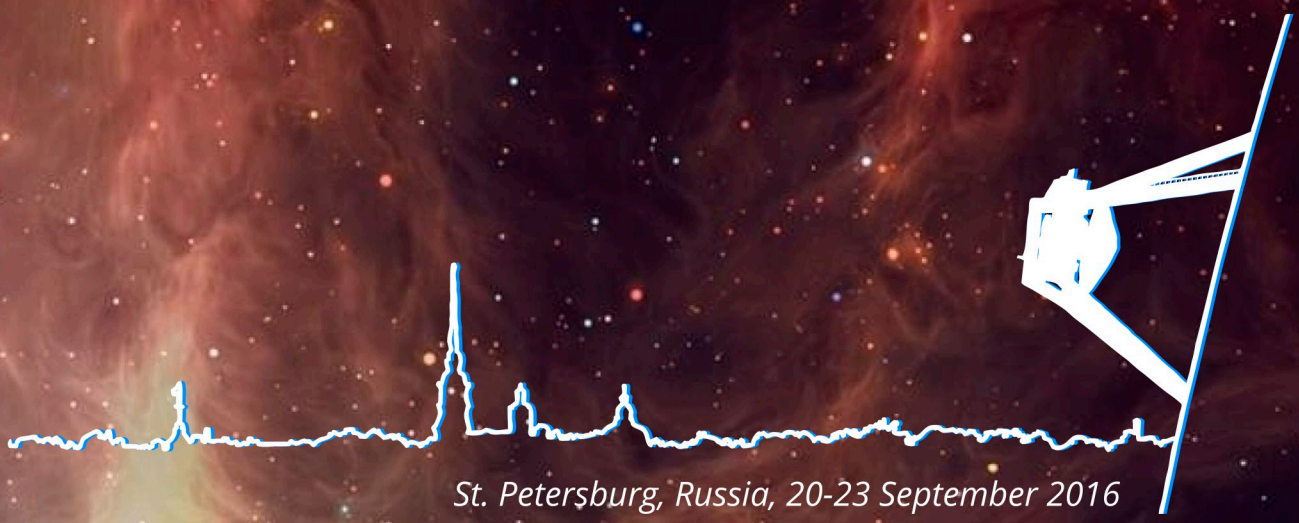
13th EUROPEAN VLBI NETWORK SYMPOSIUM & USERS MEETING

Program & Abstracts Book



St. Petersburg, Russia, 20-23 September 2016

Dear Colleagues,

It is a great pleasure for me to welcome you in St. Petersburg to our 13th European VLBI Network Symposium and Users Meeting. More than 120 participants from 21 countries and from 40 different institutions have registered for this conference. The science program has a total of 8 sessions containing 62 oral and 65 poster talks.

During the conference the latest scientific results and technical developments on Very Long Baseline Interferometry with the EVN and related facilities around the word will be reported and discussed. Scientific sessions will include the life cycle of matter in stars and galaxies, AGN and cosmic star-formation, Extreme Astrophysics, Astrometry and Geodesy, planetary and space science, as well as techniques and developments.

The program also includes the EVN Users Meeting, which is an important forum for interaction between the EVN users and the EVN organization. In addition, there are several social events planned during the week, such as the conference dinner, tour to Svetloe observatory and boat tour along the Neva River. Please spend some time, together with your colleagues, visiting the attractions the city has to offer.

I express my thanks to Rene Vermeulen, Chair of EVN Consortium Board of Directors who coordinated the Scientific Organizing Committee and to Yuri Bondarenko, Chair of Local Organizing Committee who has done an outstanding job in preparing the Symposium and also to all members of SOC and LOC.

I hope that the Symposium will be very successful and will foster the exchange of ideas with your colleagues and I wish all attendants to enjoy the conference as well as the Russian hospitality!

With best wishes,
Prof. Alexander Ipatov

Organizers

The Symposium is organized with the support of European VLBI Network, Institute of Applied Astronomy of the Russian Academy of Sciences, Joint-stock company "Institute of Applied Astronomy", St. Petersburg Scientific Centre of the Russian Academy of Sciences, Russian Foundation for Basic Research, The Federal Agency for Scientific Organizations, St. Petersburg Committee for Science and Higher School and St. Petersburg Convention Bureau.

Conference Venue

Location: St. Petersburg Scientific Center, Universitetskaya nab. 5

Date: from Tuesday 20 September to Friday 23 September

The 13th European VLBI Network Symposium and Users Meeting are held at the St. Petersburg Scientific Center of the Russian Academy of Sciences. St. Petersburg Scientific Center is a regional division of the Russian Academy of Sciences. The building was designed by Giacomo Quarenghi in 1785 especially for the Imperial St. Petersburg Academy of Sciences. The building is fully equipped for holding conferences and symposiums. The capacity of the main room is about 200-250 participants. Wireless internet access is available in the Scientific Center.

Registration and Information Desk

Location: Institute of Applied Astronomy, nab. Kutuzova 10

Date: Monday 19 September, from 18:00 to 21:00

Registration to the Symposium will be held in the main building of the Institute of Applied Astronomy of the Russian Academy of Sciences on Monday 19 September, from 18:00 to 21:00. Registration will also be available on Tuesday September 20 from 8:00 to 9:00 at the conference venue. The registration and information desk is located next to the conference entrance.

Coffee Breaks & Lunches

Free coffee breaks will be served at the Scientific Center Lobby from Tuesday to Wednesday at 10:30 – 11:00 and 16:00 – 16:30 and from Thursday to Friday at 10:30 – 11:00. Free Lunches will be provided at the Restaurant near the Scientific Center from Tuesday to Wednesday at 13:00 – 14:30 and on Friday at 13:30 – 15:00. Furthermore, the Scientific Center is located in the center of St. Petersburg. Many restaurants and bars can be found nearby.

Presentations Format

Oral Presentations

Each presentation will last 15 minutes including questions. Invited talks will last 30 minutes including questions. The presentation (PowerPoint or PDF format) will be copied on the symposium computer during the coffee breaks or lunch breaks. Please have a PDF version of the talk ready. No personal computer will be accepted.

Poster Presentations

The maximum size for posters is A0 portrait or landscape (84x119 cm). Please note that there will be no specific session dedicated to posters.

Official Language

The official language of the EVN Symposium & Users Meeting 2016 is English. Simultaneous interpretation is not provided. It is therefore expected that authors are able to present their research more or less fluently in the English language.

Social Events

Welcome Cocktail

Location: Institute of Applied Astronomy, nab. Kutuzova 10

Date: Monday 19 September, from 18:00 to 21:00

A welcome aperitif with snacks will be offered at the main building of the Institute of Applied Astronomy. Institute is located on the Kutuzova embankment of the Neva River in a historical building dating back to the beginning of 19th century. In 1892 the house was purchased by the government of the French Republic, and for many years it became the residence of the Embassy. In the early nineties of the twentieth century, the building was handed over to the Institute and became its headquarters. Currently the laboratories of theoretical astronomy, as well as administrative staff are located in this building. The correlation and data processing center was created in 2006.

Conference Dinner

Location: Palace of Grand duke Vladimir (Academics House), Dvortsovaya nab. 26

Date: Wednesday 21 September, from 19:30 to 22:30

Dinner will include transportation, a buffet dinner with drinks and entertainment. Before the dinner a half-hour tour of the palace will be offered. One of the last Imperial palaces to be built in St. Petersburg, the Palace of Grand Duke Vladimir was built between 1867 and

1872 for the third son of Emperor Alexander II. The palace's simple, somewhat dour facade is in stark contrast to the wonderfully preserved interiors, where the architects employed a hugely eclectic range of styles and periods, from neo-gothic to rococo to oriental. Fortunately, soon after the October Revolution, the Vladimir Palace was assigned as the Academics House, a social and cultural club for the scientists. For this reason, it has probably the most authentic and best preserved interiors of any of St. Petersburg's royal residences. While much of Vladimir's art collection has gone to the Hermitage collections and elsewhere, his impressive collection of fine porcelain is still mostly intact and on display in the palace.

Tour to Svetloe Observatory

Location: Svetloye village, Leningrad region

Date: Thursday 22 September, from 13:00 to 20:00

The Observatory is located approximately in hundred kilometers to the North-West from St. Petersburg. Buses will depart from the conference venue at 13:00. It is recommended to wear comfortable clothes and, in particular, to bring an extra layer (e.g. a wind jacket) since the weather at the Svetloe site can be quite cooler than that in St. Petersburg. Tour of the Observatory with the lunch buffet will be organized on the site. "Quasar" VLBI network is a unique astronomical instrument created in the Institute of Applied Astronomy. The network consists of three radio astronomical observatories: Svetloe near St. Petersburg, Badary in Eastern Siberia and Zelenchukskaya in the North Caucasus connected with the Correlation Processing Center in St. Petersburg. The main instrument in each of three observatories is a 32-m radio telescope (RT-32), which provides a completely automatic process of observing the radio sources and satellites. Observations can be carried out both in radiometric mode, when the telescope is working alone, and in radio interferometric mode, when several telescopes operate synchronously in the same network.

Boat Tour along the Neva River

Location: Pier in front of the Scientific Center, Universitetskaya nab. 3

Date: Wednesday 22 September, from 13:30 to 17:30

A city built over 42 islands, St. Petersburg is surrounded by water and interlaced with a complex web of rivers and canals that seem to bind the city together, while also marking the borders of its different districts and neighborhoods. St. Petersburg's low-rise classical architecture means that great vistas of the city are often visible from the water, and therefore an essential part of any exploration of the city is to get out in a boat and cruise the rivers and canals of St. Petersburg. A large and comfortable riverboat with panoramic windows is styled to resemble steamboats of the early 20th century. The simple menu offers inexpensive European cuisine with Italian accents. Boat Tour will include lunch with drinks and 1^h guided tour.

Scientific Organizing Committee

Zhores Alferov (Russian Academy of Sciences, Russia)

Alexander Ipatov (Institute of Applied Astronomy, Russia) (Chair)

Rene Vermeulen (Westerbork Observatory, Netherlands) (EVN CBD Chair)

Eduardo Ros (Max Planck Institute for Radio Astronomy, Germany)

Francisco Colomer (Observatorio Astronómico Nacional, Spain)

Michael Lindqvist (Onsala Space Observatory, Sweden)

Steven Tingay (Radioastronomical Observatory of National Institute for Astrophysics, Italy)

Simon Garrington (Jodrell Bank Centre for Astrophysics, UK)

Hong Xiaoyu (Shanghai Astronomical Observatory, China)

Huib van Langevelde (Joint Institute for VLBi in Europe, The Netherlands)

Andrzej Marecki (Torun Center for Astronomy, Poland)

Wang Na Xinjiang (Astronomical Observatory, China)

Joan Schmelz (Arecibo Observatory, USA)

Ludwig Combrinck (Hartebeesthoek Radio Astronomy Observatory, South Africa)

Merja Tornikoski (Metsähovi Radio Observatory, Finland)

Torben Schueler (Geodetic Observatory Wettzell, Germany)

Bong Won Sohn (Korean VLBI Network, South Korea)

Local Organizing Committee

Yuri Bondarenko (Institute of Applied Astronomy, Russia) (Chair)

Dmitry Marshalov (Institute of Applied Astronomy, Russia)

Nadya Shuigina (Institute of Applied Astronomy, Russia)

Alexey Melnikov (Institute of Applied Astronomy, Russia)

Voytsekh Ken (Institute of Applied Astronomy, Russia)

Yevgeny Lysenkov (Institute of Applied Astronomy, Russia)

Vlad Yakovlev (Institute of Applied Astronomy, Russia)

Monday 19th September

18:00 – 21:00 **Registration and Welcome Cocktail**
Held in Institute of Applied Astronomy, nab. Kutuzova 10

Tuesday 20th September

08:00 – 09:00 **Registration**
Held in St. Petersburg Scientific Center, Universitetskaya nab. 5

Welcome

09:00 – 09:10 **Zhores Alferov** (Russian Academy of Sciences, Russia)
Welcome

09:10 – 09:15 **Alexander Ipatov** (Institute of Applied Astronomy, Russia)
Welcome and opening remarks

09:15 – 09:30 **Rene Vermeulen** (Westerbork Observatory, The Netherlands)
EVN Highlights

SESSION 1: AGN Samples and Cosmology

Chair: Eduardo Ros

09:30 – 10:00 **Andrei Lobanov** (Max-Planck-Institut für Radioastronomie, Germany)
Central regions of AGN in the VLBI spotlight (Invited)

10:00 – 10:15 **Yuri Kovalev** (Astro Space Center of Lebedev Physical Institute, Russia)
RadioAstron brightness temperature survey of AGN cores

10:15 – 10:30 **Jose L. Gómez** (Instituto de Astrofsica de Andalucia, Spain)
Probing the innermost regions of AGN jets and their magnetic fields with RadioAstron

10:30 – 11:00 **Coffee Break and Poster Session**

11:00 – 11:15 **Evgeniya Kravchenko** (Astro Space Center of Lebedev Physical Institute, Russia)
Linearly polarized properties and Rotation Measure study of parsec-scale AGN jets

11:15 – 11:30	**Leonid Gurvits** (Joint Institute for VLBI ERIC / Delft University of Technology, The Netherlands) *Compact structures in AGN across the redshift pace under a Space VLBI magnifier*
11:30 – 11:45	**Roberto Angioni** (Max-Planck-Institut für Radioastronomie, Germany) *VLBI and gamma-ray studies of TANAMI radio galaxies*
11:45 – 12:00	**Noelia Herrera Ruiz** (Astronomisches Institut der Ruhr Universität Bochum, Germany) *Sensitive wide-field VLBI observations of the COSMOS field*
12:00 – 12:15	**Dhanya Gopalakrishnan Nair** (Max-Planck-Institut für Radioastronomie, Germany) *86 GHz VLBI survey of Ultra compact radio emission in Active Galactic Nuclei*
12:15 – 12:30	**John McKean** (ASTRON / Kapteyn Astronomical Institute, The Netherlands) *Probing dark matter on the smallest-scales with gravitational lensing*
12:30 – 12:45	**Jay Blanchard** (Joint Institute for VLBI ERIC) *Multi-Epoch VLBA observations of LLAGN*
12:45 – 13:00	**Minnie Mao** (Jodrell Bank Centre for Astrophysics, UK) *The heart of a spiral DRAGN*
13:00 – 14:30	**Lunch**
	SESSION 2: Astrometry, Geodesy and Space Applications *Chair: Francisco Colomer*
14:30 – 15:00	**Patrick Charlot** (Laboratoire d'Astrophysique de Bordeaux, France) *Astrometry and Reference Frames in the Gaia era (Invited)*
15:00 – 15:15	**Sergei Kurdubov** (Institute of Applied Astronomy, Russia) *VLBI astrometry: IAA CRF solution*
15:15 – 15:30	**Maria Cristina Garcia Miro** (Madrid Deep Space Communications Complex, Spain) *Towards an optical-radio frame tie using Gaia and VLBI*

15:30 – 15:45	**Elena Pitjeva** (Institute of Applied Astronomy, Russia) *VLBI data are the base of orientation of planetary ephemerides respect to ICRF2 and improvement of other ephemeris parameters*
15:45 – 16:00	**Eleonora Yagudina** (Institute of Applied Astronomy, Russia) *Expected impact of lunar landers VLBI observations on the lunar ephemerides accuracy*
16:00 – 16:30	**Coffee Break and Poster Session**
16:30 – 16:45	**Oleg Titov** (Geoscience Australia, Australia) *Estimation of the PPN parameter gamma with geodetic VLBI*
16:45 – 17:00	**Dmitry Litvinov** (Astro Space Center of Lebedev Physical Institute, Russia) *Probing general relativity with RadioAstron*
17:00 – 17:15	**Giuseppe Cimo'** (Joint Institute for VLBI ERIC) *Phobos flyby observed with EVN and global VLBI*
17:15 – 17:30	**Akiharu Nakagawa** (Kagoshima University, Japan) *Astrometry of the Galactic Miras and LPVs with a Japanese VLBI array "VERA"*
17:30 – 17:45	**Gabor Orosz** (Kagoshima University, Japan) *MultiView – a pilot study for precise VLBI astrometry at low frequencies using multiple calibrators*
17:45 – 18:00	**Fran Abellan** (University of Valencia, Spain) *43 GHz High-Precision Wide-Angle VLBI Astrometry of the Complete S5 Polar Cap Sample at the Technical Limit*
19:00 – 21:00	**Football Match** *Bus to Football match pitch departs from the Scientific Center at 18:30*

Wednesday 21th September

SESSION 3: VLBI Technology
Chair: Arpad Szomoru

09:00 – 09:30 **Alexander Ipatov** (Institute of Applied Astronomy, Russia)
Quasar/IAA Highlights

09:30 – 09:45 **Walter Alef** (Max-Planck-Institut für Radioastronomie, Germany)
BRAND - a VLBI receiver to cover the band from 1.5 GHz to 15 GHz

09:45 – 10:00 **Bob Campbell** (Joint Institute for VLBI ERIC)
Real-time e-VLBI in the EVN and software correlation at JIVE

10:00 – 10:15 **Pablo de Vicente** (Observatorio de Yebes, Spain)
Technical status and developments at the EVN (Invited)

10:15 – 10:30 **Huib van Langevelde** (Joint Institute for VLBI ERIC)
The course of the EVN (Invited)

10:30 – 11:00 **Coffee Break and Poster Session**

USERS MEETING
Chair: Michael Lindqvist

11:00 – 13:00 **Oral Presentations, Feedback from the Users and Open Discussion**

13:00 – 14:30 **Lunch**

SESSION 4: Starbursts and Extragalactic Masers
Chair: TBD

14:30 – 15:00 **Tom Muxlow** (Jodrell Bank Centre for Astrophysics, UK)
Star-formation Across Cosmic Time (Invited)

15:00 – 15:15 **Ivan Marti-Vidal** (Onsala Space Observatory, Sweden)
VLBI tomography of molecular clouds at half the age of the Universe

15:15 – 15:30 **Miguel Perez-Torres** (Instituto de Astrofsica de Andalucia, Spain)
The nature of the extremely energetic event in the nucleus of Arp 299B1 unveiled by EVN and near-IR observations

15:30 – 15:45 **Cristina Romero-Canizales** (Millennium Institute of Astrophysics / Universidad Diego Portales, Chile)
AGN activity unveiled in the nearby LIRG IC883

15:45 – 16:00 **Eskil Varenius** (Chalmers University of Technology / Onsala Space Observatory, Sweden)
VLBI imaging of the starburst galaxy Arp 220 at MHz and GHz frequencies

16:00 – 16:15 **Leonid Petrov** (Astrogeo Center, USA)
VLBI survey of nearby infra-red luminous galaxies

16:15 – 16:45 **Coffee Break and Poster Session**

SESSION 5: VLBI Arrays
Chair: TBD

16:45 – 17:00 **Bong Won Sohn** (Korea Astronomy and Space Science Institute, Republic of Korea)
KaVA stands for KVN and VERA Array which is a Korean-Japanese joint VLBI facility

17:00 – 17:15 **Seog-Tae Han** (Korean Astronomy and Space Science Institute, Republic of Korea)
A Compact Triple Bands Receiver System for Millimeter-wave VLBI Observations

17:15 – 17:30 **Anita Richards** (Jodrell Bank Centre for Astrophysics, UK)
Preparing for the African VLBI Network

