseline fringes. In this talk, I will demonstrate the current status of this project and the plans.

Session IX: Radio Galaxies and EATING VLBI

44. Gabriele Giovannini, et al.

Affiliation: INAF/Bologna Univ.

Title: **EATING VLBI Results**

Abstract:

45. Yosuke Furuya, Kenta Fujisawa, Kotaro Niinuma

Affiliation: Yamaguchi Univ.

Title: **An Observational Study of Cosmological Evolution of High-z AGN Jet**

Abstract: The interaction between jet of high-z AGN and environment gas is an important subject in order to understand co-evolution of galaxies and SMBHs. So far, 42 high-z AGNs with redshift higher than four have been detected by VLBI, and it is known that the intrinsic size of the jets of these high-z AGNs tend to be smaller than that of low-z ones. This can be interpreted that the AGN jets are confined in compact region due to the high density gas in the early universe. However, this interpretation might be affected by the rest-frequency bias in which observing frequencies are different depending on the redshift of each source. For studying the property of jet in high-z AGNs without the rest-frequency bias, it is necessary to study them at the same rest-frequency. We investigated the radio structures of the 42 sources at the same rest-frequency (~11 GHz), and discovered a negative correlation between the size and the redshift of them. To confirm the correlation and to prove that the size-redshift relation is caused by the confinement of the dense gas, it is necessary to observe the fine structure of jets for large number of high-z AGNs at higher frequencies with high sensitivity. EAVN which can observe at 22/43 GHz with high sensitivity is appropriate for this purpose. Before starting EAVN observation, it is necessary to select appropriate target objects for EAVN. We have been selecting such sources from 523 AGNs listed in the FIRST/SDSS catalog with redshift higher than three. Until now, 69 out of 523 sources were observed by Ibaraki-Yamaguchi baseline in JVN to find fringes, and 39 sources have been detected. This selection with JVN observation will be finished within a year. After that, we plan to do imaging observations for the target sources with EAVN so that to study the cosmological evolution of AGN jet.

46. Xiaopeng Cheng, Tao An

Affiliation: SHAO

Title: **Parsec-Scale Radio Properties of FR0 Radio Galaxies**

Abstract:

47. Kosuke Shiotani, Kenta Fujisawa, Kotarou Niinuma

Affiliation: Yamaguchi Univ.

Title: **A Study of Magnetic Field by Using Core Shift for Radio Galaxy 3C111**

Abstract: Several theoretical models of AGN jet have been proposed, among which the magnetically driven models are considered to be the most plausible model. However, a realistic theoretical model of AGN jet has not been constructed because magnetic field of AGN jet at pc-scale have not been measured at enough accuracy. In order to estimate the strength of magnetic field at pc-scale using the core shift phenomenon, we have performed VLBI observations for a radio galaxy 3C111 with KaVA 22/43 GHz in total 3 Epoch at interval of approximately 2 months. As a result, a magnetic field strength at 1pc from the base of the jet, ~ 100 [mG] was obtained. It is also shown that the physical state including magnetic field may change with a time scale of 2 to 3 months. We present the KaVA results and discuss the magnetic field and physical properties of 3C111.

48. Minchul Kam, Sascha Trippe

Affiliation: SNU

Title: **Probing the Faraday Screen in the Nuclear Region of 3C84**

Abstract: We present the result of the multi-frequency polarimetric observations to explore the environment of 3C84 in the center of giant elliptical galaxy NGC1275. We used the Korea VLBI Network (KVN) at 22, 43, 86, and 129 GHz as part of our Plasma-physics of Active Galactic Nuclei (PAGaN) project and Very Long Baseline Array (VLBA) archival data at 43 GHz. At the VLBI core, the linear polarization is extremely weak whereas it is relatively strong at a hotspot in the jet. By using the 256 MHz bandwidth of VLBA at 43 GHz, we detected the rotation measure (RM) at the core. Surprisingly, the core shows both positive and negative RM and its absolute value is lower than the expectation. This might be inconsistent with previous results from the Submillimeter Array (SMA) and the Combined Array for Research in Millimeter wavelength Astronomy (CARMA) observation at 220 and 340 GHz whose RM were always positive. To explain this, we suggest two possible scenarios. One is that EVPA rotations are saturated because the Faraday screen is internal to the jet. The other one is that the Faraday screen is hot accretion flow. To probe the origin of the Faraday rotation at the core, we proposed KVN observation at 86, 90, 94, 129, 138, and 144 GHz.

