Abstracts

Navigation of high-apogee orbit of the SRT in RadioAstron mission

Akim E.L., *Keldysh Institute of Applied Mathematics*
Bebenin R.M., *Astro Space Center of the Lebedev Physical Institut*e
Ponomarev Yu. N., *Astro Space Center of the Lebedev Physical Institut*e
Stepanyans V.A., *Keldysh Institute of Applied Mathematics*
Tuchin A.G., *Keldysh Institute of Applied Mathematics*

Space radio telescope (SRT) will be launched on near Earth orbit, having perigee close to the Earth and near-apogee distance ~ 350,000 km. SRT will have an antenna with diameter 10 meters. The orbital parameters are chosen to maximize evolution of the normal to the orbit plane (W-right ascension and i-declination) using the gravitational fields of the Moon and the Sun. The name of the spacecraft is “Specter-R”. SRT together with the stations on the Earth will be an interferometer with a very large base.

To determine current orbital parameters of the SRT tracking stations (TS) and command stations (CS) will be used. To provide high-stability frequency generation an on-board H-maser will be installed. CS will measure range and range rate, and the TS will measure only range rate of the SRT. The laser retroreflectors which will be used for the SRT ranging will increase precision of laser measurements.

This presentation discusses the questions of the SRT orbit determination. From the ballistic point of view the SRT is a difficult object. The pressure of solar radiation has a lot of effects on the different elements of the spacecraft surface. As a result, the force-moments around the spacecraft center of mass appear. To keep spacecraft orientation constant reaction-wheel system (RWS) will be used. Long-run effects of the force-moments lead to permanent increase of angular velocity momentum which, in turn, will require unloading the momentum of the spinning reaction wheels by switching on gas engines.

The absence of the orientation moments scheme results in perturbation of the SC center of masses motion. As the performed estimation shows, the velocity change, caused by such perturbations, for a day can achieves value of 1-5 mm/sec. Per day shift may be within 100-500 m, what sometimes exceeds an accuracy of radio range measurements. The span of an interval of measurements used for determination of orbit parameters should be not less that one full orbit.

During this period the sessions of RWS unloading will be carried out some times, so the SC motion on this span can not be considered as passive. Thus the motion model should take into account perturbations originating owing to work of the attitude control system engine in sessions RWS unloading. The duration of a session of unloading is insignificant (presumably less than 5 minutes), therefore disturbing effects on the SC center of masses motion can be considered as instantaneous impulses of velocity changes in a middle of the RWS unloading session.

The parameters of these impulses should be evaluated with the most accuracy by using all availed information. As such information will be used: - the tracking radio measurements of range and range rate, - the laser location measurements, - magnitudes and directions of impulses obtained as a result of telemetry information processing, - angular velocity of the wheels which will be monitored during the flight. The estimations have shown that accuracy of available measurements for the SRT position and velocity give possibility to realize the high-precision reconstruction of the SRT orbit.

RadioAstron status & main parameters
Andreyanov Vladimir, *ASC FIAN*

Payload basic parameters are listed for project RadioAstron. Detail of the Space Radio Telescope (SRT) composition is given as general scheme. SRT reliability is provided by the electrical, mechanical and thermal tests of the separate devices, constructions and integrated modules; the test steps are indicated. SRT noise temperature and its terms are defined taking into account the measurements and calculation. Data for frequency compatibility SRT and GRTs are mentioned. Radio links scheme SRT-TS (including H-maser application) is given.

OH masers, OH megamasers, and nuclear starbursts
Baan Willem, *ASTRON, The Netherlands*

The nature and structure of high-gain OH maser emission sources will be considered in Galactic and extragalactic sources. The properties of OH megamasers are related to the properties of nuclear starbursts.

Multi-frequency synthesis technique in radio interferometric imaging using generalized maximum entropy method
Bajkova Anisa, *Central Astronomical Observatory RAS*

Multi-frequency synthesis (MFS) in radio interferometry assumes mapping of a source at several observing radio frequencies simultaneously to improve UV-coverage and thus the quality of the synthesized image. At present the MFS technique is especially urgent for Russian radio astronomy in connection with putting into operation Russian "Quasar" VLBI system with only three elements in Svetloe, Zelenchukskaya and Badary (Bajkova, 2004) and future high-orbit space-ground RadioAstron mission (Kardashev, 1997; Bajkova, 2005).

