Spaceborne VLBI beyond 2000

József Ádám

After a long preparation period, the idea of space VLBI has became a reality. In February 12th, 1997 a dedicated radio telescope has been launched into Earth orbit by the Institute of Space and Astronautical Science (ISAS) from Japan and integrated in the ground-based VLBI networks for astrophysical studies.

A straightforward extension from the ground - based VLBI to space is called *space VLBI* (or orbiting VLBI), which uses radio telescopes in space. With launching of one or more space VLBI satellites, space VLBI observations will be available for astrometric, geodetic and geodynamic applications as well. *The space VLBI observables may be useful to improve the determination of the Earth's gravity field and in the unification and connection of reference frames inherent in the space VLBI technique.* The space VLBI missons offer and will provide new types of satellite observables (VLBI time delay, delay rate and differential VLBI tracking data) with high accuracy for these potential applications.

After the successful launch of the first space VLBI satellite, known as MUSES-B before launch, was renamed HALCA (which stands for Highly Advanced Laboratory for Communications and Astronomy, and is meant to sound like *haruka*, the Japanese word for „distant"). HALCA is the orbital element of the VLBI Space Observatory Programme (VSOP), a large international collaboration of space agencies and radio astronomy observatories which have combined resources to create the first dedicated space VLBI mission. Simultaneous observations with HALCA's 8 meter diameter radio telescope and ground-based radio telescopes synthesize a radio telescope that has an effective diameter over twice the size of the Earth, providing finer detail images at a given radio wavelength than can be obtained from the Earth. In its elliptical orbit, HALCA ranges as far as 21000 km from Earth's center, so that when it observes in conjunction with a ground-based telescope, a maximum baseline of 33000 km is achieved, yielding a resolution of 0,3 milliarcseconds at an operating frequency of 5 GHz. That's enough to see things the size of 10 light-years at the quasar's distance of 6.5×10^9 light-years (a threefold improvement over ground-based arrays operating at the same frequency). VSOP observations at 1.6 GHz (18 cm) and 5 GHz (6 cm) have yielded the highest resolution images ever made of extragalactic radio sources at these frequencies (*e.g. Day, 1997; Hirabayashi, 1999; Hirabayashi et al., 1998; Paragi et al., 1998*). Further details about the VSOP mission, including the current observation schedule, images from previous observations, and information about proposing for observations, are available from *http://www.vsop.isas.ac.jp.*

The potential geodetic-geodynamic applications of the space VLBI technique were first pointed out by *Fejes et al.(1986).* Based on the paper by *Dermanis and Grafarend (1981), J. Ádám* started the theoretical work as a Humboldt Fellow during his research stay at the Department of Geodetic Science, Stuttgart University in 1985 (*Adam, 1989*). In the following years several very detailed theoretical studies were carried out on this subject (see e.g. *Adam (1990), Kulkarni (1992), Kulkarni et al. (1991), Klatt (1995), Zheng (1992)).* After the theoretical investigations and simulation studies made by these experts in different institutions in the frame of the IAG Special Study Group 2.109 („Application of Space VLBI in the Field of Astrometry and Geodynamics"), see *Ádám (1995), Fejes (1992),* the next obvious step was to formulate a plan to experiment with real potential measurements, when available in order to prove the feasibility of space VLBI for geodesy and geodynamics. In response for the First VSOP Announcement of Opportunity, the GEDEX (Space VLBI Geodesy Demonstration Experiment) proposal was submitted by an international team (*I. Fejes as P.I. and J. Ádám, P. Charlot, S.Frey, N. Kawaguchi, Z.H. Qian, and H. Schuh* as co-I.-s). The VSOP Scientific Review Committee accepted the proposal in 1996 with assigned code V002. For a more detailed description of the GEDEX concept is given by *Fejes et al. (1996)* and status reports are in *Fejes (1998) and Kulkarni et al. (1998).*

The future of spacebore VLBI beyond 2000 is promising. An other space VLBI satellite called RADIOASTRON in Russia is still planned to be launched, possibly in 2001. A preproject of NASA called ARISE (Advanced Radio Interferometry between Space and Earth) will be a mission consisting of one (or possibly two) 25-meter radio telescopes in highly elliptical Earth orbit. The telescope(s) would observe in conjunction with a large number of radio telescopes on the ground, using the technique of space VLBI, in order to obtain the highest resolution (10-microarcsecond) images of the most energetic astronomical phenomena in the universe. Details on ARISE are available from

http://arise. jpl. nasa.gov/arise/whatisarise/what-is-arise.html.

References used for this review and for the outlook are as follows.

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