49. Sohn, Bong Won

Affiliation: KASI

Title: **KaVA Test Polarimetry of 3C84**

Abstract:

Session X: Blazars

- 50. Shoko Koyama, K. Asada, M. Kino, M. Nakamura, M. Giroletti, G. Giovannini, M. Orienti, K. Hada, K. Niinuma, G. Zhao, J-C. Algaba, H. Nagai, W-P. Lo, R. Lu, D. Paneque, E. Ros, T. Krichbaum, R. Lico, T. Savolainen et al.**

Affiliation: ASIAA

Title: **Probing the Gamma-Ray Emission and Jet Collimation Region in TeV Blazar Mrk 501**

Abstract: Extremely relativistic jet emanating from the TeV blazars is one of the candidate sites for the origin of the high energy photons emitting region. We would like to present our proposal to probe the existence of the gamma-ray emitting region in one of the closest blazar Mrk 501 with EHT+ALMA at 230 GHz. By resolving the core region, we will identify the origin of the high energy photon emission region, and discriminate the origin of the relativistic jet. Future prospects of blazar studies with East Asian VLBI will be also discussed.

- 51. Kunwoo Lee, Jongho Park, Sascha Trippe**

Affiliation: SNU

Title: **The Jet Kinematics of FSRQ 1928+738**

Abstract: Here we present the preliminary results of ≈ 1.5 year monitoring of the quasar 1928+738 with KaVA at 43 GHz. This source deviates from the relation between the long-term (Doppler-corrected) variability timescales of radio-loud AGN jets at cm wavelengths and the accretion rate, out of ≈ 40 sources according to a recent study. We aim to find out whether it is really an outlier in the relation by measuring its Doppler factor. On the way, we found unusual kinematics for this source. We found increasing apparent velocities from $1.33c$ to $5.51c$ and the varying position angles from 77 degree to 71 degree as function of distance from the black hole. Also, we found that the time derivative of the position angle decreases as a function of distance from the black hole. We attribute its unusual kinematics to jet bending toward our line of sight.

52. Hyunwook Ro, Bong Won Sohn, Aeree Chung, Thomas P. Krichbaum

Affiliation: Yonsei Univ./KASI

Title: **Exploring the Non-Linear Motion of the Parsec-Scale Jet of FSRQ 1633+382**

Abstract: Physics of relativistic jet in Active Galactic Nuclei (AGNs) is one of the prominent questions in astrophysics that has not been resolved to date. Particularly, the launching mechanism of the jet which occurs near the supermassive black hole is still poorly understood. FSRQ 1633+382 ($z = 1.814$), a powerful AGN with a prominent radio jet, is one of the best laboratories to study the innermost jet in detail. In this study, we have investigated kinematics of parsec-scale jet of FSRQ 1633+382 using Very Long Baseline Array (VLBA) data from 1994 to 2017. We found that at some point the radial distances of the propagating jet components are temporarily stopped. This indicates that the inner jet of FSRQ 1633+382 changes their direction multiple times. We applied a helical trajectory model to the non-linear motion and extracted the physical properties of the motion. Since the trajectory of the jet component reflects the topology of the magnetic field, our results suggest the presence of twisted magnetic field lines which are arisen from a magnetized accretion disk or a rotating supermassive black hole.

53. Jongho Park, Sascha Trippe, Sang-Sung Lee, et al.

Affiliation: SNU

Title: **Detection of a Moving Spine-Sheath Jet Structure after a VHE Gamma-Ray Flare in PKS 1510-089 in 2015**

Abstract: PKS 1510-089 is a bright and active gamma-ray source and is one of only a few flat spectrum radio quasars detected in the very high energy (VHE; photon energies > 100 GeV) band. It showed complex gamma-ray flares for more than a half year in 2015 during which the Major Atmospheric Gamma Imaging Cherenkov (MAGIC) telescope detected variable VHE emission. We present long-term multi-wavelength radio light curves, optical light curves, and results from jet kinematics and linear polarization analysis. The optical and gamma-ray flares are coincident with each other, while a huge radio flare follows the gamma-ray flares with optically thick radio spectrum in the beginning of the flare which becomes optically thin in later epochs. We found that two knots of emission well separated from each other in a transverse jet direction nearly simultaneously emerge from the radio core near in time to the gamma-ray flares and the VHE emission. One of them moves along the global jet direction and survives more than two years, while the other moves along the eastern side of the jet and disappear after one year from its appearance. Significant linear polarization is detected on distinct two stream lines which are coincident with the trajectories of the knots, showing an increase in degree of linear polarization toward the edges of the jet and indication of magnetic fields parallel to the jet direction. We conclude that the two knots represent a "spine-sheath" structure and the 2015 flares at gamma-ray and VHE originate from relativistic electrons in the jet spine accelerated when they pass through a standing shock in the 43 GHz core, provided by seed photons from the jet sheath.