The main problem of MFS is connected with a spectral dependence of the source brightness distribution. In order to avoid possible artifacts in the image it is necessary to fulfill spectral correction during the deconvolution stage of the image formation. Cornwell (1984) appears to have been the first to consider this problem and to propose a deconvolution approach to remove these artifacts. These ideas based on CLEAN deconvolution algorithm were developed further by Conway et al. (1990), Conway (1991) and Sault and Wieringa (1994) and summarized in recent paper by Sault and Oosterloo (2007). The generalization of these algorithms was proposed by Likhachev et al. (2006).

Maximum entropy method (MEM) is well known as an alternative deconvolution algorithm which is preferable for use in case of sources with extended emission. In this work a new generalized MEM-based algorithm (Bajkova, 2008) is presented to realize accurate spectral correction of images in broad-band frequency region and estimation of two-dimensional spectral index distribution over the source. Numerous simulation results are presented to demonstrate possibilities of the technique developed.

A test of the gravitational redshift with RadioAstron
Bartel Norbert, *York University*

General relativity and quantum theory are the two pillars of modern physics. However, they are incompatible and may show inconsistencies with observations. While quantum theory has been verified at a level of 0.7 parts in a billion, general relativity has only been tested at a level orders of magnitude lower. One of the most accurate tests of general relativity was provided by the gravitational redshift experiment of Gravity Probe A. It verified the equivalence principle, part of general relativity, with an accuracy of 70 parts in a million. RadioAstron with its highly eccentric orbit and large apogee, two hydrogen masers on board the spacecraft, and three-way Doppler system should allow a gravitational redshift test with an accuracy one to two orders of magnitude higher than that of Gravity probe A. It would therefore be the most accurate test of general relativity by far. I will elaborate on the test and emphasize its importance.

Supernova VLBI with RadioAstron
Bartel Norbert, *York University*

From thousands of known supernovae, about 50 have been detected at radio wavelengths and 12 studied with VLBI. VLBI of supernovae has allowed angular diameters, angular velocities, decelerations, and their variations to be measured. These measurements provide information on the emission and absorption processes, the ejecta and circumstellar medium, and the interaction between the latter two. Combined with optical spectra, the measurements also allow a geometric determination of the distance to the supernova and its host galaxy. VLBI with RadioAstron may provide unique information about the emission and absorption processes and the nature of a supernova at the earliest time in its evolution when the optical depth decreases below unity. I will elaborate on supernova VLBI and describe the chances of observing a supernova with RadioAstron.

Radiospectrometer on the gravitational lense: estimations for the RadioAstron.
Bisnovatyi-Kogan Gennadyi, *Space Research Institute RAS*

When a gravitating body is surrounded by a plasma, the lensing angle depends on a frequency of the electromagnetic wave due to refraction properties, and the dispersion properties of the light propagation in plasma. The last effect leads to dependence, even in the uniform plasma, of the lensing angle on the frequency, what resembles the properties of the refractive prism spectrometer. The strongest action of this spectrometer is for the frequencies slightly exceeding the plasma frequency, what corresponds to very long radiowaves. Some estimations are presented for possibility of detection of this effect by RadioAstron.

This talk is based on the recent paper with O.Yu. Tsupko: “Gravitational radiospectrometer”, G.S. Bisnovatyi-Kogan and O.Yu. Tsupko, arXiv:0809.1021v2 [astro-ph] 19 Sep 2008; Gravitation and Cosmology (accepted).

Mirror matter as a form of dark matter and RadioAstron
Blinnikov Sergey, *ITEP*

Mirror Matter is one of the oldest but still viable Dark Matter candidate. Some versions of Mirror Matter model allow to explain Pioneer anomalies, DAMA experiments etc. Relation of these problems to RadioAstron mission will be discussed.

Two-dimensional time delay measurement of a fast scintillator using VLBI arrays
Cimo' Giuseppe, *JIVE*

Scintillation of flat spectrum radio sources provides an unique instrument to study the characteristics of the electron density distribution throughout the interstellar medium as well as to study the microarcsecond structure of these compact radio objects. A new approach, using VLBI techniques, to measure the distance of the scattering screen in the interstellar medium will be described. The aim is to measure the time delay, caused by the scintillation pattern, between the different array elements. Results of recent EVN observations will be presented.

