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VLBI astrometry of a water maser source in the Sgr B2 complex with VERA

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Abstract. We have conducted astrometric observations toward a 22 GHz water maser source associated with the Sgr B2 complex in the Galactic center region with VERA (VLBI exploration of Radio Astrometry). We measured a trigonometric parallax and absolute proper motion of the Sgr B2 complex with respect to an extra-galactic source by observing the water maser source at 10 epochs from 2014 to 2017. The measured distance was $7.52^{+3.01}_{-1.67}$ kpc for the Sgr B2M region.

We also succeeded to measure internal motions of maser spots in Sgr B2M, and N region. The number of spots which we could measure the internal motions is about 400. The distribution of the maser spots shows that the maser spots are associated with envelope of HII region seen in radio continuum image obtained with VLA and ALMA. We discuss relative motions between Sgr B2M, and N by using the internal motion.

Keywords. Galaxy: kinematics and dynamics, masers, astrometry

1. Overview

We conducted astrometric observations toward a 22 GHz water maser source associated with the Sgr B2 region, which is one of the most intense star-forming region in our Galaxy. Trigonometric parallax of this source was measured by Reid *et al.* (2009) with VLBA. Their results suggested that the distance was $7.8^{+0.8}_{-0.7}$ kpc. The precise position and motion of Sgr B2 region on the central molecular zone (CMZ) is important to understand the dynamics of the Galactic center (Sawada *et al.* 2004, Molinari *et al.* 2011). Then, it is important to measure the proper motion of the source accurately. We measured internal motions of maser spots in Sgr B2 region, and corrected the proper motion obtained by phase-reference observations with VERA. Observations have been conducted at 10 epochs from 2014 to 2016. In phase reference observations, we observed an extragalactic source J1745-2820 as a phase and position reference source, simultaneously.

2. Results

Figure 1 depicts the internal proper motions for each maser spot. In Sgr B2 Main region, maser spots extend over 2 arcsec, and the line-of-sight velocities range from 30 to 110 $\mathrm{km\,s^{-1}}$. Redder spots located at east side of the map have larger internal motions of 5 $\mathrm{mas\,yr^{-1}}$ than bluer spots whose internal motions is about 2 $\mathrm{mas\,yr^{-1}}$. In Sgr B2 North, maser spots distribute on two different sites about 1 arcsec separated with each

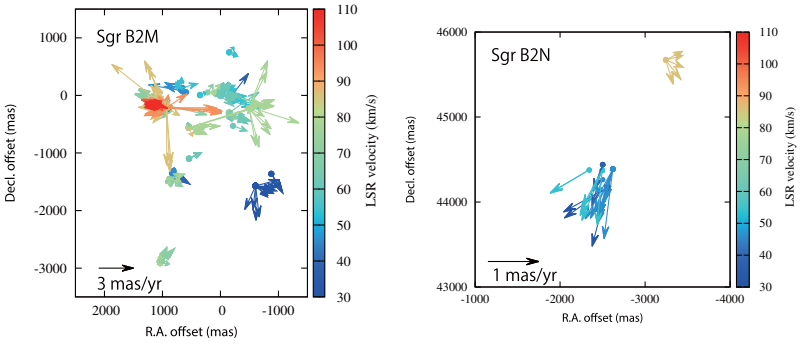

Figure 1. Internal motion of water maser in Sgr B2 region for (Left) Sgr B2M region and (Right) Sgr B2N region.

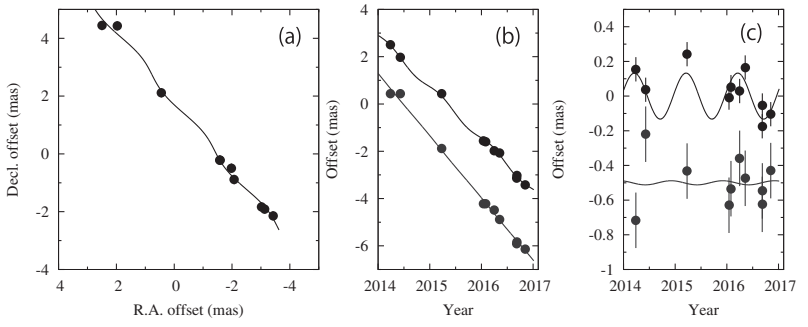

Figure 2. (a) Absolute proper motions of the maser feature at the line-of-sight velocity of $59.58\,\mathrm{km\,s^{-1}}$ Filled circles show the observed points from phase reference observations. (b) Motions toward R.A. and Dec. as a function of time. Black circles show the motion in the R.A. direction, and gray circles show the motion in the Dec. direction. (c) Result of parallax fitting. Error bars are evaluated so that a χ^2 value in the model fitting becomes unity.

other. The line-of-sight velocities of these spots are $80\,\mathrm{km\,s^{-1}}$ for the northern spot, and $50\,\mathrm{km\,s^{-1}}$ for the southern spots.

Figure 2 shows the parallax and absolute proper motion measured by phase-referencing observations for a maser spot at Sgr B2M. Fitting results indicate that the absolute proper motions are $-2.17\pm0.03\,\mathrm{mas\,yr^{-1}}$ and $-2.63\pm0.06\,\mathrm{mas}^{-1}$ in the direction of R.A. and Dec., respectively. The proper motions are consistent with those obtained by Reid *et al.* (2009) within errors. The measured parallax is $0.133\pm0.038\,\mathrm{mas}$, corresponding to $d = 7.52^{+3.01}_{-1.67}\,\mathrm{kpc}$ in the distance domain. The errors on the figure are derived by setting χ^2 per degree to be unity for both the R.A. and Dec. data.

After the correction of internal motion for the spot and the conversion of the coordinate system from the equatorial heliocentric flame (μ_α, μ_δ) to the Galactic heliocentric frame (μ_l, μ_b), we obtained the systematic proper motion of Sgr B2M relative to Sgr A* as $(\mu_l \cos b, \mu_b) = (2.66, -0.29)\,\mathrm{mas\,yr^{-1}}$. This suggests that Sgr B2M is located at near-side of Sgr A* when we assume a low eccentric orbit of the CMZ.

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