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VSOP: SPACE VLBI PROJECT

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ABSTRACT

The VLBI Space Observatory Program (VSOP) is a worldwide project of one radio telescope in space with many ground radio telescopes. The concerted space VLBI network enables us to reveal high resolution and high quality images of radio sources. The space radio telescope is anticipated to be launched in January/February 1997, and collaborative observations have been coordinated. The basic parameters of the system and present status are given.

Key Words : active galactic nucleus, OH and water maser source, space VLBI, radio observation

I. INTRODUCTION

The first space VLBI experiment was conducted using the Tracking Data Relay Satellite System (TDRSS), connected with some ground radio telescopes in Japan and Australia (Levy et al. 1989). This experiment conveyed the idea of space VLBI into reality. Several space VLBI projects were planned in 1980's; QUASAT in Europe, RadioAstron in Soviet Union, and VLBI Space Observatory Program (VSOP). Among them, VSOP obtained a chance to be the first dedicated space VLBI project in the world.

In ground VLBI system, the baseline length is limited by the Earth's diameter, and this yields a limitation of the resolution. A radio telescope in space removes this limitation. Furthermore, combinations of space-ground telescopes give many two- dimensional Fourier components (u-v coverage). By these, space VLBI will provide us fine images with high resolution and high quality.

Many ground radio telescopes and VLBI networks are participating for the observations. In addition, other facilities like satellite link and data correlation are collaborating with the VSOP. Here we describe scientific targets and the satellite system together with ground participants.

II. SCIENTIFIC TARGETS

Because of the moderate height of the orbit (see §III), the VSOP has a potential facility for both high resolution and high quality images. With these, several fine structures of Active Galactic Nucleus (AGN) could be deeply investigated: jet structure and motions, outskirts of the accretion disk, and acceleration mechanism of the jets. It is almost certain to get very high brightness temperature for very compact cores, which could be studied in conjunction with the emission mechanism and beaming effect.

For maser sources, OH maser at 1.6 GHz and water maser at 22 GHz can be observed. One concern for the maser sources is to resolve out the maser spot by the longer baselines. However, recent pre-launch observations indicate that one third of maser sources is still compact with the baselines longer than 5,000 km. Then size and brightness of the maser spots will be very interesting targets for VSOP observations to investigate emission mechanism and physical condition of masers. The distribution and motion of maser spots are also of great interest to see global motion of gas clouds. Rotating disk of mega-masers and also of proto-stars will be one of key targets to date.

Among the proposed observations, Key Science Programs (KSPs) are selected to ensure that important scientific goals of the mission are realized by observations carried out with a close collaboration between proposal teams and mission personnel. Objects of KSPs are; jet motions, blazars, mega-masers, maser spots, high brightness temperatures and intraday variables, and some nearby AGNs.

III. SATELLITE SYSTEM

Basic parameters of the satellite system are shown in Table 1. The satellite is designed and fabricated by the Institute of Space and Astronautical Science (ISAS), Japan, with close collaboration of the National Astronomical Observatory of Japan (NAOJ). It will be launched using a newly developed vehicle of the M-V solid propellant rocket by ISAS in January/February 1997. As no maser frequency standard nor data recorder is on board, the satellite should be linked with a ground link station during VLBI observing. The orbital plane and apogee are precessing so that sky area for good u-v coverage changes from time to time. Due to the Sun avoidance angle of 70°, ground telescopes make observing mainly in the night.

IV. SUPPORTING AND COLLABORATING STRUCTURE

As mentioned in the previous section, satellite data are transferred to one of the five link stations on the ground. Three of them are at the Deep Space Network (DSN) sites of Goldstone in California, Tidbinbilla in Australia, and Madrid in Spain, operated by

Table 1. Basic parameters

Weight	830 kg
Antenna size	8 m equivalent
Antenna accuracy	0.5 mm rms
Frequencies	1.6, 5, 22 GHz
Apogee height	22,000 km
Perigee height	1,000 km
Orbital period	6 hr.
Life time	3-5 yr.
Recording modes	2 ch/32 MHz/1 bit
	1 ch/32 MHz/2 bit
	2 ch/16 MHz/2 bit

the Jet Propulsion Laboratory (JPL). Others are at Usuda in Japan (ISAS), and at Green Bank in the US (National Radio Astronomy Observatory). Both VLBI data recorder and hydrogen maser clock are equipped in each link station. The maser clock is to transfer frequency standard to the satellite during the VLBI observing.

The VLB Array (VLBA) and the European VLBI Network (EVN) are powerful partners for the VSOP observations. Australia Telescopes and some other radio telescopes are collaborating with the observations. Those ground telescopes and networks are arranged by the Global VLBI Working Group. The VSOP International Science Council manages the scientific aspects of the project, and the Science Review Committee (SRC) makes peer review of proposals. In addition to the general observations mentioned above, the survey program is led by the VSOP mission through the Survey Working Group (SWG). The SWG will carry out surveys of AGNs and water maser sources to determine general characteristics of various class of sources (e.g., brightness temperatures).

V. ANNOUNCEMENT OF OPPORTUNITY AND SCHEDULING

The first Announcement of Opportunity (AO) was released at the end of June 1995, and the proposals due at 17 November 1995. The second AO is planned to be released in the middle of 1997 with due date sometime in the third quarter of 1997. Among 150 proposals for the first AO, 118 proposals are for AGNs, 25 for maser sources. These are oversubscribed by roughly four times in terms of requested observing time.

After the SRC reviewing, proposals have been scheduled using scheduling software, since combination of the ground resources (e.g., availability of ground radio telescopes, conditions of link stations, etc.), constraints of the satellite, and precessing orbital elements makes scheduling too complex for manual handling. According to the rate of the SRC, proposals are allocated so as to get better u-v coverage.

In-Orbit-Checkout is planned for the first few months after launch, and the proposed VLBI observations are expected to start in early time of the second quarter of 1997.

Further information is available in the VSOP homepage: http://www.vsop.isas.ac.jp.

REFERENCES

Levy G.S. et al. 1989, ApJ, 336, 1098