Formation, evolution and observational evidences of supermassive black holes
Doroshkevich Andrey, *ASC FIAN*

The Super Massive Black Holes (SMBH) are observed up to redshifts $z\sim6.5$ as the Active Galactic Nucleis (AGNs) and quasars. AGNs include usually the central SMBHs, the gaseous accretion discs and the one-side or two side jets. Now the processes of the formation and evolution of the SMBHs and structure and dynamics of AGNs are yet badly investigated. Thus, the formation of the SMBHs can be linked with the black holes with moderate masses created in the course of evolution of first massive stars of Population III or are related to the hypothetical population of primordial black holes. The processes of the matter accretion and jet formation are also remain unclear in many aspects. The RadioAstron mission allows us to investigate the structure of central regions of AGNs with unprecedented resolution down to $\sim 7\mu as$ and to obtain a more clear knowledge of the properties of magnetic field and plasma nearby the SMBHs, the shape of the disc and of the process of jet formation.

High-resolution RadioAstron polarisation observations with limited imaging
Gabuzda Denise, *University College Cork*

The successful and high informative polarization observations carried out with the Japanese-led mission VSOP clearly show the value of space-VLBI polarization observations. One of the main challenges posed by possible polarization observations with the RadioAstron space-ground interferometer is the limited imaging capabilities of the mission, due to the highly elongated orbit. Nevertheless, RadioAstron polarization observations can potentially be very valuable, for example, in identifying highly polarized knots/shocks on small scales, as they emerge from the VLBI core.

An 'adhoc' VLBA 327 MHz survey
Garrett Mike, Ramparadath Hayden, Lenc Emil, Wucknitz Olaf, Tingay Steve, *ASTRON*

We present the results of an automated analysis of VLBA 327 MHz data obtained from the NRAO archive. Around 50 sources are detected, some of which may be useful as calibrators for LOFAR and RadioAstron. I will also present the results of a wide-field 327 MHz VLBI imaging survey of relatively faint sources in fields including bright, compact sources.

New results on the parsec scale properties of the Bologna Complete Sample
Giovannini Gabriele, *Astronomy Dept. - Bologna University*

The Bologna Complete Sample consists of 95 radio sources selected from the B2 Catalog of Radio Sources and the Third Cambridge Revised Catalog (3CR), with $z<0.1$. Since no selection effect on the core radio power, jet velocity, or source orientation is present, this sample is well suited for statistical studies. It contains a large fraction of radio galaxies, mostly FRI (70%), but also FRIIs, compact sources, and BL Lacs. Thanks to new observations in phase reference mode we have the opportunity to study the parsec scale properties of radio galaxies with a low power radio core. In many cases we find evidence of restarting sources as well as of peculiar structures suggesting a strong interaction between jets and the ISM on the parsec scale.

Magnetic fields of quasars and active galactic nuclei
Gnedin Yu.N., Piotrovich M.Y., Natsvlishvili T.M.**,** *Central Astronomical Observatory RAS*

We present the review of basic methods of measurements of magnetic fields with application to accreting supermassive black holes. The problem of the connection between jet and accretion disk is discussed. The results of polarimetric radio and optical observations of QSOs and AGNs are presented in this talk.

Redshift-dependent properties of sub-milliarcsecond structures in extragalactic radio sources
Gurvits Leonid, *JIVE*

Statistical studies of compact structures in thousands of extragalactic sources make it possible to verify some wide-spread models of radio emission on the parsec-scales and trace faint correlations between structural properties and redshift. I will present recent results based on large samples of VLBI images of quasars and other types of AGN at frequencies from 2 to 90 GHz. These studies pave the way for conclusive cosmological tests with compact structures of AGN and in-depth investigation of astrophysical properties of AGN. I will review recent results in this field with the emphasis on the observing strategy and techniques for the next generation of radio astronomy facilities.

Scintillating pulsars
Gwinn Carl, *Univ. California, Santa Barbara*

Pulsars are the most compact radio sources yet observed, with emission regions only a few hundred km in size. Because of their small size, they scintillate because of small-scale density fluctuations in the interstellar plasma. Observations of their scintillations yields insights into the

properties of that plasma and the emission mechanisms of pulsars. RadioAstron, in combination with ground antennas, will make possible novel observations of pulsar scintillation. Its high apogee will allow, for the first time, studies of scattering at spatial scales as great as, or even larger than, the spatial scale of the scintillation pattern at the Earth. At the meter wavelengths accessible to Radioastron, pulsars are most intense, scattering is stronger, and spatial scales of scintillation are least enormous. Phenomena accessible for study include the distribution of scattering material along the line of sight and its scaling with spatial scale (indicative of Kolmogorov and/or Levy scaling); the parabolic arcs predicted to be observed in secondary spectra; and the sizes of emission regions for a number of pulsars. I will discuss hardware and software requirements for correlators to make such measurements.