19:30 – 22:30 **Conference Dinner**
Held in the Palace of Grand duke Vladimir, Dvortsovaya nab. 26

Thursday 22th September

SESSION 6: Stellar Evolution and Stellar Masers
Chair: Michael Lindqvist

09:00 – 09:30 **Francisco Colomer** (Instituto Geográfico Nacional, Spain)
Review of Maser science (Invited)

09:30 – 09:45 **Youngjoo Yun** (Korean Astronomy and Space Science Institute, Republic of Korea)
Simultaneous observations of the H2O and SiO masers toward the late-type stars using KVN

09:45 – 10:00 **Malcolm Gray** (Jodrell Bank Centre for Astrophysics, UK)
SiO Maser Movies: The Re-Make

10:00 – 10:15 **Fiona Healy** (University of Manchester, UK)
From observation to simulation: Understanding surprising evolutions in nova ejecta

10:15 – 10:30 **Marcin Gawronski** (Torun Centre for Astronomy, Poland)
e-EVN observations of AM Herculius

10:30 – 11:00 **Coffee Break and Poster Session**

11:00 – 11:15 **Alexey Alakoz** (Astro Space Center of Lebedev Physical Institute, Russia)
Compact structures in cosmic masers: an overview of the current results of RadioAstron maser survey

11:15 – 11:30 **Ross Alexander Burns** (Joint Institute for VLBI ERIC)
Bowshocks and non-linear motions seen in the H2O masers of AFGL 5142

11:30 – 11:45 **Pawel Wolak** (Torun Centre for Astronomy, Poland)
Properties of methanol maser clouds from EVN observations

11:45 – 12:00 **Krzysztof Katarzynski** (Torun Centre for Astronomy, Poland)
Emission of exoplanets in the GHz range

SESSION 7: Transients
Chair: Huib van Langevelde

12:00 – 12:30 **Zsolt Paragi** (Joint Institute for VLBI ERIC)
The SLOW and the FAST: transients with the e-EVN (Invited)

12:30 – 12:45	**Jun Yang** (Onsala Space Observatory, Sweden) *Discovery of an extremely compact and steady jet in the tidal disruption event Swift J1644+5734*
12:45 – 13:00	**Benito Marcote** (Joint Institute for VLBI ERIC) *Is FRB 150418 localized in WISE J0716-19? Clues from EVN observations*
	Social Event 1
13:00 – 20:00	**Tour To Svetloe Observatory** *Approximately a hundred kilometers from St. Petersburg*
	or Social Event 2
13:30 – 17:30	**Boat Tour along the Neva River** *The boat departs from the pier in front of the Scientific Center*

Friday 23th September

Session 8: AGN Astrophysical Processes
Chair: Sándor Frey

09:00 – 09:30 **Tuomas Savolainen** (Aalto University Metsähovi Radio Observatory, Finland)
Space-VLBI observations of nearby radio galaxies with RadioAstron (Invited)

09:30 – 09:45 **Silke Britzen** (Max-Planck-Institut für Radioastronomie, Germany)
A new view on M87

09:45 – 10:00 **Anne-Kathrin Baczko** (Max-Planck-Institut für Radioastronomie, Germany)
mm-VLBI studies of NGC1052

10:00 – 10:15 **Biagina Boccardi** (Max-Planck-Institut für Radioastronomie, Germany)
The disk-driven jet of Cygnus A

10:15 – 10:30 **Vassilis Karamanavis** (Max-Planck-Institut für Radioastronomie, Germany)
Following the flare of PKS 1502+106 with mm-VLBI imaging and light curve modelling

10:30 – 11:00 **Coffee Break and Poster Session**

11:00 – 11:15 **Jae-Young Kim** (Max-Planck-Institut für Radioastronomie, Germany)
Ultra-high resolution study of the innermost jet of M87 with mm-VLBI

11:15 – 11:30 **Mikhail Lisakov** (Astro Space Center of Lebedev Physical Institute, Russia)
Comprehensive study of a gamma-ray to radio connection in 3C273

11:30 – 11:45 **Rusen Lu** (Max-Planck-Institut für Radioastronomie, Germany)
Anatomy of the horizon-scale structure of Sagittarius A with a resolution of ~3 Schwarzschild radii*

11:45 – 12:00 **Robert Frank Schulz** (ASTRON, The Netherlands)
Multi-frequency VLBI and single-dish observations of the extremely variable TeV active galaxy IC 310

12:00 – 12:15	**Laura Vega García** (Max-Planck-Institut für Radioastronomie, Germany) *RadioAstron imaging of compact jets: Observations of the jet in 0836+710*
11:15 – 12:30	**Shoko Koyama** (Max-Planck-Institut für Radioastronomie, Germany) *The origin of the off-axis jet component in Mrk 501 with VLBI astrometry*
12:30 – 12:45	**Leonid Matveyenko** (Space Research Institute, Russia) *Multi Face Unity*
	Closing
12:45 – 13:15	**John Conway** (Onsala Space Observatory / Chalmers University of Technology, Sweden) *Summary of Symposium*
13:15 – 13:30	**Alexander Ipatov** (Institute of Applied Astronomy, Russia) *Acknowledgements and Closing Remarks*
13:30 – 15:00	**Lunch**
	End of Symposium

List of Posters

1. **Alexey Alakoz** (Astro Space Center of Lebedev Physical Institute, Russia)
   The most compact H2O maser spots and their locations in W3 IRS5

2. **Walter Alef** (Max-Planck-Institut für Radioastronomie, Germany)
   Digital Base-Band Converter 3 - VLBI @ 128 Gbps

3. **Andrey Andrianov** (Astro Space Center of Lebedev Physical Institute, Russia)
   ASC Correlator and Astro Space Locator software: Data processing in "Radioastron" mission

4. **Andrey Andrianov** (Astro Space Center of Lebedev Physical Institute, Russia)
   Interstellar plasma scattering effects studied with Radioastron

5. **Rebecca Azulay** (University of Valencia, Spain)
   Dynamical mass determination of the young nearby system HD 160934

6. **Uwe Bach** (Max-Planck-Institut für Radioastronomie, Germany)
   Asteroid Sizing by Radiogalaxy Occultation at 5 GHz

7. **Francisco Javier Beltrán Martínez** (University of Alcalá, Spain)
   Design of a control system to use twin radiotelescopes simultaneously in VLBI

8. **Ilya Bezrukov** (Institute of Applied Astronomy, Russia)
   Operating Experience and Future Prospects of Data Transfer and Recording System

9. **Yuri Bondarenko** (Institute of Applied Astronomy, Russia)
   Observations of near-Earth asteroid 2011 UW158 using Quasar VLBI network

10. **Ross Alexander Burns** (Joint Institute for VLBI ERIC)
    Episodic ejection in massive young stellar objects

11. **Do-Young Byun** (Korea Astronomy and Space Science Institute, Republic of Korea)
    Linear Polarization of Class I Methanol Masers in Massive Star Forming Regions

12. **Guifre Molera Calves (Aalto University, Finland)**
    Exploring events in the Solar System with spacecraft radio signal

13. **Wen Chen** (Yunnan Observatories, China)
    The Introduction of VLBI Observation in Yunnan Observatories and the new C Band Receiver

14. **Vitaliy Chernov** (Institute of Applied Astronomy, Russia)
    Feeds of the Radio Telescopes RT-13 of the Quasar VLBI Network

15. **Se-Hyung Cho** (Korea Astronomy and Space Science Institute, Republic of Korea)
Simultaneous Monitoring Observations of KVN 4 Bands toward Evolved Stars

16. **Lang Cui** (Xinjiang Astronomical Observatory, China)
The first VLBI image of 6 GHz OH masers toward PN K3-35

17. **Roger Deane** (Rhodes University / SKA SA, South Africa)
Binary supermassive black holes and radio-jet feedback in post-merger galaxies

18. **Alexander Evstigneev** (Institute of Applied Astronomy, Russia)
The ultra-wideband receiver system for RT-13 radio telescope IAA RAS Quasar network

19. **Alexander Evstigneev** (Institute of Applied Astronomy, Russia)
New C-band receiver for RT-32 radio telescope IAA RAS Quasar network

20. **Sándor Frey** (FÖMI Satellite Geodetic Observatory, Hungary)
Compact radio quasars at z>4.5 observed with the EVN

21. **Krisztina Gabanyi** (FÖMI Satellite Geodetic Observatory, Hungary)
SDSS J1425+3231: the nature of a dual AGN candidate revealed

22. **Denise Gabuzda** (University College Cork, Ireland)
Using Linear Polarization, Circular Polarization and Faraday Rotation Measurements to Determine the Spin Direction of the Central Accretion Disks of AGN

23. **Maria Cristina Garcia Miro** (Madrid Deep Space Communications Complex, Spain)
VLBI digital terminal at the Deep Space Network: enhancements for external VLBI users

24. **Nectaria Gizani** (Hellenic Open University, Greece)
EVN observations of Hercules A

25. **Nectaria Gizani** (Hellenic Open University, Greece)
The Magnetic Field of the Hercules A cluster revisited

26. **Ciriaco Goddi** (Radboud University, Nijmegen, The Netherlands)
Measuring Magnetic Fields from Water Masers in the Synchrotron Protostellar Jet in W3(H2O)

27. **Igor Gosachinskij** (SPb Branch of SAO RAN, Russia)
Short time variabilty of OH masers in W3(OH)

28. **Sergey Grenkov** (Institute of Applied Astronomy, Russia)
Extending Facility of BRAS by External Digital Downconverter Bank

29. **Jose Carlos Guirado** (University of Valencia, Spain)
Radio emission in ultracool dwarfs: the nearby planetary system VHS1256-1257

30. **Jeffrey Adam Hodgson** (Korea Astronomy and Space Science Institute, Republic of Korea)
Multi-year multi-frequency monitoring of 3C 84

31. **Gennadii Ilin** (Institute of Applied Astronomy, Russia)
Measuring TWD in "Quasar" network observatories

32. **Valery Ivanov** (Institute of Applied Astronomy, Russia)
Spectrum dynamics of supernova remnant 3C58

33. **Valery Ivanov** (Institute of Applied Astronomy, Russia)
Absolute spectra of standard sources at epoch 2016.3

34. **Taehyun Jung** (Korea Astronomy and Space Science Institute, Republic of Korea)
Multi-frequency AGN Survey with the KVN (MASK)

35. **Vassilis Karamanavis** (Max-Planck-Institut für Radioastronomie, Germany)
VLBI and filled-aperture monitoring of GeV-emitting narrow-line Seyfert 1 galaxies

36. **Voytsekh Ken** (Institute of Applied Astronomy, Russia)
RASFX Correlator Accuracy Characteristics

37. **Mikhail Kharinov** (Institute of Applied Astronomy, Russia)
Observation of intraday variability of extragalactic radio sources on IAA antennas

38. **Evgeniy Khvostov** (Institute of Applied Astronomy, Russia)
The S/X/Ka receiver system for radio telescope RT-13 of Quazar VLBI Network

39. **Alexander Kutkin** (Astro Space Center of Lebedev Physical Institute, Russia)
Jet velocities in VLBI cores of blazars

40. **Alexey Lavrov** (Institute of Applied Astronomy, Russia)
Receiver module Power, Control and Monitoring system for RT-32 and RT-13 radio telescopes

41. **Ivan Marti-Vidal** (Onsala Space Observatory, Sweden)
APSYNSIM - A pedagogical interactive simulator of Aperture Synthesis

42. **Alexey Melnikov** (Institute of Applied Astronomy, Russia)
Experience in Creating Schedules of KVAZAR VGOS Antennas

43. **Alexey Melnikov** (Institute of Applied Astronomy, Russia)
Improving UT1-UTC Estimates of KVAZAR VGOS Sessions

44. **Vladimir Mishin** (Institute of Applied Astronomy, Russia)
Correlation Processing System for "Spectr-R" (RadioAstron) Spacecraft Beacon Signal

45. **Gabor Orosz** (Kagoshima University, Japan)
Water fountain jets as seen by VLBI maser astrometry

46. **Miyako Oyadomari** (Kagoshima University, Japan)
Correlation of the relative SiO maser distributions with the stellar light curves

47. **Zsolt Paragi** (Joint Institute for VLBI ERIC)
EVN localization of short transients

48. **Ilya Pashchenko** (Astro Space Center of Lebedev Physical Institute, Russia)
Assessing uncertainties of VLBI results

49. **Alexander Plavin** (Astro Space Center of Lebedev Physical Institute, Russia)
Variability of the core shift effect in AGN jets

50. **Alexander Pushkarev** (Crimean Astrophysical Observatory, Russia)
Jet orientation and gamma-ray brightness of AGN

51. **Kazi Rygl** (INAF - Istituto di Radioastronomia, Italy)
A Herschel and BIMA study of the sequential star formation in the W 48A star forming region

52. **Robert Frank Schulz** (ASTRON, The Netherlands)
Tracing the evolution of fast jet-driven outflows

53. **Marina Shatskaya** (Astro Space Center of Lebedev Physical Institute, Russia)
IT support of space-VLBI projects: storage and processing of big data volume

54. **Viktor Shor** (Institute of Applied Astronomy, Russia)
New opportunities of the computing-analytical complex for predicting collisions of the Earth with asteroids and comets and creating scenarios of collision catastrophes produced by celestial body falls

55. **Elena Skurikhina** (Institute of Applied Astronomy, Russia)
CONT14 VLBI Observations Results

56. **Andrey Smirnov** (Institute of Applied Astronomy, Russia)
Pipeline processing procedure for spectral experiments on KVAZAR VLBI network

57. **Rebeca Soria-Ruiz** (Observatorio Astronómico Nacional, Spain)
Reliable dense-gas tracers at high redshift: CN in the z~4 quasar APM 08279

58. **Cristiana Spingola** (Kapteyn Astronomical Institute, The Netherlands)
A panchromatic study of the Gravitational Lens MG J0751+2716 at z=3.2

59. **Igor Surkis** (Institute of Applied Astronomy, Russia)
The RASFX VGOS GPU Based Software Correlator

60. **Kazuhiro Takefuji** (National Institute of Information and Communications Technology, Japan)
Technical Development of Broadband system at Kashima Space Technology Center

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Space vehicles observations using VLBI Network "Quasar-KVO"

62. **Yuriy Vekshin** (Institute of Applied Astronomy, Russia)
The parameters of the RT-13 radio telescopes of the "Quasar" VLBI network of the IAA RAS in S/X/Ka bands

63. **Petr Voytsik** (Astro Space Center of Lebedev Physical Institute, Russia)
Apparent frequency dependent shift of ultra-compact AGN cores determined by VLBI phase-referencing

64. **Nikolay Zheleznov** (Institute of Applied Astronomy, Russia)
Software complex "Asteroids and Comets" at the site of Institute of Applied Astronomy RAS

65. **Dmitry Zhuravov** (Institute of Applied Astronomy, Russia)
RASFX Correlator Processing Result

66. **Maksim Zotov** (Institute of Applied Astronomy, Russia)
The highly sensitive receiving system of S/X band of wavelengths to address the problems of astrometry and geodesy on the radio telescope RT-70

SESSION 1: AGN Surveys

CENTRAL REGIONS OF AGN IN THE VLBI SPOTLIGHT (INVITED)

Andrei Lobanov[1]

[1]*Max-Planck-Institut für Radioastronomie, Germany*

Continued improvements of sensitivity, fidelity, and resolution of VLBI observations make them an excellent tool to study the central regions of radio-loud active galactic nuclei (AGN), on scales from ~1 to one million gravitational radii of the central supermassive black holes (SMBH). At these scales, radio emission produced in relativistic jets and highly-magnetized portions of the accretion disks can be used as an effective probe of the presence and properties of the SMBH and the physical conditions in its extreme vicinity (including the strength and structure of the magnetic field, production of broadband continuum emission, physical mechanisms governing the jet acceleration, and the overall energy balance in the AGN). An overview of recent results in these areas of study will be given here, providing a basis for a more general discussion of the implications of these measurements for the physical nature and cosmological evolution of the central engine in AGN.

RADIOASTRON BRIGHTNESS TEMPERATURE SURVEY OF AGN CORES

Yuri Kovalev[1] for the RadioAstron AGN survey team

[1]*Astro Space Center of Lebedev Physical Institute, Russia*

The RadioAstron AGN survey is performed by the space radio telescope Spektr-R and many sensitive ground radio telescopes in Russia, Europe, Asia, USA, South Africa, Australia, Japan at 18, 6, and 1.3 cm and has detected more than 160 AGNs at projected spacings up to 350 000 km (27 Earth diameters). Formal resolution as high as 14 microarcsec has been achieved for AGNs observed at 22 GHz. Results of measurements of very high brightness temperatures in AGN cores and physical implications of these findings will be presented and discussed.

PROBING THE INNERMOST REGIONS OF AGN JETS AND THEIR MAGNETIC FIELDS WITH RADIOASTRON

Jose L. Gómez[1], A. Lobanov[2], G. Bruni[2], Yu. Kovalev[3] et al.

[1]*Instituto de Astrofsica de Andalucia, Spain*
[2]*Max-Planck-Institut für Radioastronomie, Germany*
[3]*Astro Space Center of Lebedev Physical Institute, Russia*

RadioAstron provides the first true full-polarization capabilities for space VLBI observations on baselines longer than the Earth diameter. We present the results of more than three years of RadioAstron observations, obtained as part of our Key Science Program to study the innermost regions of a sample AGN jets and their magnetic fields at the highest angular resolutions achieved to date.

LINEARLY POLARIZED PROPERTIES AND ROTATION MEASURE STUDY OF PARSEC-SCALE AGN JETS

Evgeniya Kravchenko[1]

[1]*Astro Space Center of Lebedev Physical Institute, Russia*

We present wavelength-dependent analysis of linearly polarized properties in 20 AGN jets. Sources were observed by the NRAO VLBA at 1.4, 1.6, 2.2, 2.4, 4.6, 5.0, 8.1, 8.4 and 15.4 GHz frequencies, which allows to account for opacity and Faraday effects in core and jet components. Linear fractional polarization and its position angle showed complex wavelength-dependent behavior in all sources. We construct and analyze Faraday rotation measure maps and model observed depolarization. We find that depolarization effects occur in the jet medium and its surrounding environment and are common in relativistic jets.

COMPACT STRUCTURES IN AGN ACROSS THE REDSHIFT PACE UNDER A SPACE VLBI MAGNIFIER

Leonid Gurvits[1] and the RadioAstron High-redshift Project Team

[1]*Joint Institute for VLBI ERIC / Delft University of Technology, The Netherlands*

Compact (milliarcsecond-scale and sharper) structures in AGN are efficient probes for studying astrophysical properties and their cosmological manifestations in a broad range of redshifts reaching the current record of z = 6.2. If observed at a fixed wavelength, a typical core-jet AGN morphology would appear as having a steep-spectrum jet fading away with the increasing redshift while a flat-spectrum core becoming more dominant. If core-jet AGN constitute the same population of objects throughout the redshift space, the apparent

"prominence" of jets at higher redshifts must decrease: well pronounced jets at high z must appear less frequent than at low z. However, investigations of powerful jets at high redshifts are of special value in view of their diagnostic importance for both studies of astrophysical parameters of individual sources and potential impact on cosmological tests with compact radio structures in quasars. In this mini-review, a summary of investigations by the first dedicated Space VLBI Mission VSOP of strong (hundreds of mJy at 1.6 and/or 5 GHz) high-redshift (z > 3) AGN will be re-considered in view of the preliminary results of the on-going RadioAstron Space VLBI project of studying high-redshift quasars. The project is focused at three interrelated topics: – Physical parameters of inner parsec-scale regions of AGN and their potential (in)dependence on cosmological epoch; – Extension of studies of proper motion in AGN jets into the high-redshift Universe; – Evaluation of parsec- and sub-parsec radio structures in AGN as "standard" objects of cosmological tests. The presentation will address the current status of the project and compare its available to date results with the past VLBI surveys, including the VSOP AGN Survey, as well, as the ongoing RadioAstron AGN Survey and other relevant recent RadioAstron results.

