VSOP-2, A SECOND GENERATION SPACE-VLBI MISSION

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ABSTRACT

Following the success of the VLBI Space Observatory Programme (VSOP), a next generation space VLBI mission, dubbed VSOP-2, is being planned in Japan. Higher observing frequencies, cooled receivers, increased bandwidths, dual-polarization capability, and a larger telescope diameter will result in gains in resolution and sensitivity by factors of about 10 over the VSOP mission. VSOP-2 science goals include studies of emission mechanisms in conjunction with X-ray and gamma-ray satellites, studies of magnetic field orientation and evolution in jets, and the highest resolution studies of spectral line masers and mega-masers.

INTRODUCTION

The successes of the VLBI Space Observatory Programme (VSOP) are described elsewhere in these proceedings [1]. Planning for the next generation space VLBI mission VSOP-2 is well underway [2]. The VSOP-2 spacecraft will have a 10 m class antenna with cryogenically cooled low-noise receivers and a downlink data rate of at least 1 Gbps, resulting in an improvement of an order of magnitude in sensitivity over the VSOP mission [3]. Observing frequencies up to 43 GHz will allow high angular resolution observations of the optically thin emission in many AGN cores. An apogee height of at least 30,000 km will allow an angular resolution of 25 micro-arcseconds to be achieved at 43 GHz, corresponding to around 10 Schwarzschild radii at the distance of M87.

THE VSOP-2 SATELLITE

The VSOP-2 spacecraft will, like HALCA, be three-axis stabilized. However, the VSOP-2 satellite will probably employ an off-axis paraboloid antenna, in contrast to the on-axis design of HALCA. One of the technical challenges wil be the requirement placed on the surface accuracy of the mesh antenna by the highest observing frequency of 43 GHz (a wavelength of 7 mm).
Due mainly to mass constraints, HALCA detected only Left-hand Circular Polarization (LCP) radiation, and its front-end radio-astronomy receivers were not cooled. The VSOP-2 satellite will detect both LCP and RCP, and will use cryogenic coolers to reduce the system temperature of the receivers by a factor of around three. Sensitivity is ultimately limited by the coherence time, which becomes increasingly affected by atmospheric fluctuations above the ground telescopes at higher frequencies. Several possibilities for "phase-referencing" to improve sensitivity by extending the coherence time are under study.
Observing requires a two-way link between the satellite and a tracking station: a reference tone, derived from a hydrogen maser frequency standard is uplinked, and the science data downlinked from the satellite in real-time. HALCA used the 15 GHz band for uplink and the 128 Mbps downlink, but

VSOP-2 will probably require a shift to the 37 GHz band for the 1-giga-bit-per-second tracking link. Testing of potential high-speed samplers for the on-board has been started.
Over 25 ground telescopes and arrays from 14 countries have participated in VSOP observations. By the time of the launch of the VSOP-2 spacecraft a number of new arrays and telescopes will also be operation, such as the VERA array of the National Astronomical Observatory of Japan.
VSOP-2 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 FUTURE

There has been considerable activity within the USA recently, culminating in the submission of a white paper to NASA's Structure and Evolution of the Universe (SEU) roadmap committee. The white paper describes iARISE, an international future space VLBI mission involving two orbiting satellites, with nominally one of these being the VSOP-2 satellite and the other a US-funded satellite. The advantage of a two spacecraft mission is that by placing the two satellites in perpendicular orbits, a better all-sky coverage and more two-dimensional (u, v)-coverages can be obtained. The likelihood of a two spacecraft mission eventuating will be better known later this year.
The international cooperation and coordination required for VSOP observations make it one of the most complex space science missions undertaken, and similar level of collaboration between all mission elements — ground radio telescopes, tracking stations, orbit determination teams, correlators etc. — will be required for VSOP-2. Submission of the VSOP-2 proposal will take place within the next year. Launch on an ISAS M-V rocket could be as early as 2008.

ACKNOWLEDGEMENTS

We gratefully acknowledge the VSOP Project, which is led by the Japanese Institute of Space and Astronautical Science in cooperation with many organizations and radio telescopes around the world.

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