Inter-stellar scintillation and micro-arcsecond structure in flat-spectrum radio sources
Jauncey David, *Australia Telescope National facility, CSIRO*

Scintillation in the turbulent, ionized interstellar medium (ISS) has been demonstrated to be the principal mechanism responsible for the rapid intra-day and intra-hour variability seen in many flat-spectrum radio sources at cm-wavelengths. For reasonable screen distances of tens to hundreds of parsecs, this implies source component angular sizes of ~10 - 100 microarcseconds. We have recently undertaken a large-scale 5 GHz VLA scintillation survey, MASIV, and I will discuss the results and note specific areas of considerable relevance to the RadioAstron Mission.

Brightness temperature limits of compact radio sources
Kellermann Kenneth, *NRAO*

I will review the limitations to the brightness temperatures of quasars and AGN that might be observed with RadioAstron. Particular attention is given to the effects of Doppler boosting which can increase the apparent brightness temperature above the canonical inverse Compton limit of 10^{11-12} K by factors of 10 to 100, as well as to the effects of particle acceleration and radiation loses on the observed brightness temperature.

Some special aspects of imaging at space VLBI
Kogan Leonid, *NRAO*

1. Model fitting near Apogee.
2. Compact maser source mapping using fringe rate. (AIPS task FRMAP). The high speed near perigee will give better angular resolution in comparison with ground based VLBI.
3. Global fringe fitting (AIPS task FRING) can serve to decrease the minimum detectable flux similar to combining a group of ground based antennas.
4. Addng acceleration term in fitting the visibility phases can improve the VLBI sensitivity (first of all space VLBI). This option is available at the ASL software.

Prelaunch antenna parameters of SRT-10 from measurements and estimations

Vasil'kov V.I., Kovalev Yu.A., Larionov M.G., Kovalenko A., Nikolaev N.Ya., Starikov V.D., *ASC FIAN*

In winter of 2003--2004 in Pushchino Observatory we and our colleagues have measured the main antenna parameters for an ingeneering model of the 10-m Space Radio Telescope for the RadioAstrom Mission. The effective area and the beam width were measured at 1.35, 6.2, 18 and 92 cm. We will present the results of these measurements.

We report here on the results for other antenna parameters, in particular: 60, 37, 36, 63 percents of power are dissipated out of the main beam; the mean level of the lobe out of the beam is 3x10^-7, 3x10^-6, 2x10^-5 and 2x10^-3 relative to the maximum of the beam at 1.35, 6.2, 18 and 92 cm, respectively, by these estimations. Results can be used for estimation of the interferences and the antenna noise temperature in the space.

RadioAstron KSP: AGN jets at fine scales

Kovalev Yuri, *MPIfR, ASC FIAN*

Previous space VLBI and ground based observations of compact extragalactic jets did not resolve the base of the jet in majority of active galactic nuclei. The combination of the achievable sensitivity and available baseline length did not allow to measure brightness temperature values in excess of 1e13-1e14 K. For most of the cores, their structure across the jet flow was not resolved. Much larger baseline length will become available for VLBI studies with the launch of the Russian space VLBI mission RadioAstron.

In this talk we summarize ideas and requirements for a RadioAstron space VLBI survey of compact extragalactic jets to probe their fine scale structure with ultimate angular resolution. This will allow to learn physics of the jet origin in the vicinity of super-massive black holes.

Pre-launch test observations in MFS mode

Kovalev Yuri, *MPIfR, ASC FIAN*

Multi-frequency synthesis (MFS) VLBI technique allows high-quality radio images to be obtained from sparse interferometric arrays, in short times. Radioastron Space VLBI mission will utilize this MFS mode of observing to fill in the aperture-plane during the mission's common mode of observing at K-band (18-26 GHz) that will include only a few large ground antennas and the high-orbit spacecraft. This talk discusses a first pre-launch observing test performed with a two element interferometer formed by Goldstone and Robledo 70m Deep Space antennas. The wide-band DSN K-band receiver is very adequate to test and carry out MFS observations.