VLBI AND GAMMA-RAY STUDIES OF TANAMI RADIO GALAXIES

Roberto Angioni[1], E. Ros[2], M. Kadler[3], R. Ojha[4], C. Müller[5] and F. Krauss[6]

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[2]*University of Würzburg, Germany*
[3]*Goddard Space Flight Center, USA*
[4]*Radboud University Nijmegen, The Netherlands*
[5]*Dr. Karl Remeis Observatory & ECAP, Germany*
[6]*University of Erlangen-Nuremberg, Germany*

Radio galaxy jets, in contrast to blazars, are not heavily affected by relativistic boosting. For this reason, they offer a unique perspective to study the intrinsic properties of AGN jets. However, for the same reason, they are relatively faint particularly at γ-ray energies, where they make up only 1-2% of all AGN detected by Fermi-LAT. The recent implementation of the Fermi-LAT Pass8 data analysis holds substantial potential to expand the LAT radio galaxy sample. Here we present a multi-wavelength characterization of the radio galaxies in TANAMI, a monitoring program of extragalactic jets in the southern hemisphere which includes Very Long Baseline Interferometry (VLBI) monitoring and extensive broadband data coverage. In the radio, we obtain high-resolution maps at 8.4 and 22 GHz, spectral index maps, and kinematic properties from multi-epoch data. At high energies we study the γ-ray emission using the upgraded Fermi science tools, and for the (so far) γ-quiet TANAMI sources, we collect multi-wavelength data, looking for common properties in the broadband SED.

SENSITIVE WIDE-FIELD VLBI OBSERVATIONS OF THE COSMOS FIELD

Noelia Herrera Ruiz[1], E. Middelberg[1], A. Deller[1] and R. Norris[1]

[1]*Astronomisches Institut der Ruhr Universität Bochum, Germany*

The Very Long Baseline Interferometry (VLBI) technique is a relatively easy and direct way to determine which galaxies do have a radio-active AGN. With this project, we want to study statistically the AGN incidence in the faint radio source population using VLBI observations. To achieve this goal, the project is divided into two parts. In the first part, ~3000 radio sources in the COSMOS field have been observed with the Very Long Baseline Array (VLBA) at 1.4GHz. We have detected 468 sources. In the second part, we have observed ~200 radio sources with extremely high sensitivity using the VLBA together with the Green Bank Telescope (GBT) at 1.4GHz, to explore an even fainter population in the flux density regime of tens of μJy. This data is currently under calibration. In this overview I will present the survey design, observations, and calibration, along with some first results.

86 GHZ VLBI SURVEY OF ULTRA COMPACT RADIO EMISSION IN ACTIVE GALACTIC NUCLEI

Dhanya Gopalakrishnan Nair[1], A. Lobanov[1], T. Krichbaum[1], E. Ros[1] and A. Zensus[1]

[1]*Max-Planck-Institut für Radioastronomie, Germany*

Very Long Baseline Interferometry (VLBI) observations at 86 GHz reach a resolution of about 50 microarcseconds and sample the scales as small as 10^3–10^4 Schwartzchild radii of the central black hole in Active Galactic Nuclei (AGN), and uncover the jet regions where acceleration and collimation of the relativistic flow takes place. The high resolution VLBI studies (with 3mm) makes it possible to look deeper into the core and inner jets of AGN which is invisible at cm and longer wavelengths due to self absorption or free-free absorption by the torus. We have done a large global VLBI survey of 162 unique ultra compact radio sources at 86 GHz conducted in 2010-2011. All the sources were detected and imaged; increasing by a factor of ~2, the total number of AGN ever imaged with VLBI at 86 GHz. The survey data attained a baseline sensitivity of 0.1 Jy and the image sensitivity of 5 mJy/beam. We have used Gaussian model fitting to represent the structure of the observed sources and to estimate the flux densities and sizes of the core and jet components. The model fitting yields estimates of the brightness temperature (Tb) of the VLBI bright core (base) of the jet and inner jet components of AGN, taking into account the resolution limits of the data at 3mm. The brightness temperatures of the VLBI cores peak at ~10^{11} K. We have applied a basic population model with a single value of intrinsic brightness temperature, To, in order to reproduce the observed distribution of Tb. Our data are consistent with a population of sources that have To~(1-7)x10^{11} K in the VLBI cores and To≤5x10^{10} K in the jets. We also find a correlation between the brightness temperatures obtained from the model fits with estimates of the brightness temperature

limits made directly from the visibility data. For objects with sufficient structural detail detected, we investigated the effect of adiabatic energy losses on the evolution of brightness temperature along the jet.

PROBING DARK MATTER ON THE SMALLEST-SCALES WITH GRAVITATIONAL LENSING

John McKean[1]

[1]*ASTRON / Kapteyn Astronomical Institute, The Netherlands*

Gravitational lensing of compact images and extended arcs can be used to detect and quantify the presence of low-mass substructure in lensing haloes, potentially constraining the dark matter halo mass function and differentiating between cold and warm dark matter models. I will present the latest results from the SHARP collaboration, which is using high resolution optical (HST), infrared (Keck adaptive optics) and radio (global VLBI) imaging to constrain the nature of dark matter with gravitational lensing.

MULTI-EPOCH VLBA OBSERVATIONS OF LLAGN

Jay Blanchard[1], N. Nagar[2] and N. Lasso-Cabrera[3]

[1]*Joint Institute for VLBI ERIC*
[2]*University of Concepción, Chile*
[3]*Centro de Estudios de Física del Cosmos de Aragón, Spain*

Low luminosity AGN (LLAGN), that is low-luminosity Seyferts, LINERS, and transition nuclei, are still somewhat contentious objects as their emission can be modeled as photoionization by young hot stars, collisional ionization in shocks, and starbursts. They often however contain compact nuclear cores, water megamasers, and H-α lines consistent with more powerful radio galaxies and Seyferts. We present multi-epoch VLBI monitoring of eight of these objects using the VLBA and discuss the implications of these observations on their nature.

THE HEART OF A SPIRAL DRAGN

Minnie Mao[1] et al.

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In the nearby Universe, DRAGNs (Double Radio sources associated with AGNs) are almost invariably hosted by giant elliptical galaxies. The existence of DRAGNs hosted by spiral galaxies defies our current understanding of galaxy formation. Nonetheless, there are now

four confirmed examples of spiral DRAGNs. Spiral galaxies are known to contain significantly more gas than elliptical galaxies, thus spiral DRAGNs are the ideal laboratory for studying the interaction of radio jets with the ISM. Here we present VLBI observations of spiral DRAGNs.

SESSION 2: Astrometry, Geodesy and Space Applications

ASTROMETRY AND REFERENCE FRAMES IN THE GAIA ERA (INVITED)

Patrick Charlot[1]

[1]*Laboratoire d'Astrophysique de Bordeaux, France*

This presentation will review current activities in the field of astrometry and reference frames with focus on the next realization of the International Celestial Reference Frame (ICRF3) and the initial results of the Gaia mission. ICRF3 is being built by a Working Group of the IAU and should be completed by 2018 for adoption at the IAU General Assembly in Vienna. ICRF3 will be based on state-of-the-art astronomical and geophysical modeling and will benefit from the wealth of VLBI data acquired since ICRF2 was built in 2009 (an additional 60% of data). Specific attention will be paid to sources that have a bright optical counterpart as they are of particular interest for the alignment of the Gaia optical frame. The Gaia mission, launched on 19 December 2013 and operating since 19 July 2014, is observing 30-40 million sources per day and performs largely nominally despite a few problems which slightly degrade accuracy for the weaker objects. The first Gaia Data Release, scheduled for 14 September 2016, will report one billion positions and two million proper motions and parallaxes with exquisite accuracies. Notably, this will permit unprecedented comparisons between radio and optical positions, holding promises for a broad range of new science in the coming years.

VLBI ASTROMETRY: IAA CRF SOLUTION

Sergei Kurdubov[1] and V. Gubanov[1]

[1]*Institute of Applied Astronomy, Russia*

In this report we present recent VLBI global solution of all available geodetic and astrometric programs with the QUASAR software for VLBI data processing created in IAA RAS. The estimated radio source position catalogue is the main result of solution as realization of Celestial Reference Frame. Also we estimated the Solar system acceleration.

TOWARDS AN OPTICAL-RADIO FRAME TIE USING GAIA AND VLBI

Maria Cristina Garcia Miro[1], C. Jacobs[1], S. Horiuchi[1], J. Clark[1], L. Snedeker[1], G. Bourda[1], P. Charlot[1], A. De Witt[1], J. Quick[1], J. Lovell[1] and J. McCallum[1]

[1]*Madrid Deep Space Communications Complex, Spain*

Until recently, VLBI at cm wavelengths provided the only celestial reference frame with sub-mas accuracy. Given that ESA's Gaia optical satellite is successfully operating and the first public release of results is scheduled for the second half of 2016, we expect that for the first time a sub-mas frame from an independent wavelength and technique will be available. Different methods are being considered for an accurate optical-radio frame tie using objects that can be well observed by both Gaia and VLBI. This paper will discuss one such method which uses quasars observed directly by both Gaia and VLBI. For part per billion or better precision, Gaia requires objects brighter than 18th magnitude. Given that previous ICRF-2 VLBI based work has accurate data on only 195 such objects, an observing program using the EVN was initiated to increase the number of potential tie objects to about 120 objects more. Using NASA's Deep Space Network, we have now obtained VLBI data covering declinations north of -45 deg for 294 sources not in the ICRF-2, including the new sources detected with the EVN. Median precision is approximately 200 μas. In order to complete coverage over the south polar cap and to improve accuracy in the southern hemisphere in general, we have begun a complementary VLBI program using South Africa to Australia baselines. Simulations predict that a frame tie with approximately 10 μas precision or better should be achievable. Given that precision, we expect that true accuracy will be limited by systematic errors. While both optical and radio techniques will contribute to systematics, we hope to control those errors so that astrophysical differences between the optical and radio centroids will be exposed for scientific study. In summary, the frame tie work we have begun should permit registration of optical and radio results with unprecedented accuracies which may enable new insights into the processes within AGNs.

VLBI DATA ARE THE BASE OF ORIENTATION OF PLANETARY EPHEMERIDES RESPECT TO ICRF2 AND IMPROVEMENT OF OTHER EPHEMERIS PARAMETERS

Elena Pitjeva[1]

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Until 1960, classical analytical theories of planets were based entirely on optical observations having accuracy no better than 0.5". Detection of Venus radioechoes made in 1961 has opened the era of astrometrical radio observations, who led to a revolution in astrometry and ephemeris astronomy. Two new types of measurements appeared: the time delay and the Doppler-shift, while the accuracy of observations increased by the orders. Ranging data of planets and spacecraft that made possible to produce ephemerides of the inner planets with millisecond accuracy and to determine a wide range

of astronomical constants from planet orbits to relativistic parameters. However, the ranging data provide just relative angles and distances between the Earth and the other observed object, i.e. ranging allows to determine all orbital elements of planets, except orientation of the planetary system. In the past, planet ephemerides were aligned to FK4, FK5 or other fundamental star catalogs depend on using included optical observations. JPL DE200 was aligned to the dynamical equator and equinox of J2000 by Dr. Standish with a least-square fit to the motion of the instantaneous node of the Earth-Moon barycenter about the Sun. Fundamental planetary ephemerides have been referenced to ICRF2 by including the ICRF2-based VLBI measurements of spacecraft in the total adjustment since DE403 and EPM98 (Ephemerides of the planets and the Moon by IAA RAS). Two types of observations were used: one component of the direction to a planet relative to radio source made by pairs of tracking stations from NASA DSN and ESA (at first, Magellan and Phobos, then MGS, Odyssey, MRO, VEX near Venus and Mars) 1990-2013, as well as antennas of VLBA with rapidly alternating scans between Cassini and nearby reference sources 2004-2014. Using all these measurements, the orientation of EPM has been improved considerably by the addition of new VLBI points and increase of their accuracy up to fractions of mas. The VLBI measurements of spacecraft near the planets are used also for the improvement of ephemerides of these planets particularly for Jupiter (new Juno data are not available at present, and other radar data is too few, but there are 24 VLBI measurements of Galileo orbiting Jupiter). At present the new version of our EPM ephemerides - EPM2015 has been constructed and available on the FTP server of the IAA RAS: ftp://quasar.ipa.nw.ru/incoming/EPM/. This version has been fitted to about 800,000 observations of different types: ranging, LLR, VLBI, optical (1913-2014).

EXPECTED IMPACT OF LUNAR LANDERS VLBI OBSERVATIONS ON THE LUNAR EPHEMERIDES ACCURACY

Eleonora Yagudina[1], M. Vasilyev[1] and N. Shuygina[1]

[1]*Institute of Applied Astronomy, Russia*

The modern Lunar Ephemerides DE, INPOP, EPM-ERA have been obtained through the comparison of dynamical models of the Moon orbital-rotational motion with modern highly precise lunar laser observations (LLR) since 1969 till the present time. The main purpose of the paper is to evaluate the impact of adding new types of observations on the accuracy of lunar ephemerides. These types are VLBI and radio ranging observations of lunar lander equipped with a transponder like the one in the Chinese space project Chang'E-3 with the Yutu rover placed at the Moon's surface. The evaluation was performed through the mathematical simulation method for different nets of radio telescopes and measurements accuracies. The simulation was carried out within the framework of ERA system developed in IAA RAS. The result shows that VLBI observations processing together with LLR ones can considerably improve the accuracy of some lunar parameters.

ESTIMATION OF THE PPN PARAMETER GAMMA WITH GEODETIC VLBI

Oleg Titov[1]

[1]*Geoscience Australia, Australia*

The geodetic VLBI technique is capable of measuring the Sun's gravity light deflection from distant radio sources around the whole sky. This light deflection is equivalent to the conventional gravitational delay used for reduction of geodetic VLBI data. While numerous tests based on a global set of VLBI data have shown that the parameter gamma of the post-Newtonian approximation is equal to unity with precision of about 0.02 percent, more detailed analysis reveals some systematic deviations depending on the angular elongation from the Sun. In this paper a limited set of VLBI observations near the Sun were adjusted to obtain the estimate of parameter gamma free of the elongation angle impact. The parameter gamma is still found to be close to unity with precision of 0.06 per cent, two subsets of VLBI data measured at short and long baselines produce some statistical inconsistency. Details of this investigation are discussed in this paper.

PROBING GENERAL RELATIVITY WITH RADIOASTRON

Dmitry Litvinov[1] and the RadioAstron gravitational redshift experiment team

[1]*Astro Space Center of Lebedev Physical Institute, Russia*

A test of a cornerstone of general relativity, the gravitational redshift effect, is currently being conducted with the RadioAstron spacecraft, which is on a highly eccentric orbit around Earth. Using ground radio telescopes as recipients of the spacecraft signal, synchronized to its ultra-stable on-board H-maser, we intend to probe the varying flow of time on board with unprecedented accuracy. The observations performed so far, currently being analyzed, have already allowed us to measure the effect with a relative accuracy of $4x10^{-4}$. Our goal is to reach $2.5x10^{-5}$ with additional observations in 2016, an improvement of almost a magnitude over the 40-year old result of the GP-A mission.

PHOBOS FLYBY OBSERVED WITH EVN AND GLOBAL VLBI

Giuseppe Cimo'[1] and the PRIDE[2] team

[1]*Joint Institute for VLBI ERIC*
[2]*ASTRON, The Netherlands*

Spacecraft observations by means of VLBI provide high accuracy positional data that can be applied to a variety of fields: interplanetary scintillation, planetary ephemeris, and ultra precise measurements for a number of gravity and fundamental physics experiments. A VLBI campaign involving 35 radio telescopes has been carried out in December 2013 to

observe the closest (47Km) Phobos flyby by the ESA's spacecraft Mars Express. These observations allow us to study Mars atmosphere and to improve our knowledge of Phobos interiors, and therefore its origin. These observations are part of the ongoing efforts of our group to establish and improve the Planetary Radio Interferometry and Doppler Experiment (PRIDE). PRIDE is a selected experiment of the JUpiter ICy moons Explorer (JUICE), the forthcoming ESA's flagship mission to the Jupiter system. We will describe our novel approach to spacecraft observations and data processing using Doppler data and phase -referenced VLBI spacecraft tracking. With this technique we can reach mHz precision for radial Doppler estimates, and sub-nanoradian precision for lateral position measurements.

ASTROMETRY OF THE GALACTIC MIRAS AND LPVS WITH A JAPANESE VLBI ARRAY "VERA"

Akiharu Nakagawa[1], T. Kurayama[2] and VERA Project[3]

[1]*Kagoshima University, Japan*
[2]*Teikyo University of Science, Japan*
[3]*National Astronomical Observatory of Japan, Japan*

Long Period Variables with pulsation period of several hundreds to thousands days are important sources to understand chemical enrichment of the universe. And also, it should be emphasized that they offer an important distance indicator known as the period-luminosity relation (PLR). We will introduce our ongoing program to measure distances of the Galactic Miras in order to calibrate the PLR of the sources in our own Galaxy. Current results of the PLR applied for the Miras with period of about 300 days will be presented. An extension of the relation to the period > 1000 days will also be discussed.

MULTIVIEW – A PILOT STUDY FOR PRECISE VLBI ASTROMETRY AT LOW FREQUENCIES USING MULTIPLE CALIBRATORS

Gabor Orosz[1], M. Rioja, R. Dodson, H. Imai and S. Frey

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[2]*International Centre for Radio Astronomy Research / University of Western Australia, Australia*
[3]*FÖMI Satellite Geodetic Observatory, Hungary*

Traditionally, VLBI astrometry is achieved by phase-referencing observations using a close-by calibrator, where the errors are dominated by the target-calibrator separation. However, at low VLBI frequencies the slowly changing spatial variations in the dominant ionospheric contribution greatly degrade the accuracy of traditional phase-referencing, making sub-milliarcsecond level astrometry difficult to achieve. One can try to circumvent this issue by using a very close "in-beam" calibrator, but the availability of suitable

calibrators can be limited or calibrators further away may be preferred (e.g. for sources towards the Galactic center). A proposed alternative approach, termed MultiView, is to use multiple calibrators around the target up to several degrees away. MultiView allows to interpolate the calibrator phase solutions to the line-of-sight of the target, thus solving for the dominant ionospheric error terms. We demonstrate this method by presenting our pilot results from L-band VLBA observations, where we achieved 0.1 mas level astrometric reproducibility on a continuum source. The presented technique is equally applicable to all VLBI arrays. We also tested the performance of in-beam and MultiView phase-referencing using OH masers. We show our scientific results, including two new OH maser parallaxes, and mention future MultiView projects with the VLBA, LBA and EVN.