54. JeongUk Kim, Guang-yao Zhao, Bong Won Sohn

Affiliation: Yonsei Univ./KASI

Title: **Wiggly Jet Distribution and Jet Wobbling with Strong Variability in 3C 66A**

Abstract: We carried out imaging/astrometric observations of 3C 66A with KaVA and KVN. Our KaVA image shows that the jet components of 3C 66A were distributed wiggly. Possible core position wander was reported in 3C 66B when using 3C 66A as a reference source. A multi-epoch analysis on the Boston University 43 GHz monitoring data suggest the position angle of the inner jet of 3C 66A varies by ~ 13 degrees in ~ 9 years, which is also correlated with the flux density and optical polarization angle variation. We will discuss the possible scenarios that could explained these observations, including jet precession, helical trajectory of the jet components, and non-stationarity of the core. We perform simple tests on different models to identify the most favoured one and we argue that the new multi-frequency, multi-source astrometric observations will be critical to distinguish between models.

Session XI: Galactic Astrometry

55. Nobuyuki Sakai

Affiliation: NAOJ

Title: **Parallaxes and Proper Motions of Perseus Arm Sources: Implications for the Nature of Spiral Arms**

Abstract: We report measurements of parallax and proper motion for five sources of 6.7 GHz masers in the Perseus arm as part of the BeSSeL Survey of the Galaxy. By combining our results with previous astrometric results, we determined a pitch angle of 9.2 ± 1.6 degrees and an arm width of 0.37 kpc for the Perseus arm. By using larger sample for the Perseus arm (26 sources), we examined three-dimensional, non-circular motions (defined as U, V and W) of the Perseus-arm sources as a function of distance perpendicular to the arm (defined as "rho"). The largest radially inward motion (with an unweighted mean of $\langle U \rangle = 13.6 \pm 5.4$ km/s) was detected on the interior side of the Perseus arm as viewed from the Sun, while the smallest radial motion ($\langle U \rangle = 2.0 \pm 6.0$ km/s) was obtained at the exterior to the arm. These tendencies are consistent not only with optical astrometric results of Cepheid variables, but also with a model of the density-wave theory. For other two components of V and W, we could not find statistically significant results as a function of "rho", which is not consistent with both the Cepheid results and the density-wave model (especially for $\langle V \rangle$). To understand the origin of the systematic non-circular motion in the Perseus arm, a lot of possibilities (e.g., quasi-stationary density-wave theory; non-stationary dynamic spiral model; high- and intermediate-velocity interstellar clouds) should be tested observationally by using VLBI astrometric results as well as stellar astrometric results (e.g. Gaia catalogs).

56. Shuangjing Xu, Bo Zhang

Affiliation: SHAO

Title: **Radio Astrometry in the Gaia Era**

Abstract: In this talk, I will show some comparisons of radio and optical astrometry, and discuss the challenges and opportunities of radio astrometry in the Gaia era.

57. Yuanwei Wu

Affiliation: NTSC

Title: **Revisit LSI +61° 303 with VLBA**

Abstract: LSI +61 303 is a unique X-ray binary and Galactic Gamma-ray source. The periodograms show three periodicities, P1, P2, P3. The elliptical trajectory of 8.4 GHz radio core is regard as a precession of the microquasar. We conducted 10-epoch astrometric observations with VLBA. By combing historical data, with a time span of 9 years, we successfully determined its precession period with an accuracy of 7 min, and determined its proper motion with 0.006 mas/yr. The proper motion suggest a very low peculiar motion (< 20 kms), which strongly suggest the compact companion of this binary is a black hole.

