Galaxies and Their Constituents at the Highest Angular Resolutions
IAU Symposium, Vol. 205, 2001
R.T. Schilizzi, S. Vogel, F. Paresce and M. Elvis

Current Status of the VSOP-2 Mission

H. Hirabayashi, Y. Murata, P.G. Edwards, D.W. Murphy,

Institute of Space and Astronautical Science, 3-1-1 Yoshinodai, Sagamihara, Kanagawa 229-8510, Japan

M. Inoue, H. Kobayashi, S. Kameno

National Astronomical Observatory, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan

Abstract. The VLBI Space Observatory Programme (VSOP) is the first dedicated Space-VLBI mission. We report here on the planning for a second generation mission which builds on and extends the successful collaborations established for the VSOP mission, and which aims to improve both resolution and sensitivity by a factor of ~10.

1. Overview

The launch of the HALCA satellite in 1997 as part of the VLBI (Very Long Baseline Interferometry) Space Observatory Programme (VSOP) has allowed imaging on baselines up to three times longer than obtainable on Earth at 1.6 and 5 GHz (Hirabayashi et al. 1998). The VSOP-2 mission will build upon the successes of VSOP, with a 10 m class antenna with low-noise receivers and a downlink data rate of 1 Gbps. Observing bands under consideration include the 5 or 8 GHz, 22 and 43 GHz. An angular resolution of ~25 μas at 43 GHz will be achievable, corresponding to ~10 Schwarzschild radii at the distance of M87.

2. The VSOP-2 Spacecraft, Orbit and Tracking

Observing at 43 GHz (λ7mm) places stringent requirements on the surface accuracy of the antenna, which in turn impacts upon its size. The VSOP-2 spacecraft is therefore likely to have a 10 m–class mesh antenna. This year, for the first time, ISAS has made funds available for development studies, and funding was received to study the various options for deployable antennas.

Due mainly to mass constraints, HALCA detected only LCP radiation, and its receivers were not cooled. The VSOP-2 satellite will detect both LCP and RCP radiation, and it is planned to use cryogenic coolers to reduce the system temperatures to ~30 K.

The VSOP-2 orbit currently being studied has an apogee height (above the Earth's surface) of ~30,000 km, perigee height of ~1,000 km and period of ~8.9 hours — providing a significant increase in the longest baseline lengths but retaining a reasonable orbital precession rate.

A two-way real-time link between the satellite and a dedicated tracking station is required for observing (Hirabayashi et al. 2000). The VSOP mission used the 15 GHz band for the reference signal uplink and, with a bit-rate of 128 Mbps, for the science data downlink, but the order of magnitude increase in down-link bit-rate for VSOP-2 will probably require the adoption of the 37 GHz band for the tracking link. VSOP observations are supported by a network of five tracking stations (Hirabayashi et al. 1998), however as only one of these is located in the southern hemisphere, significantly less tracking coverage was available when HALCA's apogee is in the south. Potential solutions for VSOP-2 include the addition of an ESA tracking station in Malindi, Kenya, or a tracking station at the ALMA/LMSA site in Chile.

3. Ground Arrays & Correlating

Over 25 ground telescopes and arrays from over 12 countries have participated in VSOP observations (Hirabayashi et al. 2000). By the time of the launch of the VSOP-2 spacecraft a number of new arrays and telescopes will also be operation, with 1 Gbps recording widely available. VSOP data is being correlated at the VSOP correlator (Japan), the VLBA correlator (USA) and the S2 correlator (Canada). Upgrades to all three will be required for the correlation of VSOP-2 data. In addition, the JIVE MkIV correlator (the Netherlands) may also be upgraded to handle space VLBI data.

4. Science Goals and Mission Timeline

The science goals of the VSOP-2 mission include: Investigation of radio/X-ray/gamma-ray emission mechanisms in conjunction with the next generation of X-ray and gamma-ray satellites; use of the longest possible baselines to probe sources with brightness temperatures in excess of the $\sim 10^{12}$ K inverse-Compton limit; polarization mapping for studies of magnetic field orientation and evolution near the core; spectral index studies combining space VLBI observations with ground VLBI observations at higher frequencies; and studies of H_2O masers and mega-masers at 22 GHz, as space VLBI provides the only way to gain improved resolution for spectral line maser sources.

The international cooperation and coordination required for VSOP observations make it one of the most complex space science missions undertaken, and a lot has been learnt for future space VLBI missions. A similar level of collaboration will be essential for the success of VSOP-2. Funding for the VSOP-2 spacecraft will be formally proposed within the next year. If funding is available in the fiscal year 2002, a launch in late 2007 or early 2008 can be looked forward to.

References

Hirabayashi, H. et al. 1998, Science, 281, 1825

Hirabayashi, H. et al. 2000, PASJ in press