43 GHZ HIGH-PRECISION WIDE-ANGLE VLBI ASTROMETRY OF THE COMPLETE S5 POLAR CAP SAMPLE AT THE TECHNICAL LIMIT

Fran Abellan[1], I. Marti-Vidal[2], J. Marcaide[1] and J. Carlos Guirado[1]

[1]*University of Valencia, Spain*
[2]*Onsala Space Observatory, Sweden*

Minute motions of the cores of radio quasars and BL Lac objects and the chromatic dependence of the positions of those cores (the so-called core-shift) can be studied by means of VLBI and phase delay astrometry. We report on the results of 14.4/43.1GHz VLBA observations of the complete S5 polar cap sample carried out in 2010 compared to observations made in 2000. The successful 43 GHz observations, globally phase-delay connected for the first time, mark the state-of-the-art of the technique and probably its limit.

SESSION 3: VLBI Technology

QUASAR/IAA HIGHLIGHTS

Alexander Ipatov[1] et al.

[1]*Institute of Applied Astronomy, Russia*

This report presents an overview of the structure of the IAA RAS and the main directions of scientific activity of the Institute. Development of the "Quasar" VLBI Network over the past two years will be presented. The Network is equipped with the radio telescopes of new generation and modern receiving, registering and data transmission systems to transfer large amounts of data by fiber optic links to the data center of the Russian Academy of Sciences in St. Petersburg. This work opens up the prospect of research on the astrometric and astrophysical programs as part of international VLBI Networks of new generation. This

was confirmed by the result of a joint experiment with Spanish colleagues. Opportunities of the "Quasar" Network in the area of VLBI observations on scientific programs carried out in cooperation with EVN have been expanded. Considerable attention was paid to the performance of RT-32 radiotelescopes equipment. The results of joint observations with the EVN during the reporting period will be summarized and proposed promising options of the future research directions.

BRAND - A VLBI RECEIVER TO COVER THE BAND FROM 1.5 GHZ TO 15 GHZ

Walter Alef[1], G. Tuccari[2], M. Wunderlich[2], M. Lindqvist[3] and F. Colomer[4]

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[2]*INAF-Noto, Italy*
[3]*Onsala Space Observatory, Sweden*
[4]*Observatorio Astronómico Nacional, Spain*

For the RadioNet4 proposal we put forward a Joint Research Activity to develop a true wide-band VLBI receiver for the European VLBI Netword (EVN). The receiver will have a single wide-band feed and amplifier. The analogue signal will not be mixed, but sampled directly for further processing. We will present the project together with some of the science drivers.

REAL-TIME E-VLBI IN THE EVN AND SOFTWARE CORRELATION AT JIVE

Bob Campbell[1], A. Szomoru[1] and A. Keimpema[1]

[1]*Joint Institute for VLBI ERIC*

Real-time e-VLBI forms an integral element of the EVN, accounting for about a quarter of all EVN hours and providing unique rapid-response capabilities to transient events as well as the opportunity for higher-cadence observations compared to the standard EVN sessions. The classes of e-EVN proposals has grown to include two new types of triggered observations: "generic" triggers and "automatic" triggers. e-EVN observations can also now be recorded at JIVE while correlating real-time, enabling multiple correlation passes. The EVN software correlator at JIVE (SFXC) has removed the physical limitations to number of stations, the channel and total bit-rate, and the number of frequency points. It also now permits a choice of spectral-windowing function and can correlate observations containing a mixed number of channels, mixed channel bandwidths, and mis-matched subbands. The new astronomical areas opened up by SFXC capabilities in pulsar gating/binning, multiple phase-center output, and phased-up mode have received growing attention from EVN projects. We will review the recent developments in these areas, highlighting their direct impact on your science and how you can best take advantage of them.

TECHNICAL STATUS AND DEVELOPMENTS AT THE EVN (INVITED)

Pablo de Vicente[1] and A. Szomoru[2]

[1]*Observatorio de Yebes, Spain*
[2]*Joint Institute for VLBI ERIC*

An overview of the operations and technical developments at the EVN will be presented. Special emphasis will be on technical developments in the last 2 years, including 2 Gbps recording in DDC mode, 2 Gbps recording in VDIF format supported by the FS for Mark5C, Mark6 and Flexbuff, the works to get PFB mode and 2 Gbps e-VLBI. These developments are the result of collaboration works from different parties in the EVN, JIVE and NVI Inc.

THE COURSE OF THE EVN (INVITED)

Huib van Langevelde[1]

[1]*Joint Institute for VLBI ERIC*

In this talk the EVN strategy and science case will be reviewed, in particular, the progress since the adoption of EVN2015 in 2007. The EVN consortium board of directors have agreed that it is time to produce a new science case and derive a strategy based on it. This process will be undertaken in consultation with the user community. With the start of a number of EC projects in 2016 there will be an opportunity to upgrade various aspects of the EVN. In the presentation a number of (possible) developments will be discussed.

SESSION 4: Starbursts and Extragalactic Masers

STAR-FORMATION ACROSS COSMIC TIME (INVITED)

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The e-MERGE survey is an ambitious multi-tiered legacy survey to exploit the unique combination of very high sensitivity and spatial resolution to study the formation and evolution of star-forming galaxies and AGN out to redshifts of z~5. The observations will provide a powerful, obscuration-independent tool for measuring the massive star formation and AGN activity in high-redshift galaxies, hence tracing the development of the stellar populations and the black hole growth in the first massive galaxies. With a resolution of 50-200 mas in C- and L-Bands, corresponding to ~0.5-1.5kpc at z ~1, e-MERLIN

gives us our first truly reliable view of the distribution of star-formation within typical galaxies at the epoch where the bulk of the stars in the present-day Universe were being formed. High angular resolution imaging of the distant radio source population with the EVN and e-MERLIN is able to separate radio emission from AGN and star-forming regions. Thus in the deep e-MERGE Tier 1 observations of a 30 arcminute field centred on GOODS-N, combination EVN+e-MERLIN+JVLA imaging will disentangle the relative contributions of AGN and star-formation - an essential step given the apparently simultaneous growth of the black holes and stellar populations in galaxies. With the central region of the Tier 1 field ultimately reaching sub-μJy noise levels, e-MERGE will image several thousand star-forming galaxies, and statistically characterize the nature of the sub-μJy radio population - which are the target objects for the SKA. Initial results from e-MERLIN, JVLA, and EVN on the e-MERGE Tier 1 region are presented here, demonstrating how high resolution images can separate regions of star-formation and AGN activity in the differing μJy radio source populations, together with showing the angular size distributions for each source type for an interim sample of 248 sources within the central part of GOODS-N.

VLBI TOMOGRAPHY OF MOLECULAR CLOUDS AT HALF THE AGE OF THE UNIVERSE

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We report on our recent mm-VLBI observations (at 96GHz) of the HCO+ 2-1 line (178 GHz restframe) in the molecular absorber towards the gravitational lens PKS1830-211, as well as new ALMA observations covering a wide range of mm/submm wavelengths. We discuss about the possibility of spatially resolving the velocity sctructure of the molecular cloud(s) in this source using mm-VLBI. These results have important implications in the study of star formation across cosmic time, but may also challenge several cosmological studies that have been performed so far using this source (e.g., test of variations in Fundamental Constants of Physics), since essential assumptions (co-spatiallity for the different chemical species) may not hold, based on our findings.

THE NATURE OF THE EXTREMELY ENERGETIC EVENT IN THE NUCLEUS OF ARP 299B1 UNVEILED BY EVN AND NEAR-IR OBSERVATIONS

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In luminous and ultraluminous infrared galaxies (U/LIRGs), the infall of gas into the central regions strongly enhances the star formation rate (SFR), especially within the extremely dense, nuclear (<500 pc) regions, which have also very large amounts of interstellar dust.

Within these regions, SFRs range from a few tens to a few hundreds of solar masses per year, corresponding to core-collapse supernova (SN) rates up to 1-2 SNe/yr/galaxy. However, these dusty buried SNe go unnoticed at optical wavelengths. Here, we present an extensive monitoring of the nucleus Arp 299B1 in the radio (EVN, VLA and VLBA) and the near-IR (Gemini, VLT), which are essentially free from the effects of dust extinction. Our observations show unambiguous evidence for an extremely energetic transient buried deep in the nucleus B1 of Arp 299, a merging system of two galaxies that hosts one of the most prolific supernova factories in the local Universe. We discuss three plausible scenarios for this extraordinary burst: an AGN-driven event, a tidal disruption event (TDE), and a superluminous supernova (SLSN). Our extensive multi-wavelength observations show that this transient rivals the most energetic known stellar explosions and is most likely explained by a SLSN that occurred within the dense and dusty nuclear environment. There, most of its kinetic energy was initially converted into ultraviolet and optical radiation by interaction with the dense environment, and then absorbed and re-radiated at infrared wavelengths by large amounts of dust within the nuclear regions. The radiated energy is larger than 10^{52} ergs over a timespan of about 10 yr. Such energetic transients, if ubiquitous in the dense nuclear regions of starburst galaxies, will provide an additional energetic input that must be accounted for in models of galaxy feedback and evolution.

IC 883 AND PGC 043234: THE STORIES OF STEADY AND INTERMITTENT ACCRETION ONTO A SMBH

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It is well established that the merger among gas-rich galaxies can trigger both starbursts and the onset of an active galactic nucleus (AGN). In this talk I will present results on EVN observations toward IC 883 and PGC 043234, both host of a low-luminosity AGN (LLAGN) and both being mergers although at different stages in their evolution. IC 883 is an advanced merger in which the star formation dominates the global energetics of the system. However, our observations show that the nuclear region is dominated by a LLAGN that has a core-jet morphology. The core has a very inverted spectrum and a low frequency turnover at ~4.3 GHz, indicating this is a young source (~3E+03 yr). PGC 043234 is a post-starburst galaxy which seems to be the remnant of a merger and has a negligible star formation. This system recently hosted the tidal disruption event (TDE) ASASSN-14li. Our EVN observations have allowed us to resolve the system into two components ~2pc apart. The components resemble a core-jet/outflow system, whose jet can be related directly to ASASSN-14li, if its motion is superluminal, or a past AGN flare or TDE if its motion is subluminal. The exciting possibility exists that both components are instead a binary BH system. We discuss briefly whether there could be a connection among IC 883-like systems

with an active but radiatively inefficient AGN, and PGC 043234-like systems with an inactive AGN that has large radiative losses and it is only fed in an intermittent fashion.

VLBI IMAGING OF THE STARBURST GALAXY ARP 220 AT MHZ AND GHZ FREQUENCIES

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I will present new global VLBI observations of over 80 compact objects in the starburst galaxy Arp 220. Most objects are thought to be luminous supernovae and supernova remnants, tracing the extreme star formation in the two nuclei of this merging galaxy. By using the exquisite resolution available with global VLBI we can study the evolution of source luminosity and size over time. By a self-consistent analysis of 17 years of data we improve the understanding of the compact sources and the extreme environment in Arp 220. In addition, I will present results of international LOFAR observations of Arp 220, achieving subarcsecond resolution at 150MHz. By resolving the galaxy at these low frequencies we can study the effect of free-free emission in the nuclei and look for unknown steep-spectrum components.

VLBI SURVEY OF NEARBY INFRA-RED LUMINOUS GALAXIES

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A sample of 1321 galaxies at distances up to 200 Mpc that are brighter than 12.25 magnitude in the Two Micron All Sky Survey and exhibit radio emission stronger than 50 mJy at wavelength 21 cm have been observed with VLBI at 8-9 GHz. Of them, one half has been detected. The project has to major goals: 1) to find the galaxies with supermassive black holes, which position are determined with VLBI, that have a significant offset with respect to the center of mass traced by their IR emission; 2) to perform population analysis of a large sample of galaxies with strong non-thermal emission. We will show results of this project.

SESSION 5: VLBI Arrays

KAVA STANDS FOR KVN AND VERA ARRAY WHICH IS A KOREAN-JAPANESE JOINT VLBI FACILITY

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Here we briefly present the imaging capabilities of KaVA array which actually achieves more than three times better dynamic range than that achieved by VERA or KVN alone. The KaVA images clearly show detailed structures of extended radio jets in AGNs. With the improved imaging capabilities, we proposed the KaVA AGN Large Program. We launched the intensive monitoring observations of two super-massive black holes, Sgr A* and M87. The main scientific goals of the program are (i) testing magnetically-driven-jet paradigm by mapping velocity fields of the M87 jet and (ii) obtaining tight constraints on physical properties of radio emitting region in Sgr A*.

A COMPACT TRIPLE BANDS RECEIVER SYSTEM FOR MILLIMETER-WAVE VLBI OBSERVATIONS

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A receiver optics designed for KVN (Korean VLBI Network) has been conducting simultaneous millimeter-wave VLBI observations at frequencies of 22 GHz, 43 GHz, 86 GHz and 130GHz. This system was constructed using individual receivers in separate dewars. This results in a large optical bench measuring 2600 mm x 2300 mm x 60 mm. Even though the receiver system has performed well by using a unique phase referencing technique to compensate phase fluctuations due to atmosphere, such a large optical bench is inconvenient. Transportation, installation, individual beam alignment for each beam axis is difficult. In order to solve these problems, and integrated quasi-optical circuit using a compact triple band receiver in single dewar is purposed. The recommended frequency bands of the compact triple band receiver are K (18~26 GHz)-band, Q (35~50 GHz)-band, W (85~115 GHz)-band. We will present the design detail of the quasi-optical circuit and the triple bands receiver optimized for simultaneous observations. In addition, we will present the results.

PREPARING FOR THE AFRICAN VLBI NETWORK

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Within the next couple of years, radio telescopes in a number of African countries will become ready for astronomical observing, followed by use in VLBI. DARA (Development for Africa with Radio Astronomy) is a skills exchange program in preparation for the African VLBI Network. Groups of ten students/early-career engineers and astronomers participate in lectures and practical training, including data reduction. In order to facilitate this we wrote EVN data reduction scripts in CASA; for well-behaved C-band data this works well but revealed some issues. (In this instance, full fringe-fitting is not needed, but will be at shorter and longer wavelengths, and a CASA task is being developed in a separate initiative between JIVE and NRAO). An online simulator for the EVN and AVN is also being developed (based on the ALMA OST), along with more flexible simulation inside CASA. We demonstrate the software, comment on the lessons learnt and outline the uses of these tools in expanding the skills of future VLBI staff and users.

SESSION 6: Stellar Evolution and Stellar Masers

REVIEW OF MASER SCIENCE (INVITED)

Francisco Colomer[1] and Valentin Bujarrabal[1]

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VLBI observations of maser emission are a basic tool to study the circumstellar envelopes (CSEs) around evolved stars, mainly around AGB and post-AGB stars. The maser lines of silicon monoxide are particularly intense. They provide us with high spatial resolution data on the very inner CSEs around AGB stars, including the pulsating layers previous to grain formation. The analysis of the pumping mechanism of SiO masers and of the physical conditions in the emitting clumps requires accurate maps of the various lines, which show different excitation requirements. A large observational effort is being done to obtain (quasi-)simultaneous multiline data at the highest spatial resolution, using VLBI techniques, which makes possible to compare the relative distribution of the maser lines. However,

VLBI baselines often miss a large fraction (up to 90%) of the total maser flux. A pilot project with the GMVA is being conducted to understand this effect.

SIMULTANEOUS OBSERVATIONS OF THE H2O AND SIO MASERS TOWARD THE LATE-TYPE STARS USING KVN

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We present the results of the simultaneous observations of the H2O and SiO masers emitted from the circumstellar envelopes (CSEs) of the late-type stars. These observations have been carried out simultaneously at four frequency-bands (K, Q, W and D bands) towards 16 target sources using KVN since August 2014. In order to find out the spatial distributions of the H2O and SiO masers around the late-type stars, we use the source frequency phase referencing (SFPR) method in our study, which can give us the astrometric information's of the maser sources. The relative spatial distributions between the H2O and SiO masers are precisely determined from the SFPR method, which are crucial to investigate the physical links between the inner and outer parts of the CSEs of the late-type stars. The 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 environments of the CSEs of the late-type stars along the stellar phase. From our results, the simultaneous multi-band observation of KVN is proved to be powerful to investigate the characteristics of the evolutionary process of the late-type stars relating to the maser pumping mechanism.

SIO MASER MOVIES: THE RE-MAKE

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A new model of SiO maser emission in long-period variable stars is presented. The model is based upon CODEX hydrodynamic solutions for the physical conditions and considers the three most common isotopomers of SiO with full radiative line overlap included. We present theoretical counterparts to VLBI maps in up to 120 lines, and simulated spectra from the same data.

FROM OBSERVATION TO SIMULATION: UNDERSTANDING SURPRISING EVOLUTIONS IN NOVA EJECTA

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A classical nova occurs when a white dwarf (WD) in an interacting binary undergoes a thermonuclear runaway (TNR) on its surface, leading to a large expulsion of material into the interstellar medium, as well as a dramatic optical brightening. Simple isothermal, spherically symmetric, homogeneous models for thermal radio emission from novae predict a light curve which brightens as t^2 (while the ejected shell is optically thick) and then declines as t^{-3} (once it becomes optically thin). Recent observations of novae indicate that these models are flawed. For example, e-MERLIN, VLBI and VLA observations of Nova Mon 2012 have shown a complex, aspherical ejecta which evolves over time, whilst other studies have shown light curves which evolve in a non-standard manner. In this talk we present new modeling of the radio emission from a variety of hypothesized ejecta structures. These models allow improved estimation of mass loss rate, which in turn tell us more about the mechanisms whereby the mass is lost, and allow us to investigate classical novae as possible Type 1A supernova progenitors. Developing an understanding of the geometry and possible collimation of the ejecta may also have implications for the study of particle acceleration in radio novae and similar systems.

E-EVN OBSERVATIONS OF AM HERCULIUS

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AM Her is the prototype of the class of magnetic cataclysmic variables called Polars. In these systems, a white dwarf primary magnetic field is strong enough to synchronize the rotation of the primary with the binary orbit and dominates the accretion flow near the primary star. The transferred material is channeled via the magnetic lines of the primary to one or two accretion spots located above the magnetic poles of the white dwarf. We conducted an astrometric survey of AM Her with the e-EVN at 5GHz in 2013. We were able to detect the AM Her quiescent radio emission in the range 0.18-0.37 mJy. Our new parallax measurement leads to the distance of 88.5+/-1.3 pc. We also present evidence that the AM Her quiescent radio flux is modulated with orbital phase of the system with two minima detected. We suggest that an emission mechanism similar to proposed for RS CVn binary systems could explain observed properties of the AM Her ;phased radio light curve. In this picture both components are magnetically active and the quiescent radio emission distinguish this kind of systems from other Polars.

COMPACT STRUCTURES IN COSMIC MASERS: AN OVERVIEW OF THE CURRENT RESULTS OF RADIOASTRON MASER SURVEY

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Maser sources represent one of the main targets of the RadioAstron science program along with active galactic nuclei and pulsars. The RadioAstron project facilitates observations of water vapor (H2O) maser sources at 22.235 GHz and of hydroxyl (OH) sources at 1665 and 1667 MHz with an ultimate angular resolution of tens of micro-arcseconds. We present the results of the maser survey during the first 3.5 years of RadioAstron operation. Very compact features with angular sizes less than about 20 – 60 micro-arcseconds have been detected in a number of star-forming regions. A first analysis will be presented of the stringent size limits of the most compact maser spots and their brightness temperatures, of the nature of the masering features, and of the implications for the maser formation mechanisms.