58. Maria Rioja, Richard Dodson

Affiliation: UWA/CSIRO/OAN

Title: **Micro-Arcsecond Astrometry at 1 GHz Using “MultiView” and Multi-Beam Technology**

Abstract: Astrometric measurements play a fundamental role in a wide variety of research fields, with VLBI holding the record for the highest precision measurements in astronomy. In the last decade there have been huge strides in achieving the full astrometric potential, arising from advanced calibration strategies that accurately compensate the dominant tropospheric propagation residual effects that have led to micro- arcsecond precision measurements, most notably at ~ 22 GHz. The arrival of the Square Kilometer Array (SKA), which will focus on the lower frequencies in Radio Astronomy will revitalise all aspects of astronomy at these wavebands. Significant new developments will be required to extend the above mentioned level of astrometric precision to the low frequency regime, which are dominated by ionospheric effects that pose a rather different set of challenges. Chief of those challenges is the fact that the ionospheric effects have a strong spatial structure (i.e. they are direction-dependent) that prevents the use of observations of a reference source, along a different line of sight than that of the target, to correct for the target. This presentation reports on a promising method, i.e. MultiView, I will present a demonstration of the MultiView technique and a comparison with other existing astrometric methods. MultiView combined with the innovative multi-beam technology has the potential to achieve micro- arcsecond precision measurements at 1 GHz. I will present expected performance and a science case in the light of current and planned multi-beam instruments, among them FAST, SKA and the pathfinders.

59. Nobuyuki Sakai

Affiliation: NAOJ

Title: **Toward Openig of KaVA Astrometric Mode**

Abstract: We, KaVA Galactic Astrometry sub-WG, have been evaluating KaVA astrometric capability using two types of KaVA test observations. Those are (1) Maser-QSO and (2) QSO-QSO observations, which allows us to evaluate position repeatability of relative astrometry and accuracy of parallax determination with KaVA. Here we introduce current results of our evaluation and timeline for opening of KaVA astrometric mode in the KaVA common use. We aim to expand astrometric capability of KaVA into EAVN array, so as to conduct several types of astrometric researches in the SKA era.

Poster Presentation

P-1. Yoshinori Yonekura

Affiliation: Ibaraki Univ.

Title: **Present Status of Ibaraki Station: Hitachi and Takahagi 32-m Antennas**

Abstract: Two 32-m antennas at Ibaraki station (Hitachi 32-m and Takahagi 32-m) are operated by Ibaraki University jointly with NAOJ and the members of the Japanese VLBI network. Two receivers are available for each antenna: The low-frequency-band receiver (C/X-RX) covering 6.3-7.0 and 8.0-8.8 GHz, and the high-frequency-band receiver (K-RX) covering 20.5-25.0 GHz. Both receivers receive LHCP and RHCP simultaneously. The VLBI (JVN and EAVN) observation mode (1024 Msps x 2 bit x [1 or 2] ch using ADS-3000+ and OCTADISK) and the single-dish observation mode (64 Msps x 2 bit x 1 ch for the observations of H₂O maser at 22.235 GHz, and 16 Msps x 4 bit x 1 ch for the observations of methanol maser at 6.668 GHz using K5/VSSP32) is now available. The daily observations of the methanol masers are now conducted using Hitachi antenna (Yonekura et al. 2016). From 2017, two new observing modes became available: One is the Hitachi-Takahagi 2-element interferometer for the sensitive continuum observations. The sensitivity (SNR = 10) is about 5 mJy at C and X band for 10 min observations. The other is the output of time-series data for pulsar observations.

P-2. Se-Hyung Cho, Youngjoo Yun, and KVN Evolved Star WG Members

Affiliation: KASI

Title: **KVN Key Science Project: Simultaneous Monitoring Observations of H₂O and SiO Masers toward Evolved Stars**

Abstract: We have performed simultaneous time monitoring observations of 22.2 GHz H₂O and 43.1/42.8/86.2/129.3 GHz SiO masers toward 16 KVN Key Science Project(KSP) sources of evolved stars at the first stage of the KSP. We aim at investigating spatial structure and dynamical effect from SiO to 22.2 GHz H₂O maser regions associated with a mass-loss process and development of asymmetry in circumstellar envelopes. Since 2015A observing season, astrometrically registered maps of SiO and H₂O masers were obtained toward nine KSP sources using the source frequency phase referencing(SFPR) method. Here we report the KSP results of evolved stars focused on these successful SFPR sources.

