Science Priorities of the RadioAstron Space VLBI Mission

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and the International Space VLBI Collaboration

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10m Diameter Space Radio Telescope

Designed by Astro Space Center, Moscow.

International Collaboration

Dual Circular polarization with high sensitivity cooled front end.

High downlink data rate, 128 MBps.

Launch delayed more than 1 decade.

Scheduled for 2008.

Orbit: period 9.5 days. Semi-major axis 189 000 km, inclination 51.6 deg

<table>
<thead>
<tr>
<th>Band (GHz)</th>
<th>0.327</th>
<th>1.665</th>
<th>4.830</th>
<th>18-25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band width (MHz)</td>
<td>4</td>
<td>32</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>Fringe size (μas) [ base line 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 upgrated VLA, 300s integration time ]</td>
<td>10</td>
<td>1.3</td>
<td>1.4</td>
<td>3.2</td>
</tr>
</tbody>
</table>

Kardashev, Langston AAS 2007

Construction Progress

Launch Configuration

Deployed Configuration with solar panels and downlink antenna
VLBI Observations

First Light: Radio astronomical tests of SRT Engineering Model in Pushchino in 2004

Future Space VLBI observations in simultaneous with ground radio telescopes.
Orbit reaches nearly to the Moon.
Unprecedented Angular Resolution

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Angular Resolution</th>
<th>Improvement Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye</td>
<td>60”</td>
<td>1</td>
</tr>
<tr>
<td>HST</td>
<td>0.1”</td>
<td>600</td>
</tr>
<tr>
<td>Radio Astron</td>
<td>0.00001”</td>
<td>6,000,000</td>
</tr>
</tbody>
</table>
Scientific Objectives

• Active galactic nuclei (super massive black holes, event horizon, particle acceleration, brightness temperature limits, Faraday rotation, magnetic field, cosmic rays, super luminal motion, new physics),

• Cosmology, red shift dependencies, dark matter, dark energy

• Regions of star and planet formation (masers and Megamasers),

• Black holes of stellar masses and neutron stars,

• Interstellar and interplanetary medium,

• Fundamental astrometry and high accuracy coordinate system,

• High precision measurements of the Earth gravity field.
Megamaser in Galaxy NGC4258

Physics of Massive Black Hole
(Distance 6.4 million pc)
Unique Application

Transient pulsed radio emission from a magnetar

Fernando Camilo 1, Scott M. Ransom 2, Jules P. Halpern 1, John Reynolds 3, David J. Helfand 1, Neil Zimmerman 1 & John Sarkissian 3

Applications:
- Micro-lensing
- Physics of compact objects
- Structure of the Milky Way
- Studies of the interstellar medium


XTE J1810-197, distance 3.3 kpc
Russia Set To Implement Ambitious Space Program

by Yury Zaitsev
Moscow, Russia (RIA Novosti) Dec 20, 2006

Although the Russian government approved a new federal space program this year for the period between now and 2015, there have been no breakthroughs in the last 12 months. True, the national space program, which is supported by President Vladimir Putin and the government, has started receiving additional resources.

Four Spektr-class astrophysical orbital observatories will lift off under the 2006-2015 federal space program. The first such observatory, the Spektr-Radioastron, was supposed to go into orbit this year, but the launch has been rescheduled for late 2008. These delays can be explained by the fully-fledged crisis that plagued the Russian space program throughout the 1990s, whose consequences have not yet been completely overcome.

There is now every reason to believe that the Spektr - Radioastron observatory will lift off in 2008 and operate in conjunction with a global ground instrument network. Known as radio interferometers, these combined systems have an impressive resolving power comparable to that of a radio telescope whose antenna diameter is equal to the distance between the system's ground and space instruments.
Opportunities

Radio Astron shares “Beyond Einstein” Science Goals.

Radio Astron shares some “Return to the Moon” technology development goals.

Radio Astron mission is revived by Russian Funding

Radio Astron VLBI collaborations will have unique, powerful, capabilities.

Graphic from Turner, M. 2006
http://www7.nationalacademies.org/ssb/SSB_Decadal06_MTurner.pdf
Interstellar interferometer


PSR 1237+25 (P=1.4c, D=560 nc)
Radio Observations of the Afterglow of GRB 030329
(astro-ph/0401258)

Nario Kuno¹,², Naoko Satô¹,³, Hiroyuki Nakanishi⁴, Aya Yamauchi¹,⁵, Naomasa Nakai¹, Nobuyuki Kawai⁶,⁷

• First e-VLBI Target of Opportunity Observations (May 2006, Cygnus X-3), *Tudose et al. (in prep)*.
W3(OH) (VLBA, V. Slysh et al.)
Any pictures from

Sub-Milliarcsecond Imaging of Quasars and Active Galactic Nuclei.
IV. Fine-Scale Structure
Y.Y. Kovalev at al.

Magnetic Tunnels (Wormholes) in Astrophysics
N. S. Kardashev, I. D. Novikov, and A. A. Shatskii
Orbit: period 9.5 days (7 - 10 days), semi-major axis 189 000 km, inclination 51.6 deg, perigee arise due to evolution from 300 km up to 70 000 km.
AN ENERGETIC AFTERGLOW FROM A DISTANT STELLAR EXPLOSION

D. A. Frail,1 P. B. Cameron,2 M. Kasliwal,2 E. Nakar,3 P. A. Price,4 E. Berger,5,6,7 A. Gal-Yam,2,7 S. R. Kulkarni,2

60 GRB radio afterglow at 8.5 GHz
Giant pulse from the Crab pulsar with the observed flux density about 7 MJy at 2.2 GHz leading to the estimate of brightness temperature $T_b > 10^{40} \text{ K}$ (64-m radio telescope in Kalyazin)

Rotation period of neutron star is 33 mc