BOWSHOCKS AND NON-LINEAR MOTIONS SEEN IN THE H2O MASERS OF AFGL 5142

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In this contribution we present new VLBI observations of 22 GHz H2O masers in the well-known massive star forming region, AFGL 5142. The masers exhibit prototypical well-defined symmetric bowshocks about a central driving source, revealing episodic ejection is at play. One water maser located close to the central accreting star shows clear non-linear motion and may be the first known case of water masers associated with the accretion disk. These phenomena (episodic ejection and disk accretion) reveal the details of the evolution of AFGL 5142 and highlight a parallel in the processes of low- and high-mass star formation.

PROPERTIES OF METHANOL MASER CLOUDS FROM EVN OBSERVATIONS

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A sample of more than 60 high-mass young stellar object candidates was studied in the 6.7 GHz methanol maser line using the European VLBI Network in the period of 2003-2010. The resulted database of images with the milliarcsecond resolution and a few mJy sensitivity was previously used to search for the origin of methanol maser emission (Bartkiewicz et al. 2009, 2014, 2016). Here we report preliminary results of statistical investigations on the maser cloud properties relevant to understanding maser beaming. One of the interesting results is identification of 6.7 GHz features which might be interpreted as amplification-bounded masers.

EMISSION OF EXOPLANETS IN THE GHZ RANGE

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We will demonstrate how to estimate possible radio emission of massive exoplanets and brown dwarfs. We assume that such radiation originates in processes similar to those observed in the Jupiter system. Therefore, we analyze two possible mechanisms. The first process assumes interaction between the stellar wind and the planetary magnetosphere. The second mechanism needs a moon orbiting close to the planet and is similar to the Jupiter-Io interaction. We will show that the emission of exoplanets and brown dwarfs, in young systems (age < 0.5 Gyr) can be observed even at GHz frequencies. Therefore, VLBI networks could possibly detect such radiation. Moreover, an excellent angular resolution of VLBI should also allow to observe orbital motions in nearby (distance < 50 pc) systems.

SESSION 7: Transients

THE SLOW AND THE FAST: TRANSIENTS WITH THE E-EVN (INVITED)

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The transient sky at high frequencies is dominated by synchrotron sources that vary on timescales of >> seconds to days and years. There is a range of phenomena where VLBI observations can provide a detailed view of expansion and/or proper-motion of (relativistic) synchrotron ejecta, to constrain emission mechanisms and probe the

surrounding interstellar medium. These include novae, supernovae, gamma-ray bursts, jets from X-ray binaries and tidal disruption events etc. The e-EVN observations are especially valuable when they are part of multi-instrument/multi-band campaigns - examples of recent results will be shown. A relatively unexplored area - at least for VLBI - is the detection and localization of very short timescale (<<1s) coherent pulses for example from rotating radio transients (RRAT), and fast radio bursts (FRB). This is a developing field where the e-EVN can potentially make a great impact. I will show some initial results on localizing fast transients with milliarcsecond resolution.

DISCOVERY OF AN EXTREMELY COMPACT AND STEADY JET IN THE TIDAL DISRUPTION EVENT SWIFT J1644+5734

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The first-known tidal disruption event (TDE) with strong evidence for a relativistic jet is Swift J1644+5734. In order to directly verify the existence of the radio jet, we carried out very long baseline interferometry (VLBI) observations with the European VLBI network (EVN) at 5 GHz. With respect to a sub-mJy in-beam reference source, we have achieved a statistical astrometric precision about 12 μas (68% confidence level) per epoch. This is one of the best phase-referencing measurements available to date. We found that the new-born jet was quite compact with an apparent average ejection speed of <= 0.3c between 2012.2 and 2015.2. This steady jet is a direct observational evidence for either a very small viewing angle or a strong jet deceleration due to interactions with a dense circum-nuclear medium, in agreement with some recent theoretical studies.

IS FRB 150418 LOCALIZED IN WISE J0716-19? CLUES FROM EVN OBSERVATIONS

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Fast Radio Bursts (FRBs) are transient sources characterized by exhibiting a strong single short pulse (with a duration of milliseconds or submilliseconds). They were firstly discovered by Lorimer et al. (2007), and nowadays tens of these events have been observed. Its origin remains unknown. Both Galactic and extragalactic origins have been proposed. The observed pulses resemble the pulsar ones, and thus preferring a Galactic origin. However, the large dispersion measure observed in the pulses indicates an extragalactic origin. Many scenarios have been proposed up to now to explain the FRBs, most of them based on cataclysmic events. However, the identification of the first repeating FRB (Spitler et al. 2016) indicates that could there be, at least, two different scenarios. Keane et al. (2016) reported for the first time the localization of an FRB. A

transient source coincident with the galaxy WISE J0716-1900 was observed right after the detection of FRB 150418 in the same field of view. This association would confirm the extragalactic origin of the FRBs. However, these results have been widely discussed during the last months. Here we present a monitoring of the associated galaxy, WISE J0716−1900, with the European VLBI Network (EVN). Our data show a compact radio emission persistent on day/week timescales one year after the observed FRB. This behavior perfectly fits to the expected emission of a regular active galactic nuclei (AGN), and thus hardly to be associated with FRB 150418. A comparison with VLA data would point out that the radio source exhibits variability on hour timescales, probably due to refractive scintillation.

Session 8: AGN Astrophysical Processes

SPACE-VLBI OBSERVATIONS OF NEARBY RADIO GALAXIES WITH RADIOASTRON (INVITED)

Tuomas Savolainen[1] on behalf of the RadioAstron Nearby AGN Key Science Program

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RadioAstron Nearby AGN Key Science Program aims at using the ultra high angular resolution radio observations provided by the space-VLBI mission RadioAstron to study the structure of the acceleration and collimation zone of the radio jets in nearby active galactic nuclei. Within this program we have successfully obtained near-perigee space-VLBI images of the jets in radio galaxies 3C84 and M87. Fringe detections up to 7.6 Earth diameter baseline lengths on 3C84 provide information on the structures down to scales of 27 microarcseconds at 22 GHz and the corresponding image reveals the jet collimation profile that is markedly different from the one observed earlier in M87. Space fringes up to 5 Earth diameter baseline lengths were detected for M87 at 1.6 GHz. This, together with excellent (u,v) coverage, allows us to study the internal structure of the M87 jet from the core all the way up to ~450 mas. The image reveals that helical filaments, which are seen in arcsecond scale in the VLA images, are already present in the milliarcsecond scale.

A NEW VIEW ON M87

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The nearby and giant radio galaxy M87 is well known for being the best candidate for imaging the deepest part of the jet base and thus being the best laboratory for investigating relativistic jets. Proper motion VLBI measurements of jet knots for M87, that would help to discriminate between different jet models, so far have been contradictory. We re-analyzed 31 epochs from the MOJAVE-survey observations, obtained at 15 GHz with the VLBA. We investigated in detail the pc-jet evolution over 16 years in time and discuss the implications for our understanding of the physics of the M87-jet.

MM-VLBI STUDIES OF NGC1052

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The LINER galaxy NGC1052 is an exceptional case of AGN, showing a double-sided jet system at cm and mm radio wavelengths. Owing to its close distance of about 20 Mpc it is an ideal target to study the inner regions around the central engine at scales of light days to weeks. Millimeter-wavelength observations peer through the free-free absorbing torus, that blocks our view onto the western jet base at cm-wavelength. At 86 GHz the source shows one central feature containing nearly 70 percent of the total flux density and two faint jets. We present a spectral analysis between 22GHz and 43GHz from quasi-simultaneous observations over 4 years, and a detailed kinematic study of the 43 GHz observations, revealing asymmetries in the double-sided jet system.

THE DISK-DRIVEN JET OF CYGNUS A

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In this talk, recent results from Global VLBI observations at 3 and 7 millimeters of the radio galaxy Cygnus A will be presented. At the source redshift (z=0.056), these allow an angular resolution down to 200 Schwarzschild radii to be achieved, and an extremely detailed view of the two-sided jet base on sub-parsec scales. We inferred that the emission in this object is produced by a mildly relativistic, parabolically expanding disk-wind, which is also prominently stratified in the transverse direction. Results are compatible with the expectations for a magnetically-driven jet with spine-sheath structure.

FOLLOWING THE FLARE OF PKS 1502+106 WITH MM-VLBI IMAGING AND LIGHT CURVE MODELLING

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Energetic outbursts are powerful probes of the extreme physics in blazar jets. A very prominent one was seen by Fermi originating from the blazar PKS 1502+106 (z ~ 1.835). Here, we present the findings of our triggered multi-frequency VLBI (including GMVA up to 86 GHz) and single-dish follow-up (F-GAMMA 2–142 GHz monitoring) of the event. mm-VLBI observations reveal the intimate connection between the structural evolution of the parsec-scale jet and the total flux density variability. We quantify the radio flare, by employing both a Gaussian process regression – an advanced machine learning method – and a discrete cross-correlation function analysis. Through the cross-band delays we obtain a nuclear opacity profile and a magnetic field tomography of the jet. Additionally we accurately localize the gamma-ray emission site and explore the mechanism responsible for the flare.

ULTRA-HIGH RESOLUTION STUDY OF THE INNERMOST JET OF M87 WITH MM-VLBI

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M87 is the closest FR I radio galaxy with a black hole mass of (3-6) billion solar masses. The mass to distance ratio makes M87 the best target to study jet launching and collimation. High spatial resolution imaging with the Global millimeter VLBI Array (GMVA) at 3mm resolves the inner jet region and shows a complex filamentary fine-scale structure at a spatial resolution of only ~6 Schwarzschild-radii. Here we present new results from a GMVA observation of M87 performed in May 2015. Owing to the addition of the sensitive mm-VLBI telescopes, including both IRAM telescopes and the GBT, the observation reveals many new details of the complex jet and core morphology. In our data analysis we compare the results to earlier epochs from previous GMVA sessions. The observed basic source structure appears to remain similar over several years, which is also supported by alternative imaging techniques such as MEM. We discuss our results in the context of the ongoing research on this source.

COMPREHENSIVE STUDY OF A GAMMA-RAY TO RADIO CONNECTION IN 3C273

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In late 2009 quasar 3C273 experienced a series of strong gamma-ray flares which triggered our 6 cm - 7 mm VLBA follow up observations. We added to our 4 multifrequency epochs four years of 7 mm data in order to trace kinematics of newborn components. The connection between gamma-ray and mm-wavelength variability is complex in 3C273 and there is no one-to-one correspondence in the lightcurves. If one connects the most prominent peaks in gamma-ray and in 7 mm VLBI core lightcurves, the latter lags the former by ~118 days. This would imply that the site of gamma-ray emission is located several parsecs upstream of the apparent jet base at 7 mm, close to the apex of the jet. This would be consistent with the distance from jet apex to the 7 mm core derived from the core shift analysis and supported by small time scale variability of gamma-ray emission and absence of gamma-ray photons above 15 GeV. We found several components ejected during the active gamma-ray state and tie up one of them with the major gamma-ray flare. Detailed analysis of kinematic data revealed that VLBI core position changes over time and is correlated with its flux. We analyzed frequency dependent core position to derive value of the magnetic field of the 7 mm VLBI core which turned out to be almost invariable over the 5 month period. Therefore we attributed the rising flux density mostly to injection of new energetic particles. We scrutinized distribution of the two-frequency spectral index along the jet direction in the core region and found that the transition zone from optically thick to optically thin emission could be reliably resolved with VLBA observations.

ANATOMY OF THE HORIZON-SCALE STRUCTURE OF SAGITTARIUS A* WITH A RESOLUTION OF ~3 SCHWARZSCHILD RADII

Rusen Lu[1] and the EHT Collaboration

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Significant progress in millimeter VLBI has recently been made with the Event Horizon Telescope project, which aims to resolve strong field General Relativistic (GR) signatures in nearby supermassive black holes (in particular Sgr A⋆ and M 87). Adding APEX to the inner American array now allows to image the Galactic center (Sgr A⋆) with a resolution of ~3 Schwarzschild radii. Strong evidence is found for a non-pointlike non-Gaussian brightness distribution, which will be discussed in this talk. With the expected improvement in the array performance, future observations could lead to direct detection of strong GR signatures, e.g., the black hole shadow.

MULTI-FREQUENCY VLBI AND SINGLE-DISH OBSERVATIONS OF THE EXTREMELY VARIABLE TEV ACTIVE GALAXY IC 310

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The Perseus cluster hosts a highly variable TeV gamma-ray emitter at a distance of only 82 Mpc, the active galaxy IC 310. Its extreme variability at very high energies challenges conventional gamma-ray emission mechanisms. We performed the first quasi-simultaneous multi-frequency VLBI observations of IC 310 with the EVN. We discuss these observations in the context of VLBA monitoring by the MOJAVE programme and single-dish flux density measurements with the Effelsberg and OVRO telescopes. The parsec-scale morphology is consistent with a single-sided jet as is found in blazars. We observe sub-luminal motion of the jet that implies Doppler factors smaller than about 3 and a lack of strong flux density variability, both of which cannot account for the TeV variability. We estimate magnetic fields of above 10^3 G in the vicinity of the central supermassive black hole based on core shift measurements.

RADIOASTRON IMAGING OF COMPACT JETS: OBSERVATIONS OF THE JET IN 0836+710

Laura Vega García[1], A. Lobanov[1, 2], M. Perucho[3] on behalf of the RadioAstron KSP "Structure and Physics of Compact Jets in AGN"

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Space VLBI observations with RadioAstron provide a remarkable improvement of angular resolution. The RadioAstron Key Science Program "Structure and Physics of Compact Jets in AGN" exploits this opportunity by detailed, multifrequency imaging of a number of selected extragalactic radio sources. In this talk, we present the results obtained from the KSP observations of the relativistic jet in the quasar 0836+710 at 1.6, 5, and 22 GHz. The space-VLBI images of the jet reveal a strongly transversely resolved flow with a wealth of structure on scales ranging from 0.2 to 150 milliarcseconds. The superb resolution

obtained with RadioAstron enables a detailed study of plasma instability in the flow. First results from modelling the development and evolution of plasma instability in the jet will be discussed, based on the analysis of jet ridge lines obtained from the images of 0836+710.

THE ORIGIN OF THE OFF-AXIS JET COMPONENT IN MRK 501 WITH VLBI ASTROMETRY

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Recent mm-VLBI observations reveal the existence of „off-axis jet components" in blazars in which a large misalignment (~90deg) is observed between a persistent jet axis and the position angle of a newly born component. Koyama et al. (2016) discovered such an off-axis component at the North-East direction from the radio core of Mrk 501, as opposed to the persistent South-East jet. Kinematics and physical properties could not be determined in this study. Now we present the complete astrometric analysis of these 6 epochs, registered with the VLBA at 43 GHz during 2012-2013. This new phase-referencing analysis yields the precise location of the radio core with an accuracy of up to ~40 microarcseconds. We find that the radio core position did not move significantly with respect to distant reference sources within a 200-microarcsecond diameter region. We also derived the evolution of the precise location of the off-axis component after combining the original self-calibrated images and the new phase-referencing results. The precise location of this component does not show a clear trend, it is apparently distributed randomly in space, North-East to the core region. We discuss the origin of the off-axis jet component as well.

MULTI FACE UNITY

Leonid Matveyenko[1]

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The studying of fine structure of a number star formation regions and galaxy nucleus had been. The structure and kinematics of its different objects corresponds to whirlwind. Instability of a moving matter leads to a turbulence – formation of whirlwind. The matter is moving to "disk" and flowing along helix trajectory to a center. Excess angular momentum

carried away in process of accumulation by the bipolar rotating coaxial flower. Surplus matter is fall to the central massive body. The body gravity are stabilized and accelerated formation of the system. Interaction with surrounding matter is accelerated and collimated the outflow. The current and magnetic field are generating in conducting medium - plasma extra stabilized and accelerated formation of the system. The jet - counter jet are equivalent, but moving along and opposite the magnetic field that accelerated jet.

POSTERS

THE MOST COMPACT H2O MASER SPOTS AND THEIR LOCATIONS IN W3 IRS5

Alexey Alakoz[1], H. Imai[2], A. Sobolev[3], J. Moran[4] et al.

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The RadioAstron mission has succeeded in detection of Galactic and extragalactic H2O masers in its ultimate angular resolution finer than 100 microarcseconds. The maser emission in extreme physical conditions will be explored in further image synthesis and astrometry. Here we present the H2O masers in the massive-star forming region W3 IRS5 observed with the RadioAstron and the VERA (Japanese VLBI Exploration of Radio Astrometry). The former observations yielded detections of the masers in fringe spacings up to 40 microarcseconds. The brightness temperatures of the masers may be higher than 5×1013 K. The relative positions of the detected masers has been investigated in new data of imaging observations including group-delay calibration. The latter observations yielded the precise coordinates of the detected masers in the W3 IRS5 region. They were found in the clusters of masers close to the roots of the outflow from newly-born stars, where large line-of-sight velocity gradients were found. This suggests that the extremely bright masers are formed in shock fronts of the outflow interacting with the ambient gas clouds.

DIGITAL BASE-BAND CONVERTER 3 - VLBI @ 128 GBPS

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We will present the development status of the new Digital Base-Band Converter 3 (DBBC3), the successor of the most widely adopted VLBI backend DBBC2. The DBBC3 has been

developed with support from the EU sponsored RadioNet3 program. The hardware has reached production status. The firmware and software are being ported from the DBBC2 to the DBBC3 to offer the same functions as the DBBC2. In addition new wide-band modes are available with data-rates up to 128 Gbps.

ASC CORRELATOR AND ASTRO SPACE LOCATOR SOFTWARE: DATA PROCESSING IN "RADIOASTRON" MISSION

Andrey Andrianov[1], I. Guirin[1], V. Kostenko[1], V. Zharov[1], A. Rudnitsky[1], S. Likhachev[1], V. Ladygin[1] and M. Shatskaya[1]

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The "Radioastron" space mission is the unique project of Russian Space Agency (Roscosmos) and Russian Academy of Sciences to investigate the Universe by means of VLBI implementation with "Spektr-R" space satellite. "Spektr-R" onboard 10-m radio telescope has been operating since 15 November, 2011 as the Space element of the space-ground interferometer at the orbit with its apogee up to 350000 km. The first and the basic step in VLBI data processing is correlation. Space-VLBI brings new requirements to the correlation process due to significant uncertainties in delay model for space telescope. "Radioastron" mission correlator is a part of ASL (Astro Space Locator) software package, which was developed in Astro Space Center (ASC) of Lebedev Physical Institute. In this report the main features and operational procedures of the ASC Correlator are described with the emphasis on the Space-VLBI data-processing differences compared to the ground VLBI. It includes a time delay and its derivatives calculation algorithm and the procedure of correction for these parameters. This approach is critical for the correlation of space-ground interferometer data. In this report we also show the importance of the orbit accuracy and correlator requirements for the future Space-VLBI missions, such as the "Millimetron" project. Also, we describe the main features of ASL Software package, which is an unique set of software instruments and tools for VLBI data reduction, calibration and VLBI imaging deconvolution.