P-3. Ji-hyun Kang, Do-Young Byun, Kee-Tae Kim, Jongsoo Kim, Aran Lyo, Woojin Kwon (KASI), Mi-Kyung Kim (NAOJ), Wouter Vlemmings, Boy Lankhaar (Onsala Observatory) and Gabriele Surcis (INAF-Cagliari)

Affiliation: KASI

Title: **Methanol Maser Polarization toward a Massive Star Forming Region, G10.34-0.14, Using the KVN and the ALMA Telescope**

Abstract: We present the linear polarization results of the KVN VLBI and the ALMA observations of the 44 GHz and the 95 GHz Class I methanol maser transition lines toward a massive star forming region, G10.34-0.14. The ALMA data show three mm continuum sources in this region. We identified about 30 maser features together with the 20000 AU-sized thermal methanol outflow. Some strongest masers show a few percent of linear polarization. Their polarization properties are consistent to the VLBI polarimetric observations performed with the KVN telescope, in spite of two orders of magnitude scale differences, indicating that the masing regions have consistent magnetic field environments over these scale lengths (6 AU to 600 AU).

P-4. Gang Wu

Affiliation: XAO

Title: **VLBA Maser Observations in a High Mass Star Forming Region
IRAS18360**

Abstract:

P-5. Taeseok Lee, Sascha Trippe, Motoki Kino, Bong Won Sohn

Affiliation: SNU

Title: **Jet Kinematics of the Quasar 4C +21.35 from KaVA Observations**

Abstract: We present the jet kinematics of FSRQ 4C +21.35 using time-resolved KaVA radio maps obtained from September 2014 to July 2016. During two out of three observing campaigns, observations were performed bi-weekly at 22 and 43 GHz quasi-simultaneously. At 22 GHz, we identified three jet components near the core with apparent speeds from $(7.5 \pm 0.1)c$ to $(13.2 \pm 0.2)c$. The timing of the ejection of a new component detected in 2016 is consistent with a γ -ray flare in November 2014. At 43 GHz, we found four inner jet (<3 mas) components with speeds from $(1.8 \pm 0.1)c$ to $(6.7 \pm 0.4)c$. Jet component speeds tend to be higher with increasing distances from the core. We compared our data with archival VLBA data from the BU 43 GHz and the MOJAVE 15.4 GHz monitoring programs. Whereas MOJAVE data and our data are in good agreement, jet speeds obtained from the BU Program data in the same time period are about twice as high as the ones we obtain from the KaVA data. The discrepancy at 43 GHz indicates that radio arrays with different angular resolution identify and trace different jet features even when the data are obtained at the same frequency and at the same time. The flux densities of jet components decay exponentially, in agreement with a synchrotron cooling time scale of ~ 1 year. Using known Doppler factor (~ 5) and electron Lorentz factor values (~ 9000), we estimate the magnetic field strength to be $\sim 2-4 \mu\text{T}$. When adopting a jet viewing angle of 5° , the intrinsic jet speed is of order $0.99c$.

P-6. Junghwan Oh, Jeffrey A. Hodgson, Sascha Trippe, Sang-Sung Lee, Thomas Krichbaum, Jae-Young Kim, Bindu Rani, Rocco Lico, Elisabetta Liuzzo, Michael Bremer, Anton Zensus

Affiliation: SNU

Title: **Double Nuclear Structure Discovered in 3C84**

Abstract: 3C84 is a nearby active galaxy, where we can directly image the launching region of the jet. We observed the source with the Global millimeter VLBI Array (GMVA) with better than $50\mu\text{as}$ resolution over 8 years. These observations revealed a consistent double nuclear structure separated by ~ 770 gravitational radii, with the region being too broad and too bright to be the true jet base anchored in an accretion disk. We find a significant correlation between the brightness temperature and relative position angle of double nuclear components. We interpret this as being due to the expansion and cooling of a synchrotron emitting jet sheath. The cooling timescales appear to be typical of blazar-like emission.