We will describe in detail peculiarities of the observational process required by the MFS technique, from project planning and scheduling, to special observing configurations and calibration. Observational data (target: BL Lac object 1803+784) was recorded in March 2008 using the Mark5A recorder and initially correlated at Bonn correlator requiring a dedicated setup. At end of the talk we summarize results, challenges and problems encountered, and lessons learnt from this test.

RATAN-600 continuum spectra as a tool to select promising AGN jets for RadioAstron studies
Kovalev Yu.A., Kovalev Y.Y., *ASC FIAN*
Nizhelsky N.A., Zhekanis G.V., *SAO RAS*

We have studied instantaneous continuum 1-22 GHz spectra of a complete sample of VLBI selected compact extragalactic jets at 5-6 frequencies with the 600-meter ring radio telescope RATAN-600 at the North Caucasus, Russia. A very strong long-term variability dominated at high radio frequencies is observed from about 200 active galactic nuclei and is explained by jet ejections with enhanced particle density in an AGN jet model. These objects are selected as promising candidates for RadioAstron studies of compact jet origins with ultra-high angular resolution. We have also organized a RATAN monitoring program to run simultaneously with RadioAstron mission. We will select flaring extragalactic jets and add them 'on-the-fly' to RadioAstron observing program.

Design of transient event detectors for science data tracking stations
Langston Glen, *NRAO*

We discuss science projects benefiting from real-time transient event detection implemented in the science data tracking stations. Applications include detection of giant pulses from known pulsars and searches from short duration transients from various astronomical sources.

Russian network of ground radio telescopes: technical specifications, and program of prelaunch VLBI tests
Larionov Mikhail, Popov Mikhail, *ASC FIAN*

Ground network in Russia will include three 32-m radio telescopes of the “Quasar” geodetic system, 64-m radio telescope in Kalyazin, 70-m communication antenna in Ussuriisk and RT-22 in Pushchino operating if 32-m antenna in Ussuriisk will work as a tracking station. We will discuss technical specifications, current status of VLBI performance, and our plan to conduct tests of the network at RadioAstron frequency ranges and modes of VLBI observations.

Studies of ultracompact jets with RadioAstron
Lobanov Andrei, *MPIfR*

Imaging and polarimetry of radio emission on microarcsecond scales provided by RadioAstron will offer a range of possibilities for studying ultracompact regions of relativistic jets and extreme vicinity of the central supermassive bodies in AGN. RadioAstron will address a number of outstanding problems in AGN physics, including the site and the mechanism of jet formation, acceleration of relativistic flows, structure of magnetic field in the vicinity of the central engine of AGN, and the fundamental question of the physical nature of the central massive objects in galaxies. Prospects and potentials of these lines of study with Radioastron will be reviewed.

How can dark energy be measured, particularly at fine angular resolution
Lukash V.N., Stern B.E., *ASC FIAN*

We analyze basic approaches of detecting dark energy's action on the Universe's structure, dynamics and geometry. The latter can be measured through observing UCRSmas, double quasars, GRB afterglows and other compact radiosources, which reveal physical processes in the vicinity of SMBH (relativistic motions, formation and propagation of jets), and modeling the $\theta(z)$ and $\dot{\theta}(z)$ relations to determine the redshift-dependent cosmological parameters.

The fine structure of the ejector regions and jets
Matveenko Leonid, *Space Research Institute*

We are studied super fine structures of the AGN objects 3C 345, 1803+784 in synhrotron emission and the star formation region of the Orion KL in the H2O maser radiation. The structures have core and jet. Jets have helix structure with curve axies, which are determined by two modes precession of the ejector. Ratio of the angular velocities are ~20. Precession is result of ejection of matter stream. Visibility of the core region AGN objects determined by transparency of the surrounded HII medium, which absorbed synhrotron emission. They are measured by spectrums of the compact components at the different distances from the ejector and decreasing the cut off frequencies. The peak brightness temperatures of the compact components are 10^(12-13)K. The ejector region of the Orion Kl - double compact source, components of which are separated at ~ 10 msec, its the brightness temperature ~ 10^(19) K. Opened extra ordinary rotation of polarization determined by difference polarization of two sources at 45 deg, and velocities at 0.4 km/s.