INTERSTELLAR PLASMA SCATTERING EFFECTS STUDIED WITH RADIOASTRON

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On behalf of the Radioastron pulsar group this report presents an overview of the studies which were done with the Radioastron space radio telescope during the first five years of mission operation, including the early and key science programs. Space-VLBI observations

of pulsars with the highest angular resolution revealed the new interstellar plasma scattering effects, such as, resolving the substructure in the scattering disk. Diameters of scattering disks were measured for several pulsars and the distances to the effective scattering screens were estimated. Layers of scattering plasma were detected to be located relatively close to the Sun (10-100 pc). Such layers might be responsible for fast flux variations of compact extragalactic radio sources. A new insight on the interstellar scattering was demonstrated by study of the instantaneous visibilities which were measured with the Space-VLBI observations of giant pulses from the Crab pulsar.

DYNAMICAL MASS DETERMINATION OF THE YOUNG NEARBY SYSTEM HD 160934

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We present phase-reference EVN observations that are part of a program to study the radio emission and kinematics of a sample of stars belonging to the AB Doradus moving group. The main aim of this program is to obtain precise estimates of the dynamical mass of young, low-mass stars, which in combination with photometric measurements will provide precise benchmarks for calibrating pre-main-sequence (PMS) stellar evolutionary models. Calibration of PMS models appears essential, as they are widely used to predict the masses of low mass objects as brown dwarfs and planets. Previous studies show that model predictions are in disagreement with experimental results for masses below 1.2 solar masses. Among the stars included in our program, we emphasize the results obtained in the stellar system HD 160934 A/c.

ASTEROID SIZING BY RADIOGALAXY OCCULTATION AT 5 GHZ

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Stellar occultations by asteroids observed at visual wavelengths have been an important tool for studying the size and shape of asteroids and for revising the orbital parameters of asteroids. At radio frequencies, a shadow of an asteroid on the Earth is dominated by diffraction effects. Here, we show, that a single observation of an occultation of a compact radio source at a frequency of 5 GHz can be used to derive the effective size of the occulting object. Using the 100m Effelsberg radio telescope an occultation of a radio galaxy

by the asteroid (115) Thyra was observed and a diameter of 75 +- 6 km was derived for the asteroid. The observed occultation profile shows features that cannot be explained by diffraction of a single asteroid. Possible future applications of such observations could be accurate positions measurements of asteroids relative to radio sources which could be used for aligning the dynamical reference system of solar system objects with the kinematic reference system defined by VLBI observations of extragalactic objects. And second, we are going to investigate the feasibility of a serendipitous search for Kuiper belt objects, as has been done at optical wavelengths.

DESIGN OF A CONTROL SYSTEM TO USE TWIN RADIOTELESCOPES SIMULTANEOUSLY IN VLBI

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This poster presents the design of a control system for the twin radiotelescopes placed in the Ny-Ålesund Geodetic Observatory. This system allows using the twin radiotelescopes both simultaneously and individually. The goal of the design is to minimize the number of control devices used by the control system. To carry out this goal, the control system has been implemented by using the software programming infrastructure called ALMA Common Software (ACS) together with the software packet for synchronization of radioastronomical observations called Field System (FS). The design has been validated by testing with radiotelescopes simulators and the 40 and 13 meters radiotelescopes located in the Observatory of Yebes, IGN. As a result, the number of control devices used by the control system has been halved in VLBI observations where both radiotelescopes are used simultaneously.

OPERATING EXPERIENCE AND FUTURE PROSPECTS OF DATA TRANSFER AND RECORDING SYSTEM

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Since 2015 IAA RAS has been conducting regular observations with antennas of small diameter (RT-13). During observations data flow generated by broadband acquisition system (up to 16 Gbps), is routed to data transfer and recording system (DTRS) via optical line. DTRS then transfers the data to Correlation and Processing Center in St Petersburg. Registration and transmission take place simultaneously. This report presents: - Operating experience of DTRS during 2015-2016; - Review of high-speed data transfer protocols and

peculiarities of data transfer via public networks. One of the main principles of DTRS architecture is usage of only common hardware parts available on the market. Modern computer technologies make it possible to expand the system's capabilities. In particular, we are looking for ways to record data flow at 32 or even 64 Gbps rate.

OBSERVATIONS OF NEAR-EARTH ASTEROID 2011 UW158 USING QUASAR VLBI NETWORK

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We report results of intercontinental bistatic radar observations of near-Earth Asteroid 2011 UW158 during its close approach to the Earth in July 2015. High power continuous wave signal at a fixed 8.4 GHz frequency was transmitted to the asteroid from the 70 m antenna of the Goldstone Observatory (DSS-14) and then the echo reflected back from the target was received by the 32 m radio telescopes of Quasar VLBI network in Zelenchukskaya and Badary observatories. Analysis of the echo power spectra allowed us to estimate the size and spin period, which agrees with the photometric observations as well as obtain some information about asteroid's shape and near-surface roughness. We also reported 18 Doppler estimates and computed the heliocentric orbit of 2011 UW158.

EPISODIC EJECTION IN MASSIVE YOUNG STELLAR OBJECTS

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In this contribution we present new VLBI observations of 22 GHz H2O masers which clearly trace the bowshocks of protostellar jets in two well-known massive young stellar objects. The shapes of the bowsocks reveal that they are driven by jets rather than winds, and the multiplicity of outflow scales reveals short- and long-term episodic nature. The sources are strong centimeter continuum emitters and exhibit 6.7 GHz methanol masers (signposts of massive star formation) - thus confirming episodic jet production to be common to both low- and high-mass star formation.

LINEAR POLARIZATION OF CLASS I METHANOL MASERS IN MASSIVE STAR FORMING REGIONS

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Class I methanol masers have known as good tracers of collisions of outflows from central protostellar objects to their surrounding mediums, however, the observations of their linearly polarized emission have been very rare especially at 44 and 95 GHz. We present the results of the linear polarisation observations of methanol masers at 44 and 95 towards 39 massive star forming regions using the 21-m Korean VLBI Network (KVN) telescope in single dish mode. About 60% of the observed showed fractional polarisation of a few percents at least at one of the two transition lines. We compare the polarization properties of the two transition lines and discuss the association between the directions of polarization angles and outflows. We have also carried out the VLBI polarization observations with the KVN. We present some preliminary VLBI results of one of those targets, G10.34-0.14, too.

EXPLORING EVENTS IN THE SOLAR SYSTEM WITH SPACECRAFT RADIO SIGNAL

Guifre Molera Calves[1]

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Tracking and studying radio communication signals from planetary spacecraft offers a new possibility to measure the electron density of the solar wind. The aim of this work is to characterise Interplanetary Coronal Mass Ejections (ICME) by analysing the radio signals from planetary spacecraft. Observations of radio signals with ground radio telescopes have been conducted regularly with the European VLBI Network (EVN) targeting several of planetary spacecraft. Study of the propagation of Mars Express (MEX) and Rosetta radio signals in the solar wind at different solar elongations and distances from the Sun has led us to detect and study the property of ICMEs. Here I will present the methodology and the results, suggesting that this radio science method is able to well describe the properties and propagation of ICMEs in the heliosphere.

THE INTRODUCTION OF VLBI OBSERVATION IN YUNNAN OBSERVATORIES AND THE NEW C BAND RECEIVER

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Yunnan Observatories (YNAO) has a 40m Radio Telescope which is part of the Chinese VLBI Network (CVN). It is one of the data receiving station of China's Lunar Exploration Project which can receive the data of the Chang-E lunar satellites and track it by VLBI. Now the 40m Radio Telescope is the member of EVN and have installed a new C Band receiver, so we can carry on more international VLBI observations such as IVS, EAVN. This poster will introduce the 40m Radio Telescope, the VLBI Observations and the new C-band receiver, and then show some photos of the Chang-E lunar satellites.

FEEDS OF THE RADIO TELESCOPES RT-13 OF THE QUASAR VLBI NETWORK

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Design and characteristics of feeds of the radio telescopes RT-13 are presented. These feeds intended for use in cryogenic tri-band and ultra-wideband receivers. The tri-band feed operates in S, X and Ka frequency bands at circular polarization. The feed consists of a system of coaxial cavities. In S-band a relevant cavity is fed by means of microstrip hybrid couplers. In X-band a short horn is fed by means of a waveguide orthomode transducer, supplied with a differential phase section. A circular waveguide with a dielectric core and a septum polarizer are used in Ka-band. Two tri-band receivers already installed on two RT-13 radio telescopes. The ultra-wideband receiver, intended for installation on the RT-13 radio telescope, operates in the range of 4—16 GHz at linear polarization. Low-gain Quad-Ridged Flared Horn chosen as a prototype of a feed for this receiver. Four ridges, placed into the horn, are fed by means of two short coaxial lines, corresponding to two orthogonal linear polarizations. Both feeds – tri-band and ultra-wideband – have compact design and are suitable for installation inside of cryogenic dewar.

SIMULTANEOUS MONITORING OBSERVATIONS OF KVN 4 BANDS TOWARD EVOLVED STARS

Se-Hyung Cho[1], Y. Yun[1] et al.

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As a KVN Key Science Program of evolved stars, we have performed simultaneous monitoring observations of 22 GHz H2O and 43/86/129 GHz SiO masers toward 16 evolved

stars. We aim at investigating spatial structure and dynamical effect from SiO to 22 GHz H2O maser regions associated with a mass-loss process and development of asymmetry in circumstellar envelopes. We also aim at investigating mutual association and difference between SiO and H2O masers for establishing SiO and H2O maser models coupled to hydrodynamical model of circumstellar envelope. In addition, the correlation and difference of SiO maser properties among J=1-0, J=2-1, and J=3-2 transition masers are traced according to different type of stars for constraining SiO pumping models. From 2015A observing season, superposed maps of SiO and H2O masers were obtained toward nine stars using the source frequency phase referencing method (Dodson et al. 2014). Here we present the interim results of KVN Key Science Program of evolved stars.

THE FIRST VLBI IMAGE OF 6 GHZ OH MASERS TOWARD PN K3-35

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Planetary Nebulae (PNe) are born during the final stage of the life of low or intermediate mass stars. The bright and compact maser spots in PNe are the ideal targets for high resolution VLBI observations. Studying the spatial distribution, kinematics and magnetic field traced by masers in PN with VLBI observations can help us understand how an evolved star goes through the AGB phase to the PN phase. Currently, the VLBI observations of ground state 1.6 GHz OH masers in PNe are very common, however, the high resolution VLBI studies of the first excited state 6 GHz OH masers are very rare. K3-35 is a prominent young PN, which is the brighter one of two PNe detected 6 GHz OH masers. In order to study the spatial distribution, kinematics of 6 GHz OH masers in PN K3-35, we plan to carry out multi-epoch VLBI observations of 6 GHz OH masers toward this object with the European VLBI Network (EVN) in two or three years. The first epoch EVN observation has been done on 16 June, 2014, and here we will show the first VLBI image of 6 GHz OH masers in PN K3-35 with the resolution of milliarcsecond, which is the highest resolution for this kind of OH masers in PNe up to now.

BINARY SUPERMASSIVE BLACK HOLES AND RADIO-JET FEEDBACK IN POST-MERGER GALAXIES

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The unparalleled angular resolution afforded by VLBI holds a distinct advantage in using this technique to uncover the expected, yet observationally unconfirmed, population of

sub-kpc binary supermassive black holes (SMBHs). However, the inefficiency of VLBI surveys and limited time on global VLBI arrays prohibits deep, large-scale (>>1 sq. deg) surveys required to ensure an expected binary SMBH prevalence of >>1. Therefore, in order to maximise the discovery potential of VLBI, great emphasis must be placed on target selection. To this end, we have performed a VLBI 5 GHz survey of 91 FIRST/SDSS-selected, visually- identified post-merger galaxies down to ~40 micro-Jy/b sensitivity. I will present the preliminary results of this programme.

THE ULTRA-WIDEBAND RECEIVER SYSTEM FOR RT-13 RADIO TELESCOPE IAA RAS QUASAR NETWORK

Alexander Evstigneev[1], O. Evstigneeva[1], A. Lavrov[1], V. Mardyshkin[1], I. Pozdnyakov[1] and E. Khvostov[1]

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The report describes results of development in IAA RAS receiving system, operating in ultra-wide 4-16 GHz band (UWB). An overview of existing and developing UWB systems for VGOS network is provided. The principles of design, management, integrating with RT-13 radio telescope, control and power supply for IAA RAS UWB receiving system are shown. Expected and measured technical parametres are given. Technical data on receiver units such as: basic structure, frontend cooled feed, splitter and up-down convertor are presented. Special attention is focused on the frontend cryoelectronic unit, the information about the design, feed, LNAs used, results and parametres obtained during the test is provided.

NEW C-BAND RECEIVER FOR RT-32 RADIO TELESCOPE IAA RAS QUASAR NETWORK

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The report focuses on the new equipment developed in IAA RAS for the astrophysics VLBI 4.5-5.5 GHz (6.2 cm, C-band) band receivers in radiointerferometric complex «Quasar». The purposes were to increase the operational receiver reliability, to improve the technical characteristics and to expand the operating frequency band from 500 to 900 MHz. Low noise amplifiers in cryoelectronic frontend units were replaced with modern and more reliable ones. New dual channel frequency conversion units with integrated local oscillators were designed. Spectral characteristics of local oscillators were improved. Dual channel noise generators units with amplified compensating noise density were developed, their design and technical parametres are given. Modernization of the C-band receivers reduced the number of receiver units and increased overall operational reliability. Due to extended 900 MHz band the improvement of all basic receiving channel parameters is expected.

COMPACT RADIO QUASARS AT Z>4.5 OBSERVED WITH THE EVN

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Until now, only 18 extragalactic radio sources have been imaged at extremely high redshift (z>4.5) with very long baseline interferometry (VLBI). Here we report on our recent dual-frequency (1.7 and 5 GHz) European VLBI Network (EVN) observations of an additional 10 active galactic nuclei (AGN) at z>4.5 (project code: EC052). All of them are detected with mas-scale angular resolution. We discuss their compact radio structure, brightness temperature, spectral index and variability, and conclude that only half of them are flat-spectrum radio quasars. The others are likely young AGN with radio spectrum peaking at the GHz or ~100-MHz range in the observer's frame.

SDSS J1425+3231: THE NATURE OF A DUAL AGN CANDIDATE REVEALED

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According to the currently accepted structure formation scenario, galaxies and the supermassive black holes in their centers form via merging events. Interactions between galaxies are thought to increase star formation and/or activity in the galactic nuclei. Simulations show that simultaneous activity is expected at kpc-scale separations. It was proposed that double-peaked narrow emission lines may be a signature of dual AGN, as the two peaks are formed in the distinct narrow line regions of the two AGN. However, these spectral features can be explained without invoking dual AGN e.g., by jet-driven outflows. We observed SDSS J1425+3231, a radio-emitting candidate dual AGN with the EVN and e-MERLIN at 1.6 GHz and 5 GHz. Two compact features were detected with the EVN at 1.6 GHz, which seemed to support the dual AGN scenario. However, the recent e-MERLIN observations revealed that the source has a core-jet structure and thus most likely

only mimics some properties of a dual AGN. Nevertheless, SDSS J1425+3231 is still a very interesting weak radio source that shows complex radio morphology.

USING LINEAR POLARIZATION, CIRCULAR POLARIZATION AND FARADAY ROTATION MEASUREMENTS TO DETERMINE THE SPIN DIRECTION OF THE CENTRAL ACCRETION DISKS OF AGN

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The presence of a Faraday rotation gradient across the jet of an AGN can be interpreted as evidence that the jet carries a helical magnetic field, produced by the rotation of the central black hole and accretion disk plus the jet outflow. The direction of the toroidal component of this helical field is determined by the direction of the rotation and the direction of the initial poloidal field that is "wound up". Helical jet magnetic fields also provide favorable conditions for the generation of circular polarization via so-called "Faraday conversion". Using the linear polarization structure as an indicator of the pitch angle of the helical jet magnetic field and the observed direction of the transverse Faraday rotation gradient as an indicator of the direction of the toroidal field component, the sign of the circular polarization can then be used to determine the direction of the rotation of the central black hole and accretion disk together with the direction of the poloidal component of the helical field. This analysis is applied to 10 AGNs with statistically significant transverse Faraday rotation gradients, clear linear polarization structure and detected circular polarization. The results indicate that there are roughly equal numbers of "North" and "South" poloidal fields, and roughly equal numbers of central accretion disks rotating clockwise and counterclockwise on the sky. The results also provide evidence for an intriguing coupling between these two quantities, with North/South poloidal fields preferentially associated with CCW/CW rotation. A possible origin for this coupling is considered.

VLBI DIGITAL TERMINAL AT THE DEEP SPACE NETWORK: ENHANCEMENTS FOR EXTERNAL VLBI USERS

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The Deep Space Network (DSN) has replaced the Mark IV Data Acquisition Terminal (DAT) with a digital backend, the DSN VLBI Processor (DVP). The DVP is an in-house JPL development that uses a CASPER ROACH board for real-time digital signal processing and channelization and streams the data into a Mark 5C recorder in VDIF format. This

contribution presents recent enhancements made to the DVP application to improve our support to external VLBI users.

EVN OBSERVATIONS OF HERCULES A

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We present new EVN observations of Hercules A's central engine. Hercules A is a powerful radio galaxy in the Northern Hemisphere, famous for the radio-ring like features it contains on kilo-parsec scales instead of hotspots.

THE MAGNETIC FIELD OF THE HERCULES A CLUSTER REVISITED

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We report on the new analysis of the existing radio and X-ray data on Hercules A to estimate the cluster's magnetic field.

MEASURING MAGNETIC FIELDS FROM WATER MASERS IN THE SYNCHROTRON PROTOSTELLAR JET IN W3(H2O)

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We report full polarimetric VLBA observations of water masers towards the Turner-Welch Object in the W3(OH) high-mass star forming complex. This object drives a synchrotron jet, which is quite exceptional for a high-mass protostar, and is associated with a strongly polarized water maser source, W3(H_2O), making it an optimal target to investigate the role of magnetic fields on the innermost scales of protostellar disk-jet systems. The linearly polarized emission from water masers provides clues on the orientation of the local magnetic field, while the measurement of the Zeeman splitting from circular polarization provides its strength. The water masers trace a bipolar, biconical outflow at the center of the synchrotron jet. Although on scales of a few thousand AU the magnetic field inferred from the masers is on average orientated along the flow axis, on smaller scales (10s to 100s of AU), we have revealed a misalignment between the magnetic field and the velocity vectors, which arises from the compression of the field component along the shock front. Our measurements support a scenario where the magnetic field would evolve from having a dominant component parallel to the outflow velocity in the pre-shock gas, with field strengths of the order of a few tens of mG (at densities of 10^7 cm^{-3}), to being mainly dominated by the perpendicular component of order of a few hundred of mG in the post-shock gas where the water masers are excited (at densities of 10^9 cm^{-3}). The general implication is that in the undisturbed (i.e. not-shocked) circumstellar gas, the flow velocities would follow closely the magnetic field lines, while in the gas shocked by the prostostellar jet the magnetic field would be re-configured to be parallel to the shock front.

