Astrophysical Phenomena Revealed by Space VLBI
H. Hirabayashi, P.G. Edwards and D.W. Murphy (eds.)

VERA Approved !

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Abstract

A new Japanese VLBI project, VERA (VLBI Exploration of Radio Astrometry), consisting of an array of four radio telescopes, is being developed by NAO. It aims to measure distances and proper motions of astronomical maser sources distributed through our galaxy with an accuracy of a few tens of micro-arcseconds. It was funded at the end of 1999, and we have started to construct three antenna systems.

1 Towards the Detection of Dark Matter in Galaxy

It is known that a considerable mass of the Galaxy and the universe is in the form of dark matter. Dark matter, however, does not emit detectable electromagnetic radiation at any wavelength but can be detected only through its gravitational effect. Because of its dominance, understanding the nature and total amount of dark matter is one of the fundamental subjects in Astronomy, Astrophysics, and modern Physics.

The distribution and total amount of dark matter in the Galaxy can be studied based on the rotational motions of stars around the Galactic center. However, only nearby stars' distances and motions can be measured, and so studies of Galactic dark matter has suffered from large observational errors. VERA will investigate the three-dimensional structure and dynamics of the Galaxy and reveal the distribution and total amount of dark matter, measuring the position of astronomical maser sources with the highest accuracy ever achieved.

2 VERA Science Targets

The major science targets of VERA are:

- to establish the three-dimensional structure and dynamics of the Galaxy,
- to reveal the distribution and total amount of dark matter in the Galaxy,

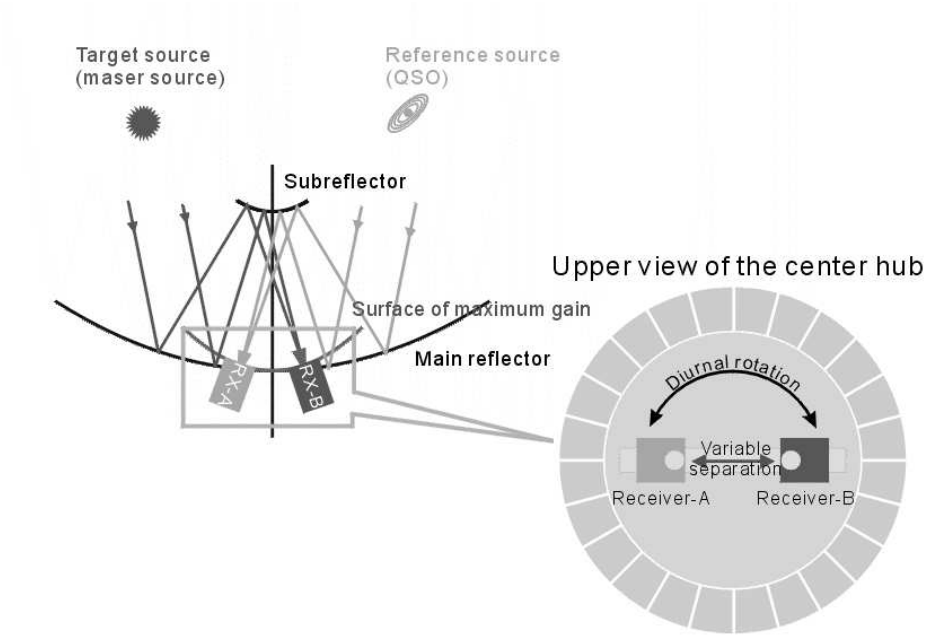

Figure 1: Dual-beam Cassegrain antenna for VERA

- to improve our understanding of the physical processes in star-forming regions and late-type stars by measuring distances and proper motions of the maser sources.
- to improve the cosmological distance scale by direct establishment of the period–luminosity relation of Mira variables and statistical parallax distances of maser sources.
- to measure proper motions of nearby active galactic nuclei and extragalactic masers,
- to support the Japanese lunar VLBI mission RISE/SELENE (Research in Selenodesy/SELenological and ENgineering Experiment) to be launched in 2004 and the next space VLBI mission (VSOP-2) as a ground array,
- to contribute to the progress of Earth science by studying the crustal deformations around Japan and the Earth's variable rotation.

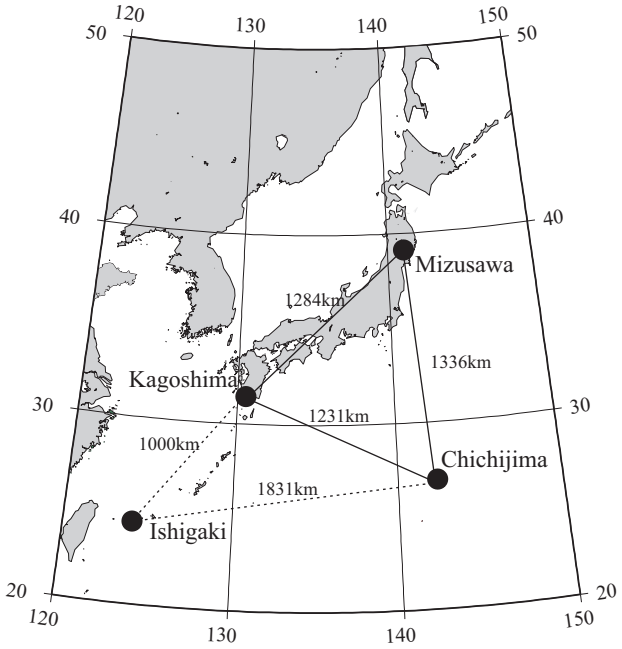

Figure 2: Location of VERA antennas

3 High Precision Astrometry

VERA will succeed the new approach in astronomy initiated by ESA's HIPPARCOS (High-Precision Parallax COllecting Satellite) astrometry satellite (1989–1993) with accuracy roughly 100 times higher than that achieved by the satellite. While HIPPARCOS provided accurate parallax distances for stars within 100 pc from the Sun, distance measurements with VERA will cover roughly the whole region of our Galaxy. Planned space optical interferometry missions like FAME (Full-sky Astrometric Mapping Explorer) (e.g. Horner et al. 1999) , SIM (Space Interferometry Mission) and GAIA (Global Astrometric Interferometer for Astrophysics) (Merat et al. 1999) aim at ten micro-arcsecond level astrometry, similar to VERA. VERA is unique among the challenges in using the well-established VLBI technology which achieved the highest angular resolution in astronomy. Radio observation enables us to see the objects beyond the Galactic center and gives us information on astrophysically interesting objects like star-forming regions and evolved stars.

4 Instrumentation

VERA will cancel the distorting effect of the atmosphere using the "phase-referencing technique" with newly designed "dual-beam antennas" (Fig. 1) which are capable of simultaneously observing a target source and a reference compact extragalactic radio source separated by up to two degrees. Model simulations and experiments using radio interferometers have shown that we could reduce the atmospheric effects below the ten micro-arcsecond level with this technique. The antennas will have a 20 m diameter Cassegrain system with S, X, K and Q band receivers. Location of antennas is shown in Fig. 2. The hardware systems in the Mizusawa–Kagoshima–Chichijima array will be constructed by the end of March, 2001, and regular observation will start in 2002. We expect in the future to build one more site at Ishigaki.

References

Horner, M. et al., 1999, in *IAU Coll. 176: The Impact of Large-Scale Surveys on Pulsating Star Research*, eds. L. Szabados & D. Kurtz (ASP Conference Series) in press.

Merat, P. et al., 1999, *Baltic Astronomy*, **8**, 1