Spectral properties and variability of radio sources near the north celestial pole
M. G. Mingaliev[1], Yu. Sotnikova[1], N. Kardashev[2], and M. Larionov[2]
[1]*Special Astrophysical Observatory of RAS, Nizhnij Arkhyz, Russia*
[2]*Astro Space Center, Lebedev Physical Institute of RAS, Moscow, Russia*

Observations at the RATAN-600 radio telescope were done to study the spectral characteristics of a complete sample of 504 radio sources selected from the NVSS survey near the North Celestial Pole ($+75° < S < +88°$) at six frequencies (1-22 GHz) with the aim of selecting sources with inverted spectra to be included in the program of the RadioAstron space VLBI mission [Mingaliev et al. 2007]. This data testify that the spectral behavior of our sample differs from that for a complete sample of sources with the same initial parameters but selected at 20 GHz [E.M. Sadler et al., 2006]. We find a 6% deficit of inverted-spectrum sources, which can be explained as an effect of the spectral characteristics of "sub-threshold" sources that were not included in the initial sample at 1.4 GHz.

We present multifrequency simultaneous spectra at the period from 1999 to 2007. 33 sources of 52 with flat spectra were studied for short term variability. Fifteen sources with the variability on the days time scale of the different spectral classes objects were derived: more than half of these sources demonstrate the rise of the variability amplitude with the frequency. Some of the sources have variability amplitude which practically doesn't change with the frequency. The sources with inverted spectra of interest as compact objects will be included in the RadioAstron observing program.

Our data for the spectral characteristics for this sample of radio sources as well as for data from a “pilot survey” at 20 GHz testify to the presence of a substantial fraction from 30 to 40% of objects with curved spectra in the studied wavelength range making it impossible for us to accurately predict the spectral behavior at high frequencies based on an analysis of low-frequency data. This is important, for instance, when estimating the contribution from individual sources to fluctuations of the cosmic microwave background, where the absence of high frequency sky surveys necessitates the use of data on the objects’ spectral characteristics extrapolated from low frequencies.

Magnetic fields of quasars and active galactic nuclei

Gnedin Yu.N., Piotrovich M.Yu., Natsvlishvili T.M., *Central Astronomical Observatory RAS*

We present the review of basic methods of measurements of magnetic fields with application to accreting supermassive black holes.

Wormholes and some methods of their search in the Universe

Novikov Igor, *ASC FIAN*

We consider the hypothesis that some active galactic nuclei and other compact astrophysical objects may be current or former entrances to wormholes. Wormholes are tunnels that connect two distant regions of our universe with each other. In the model of the Multiverse, wormholes may connect two universes together.

We discuss various astrophysical methods of proof that some objects are wormholes and discuss how the RadioAstron and the Millimetron projects can help to solve the problem.

M-theories and high resolution radio astronomy

Parijskij Yuri, *SAO RAS*

"SUSY and extremely high resolution in Radio Astronomy" Information about first attempts by several groups to see STEPS in CMB predicted by some "M-Theories" will be given. New DATA from RATAN-600 RZF deep survey with few arcsec. resolution will be presented as well. The role of RadioAstron mission in this new field will be shortly discussed also.

Giant radio pulses from the Crab pulsar as a calibrator tool for SVLBI

Popov M., Ilysov Y, *ASC FIAN*
Zharov V., *Sternberg Astronomical Institute*

Giant radio pulses (GP) are one of the most striking phenomena of pulsar radio emission. The most powerful GP were detected from the Crab pulsar (PSR B0531+21) with peak flux densities often in excess of millions of janskies at decimeter wavelengths. Such bright pulses may be used as natural signals to determine clock offset and LO frequency variations in VLBI experiments. The GP detection is especially important for interferometers with initially purely known parameters. The situation can be happened for space-ground interferometer in its early stages of operations. We have developed software correlation technique including coherent dedispersion. Some results of GPs VLBI observations of the Crab pulsar at 2244 MHz will be presented. We also estimated of detection of GPs with 10-m space radio telescope.

Radio emission from cosmic gamma-ray bursts

Postnov Konstantin, *Sternberg Astronomical Institute*

A review will be given of the existing radio observations of gamma-ray bursts and prospects of high-resolution radio observations of GRBs will be discussed.