SHORT TIME VARIABILTY OF OH MASERS IN W3(OH)

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We present data of three years observations of OH masers in W3(OH) that we developed with 32-m antenna of Svetloe observatory. It is found that the most active was the region at -46.2 km/s at 1665 MHz in December 2011 to March 2012. In the next time this region was not active. The most impressive flash occurred 23 of January 2012 at 03:27 UT. At this moment the flux of this component was increased in 7 times for interval of 90 sec and then decreased to previous level. For such characteristic time the estimate of linear dimension of this maser spot is 0.18 AU (2.7×10^{12}cm). In 2013-2014 years we have found variations of the components at -47.6 and -45.1 km/s with characteristic times about 10 hours where variations of fluxes in right and left polarizations were obviously anticorrelated. Such phenomenon of OH maser emission were discovered for the first time and were not been explained by any variability models.

EXTENDING FACILITY OF BRAS BY EXTERNAL DIGITAL DOWNCONVERTER BANK

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Broadband Acquisition System (BRAS) is a digital backend used on new fast-slew rate radiotelescopes RT-13. BRAS implements eight wideband channels of 512 MHz that allows to achieve high sensitivity of the radio interferometer but complicates processing of joint observations with narrow-band types of backends. To simplify such observations IAA RAS is developing external digital downconverter bank. This system receives VDIF frames from wideband channels of BRAS through 10G Ethernet links. It cuts wideband input signals onto narrow sub-channels of required bandwidth, repacks it back to VDIF frames and transmits to recording system. The frequency of sub-channels can be flexibly adjusted. The results of the development is presented.

RADIO EMISSION IN ULTRACOOL DWARFS: THE NEARBY PLANETARY SYSTEM VHS1256-1257

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The recently discovered planetary system VHS1256-1257 consists in a 73 Mjup M7.5 dwarf and a 11 Mjup L7 companion placed only at 12pc. Previous VLA observations showed that the host dwarf displays detectable levels of emission, 60 microJy at X-band, suggesting that both high-rotation rates and strong magnetic fields play an active role in this system. We should report on sensitive L-band EVN observations of VHS1256-1257 directed to 1) explore the presence of compact radio emission, which could contribute to constrain the magnetic properties of ultracool dwarfs, and 2) set bounds to the mass of the components of this system via astrometric monitoring of the orbital motion.

MULTI-YEAR MULTI-FREQUENCY MONITORING OF 3C 84

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The famous mis-aligned Active Galactic Nucleus (AGN) 3C 84, has been rising in both radio an Gamma-ray fluxes since at least 2010. VLBI images of the source show three main structures: the Core region (known as C1), presumed to be harbouring a central super massive black hole (SMBH), a slowly moving feature to the south of the Core (known as C3) and a fainter area of emission to the south-west of the Core known as C2. The Korean VLBI Network (KVN) is a network of 3 similar telescopes with a unique optical system that allows for simultaneous observations at 14 mm, 7 mm, 3 mm and 2 mm. We present the preliminary results of the analysis of approximately monthly KVN observations of 3C 84 since 2013. We find tentative evidence for Gamma-ray flaring to be decoupled from radio flaring, with Gamma-rays potentially coming from C1 and mm-wave radio flaring dominated by emission from C3. Additionally, we find tentative evidence for a correlation between the 3-2 mm spectral index in C1 and Gamma-ray flaring.

MEASURING TWD IN "QUASAR" NETWORK OBSERVATORIES

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The results of near real time TWD-measurements with WVR's in Quasar observatories are presented. Particular attention is paid to work of WVR's in a rainy weather. When operating under these conditions, a special data treatment algorithm for minimizing TWD measurement errors is used.

SPECTRUM DYNAMICS OF SUPERNOVA REMNANT 3C58

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Instantaneous spectra of the supernova remnant 1181, 3C58, measured at 4 frequencies from 1550 to 8450 MHz at the epochs 2003.4, 2004.4, 2013.2 and 2016.3 on the radio telescope RT-32 in Svetloe Observatory (IAA RAS). Spectra 3C58 at epoch 1966.5 to 1986.5 are obtained on the basis of published data with comparable intensities of the 3C58 and 3C295. Comparison of the spectra defined over the time interval 1966 - 2016, found significant changes in the frequency-dependent flux densities of 3C58. Since the observed phenomena are difficult to interpret based on model of single synchrotron source with central pulsar, to explain observed emission spectrum 3C58 we suggest the model, consisting of two components. The first component with a power frequency dependence and constant spectral index is due to synchrotron radiation mechanism. The second component is produced by thermal radiation. Estimates of component parameters are carried out.

ABSOLUTE SPECTRA OF STANDARD SOURCES AT EPOCH 2016.3

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We present the set of standard sources absolute spectra measured over the frequency range 1550 MHz - 8450 MHz from February to May 2016. Measuring the flux-densities of sources were made with the radio telescope RTF-32 of Svetloe observatory (IAA RAS) relative to primary standards of "artificial moon" flux-density scale Cygnus A and 3 C295. Previously, it was shown that only this flux-density scale based on absolute measurements by the method of "artificial moon" and the independent determination of the shape of the spectra through relative measurements, adequately represents the spectra of objects. Accuracy of obtained data estimates as ±2%. Repeated measurements of the spectra of

standard sources carried out with RTF-32 of Svetloe observatory since 2002, it is necessary to preserve the accuracy of the flux-density scale under conditions of the variability of standard sources. The measured data at different epochs are comparing.

MULTI-FREQUENCY AGN SURVEY WITH THE KVN (MASK)

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Available (known) VLBI sources at high frequencies (e.g. >22GHz) are very limited – mainly due to atmospheric fluctuations, which degrade coherence time, and a power-law energy distribution of particles in case of AGNs. However, simultaneous multi-frequency VLBI receiving system of the Korean VLBI Network (KVN) and its powerful VLBI phase calibration technique offer benefits in finding more (weak) sources at millimeter wavelengths. Based on this aspect, MASK (Multi-Frequency AGN Survey with the KVN), which aims to densify an existing a VLBI catalog of extragalactic radio sources at 22/43/86/129 GHz is proposed as a KVN legacy program. We selected 1220 sources of AGNs that include existing VLBI sources and new fringe-detected sources using the KVN at K-band (22GHz). Among them, 138 AGNs were observed and detected a significant fraction at 22, 43, 86, and 129 GHz simultaneously.

VLBI AND FILLED-APERTURE MONITORING OF GEV-EMITTING NARROW-LINE SEYFERT 1 GALAXIES

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Narrow-line Seyfert 1 (NLS1) galaxies are a subclass of AGN with extreme multi-wavelength properties. A fraction of them is radio loud and flare at gamma-ray energies. These provide us with unique insights into the drivers of AGN activity under extreme conditions. Given their high accretion rates and low black hole masses, they extent the blazar phenomenon into a previously unexplored parameter regime. Here, we present results from our extensive multi-epoch, multi-frequency monitoring of the population of northern gamma-ray loud NLS1 galaxies, including the nearest and the most distant gamma-ray flaring NLS1 known to date, and discuss implication for the nature of these systems. We present results from high-resolution radio imaging of 1H 0323+342, at multiple epochs, probing the kinematics of its parsec-scale jet. We present new radio data of the candidate gamma-emitting NLS1 galaxy RX J2314.9+2243, characterized by a very steep radio spectrum and shows other extreme multi-wavelength properties. Additionally, we carried out the first

systematic long-term study of the radio polarization properties of selected gamma-ray NLS1 galaxies, and present the salient results of that study.

RASFX CORRELATOR ACCURACY CHARACTERISTICS

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RASFX correlator based on hybrid-blade HPC cluster was designed in IAA RAS in 2014, and now is mainly used for UT1 determination. To estimate the correlator's true error the model of 2-station VLBI system was created using 3 pseudorandom noise generators. The first generator imitates quasar signal, and the two other - the receiving system noise. Two 16 s 2-bit 1 channel wideband (bandwidth 512 MHz) scans were created, the 1 ms baseline delay was also included. The clock offset and delay rate were produced using an ephemeris model. The 28 model combinations were used for the scans processing with the 8248 MHz carrier frequency, 2048 spectral channel resolution and 0.0625 s accumulation period. The result fringes were analyzed and compared with the prior estimate. We found that the RASFX correlator accuracy is within the formal error (less than 10 ps).

OBSERVATION OF INTRADAY VARIABILITY OF EXTRAGALACTIC RADIO SOURCES ON IAA ANTENNAS

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Investigation of intraday variability (IDV) of extragalactic radio sources in IAA are started from 2003 and still ongoing. During this time was made a lot of single-dish observations with RT-32 radio telescopes at Badary, Zelenchukskaya and Svetloe observatories. Nineteen sources was observed at 3.5 and 6.2 cm. The review describes observation and reduction methods for investigation of IDV with IAA radio telescopes. The results of the IDV measurements of sources J1819+3845, J0527+0331, J0721+0406, J1728+0427, J0721+7120, J1159+2914, J0530+1331 an J2253+1608 are also represented. In 2016 a series of VLBI observations of IDV sources was started with three RT-32 and two new RT-13 on Badary and Zelenchukskaya observatories. From the first 5-station VLBI observation recently was obtained VLBI image of J2253+1608.

THE S/X/KA RECEIVER SYSTEM FOR RADIO TELESCOPE RT-13 OF QUAZAR VLBI NETWORK

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IAA RAS has already established two-element radio interferometer which consists of two radio telescopes with dish diameter of 13.2 m. Each radio telescope is equipped with a specially designed receiver system. The main feature of this system is the cryogenic receiver unit that includes cooled tri-band feed and LNA. Such design makes possible to achieve high sensitivity to receive weak noise signals of cosmic origin. As well, feed design allows to receive signals in three frequencies bands S (2.2-2.6 GHz), X (7.0-9.5 GHz) and Ka (28-34 GHz) both in LCP and RCP simultaneously. The report includes a description of the receiver, its main properties and characteristics. Presentation describes the receiver installation at the radio telescope.

JET VELOCITIES IN VLBI CORES OF BLAZARS

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Apparent speeds of quasar jet features measured with VLBI vary greatly from one feature to another and may not reflect the actual speed of the underlying jet flow (bulk motion). We implement a different indirect method of measuring jet speed using single-dish variability time lags and frequency dependent core position shifts derived from single-epoch multi-frequency VLBI observations. Our estimates systematically differ from those obtained by means of components kinematics.

RECEIVER MODULE POWER, CONTROL AND MONITORING SYSTEM FOR RT-32 AND RT-13 RADIO TELESCOPES

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Power Control and Monitoring system providing us very important information about radio astronomical receivers. Through time it evolved from simple utilitary system to powerful scientific tool. A number of base principles of developing the system is listed. Power Control and Monitoring system providing power, control and monitoring functions for carrying out radio astronomical observations, routine checks, telemetry and monitoring is described. Sensors sensitivity and placement allowing to use PCM system as powerful

scientific tool to research receiver characteristics and improving performance of RT-13 and RT-32 radio telescopes is discussed.

APSYNSIM - A PEDAGOGICAL INTERACTIVE SIMULATOR OF APERTURE SYNTHESIS

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We present the program APSYNSIM (APerture SYNthesis SIMulator), designed for an interactive learning of the Aperture Synthesis technique. Different interferometers (and sources) are available to the user and new ones can be easily created. All the different aspects of the array geometry can be changed, and the reconstructed images are refreshed in real time. Other effects, like different visibility weightings, primary beam, and/or subarraying (heterogeneous arrays), can be applied. A basic image deconvolution (using interactive CLEAN) can be performed, which refreshes the images (model + residuals) in real time after each iteration. In addition, the user can corrupt the antenna gains in different ways and check how this affects the reconstructed images and residuals. Several auxiliary plots (in both the image plane and Fourier space) can be generated, for a better understanding of some gory details and subtle limitations of interferometry. The program is accompained with a set of suggested exercises, and has already been successfully used in several international interferometry schools. APSYNSIM is implemented in Python. The source code is open and freely available to the users. New features, like non-coplanar (VLBI) arrays, receiver noise, and atmospheric effects, are being planned for implementation. Feedback from the community is greatly appreciated. For more information, visit the project webpage at Launchpad: https://launchpad.net/apsynsim

EXPERIENCE IN CREATING SCHEDULES OF KVAZAR VGOS ANTENNAS

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While legacy geodetic VLBI observations using the large and heavy radio telescopes are still carried on, a number of the new VGOS radio telescopes with 13-m dishes have been built and run into operation. There are several fully developed scheduling software packages exist already, some people start a development of a new one, but SKED and SCHED software are still remain actual and can be adopted for VGOS purposes with external wraps and internal patches. Within this contribution we will concentrate on scheduling process for two-element radio interferometer of the KVAZAR VLBI-network.

IMPROVING UT1-UTC ESTIMATES OF KVAZAR VGOS SESSIONS

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Since November, 2015 we carry on a continuous intraday VLBI sessions using 13-m antennae Badary and Zelenchukskaya. Some changes in scheduling parameters were made to improve UT1 formal error obtained from these sessions. In this poster we present our recent efforts.

CORRELATION PROCESSING SYSTEM FOR "SPECTR-R" (RADIOASTRON) SPACECRAFT BEACON SIGNAL

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The paper describes the RadioAstron space radio telescope beacon signal processing technique and a brief review of the software package used for data processing. The beacon emits monochromatic signal at 8.4 GHz. Observations were carried out at "Quasar" VLBI network, data was processed using the software package designed in IAA RAS. The package consists of the correlation processing, postprocessing and GUI utilities implemented with C++ with Qt 4.8 and qwt 6.0 frameworks. Keywords: RadioAstron, beacon, spacecraft, correlation processing, software.

WATER FOUNTAIN JETS AS SEEN BY VLBI MASER ASTROMETRY

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One of the pivotal questions in stellar evolution is how to explain the formation of planetary nebulae, whose morphology depart significantly from spherical symmetry. Understanding this evolutionary step requires us to investigate the sudden change in the mass-loss mode from spherical to bipolar. There is a lot of observational evidence that the asymmetric shaping of the circumstellar envelopes (CSE) of evolved stars is already well under way prior to photoionization, mainly in the asymptotic giant branch (AGB) and post-AGB phases. Water fountain stars are probably key sources which may provide hints about the processes carried out during the changes in the stellar winds. They are evolved stars

that host high-velocity water masers in their CSEs, which trace the shocked regions of recently formed bipolar outflows. We can precisely measure the evolution of these compact masers on a milliarcsecond scale with VLBI astrometry, which is the only method of measuring the astrometry of the shocks themselves. Here we present the most recent results of our VLBI maser projects of two water fountain sources, IRAS 18043-2116 and IRAS 18113-2503, using VLBA and VERA K-band measurements. Based on the results, we illustrate the water fountain phenomenon, describe the shocked regions immersed within the outflows, the information obtained about the host star and the CSE, and the implications on stellar evolution.

CORRELATION OF THE RELATIVE SIO MASER DISTRIBUTIONS WITH THE STELLAR LIGHT CURVES

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We observed SiO v=2 and v=3 (J=1-0) masers around long-period variables in VLBI observations using the VLBI Exploration of Radio Astrometry (VERA) combined with the Nobeyama 45 m telescope. We find some correlation of the relative maser distributions with the stellar light curves. We suggest that the water and SiO line overlapping mechanism should get predominant only at the phase when infrared emission gets strongest. The 8 μm emission from the water molecules around the star excite SiO molecules from v=1 J=0 to v=2 J=1 and v=2 J=0 to v=3 J=1, respectively.

EVN LOCALIZATION OF SHORT TRANSIENTS

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Our efforts at JIVE to localize transient signals with duration of a few milliseconds with the EVN will be introduced. The technique can be used to measure accurate positions of Rotating Radio Transients (RRATs) and, eventually, to find counterparts of Fast Radio Bursts (FRB) in other wavebands. This latter will be important to verify the claimed cosmological origin of FRB.

ASSESSING UNCERTAINTIES OF VLBI RESULTS

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Reliable estimates of the uncertainties of VLBI results are essential for quantifying their significance. We propose to use the bootstrap for obtaining such estimates. This well known and widely used method handles spatial correlation in image domain and accounts for non-uniformity and non gaussian nature of visibility noise on different baselines of heterogeneous VLBI-arrays in uv-domain. Method allows to quantify uncertainty of the measured pixel/region flux, frequency dependent core-shift, visibility model components parameters, etc. - any function of the observed visibilities, as well as simple and straightforward formulation of the significance criteria becomes available (eg. for transverse Faraday rotation measure (RM) gradients). We apply this method to typical problems arising in VLBI observation of AGN jets - quantifying significance of RM gradients, finding uncertainties of frequency-dependent core shift and visibility model component parameters and compare them with other methods.

VLBI CALIBRATOR SURVEY 9

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An ambitious project for improving coverage of calibrators was launched in June 2015. The goals of the project are: a) To improve astrometric accuracy of Pan-STARRS and future LSST catalogs by extending the spacial coverage of VLBI astrometric catalogue to that level that any field of view of PanSTARRS (disk of 1.5 deg radius) and/or LSST (disk of 1.75 deg radius) will be guaranteed to have at least one VLBI calibrator. b) To study of the population of steep spectrum sources. Due to a heavy selection bias in prior surveys, the population of steep spectrum sources is poorly studied. All remaining sources from GB6 and PMN at declinations above -30 deg brighter 200 mJy at 4.85 GHz that were not previously observed with VLBI are scheduled. c) To study of a sample of 200 sources with large radio-optical offsets (250--800 mas) that we found by analyzing differences between the RFC and positions from the preliminary PanSTARRS catalogue. To date, more than 11,000 sources have been observed. Detection rate is at a level of 50%. The current status of the project and preliminary results will be presented.

VARIABILITY OF THE CORE SHIFT EFFECT IN AGN JETS

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The observed position of the core in radio jets of active galactic nuclei changes with the observing frequency because of synchrotron self-absorption and external absorption. Measuring this shift allows to reconstruct geometry of the jet base, probe physical conditions close to the core and determine the core position itself more accurately. We performed successful measurements for more than 300 quasars observed with VLBI at two frequencies (2.3 and 8.4 GHz) at different observing epochs. The core shift was measured by aligning the corresponding images using masked 2D cross-correlation and finding the core component position by model-fitting the calibrated visibility data. The method employed is semi-automatic, which delivers more robust and unbiased results. Results of the core-shift variability analysis for selected targets as well as changes of geometrical and physical parameters of their cores will be presented and discussed.

JET ORIENTATION AND GAMMA-RAY BRIGHTNESS OF AGN

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Using 15 GHz VLBA observations of 373 active galactic nuclei from the MOJAVE program and/or its precursor, the 2 cm VLBA Survey, we constructed a corresponding stacked image for each source averaging all available epochs for a better reconstruction of the cross section of the flow. We have analyzed jet profiles transverse to the local jet ridge line and derived both apparent and intrinsic opening angles of the parsec-scale outflows. We compared the jet opening angles between sources detected and non-detected by the Fermi Large Area Telescope (LAT) during the first 48 months of operation and derived probability functions of the corresponding viewing angle distributions. It is shown on a high level of significance that relativistic jets of the gamma-ray loud AGN are preferentially oriented at smaller angles to the line of sight compared to those of gamma-ray weak sources.

