Radio intereferometry using telescopes in earth orbit, experiences and future projects

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INTRODUCTION

Very Long Baseline Interferometry (VLBI) provides the highest spatial resolution in astronomy. The resolution is related to the distance between telescopes in wavelengths. Therefore, resolution can be improved either by increasing the observing frequency (mm-VLBI) or the baseline between antennas. Currently, the highest frequency band that can be used for routine VLBI observations is 86 GHz, limited by the atmosphere and in many cases the source spectra. Therefore, for many astronomical problems, exceeding the limits of the earth diameter and using and orbiting antenna is the only solution.

OBSERVATIONS WITH HALCA

The Highly Advanced Laboratory for Communications and Astronomy (HALCA) radio astronomy satellite was launched by the Institute of Space and Astronautical Science in 1997 February to participate in Very Long Baseline Interferometry (VLBI) observations with arrays of ground radio telescopes. HALCA provides the longest baselines of the VLBI Space Observatory Programme (VSOP), an international endeavor that has involved over 28 ground radio telescopes, five tracking stations, and three correlators [1]. HALCA was placed in an orbit with an apogee height above the Earth's surface of 21,400 km, a perigee height of 560 km, and an orbital period of 6.3 hr, Fig. 1. During the 7 years of HALCA's mission lifetime, about 75% of observing time was used for projects selected by international peer review from open proposals. This part of the scientific program of the mission constituted the general observing time. The remaining time was devoted to a mission-led survey of active galactic nuclei (AGNs) at 5 GHz: the VSOP Survey

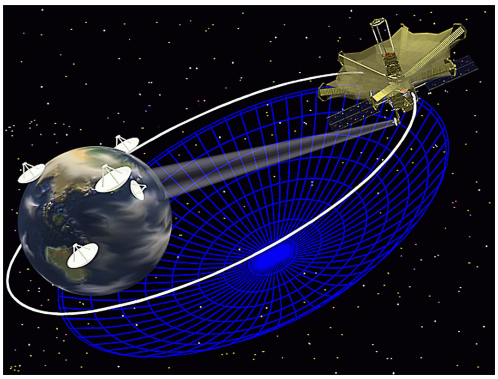

Figure 1: Generating a telescope larger than the earth: HALCA satellite of the Japanese-led VSOP program.

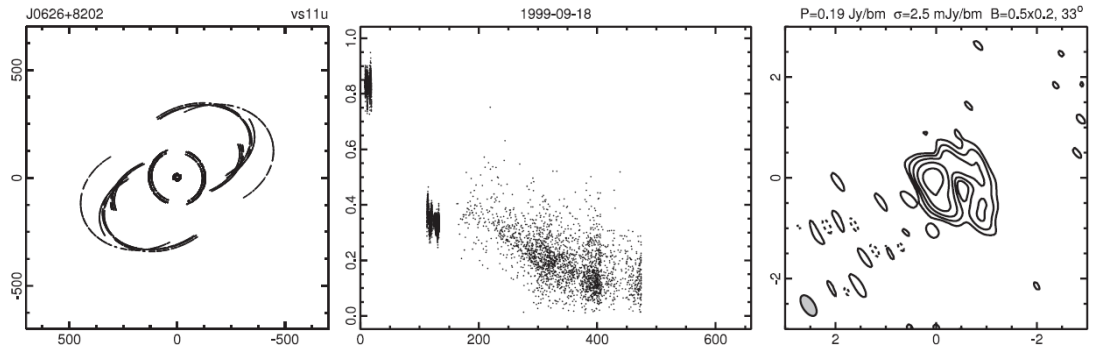

Figure 2: An example of the survey program results, active galactic nucleus imaged at 5 GHz with a resolution of 500 x 200 microarcseconds.

Program. The major goal of the survey was to determine the statistical properties of the submilliarcsecond structure of a complete sample of AGNs, Fig. 2 [2].

FUTURE SPACE-VLBI PROJECTS

The Japanese-led VSOP-2 mission, to be launched in 2012, consists of an orbiting ASTRO-G radio telescope operating with ground based VLBI arrays. It will be able to image the innermost parts of both protostars and AGN accretions discs (whose linear sizes are thought to be less than 1 AU and light days to light months) as well as image the base of relativistic jets which emanate from the central region of radio-loud AGN such as radio-galaxies and quasars at a linear resolution of a few light-years. The VSOP-2 images will have an angular resolution down to 40 microarcseconds (43 GHz) which is better by a factor of 2-3 compared to ground based VLBI images.

Russian Radioastron-project has recently re-funded after a long hibernation. It will be launched to an extremely high elliptical orbit of 350 000 km. Although at the apogee, imaging is extremely challenging, if not impossible, it will reach to a nominal resolution of around 5 microarcseconds at 22 GHz.

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