The nature of very active RS CVn type stars and the possible identification of its highly polarized emitter

Slee O.B., *Australia Telescope National Facility, CSIRO,*
Serber A., *Institute of Applied Physics RAS,*
Tsarevsky G., *ASC FIAN*

We describe the discovery by Slee et al. (2008) of highly polarised emission lasting 2-3 h from the RS CVn binary V711 Tau (HR 1099) observed by the Australia Telescope Compact Array (ATCA) at 1.4 and 2.4 GHz. The emission showed an extremely fine temporal structure < 78 ms, which indicates that the highly polarized emission is probably due to an electron-cyclotron maser emission (ECME) in the corona of one of the binary components. The ECME source may be due to an aurora-like phenomenon resulting from the transfer of plasma from the K2 subgiant to the G5 dwarf in a strong stellar wind, an idea that is based on VLBA maps showing the establishment of an 8.4 GHz source near the G5 dwarf at times of enhanced radio activity on the subgiant (which are about 2 mas apart).

We propose to use the microarcsecond angular resolution of RadioAstron to pinpoint the area from which the coherent emission originates in the V711 Tau binary system and in other very active RS CVn binaries.

Synthesis of the spacecraft orbit for space-ground interferometer

Sheikhet Aleksander, *Lavochkin Assosiation*

To guarantee the syntheses of high quality pictures with the help of earth-space interferometer it is necessary to have an orbit with papameters which would undergo essential change under the influence of the gravitation disturbances of the Sun and the Moon. At the same time similar orbits guarantee a great clearance of the interferometer and a high picture, because the vector SC-Earth projection on the picture plane in the direction of the research source variations (module) from zero to several hundreds of thousands km and the angle from zero to 360 degrees.

The report gives a detailed description of problems related to the choice of initial parameters of the working orbit SC RadioAstron which take into account the existing restrictions from the launch vehicle, booster and the time of the active life, mass characteristics of the launch vehicle, booster and the time of functioning of the systems of the SC, earth control segment. Synthesis of the best orbit is considered with regard to searching the extremal quality function.

Choice of initial parameters of the working orbit SC RadioAstron for launching in November – December 2009 has been made as an example. Illustrations, characterizing the process of the working orbit parameter choice are given.

Interstellar scintillation and nanosecond resolution in Radio Astronomy
Shishov Vladimir, *PRAO*

As was shown in some papers the interstellar scintillation can be used for measurement of angular size of pulsar emission sources with resolution of the order of tens nano arcseconds. Previous results were based on an analyses of dynamical spectra of pulsars obtained with single aperture. Unknown distribution of the turbulent medium along line of sight is the main problem for this method. Observations on a system of interferometers of RadioAstron project allow us to obtain simultaneously the spatial diffractive pattern and the dynamical spectrum for given pulsar. Using these data we can reconstruct the distribution of the turbulent medium along a line of sight and determine the position of the effective layer responsible for pulsar scintillation on the line between the observer and the source. Measuring the decorrelation between dynamical spectra for different pulse phases we can determine the displacement of pulsar emission source with changing of the pulse phase in units of characteristic scale of diffractive pattern. Using data on position of the effective layer on the line of sight we can reduce the displacement to usual spatial units.

Probing substructure lensing with RadioAstron
Tuntsov Artem, Pshirkov Max, *Sternberg Astronomical Institute*

Gravitational lensing has become a powerful probe in investigating the matter distribution througout the Universe. It is particularly useful to detect Dark Matter objects which interact with the ordinary matter only by gravitational force. One of the most important problem in DM astrophysics is the detection of DM subhaloes in various galaxies. These subhaloes are predicted by numerical simulations but have not been observed yet. We argue that they can be discovered by their influence on lensed images of distant galaxies on sub-milliarcsecond scale and show how the unprecedented angular resolution of the RA mission could possibly uncover the presence of these objects and/or seriously constrain their properties.

Recent developments with the LBA
Tzioumis Anastasios, *ATNF CSIRO*

The Long Baseline Array (LBA), consisting mainly of telescopes in Australia, is the only extensive VLBI array in the southern hemisphere and hence very critical for ground support of space-VLBI missions. In the last few years the LBA has transformed its operations. It has decommissioned the tape-based S2 system and hardware correlator. All operations now use disk recording and software correlation, with a significant component of e-VLBI. The recording system (LBADR) was evolved from the PC-EVN system using COTS computer hardware. The DiFX software correlator has been adopted (seehttp://astronomy.swin.edu.au/~adeller/software/difx/) and has revolutionised LBA operations and e-VLBI. It should be considered as an alternative correlator for space-VLBI missions like RadioAstron, offering unparalleled flexibility, scalability and ease of operation.

