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Astrometry of W49N – OH43.8-0.1 H_2O maser pair with VERA

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Abstract. We present the results of multi-epoch VERA observations of W49N – OH43.8-0.1 H_2O maser pair. Based on the dual-beam VLBI observation with VERA, we successfully obtained the phase-referenced maps of OH43.8-0.1 with respect to the W49N reference spot for 3 epochs with a time span of 6 months. The maps were in good agreement with previous studies obtained with a single-beam VLBI, and were also consistent with each other with an accuracy of about 0.2 mas. Moreover, there are systematic, rather linear displacements of maser feature positions, which may be the relative proper motions of maser features caused by the Galactic rotation as well as internal motions of individual maser features.

1. Introduction

VERA (VLBI Exploration of Radio Astrometry, Sasao 1996; Kobayashi et al. 2003 and references therein) is a VLBI array dedicated to phase referencing astrometry. Based on simultaneous dual-beam observations of target and reference sources, VERA can effectively cancel out the tropospheric fluctuation, and will enable us to measure proper motions and parallaxes of Galactic H_2O and SiO maser sources with 10 μas-level accuracy. Based on such high-precision astrometry, one can establish 3-D structure and dynamics of the Milky Way with unprecedentedly high accuracy (for detailed scientific targets, see Honma et al. 2000). Since the completion of all four stations in 2002, we have been conducting test observations to evaluate its capability of phase-referencing as well as astrometric performance. Recently VERA's high capability of phase-referencing was demonstrated based on observations of W49N – OH43.8-0.1 maser pair (Honma et al. 2003), and here we report the current status of astrometric performance evaluation using the same pair sources.

2. Observations and Reductions

Monitoring of the W49N – OH43.8-0.1 H_2O maser pair (0°.65 separation) has been performed with a typical interval of one months, and here we present 3 epochs under relative good conditions on day of year 026, 120, and 205 in 2004. Observations for each epoch lasted for 8 hours and were done with all 4 stations of VERA in the dual-beam mode. A bright continuum source, TXS 1923+210, was also observed every 2 hours as a clock and bandpass calibrator. Details of the observations and correlation processes such as recording rate, bandwidth, frequency resolution, and so, can be found in Honma et al. (2003; 2004). After the correlation processing with the Mitaka FX correlator, visibilities of all velocity channels of W49N and OH43.8-0.1 were phase-referenced to the W49N reference maser spot at V_{LSR} of 9 km s^{-1}, which is one of the brightest spots, and shows no sign of structure according to the closure phase. Phase-referenced visibilities were Fourier transformed to synthesize images, and the positions of the brightness peaks were determined with respect to the reference spot.

3. Results

3.1. OH43.8-0.1 map

We have obtained phase-referenced maser maps for both W49N and OH43.8-0.1 (for the results for W49N, see Honma et al. 2004). Here we show in figure 1 the OH43.8-0.1 maser map which are phase-referenced with respect to the W49N reference spot at V_{LSR}=9 km s^{-1}. The spot positions in figure 1 represent the sum of the position offset of OH43.8-0.1 maser spot from its tracking center and that of the reference spot from W49N tracking center. In total, we have identified 38 maser spots in OH43.8-0.1 with velocity range from 30 km s^{-1} to 50 km s^{-1}. The spot distribution in figure 1 is in good agreement with that of previous studies (e.g., Downes et al. 1979), show-

