Studying the Milky Way Galaxy with VERA (VLBI Exploration of Radio Astrometry)

By KAZUYA HACHISUKA
AND VERA PROJECT TEAM

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

VERA (VLBI Exploration of Radio Astrometry) is a VLBI array consisting of four radio telescopes (Mizusawa, Kagoshima, Chichijima and Ishigakijima) and promoted by the National Astronomical Observatory of Japan. It aims at accurately measuring distances and proper motions of astronomical maser sources that are widely distributed over our Galaxy (the Milky Way Galaxy). The target accuracy is ten-micro-arcsecond-level. With this high accuracy, VERA will investigate the three-dimensional structure and dynamics of our Galaxy and reveal the distribution and total amount of dark matter, which is a key to answer the fundamental question whether the universe will continue to expand indefinitely or not. Three (Mizusawa, Kagoshima and Chichijima) of the four telescopes are being constructed and will be completed in 2001.

1. Science

The major science goals of VERA are (Honma (2000)) :

- to establish three-dimensional structure and dynamics of our Galaxy,
- to reveal the distribution and total amount of dark matter in our Galaxy,
- to improve our understandings of the physical processes in star-forming regions and late-type stars by measuring distances and proper motions of the maser, sources
- to improve cosmological distance scale by direct establishment of the period-luminosity relation of Mira variables and statistical parallax distances of the maser sources,
- to measure proper motions of nearby active galactic nuclei and extragalactic masers,
- to support Japanese lunar VLBI mission RISE (Research in Selenodesy) /SELENE (SELenological and ENgineering Experiment) as a ground array,
- to contribute to progress of earth science by studying the crustal deformation around Japan and the Earth's variable rotation,

2. Ultra-high precision Astrometry

VERA will succeed the new approach in astronomy initiated by ESA's HIPPARCOS (High-Precision PARallax COllecting Satellite, 1989-1993) with accuracy roughly 100 times higher than that achieved by the satellite. While HIPPARCOS provided accurate trigonometric parallaxes for stars within 100pc from the Sun, distance measurements with VERA will cover roughly the whole region of our Galaxy. Planned space optical interferometry missions such as FAME (Full-sky Astrometric Mapping Explorer), SIM (Space Interferometry Mission) and GAIA (Global Astrometric Interferometer for Astrophysics) aim at the ten micro arcsecond level astrometry similar to VERA's. 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 object like star- forming regions and evolved stars.

3. Instrumentation

VERA will cancel the distorting effect of the atmosphere using “phase-referencing technique” with newly designed dual-beam antennas which are capable of observing simultaneously a target maser source and a reference compact extragalactic radio source separated by up to about two degrees (Kawaguchi (2000)). Model simulations and experiments using radio interferometers have shown that the atmospheric effects can be reduced to ten micro arcseconds with this technique. The antennas have 20m in diameter with receivers of 2, 8, 22 and 43GHz bands.

Observed data are recorded at the rate of 1Gbps (=512MHz band width) which is currently the world’s fastest. This wide bandwidth together with the phase-referencing makes it possible to observe very faint radio sources.

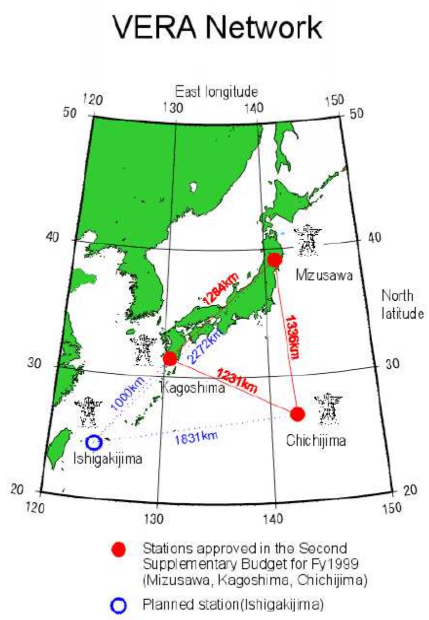

FIGURE 1. VERA site map. Filled circles are stations to be constructed in 2000. Open circle is a planned station. The longest baseline of the VERA array will be about 2300km (Mizusawa - Ishigakijima).

REFERENCES

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