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For Nikolai Kardashev

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Outline

- Basic parameters, current status
- Orbit and its determination
- Imaging capabilities and $uv$-coverage in perigee
- Tracking stations
- Recording system, correlator
- Science with Radioastron
- Radioastron meeting in Moscow, October 2008
The RadioAstron Space Observatory (the Spectr-R project) equipped with 10-m mirror antenna, is dedicated to investigate a structure of various objects in the Universe at centimeter and decimeter wavelengths with an angular resolution of up to a few millionth of arcsec (i.e., millions time better than human eye’s resolution).

Such resolution is achievable for the radio interferometer consisting of a space telescope orbiting with an apogee of up to 350,000 km, and largest ground based radio telescopes.

The Spectr-R project has been included in the Federal Space Program of Russia for 2006-2015.

Formal launch date: November 2008.
Expected to be officially shifted to April 2009 soon.
Subject to results of tests and other unpredictable aspects of space missions.
Please, keep the oil price high. Thank you.
**Basic parameters: receivers**

<table>
<thead>
<tr>
<th>Band</th>
<th>P</th>
<th>L</th>
<th>C</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequencies (MHz) of observations</td>
<td>327</td>
<td>1665</td>
<td>4830</td>
<td>18392-25112</td>
</tr>
<tr>
<td>Bandwidth (MHz) for each polarization</td>
<td>4</td>
<td>32</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>Fringe size (μas) [baseline 350 000 km]</td>
<td>540</td>
<td>106</td>
<td>37</td>
<td>7,1 -10</td>
</tr>
<tr>
<td>Min. cor. flux (mJy) [RMS with EVLA, 300 s integration time]</td>
<td>10</td>
<td>1,3</td>
<td>1,4</td>
<td>3,2</td>
</tr>
</tbody>
</table>

Dual polarization, 128 Mbps bit rate, simultaneous single-pol. observations in two bands are possible.
Basic parameters: launch vehicle
A number of tests were performed recently including vibration test. OK. Currently (Lavochkin): the space radio telescope (flight model) is being assembled.

June 10, 2008 (ASC): focal container comes back for 1.5 months for radiometric tests.

July 15, 2008 (Lavochkin):
- assembling of Space Radio Telescope / Bus,
- vacuum chamber tests,
- testing for radio compatibility, interference, etc.
The orbit of the RadioAstron gravitationally perturbed by the Moon has the following parameters:

- Perigee radius: $\geq 10,000$ km
- Initial inclination: $51.6^0$
- Average apogee radius: $350,000$ km
- Average period of revolution: $9.5$ d

Three methods to measure orbit parameters:

- Ballistic measurements provided by the Flight Control Center from telemetry sessions run at the DSN antennas in Ussurijsk and Bear Lakes (distance/velocity data).
- Closed-loop Doppler measurements of velocity by tracking stations.
- Distance measurements by laser range finders ($\sim 100$ retro-reflectors are installed on board).

Required position/velocity/acceleration accuracies: 600 m, 20 mm/s, $10^{-8}$ m/s$^2$. 
UV-coverage examples
one tracking station, perigee
UV-coverage examples
three tracking stations, perigee
One tracking station (Pushino, Moscow region, Russia) is almost finished. Three-band design: 15 GHz telemetry/data stream, 7.3/8.4 GHz uplink/downlink stream for orbit determination.

Three tracking stations are needed. Several under consideration including Ussuriysk. One more set of (very expensive) TS electronics is planned to be fabricated by Russians – to be installed on a second tracking station.
Recording system and correlator

• Radioastron Data Recording (RDR) system: disk based system designed in ASC. Data format: Radioastron data format (RDF). Maximum RDR bitrate: 448 Mbps, bitrate required by Radioastron: 128 Mbps. Eight RDR systems are made, five of them are sent to IAA (Institute of Applied Astronomy).
• RDR to Mark5 (and Mark5 to RDR) copy/reformat machine is being built. Not available yet.
• Data center is under construction (to be located in Pushino). 40TB of disk space (upgradable to 250TB) to be used as a storage of Radioastron data.

• Software correlator is developed. The correlator understands Radioastron data format and uses RDR playback systems. Currently can correlate 5 stations. Is upgradable, if needed.
• The correlator was successfully used for Space Radio Telescope (SRT) 0-baseline (SRT to Pushino) tests as well as for correlating the IAA (Russian) VLBI observations.
The main scientific goal of the mission is to investigate a variety of astronomical objects with an unprecedented angular resolution up to several millionth of arcsec.

The resolution achievable by RadioAstron would permit an investigation of the following targets of great interest of modern astrophysics:

- A study of the central engine of Active Galactic Nuclei (AGN) close to the events’ horizon of the supermassive black hole, via their structure and emitting nuclear regions dynamics, and, also, their spectra, polarization and variability.
- Parameters of the cosmological model, dark matter and dark energy in the Universe determined by means of the redshift dependence of the AGN parameters, and, also, by effects of gravitational lensing.
- Structure and dynamics of the star formation regions by the maser and megamasers spectral line emission.
- A structure of the star mass black holes, neutron and possible quark stars in our Galaxy (particularly, by the “interstellar interferometer” method), and determination of their proper motions and parallaxes.
- Structure and distribution of the interplanetary and interstellar matter by the investigation of fluctuations of the visibility function scintillation of pulsars.
- Construction of a high precision celestial coordinate frame.
- Development of a high precision model of the Earth gravitation field, and General Relativity tests by means of the precision redshift measurements.
Radioastron Symposium 2008

We are pleased to announce the Symposium "Radio Universe at Ultimate Angular Resolution" and to invite you to participate. This meeting will be organized by the Astro Space Center (ASC) of P.N. Lebedev Physical Institute, Russian Academy of Sciences, on October 20-24, 2008, in Moscow, Russia. The meeting is aimed at attracting representatives of scientific institutes, observatories, and space agencies, researchers interested in astrophysical phenomena to be studied with the unique Radioastron (RA) angular resolution, and engineers experienced in VLBI technique. The meeting will focus on scientific programs and technical aspects of space VLBI with extremely high angular resolution.

See for details:
http://radioastron.ru/symposium2008/