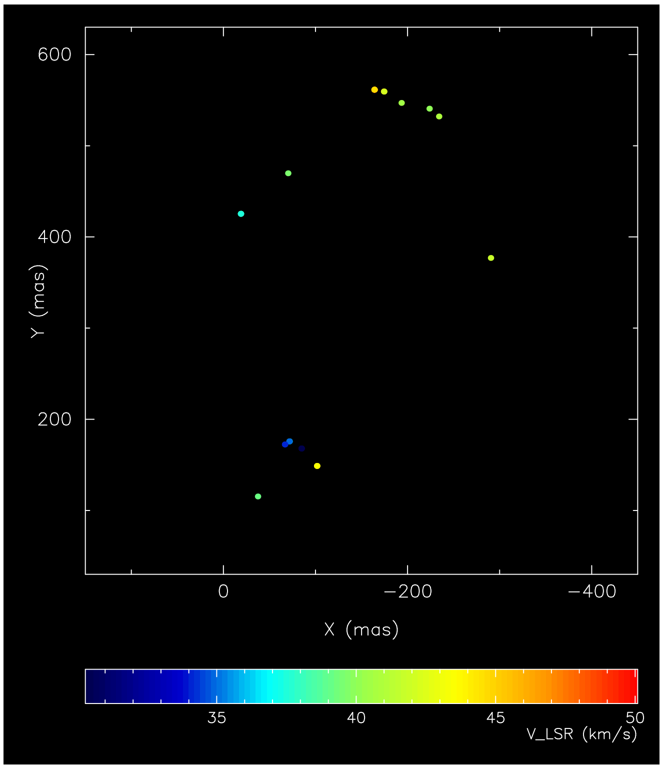

Fig. 1. Phase referenced map of OH43.8-0.1 with respect to W49N reference maser spot.

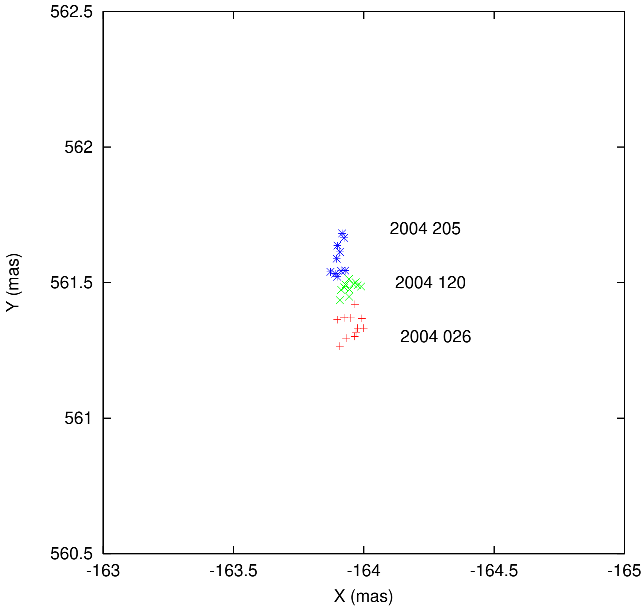

Fig. 2. A superposition of OH43.8-0.1 maser feature observed at different epochs.

ing a ring-like spot distribution. The radial velocity structure also agreements with that of the previous study.

3.2. Maser positions at 3 epochs

In order to evaluate astrometric performance of VERA, here we compare 3 epoch observations of W49N – OH43.8-0.1 pair which have a time span of about 6 months. Figure 2 shows a superposed map for one of OH43.8-0.1 maser features. The maser spots in figure 2 have $V_{\rm LSR}$ of $\sim$ 43 km s^{-1}. The spot positions for 3 epochs agree with each other with an accuracy of 0.2 mas. Thus, most conservatively one can conclude that current VERA system has a positional accuracy of around 0.2 mas, which is already enough to perform astrometry within 1 kpc from the Sun.

4. Discussion

In addition to position consistency within 0.2 mas, in figure 2 there are notable displacements of the maser feature. The position shifts are systematic from south to north, indicating a linear motion with almost constant velocity. Therefore, it is possible that we have detected maser spot motions of OH43.8-0.1 with respect to W49N reference spot. Maser features of OH43.8-0.1 other than that shown in figure 2 also show this kind of systematic motion, though the direction of the motion varies from feature to feature (which is likely to be due to internal motions). Comparisons of maps of OH43.8-0.1 masers that are phase-referenced to one of OH43.8-0.1 spots also give consistent results with figure 2, indicating that the maser feature motions are likely to be real.

In order to obtain stronger conclusions, it is necessary to obtain more data for longer time span and also to improve the delay calculation model for Mitaka FX correlator, which is crucial to high-precision VLBI astrometry, and then we will be hopefully able to perform maser astrometry in the Galactic scale.

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