The ASTRO-G (VSOP-2) project
Murata Yasuhiro, *JAXA*

The first dedicated space-VLBI project, the VLBI Space Observatory Programme (VSOP), commenced with the successful launch of radio-astronomical satellite HALCA in 1997. Plans for a second generation space-VLBI project, VSOP-2, has now been approved by Japan\'s space agency, JAXA, as the ASTRO-G project. The apogee height of ASTRO-G satellite will be 25,000 km which gives the maximum baseline length of about 30,000 km between the space and ground radio telescopes. It will have a maximum angular resolution at 43 GHz (7 mm) of about 40 micro-arcseconds. ASTRO-G will be launched by Japanese HIIA rocket, in the Japanese financial year of 2012.

The ASTRO-G science goals include: study of emission mechanisms in conjunction with the next generation of X-ray and gamma-ray satellites; full polarization studies of magnetic field orientation and evolution in jets, and measurements of Faraday rotation towards AGN cores; high linear resolution observations of nearby AGN to probe the formation and collimation of jets and the environment around supermassive black holes and the highest resolution studies of spectral line masers and mega-masers, and circum-nuclear disks.

The VSOP-2 spacecraft, ASTRO-G, will have a deployable 9-m off-axis paraboloid antenna with an uncooled receiver operating in the range 8.0 - 8.8 GHz, and cryogenically cooled receivers operating from 20.6 - 22.6 GHz and 41 - 45 GHz in both LHCP and RHCP. To achieve an order of magnitude higher sensitivity for continuum sources, VLBI data will be down-linked in real-time at 1 Gbps using the 37 - 38 GHz band. The on-board system is locked to a reference phase, derived from a H-maser at one of 3 - 4 tracking stations, and uplinked as a tone at 40 GHz. ASTRO-G has 2 IF channels with 2 sampling modes. One uses 256 MHz bandwidth, 1-bit sampled channels, and the other has 128 MHz, 2- bit sampled channels. Furthermore, a phase-referencing capability is being actively considered.

The ASTRO-G project is now in phase-B, and we are working for the basic design of the satellite, which includes many analysis, engineering model tests, the selection of the parts and components, and so on. We will finish the basic design in the first quater of 2009, and the detailed design of the flight module will start for all components.

Water megamaser observations with Space-VLBI
HagiwaraYoshiaki, *NAOJ*

Imaging of H2O megamaser using VLBI technique with increasing angular resolution is a very powerful method for investigation of the inner part of Active Galactic Nuclei. Space-VLBI observations of the H2O megamaser will refine the measurements of proper motions, accelerations, distances to galaxies, and other physical parameters. In this presentation, we present the prospects of studies of H2O megamaser using Space-VLBI.

Astrometric goals of RadioAstron mission
Zharov V.E., *Sternberg Astronomical Institute*,
Ponomarev Yu. N., *ASC FIAN*

The RadioAstron program is the next generation of the radio astrometry programs. It is proposed to launch in next year the satellite SPECTR with a 10 m radio telescope on a highly elliptical unstable orbit with ecccentricity ~ 0.96 with an apogee height of 350000 km. Period of revolution of

the satellite is about 9.5 days, and observational time during one revolution can be about 9 days. Observations can be made at next frequency bands: P(0.327 GHz), L(1.665 GHz), C(4.830 GHz) and K(22.220 GHz) with bandwidth 32 MHz. For the shortest wavelength equal to 1.35 cm and baseline of about 350000 km resolving power of the order of 8 microarcseconds can be achieved. For signal-to-noise ratio of order of 30 one can reach of angular observations precision of 2-3 microarcseconds. It is necessary for study of fine structure of radio galaxies, quasars, black holes, neutron stars. The baseline of the space-ground interferometer has to be known with very high precision to link the observed sources with the International Celestial Reference Frame (ICRF).

We discuss different methods for control of position and velocity of the space radio telescope in order to reconstruct its orbit: measurement of Doppler shift of transmitted frequency, laser satellite ranging and observation of the reference quasars. These additional observations can be used for link of kinematical and dynamical celestial reference frames; measurements of secular aberration (motion of the Solar system in Galaxy); study of motion of the reference quasars.