A HERSCHEL AND BIMA STUDY OF THE SEQUENTIAL STAR FORMATION IN THE W 48A STAR FORMING REGION

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The W48A star-forming region contains several evolutionary phases of star formation. We present an in-depth study of the W 48A region as a whole to retrieve its formation history. For this purpose we used new Herschel infrared (from the HOBYS programme) and BIMA observations combined with archival data. The data show that the clumps in W 48A are linearly aligned by age. From east (old) to west (young) we find an ultra-compact (UC) H II region, a young stellar object (YSO) with class II methanol maser emission, a YSO with a massive outflow and finally the NH2D prestellar cores from Pillai et al. The age gradient is supported by our age estimates for the compact sources derived from bolometric luminosities and envelope masses, which were obtained from the dust continuum emission, and agree within an order of magnitude with age estimates from molecular line (CH3CN, NH3) and radio data. This remarkable positioning most likely reflects the (star) formation history of the region. While we discard that the star formation in the W 48A molecular cloud was triggered by the eastern UC H II region, we find that the Aquila supershell expansion probably had a major influence on the evolution of W 48A. We conclude that the combination of Herschel continuum data with interferometric molecular line and radio continuum data is important to derive trustworthy age estimates which are crucial in interpreting the (star) formation history.

TRACING THE EVOLUTION OF FAST JET-DRIVEN OUTFLOWS

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We present results from the study of the atomic neutral hydrogen observed in absorption against the central regions of the radio galaxy 3C236. This is part of larger project to trace the location, distribution and properties of the HI absorption associated with fast outflows in a number of radio sources. The sensitivity provided by the global VLBI experiment, combined with the large bandwidth compared to previous observations, have allowed us to identify at least part of the outflowing gas located in a region relatively close to the radio core. We also trace more diffuse gas, some likely part of a regularly rotating disk, in the region of the counter-jet and lobe. We discuss the implication of these findings in the context of the impact of the radio jet on the host galaxy, both in terms of negative and positive feedback.

IT SUPPORT OF SPACE-VLBI PROJECTS: STORAGE AND PROCESSING OF BIG DATA VOLUME

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In this report IT support for two Space-VLBI Projects are considered: currently operating Radioastron mission and future Millimetron mission. Radioastron Data Processing center was implemented to collect, process and archive the data and to organize the informational exchange between all participants of this project. More than 40 ground telescopes are involved in joint observations with Radioastron. Digital data from space and ground telescopes is collected in Data Processing Center. Large interest of scientific community around the world in Radioastron mission led to the growth of number and duration of observations, as well as to the growth of number of ground telescopes participating in these observations and the total amount of data. Currently, the volume of stored data is more than 2 PB. Usually in VLBI projects the initial or raw data is being deleted after successful correlation. In Radioastron mission we have made a decision to save and store all raw observational data, because of its uniqueness in order to have a possibility for future reprocessing and re-correlation. This is one of the reasons to expand our data archive. We have organized the data storage, computer complex, high-speed internal and external networks and archive for transferring, processing and archiving all data of Radioastron mission. All these components work as an integrated system. We have done an optimization of our equipment, by improving our operation scheme and dividing the data flows. In this report we pay special attention to the elimination of "bottle necks" in our data processing complex. Additionally, we pay great attention to control the Radioastron mission data transfer and storage reliability. The structure and functions of the Astro Space Center Data Processing Center fulfill the requirements for the Radioastron Mission data processing and have been successfully confirmed during the whole period of our operation. In our next Space-VLBI project – Millimetron mission, the expected volume of scientific information is estimated to be at least 100 PB. It is much more than for Radioastron mission. In this case for Millimetron mission will be organized a separate data center. We believe that our experience in processing, transferring and storing of large data volumes for Radioastron mission will be very useful.

NEW OPPORTUNITIES OF THE COMPUTING-ANALYTICAL COMPLEX FOR PREDICTING COLLISIONS OF THE EARTH WITH ASTEROIDS AND COMETS AND CREATING SCENARIOS OF COLLISION CATASTROPHES PRODUCED BY CELESTIAL BODY FALLS

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The complex was created by a group of developers – representatives of various organizations, partly under contracts with Emercom of Russia. Work of the complex and calculation results of places and circumstances of falls of real and fictitious celestial bodies were described in a number of reports and articles and were presented on several All-Russian and international conferences. In this report new opportunities of the complex, such as the use of radar observations for orbit determination, are provided. In prior publications the organization of search for potentially dangerous near-Earth bodies has been considered. In the course of computation two standard situations may take place: 1) the body passes by the Earth, then its minimum distance from the planet's center is calculated, as well as collision probability taking into account uncertainty of body's orbit, or 2) the body in the nominal orbit penetrates into the terrestrial atmosphere up to a certain height above the surface of the Earth's spheroid. In the latter case the scenario of the possible catastrophe caused by a collision of a body with the Earth is constructed. In present report the boundary case is considered when the body in the nominal orbit does not collide with the Earth, but the probability of collision is great enough. In this case the real body has rather good chance to collide with the Earth. It is necessary to determine beforehand the area of the terrestrial surface where fall of above celestial body is possible. In other words, a strip of possible impact locations on the Earth's surface is required to be determined. Besides, in the report the problem of collision of bodies with the Moon is considered.

CONT14 VLBI OBSERVATIONS RESULTS

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Results of data processing of CONT14 15 day campaign of continuous VLBI sessions with a network of 17 globally distributed stations in May 2014 with participation of two stations of Russian QUASAR network stations Badary and Zelenchukskaya are presented. The observed intraday variations EOP are compared with a tidal model and with results of previous IVS CONT campaigns. Troposphere parameters are compared with ones obtained with GPS technique. Also results of station positions variations are presented and discussed.

PIPELINE PROCESSING PROCEDURE FOR SPECTRAL EXPERIMENTS ON KVAZAR VLBI NETWORK

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A procedure for reduction of spectral VLBI data has been developed. Based on the EVN pipeline procedure it was modified for processing maser experiments conducted on KVAZAR network. AIPS is used to perform data reduction and ParselTongue module for Python for managing the process. This procedure performs standard steps needed for calibration and imaging of spectral data. In comparison with EVN pipeline Doppler correction was added and changes specific for spectral data was made in fringe-fitting and bandpass correction algorithms.

RELIABLE DENSE-GAS TRACERS AT HIGH REDSHIFT: CN IN THE Z~4 QUASAR APM 08279

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Molecular lines have been widely used for the study of galaxy formation and evolution at high-redshift. Although weak, their emission can be detected with large mm-wave interferometers. Of special interest is how the relation between the star formation rate and the dense-gas content in these extreme objects varies with redshift because these galaxies represent a significant fraction of the star formation density in the early universe. Therefore, finding fair tracers of the dense gas is key to understanding the first phases of galaxy formation. To do this, we have performed high sensitivity observations at 115 GHz and 138 GHz of two rotational transitions, the J=5–4 and J=6–5 lines, of CN in the z~4 quasar APM 08279+5255 with the IRAM Plateau de Bure interferometer. We have detected for the first time both CN transitions in a high redshift galaxy, APM 08279. Also, combining our new data with previous information on the J=4–3 and J=1–0 lines, we have modeled the SED of CN and derive its molecular abundance in the galaxy. Our study shows that the CN line SED of APM 08279 presents a turnover of the emission at the J=5–4 transition. To reproduce both the observed CN line intensities and the overall CN SED, we have performed a preliminary analysis of the CN molecular excitation with RADEX, deriving molecular abundances of ~ [$5\ 10^{-8}$ – $5\ 10^{-6}$]. We conclude that, the derived abundances are compatible to those predicted in highly-ionized environments in extreme starburst/AGNs, and that, contrary to the other standard tracers of the dense molecular gas such as HCN, HNC or HCO+ , the CN molecular lines in APM 08279 are mostly free from IR pumping.

A PANCHROMATIC STUDY OF THE GRAVITATIONAL LENS MG J0751+2716 AT Z=3.2

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The interplay between AGN and their host galaxies, and how strong is the connection between the jets and star-forming episodes or the evolution of the AGN and the host galaxy is not well understood. I will present a detailed multi-band study of MG J0751+2716, a gravitationally lensed radio-loud active galaxy at the cosmological interesting epoch of redshift 3.2. This object consists of extended gravitational arcs, which are clearly detected in high-resolution optical, near-infrared, mm and radio wavelengths at mas-scales. By carrying out a sophisticated reconstruction of the background source using a grid-based lens modelling technique, we spatially locate the different emitting regions in the source-plane for the first time, that includes the heated dust, the molecular gas (CO), the stellar population of the AGN host galaxy and the radio core and jets. The overall mm-to-radio SED is consisted with a significant dust bump associated with ongoing dust obscured star-formation. The object is found to consist of two distinct optical components, separated by a projected distance of 1.5 kpc, that differ strongly in color. The reddest component is found to be extremely compact, while the blue star-forming object is more diffuse and shows multiple brightness components. The molecular gas distribution, as measured with the CO (1-0) emission is extended over the whole system. The radio-jets, which also extend over ~2 kpc do not appear to be interacting with the blue star-forming component. Further observations at high angular resolution at mm-wavelengths will determine the star-formation conditions within the system.

THE RASFX VGOS GPU BASED SOFTWARE CORRELATOR

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The RASFX correlator is a VGOS software correlator designed in the IAA RAS in 2014. The correlator is capable of processing data at maximum rate of 16 Gb/s from each station in near-real time mode (up to 6 stations simultaneously). Distinctive feature of the RASFX correlator is the usage of Graphical Processing Units (GPUs) for the Fourier transformation, spectra multiplication, PCal extraction and bits repacking. The correlator hardware is based on hybrid blade HPC cluster. Each of 40 servers holds two Intel Xeon CPUs and two Kepler K20x GPUs. At present correlator's hardware is up and running, processing up to 4 observation sessions on a daily basis with following setups: 4 frequency channels of 512 MHz bandwidth (X/S bands) and 2 frequency channels of 512 MHz bandwidth (X/Ka bands). Regular VLBI data processing with the correlator started in November 2015. More than 500

sessions were processed from that moment by July 2016. The results of processing are used for the UT1 determination.

TECHNICAL DEVELOPMENT OF BROADBAND SYSTEM AT KASHIMA SPACE TECHNOLOGY CENTER

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We have been developing broadband system for time and frequency transfer by VLBI technique. Currently, we have installed two compact antennas to Japanese time keeping institutes. Since our compact antennas are about 2 m diameter, broadband receiving system of VGOS is required. We will report our developments and recent results of broadband VLBI experiments in a frequency range of 3.2GHz to 14 GHz.

SPACE VEHICLES OBSERVATIONS USING VLBI NETWORK "QUASAR-KVO"

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VLBI network "Quasar-KVO" has all the capabilities to perform high-precision ground-based radio observations of the space vehicle in deep space. Multichannel broadband recording of space vehicle and quasars signals combined with the software correlator allows configuring the system for processing the target signals in different radio bands and modes including single dish one. The potential of the VLBI network "Quasar-KVO" for ephemeris support of the space programs was confirmed by the following observations: Doppler and phase measurements of RadioAstron spacecraft and VLBI observations of Mars Express, lunar landers, GLONASS and Beidou navigation satellites. The measurements errors correspond to the theoretical values.

THE PARAMETERS OF THE RT-13 RADIO TELESCOPES OF THE "QUASAR" VLBI NETWORK OF THE IAA RAS IN S/X/KA BANDS

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Measurement results of the parameters of the RT-13 radio telescopes of the "Quasar" VLBI network of the IAA RAS in S/X/Ka bands are presented in this paper. The receiver noise temperature and calibration signals are measured by special wide-aperture noise load. Load is installed at the receiver feed and cooled by liquid nitrogen. The calculated and measured system noise temperatures are compared. Focusing and directional pattern measurements are performed by point cosmic radio sources, differing for S/X/Ka bands. SEFD and antenna efficiency are measured by reference cosmic radio sources. The dependences of the system noise temperature, SEFD, antenna efficiency from the antenna elevation angle are obtained.

APPARENT FREQUENCY DEPENDENT SHIFT OF ULTRA-COMPACT AGN CORES DETERMINED BY VLBI PHASE-REFERENCING

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In VLBI images of extragalactic jets, the apparent position of the compact, bright emitting region at the narrow end of the jet (the core) depends on the observing frequency and is fundamentally determined by synchrotron self-absorption in the radio emitting plasma or in the material surrounding the flow. This dependency provides a tool to probe absolute geometry and physical conditions in the vicinity of the core. It also must be taken into account in order to achieve the highest accuracy of radio reference frame and tie it accurately to the optical GAIA frame. However, the widely used jet self-referencing method cannot be applied to highly compact ICRF2 objects with weak or undetectable jets. Relative astrometry is the only tool to detect and measure the core shift for them. We used phase-referencing EVN observations to measure the apparent frequency-dependent core shift between 1.4, 2.3, 5, and 8.4 GHz in a sample of eight ultra-compact ICRF2 objects. Results of this project are presented and discussed.

SOFTWARE COMPLEX "ASTEROIDS AND COMETS" AT THE SITE OF INSTITUTE OF APPLIED ASTRONOMY RAS

Nikolay Zheleznov[1], O. Kochetova[1], Yu. Chernetenko[1], G. Kastel[1], V. Kuznetsov[1], Yu. Medvedev[1], V. Shor[1], D. Vavilov[1] and T. Vinogradova[1]

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The software complex "Asteroids and Comets" offers an opportunity to solve a set of research problems connected with asteroids and comets in web-access mode. The list of these problems is rather wide. One of the key part of the complex is the computing-analytical package intended to predict approaches asteroids and comets to the Earth and the Moon, and to estimate the collision probability. To solve the problems a user can employ data from available databases, or introduce their own orbital parameters or observations of the object. A user has possibility to obtain information on physical and orbital parameters of asteroids and comets at the web-site, to compile their own list of object's observations and to calculate object's orbit, to get history of object's discovery and naming. Besides, a user can choose asteroids and comets according to orbital types, families of asteroids, and other information. Updating of orbital and physical characteristics of asteroids and comets is fulfilled once a month on IAA RAS web-site. To improve object orbital elements the optical and radar observations from the catalogue of the Minor Planet Centre (USA, Cambridge) as well as radar observations of Quasar VLBI network are used.

RASFX CORRELATOR PROCESSING RESULT

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RASFX correlator designed in IAA RAS in 2014 is mainly used for the UT1 determination. Since November 2015 there is regular daily VLBI data processing with R13M antennas of Badary and Zelenchukskaya observatories. At present more than 500 sessions were processed. Results of observations are shown. Sessions information (duration, frequency channels, bandwidth, polarization, bands, etc) and analisys of processing (UT1 and formal errors definition) are presented. DiFX correlator is also used for processing UT1 sessions. The result of the RASFX and DiFX correlators comparison is given.

THE HIGHLY SENSITIVE RECEIVING SYSTEM OF S/X BAND OF WAVELENGTHS TO ADDRESS THE PROBLEMS OF ASTROMETRY AND GEODESY ON THE RADIO TELESCOPE RT-70

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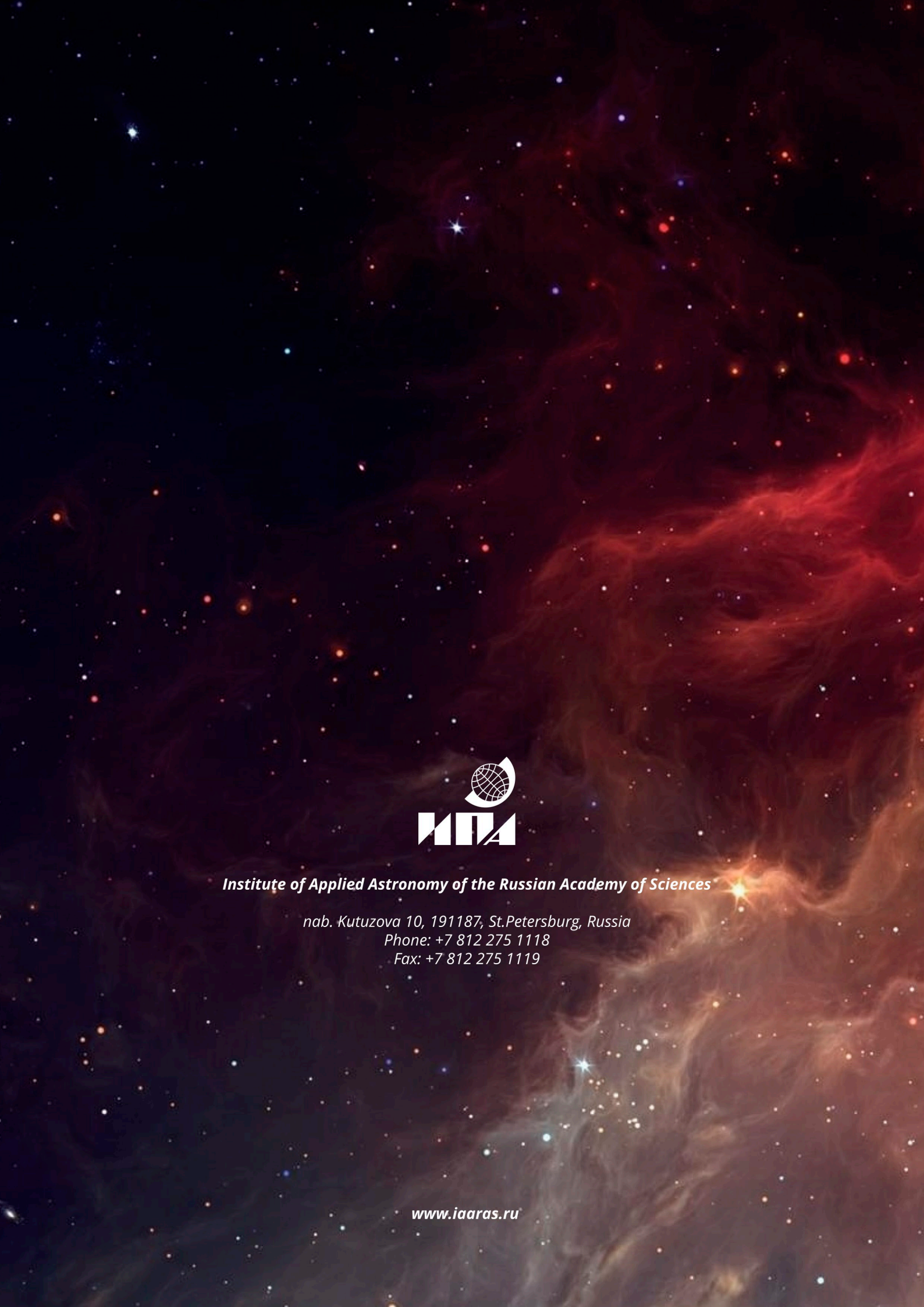
IAA RAS conducted the work on equipping the radio telescope RT-70, located near Ussuriysk, hardware and software, ensuring compatibility with VLBI-network "Quasar-KVO". However, this upgrade is not affected by the receiving system RT-70 radio telescope in order to allow for joint observations with "Quasar-KVO" VLBI-network. The radio astronomy receiver system (RRS) of S/X bands has been designed for upgrade them, able to work in radio interferometric and in radiometric mode. The RRS includes cryoelectronic receiving focal unit with dual-band cooled feed, frequency conversion units, noise generators units, and power and control units. The paper presents the results of the RRS noise temperature measurements and the gain of the receiving path of the RRS. The results of measurements the basic characteristics of the operating units are presented.



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