P-7. Sincheol Kang, Sang-Sung Lee, Do-Young Byun, Jeffrey Hodgson, Jee-Won Lee

Affiliation: KASI/UST

Title: **Interferometric Monitoring of Gamma-Ray Bright AGNs : J1159+2914**

Abstract: We present the results of multi-epoch monitoring of a blazar J1159+2914, one of the targets of a Very Long Baseline Interferometry (VLBI) monitoring program : Interferometric MONitoring of GAMMA-ray Bright AGNs (iMOGABA), as a Korean VLBI Network (KVN) Key Science Program (KSP). The observations were conducted simultaneously at 22, 43, 86, and 129 GHz, during 4 years from December 2012 to December 2016. Obtained total fluxes range 0.26 and 2.88 Jy at all frequencies with a mean rms noise of 0.026 Jy. We also use the 15 and 230 GHz data observed by Owens Valley Radio Observatory and Sub-Millimeter Array. In order to analyze the characteristics of variabilities, we estimated variability timescales from 15 GHz data, using three different functions, structure function, Gaussian distribution function, and exponential function. Also, in order to study the multi-frequency correlations, we compare the light curve of 15 GHz with that of 22, 43, and 86 GHz, using cross-correlation analysis. Moreover we estimated B-field strength using core sizes from VLBA 43 GHz data, turnover frequency and maximum total flux from KVN data, and variability timescales from OVRO data, in order to study the variability of B-field nearby the radio emission region.

P-8. Jee Won Lee, Sang-Sung Lee, Jeffrey Hodgson

Affiliation: KASI

Title: **Interferometric Monitoring of Gamma-Ray Bright AGNs: OJ287**

Abstract: We present results of VLBI observations of BL Lacertae object OJ 287 using the KVN at the 22, 43, 86, and 129 GHz bands, as part of the Interferometric Monitoring of Gamma-ray Bright active galactic nuclei (iMOGABA) KVN key science program. Observations were conducted in 30 sessions from 2013 January 16 to 2016 December 28, with the source being detected and imaged at all frequencies. The source was compact on the milliarcsecond scale in all epochs and shows multiple flux enhancements at all frequencies. The turnover frequency was found to vary between 21GHz and 50 GHz in 9 epochs. We discuss the magnetic field strength in the mas emission region.

P-9. Daisuke Sakai, KaVA GA sub-WG members

Affiliation: NAOJ

Title: **Data Analysis of KaVA Astrometric Test Observations for 22 GHz Water Maser Source in W3(OH) Region**

Abstract: KaVA Galactic astrometry sub-working group is evaluating and establishing an astrometric mode of KaVA array by conducting test observations for Maser-QSO pair and QSO-QSO pair observations. To evaluate the astrometric accuracy obtained by KaVA astrometric mode, we have to compare the phase solutions as well as astrometric positions between VERA array and KaVA array. Also, we have to confirm the consistency between datasets correlated by Mizusawa SW correlator and KJCC. By analysing two datasets of test observations for 22 GHz water maser source in W3(OH) region, we found phase differences between Mizusawa SW correlated data and KJCC correlated data. These differences appear to have a diurnal variation and is similar between two different observational epochs. As a result, these phase differences make position differences of about 0.1 milli-arcsecond by conducting phase referencing. In this poster, I will present detailed plots of delay and phase solutions obtained through data reduction process of test observations.

**P-10. Sung-Moon Yoo, Taehyun Jung, Sung-Mo Lee, Ha Su Yoon, Han-Earl Park,
Jong-Kyun Chung, Kyoung-Min Roh, Seog Oh Wi, Jungho Cho, and Do-Young
Byun**

Affiliation: KASI

Title: **Determination of the Invariant Point of Korean VLBI Network (KVN) Radio
Telescopes: First Results at KVN Ulsan and Tamna Observatories**

Abstract: We present the first results of the invariant point (IVP) coordinates of the KVN Ulsan and Tamna radio telescopes. To determine the IVP coordinates in the geocentric frame (ITRF2014), the coordinate transformation method from the local frame, in which it is possible to survey using the optical instrument, to the geocentric frame was adopted. The least-square circles are fitted in three dimensions using the Gauss-Newton method to determine the azimuth and elevation axes in the local frame. The IVP in the local frame is defined as the mean value of the intersection points of the azimuth axis and the orthogonal vector between the azimuth and elevation axes. The geocentric coordinates of the IVP is determined by obtaining the seven parameters between the local frame and the east-north-up (ENU) geodetic frame. The axis-offset between the azimuth and elevation axes is also estimated. To validate the results, the coordinates variation of the GNSS station installed at KVN Ulsan was compared to the movement of the IVP coordinates over 9 months, showing good agreement in regards to magnitude and direction. This result will provide an important basis for geodetic and astrometric applications.