

VLBI phase-referencing observations of SiO masers towards R Aquarii

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Abstract. We show a phase-referenced image of the SiO maser emissions towards the Mira variable R Aqr. These data have been obtained using the VLBI Exploration of Radio Astrometry (VERA). The proper motion we have obtained is different from that obtained using the HST. The proper motion from 2004 to 2005 is not different from that of 1991 to 2005 and supports the current orbital elements.

Keywords. SiO maser, late-type star, symbiotic Binary

1. Motivation

R Aqr is one of the brightest SiO maser sources and located close to the bright extragalactic source J2348-1631. The star is a symbiotic stellar system, but the orbital motion has not been detected directly. This project tries to detect it and estimate its orbital elements using the VERA. We also have evaluated the performance of VERA at 43 GHz.

2. Observations and results

The $v = 1, 2$ $J = 1-0$ SiO maser emissions towards R Aqr and the continuum source, J2348-1631, were observed simultaneously with 4 antennas of NAOJ VERA on 2004 December 23 and 2005 December 24. The SiO maser emission data was recorded in a 8 MHz band, and the continuum source data with a 224 MHz bandwidth. Data analysis was done in the NRAO AIPS package. The resultant synthesized beam for the image is 0.94×0.41 mas with a major-axis position angle of -27.6° .

We have obtained the spatial distributions of the SiO maser emission for both epochs. We also obtained the stellar position by circular fitting. The positions of the star relative to the tracking center ($23^h 43^m 49^s.4616 - 15^d 17' 04''.202$ (J2000)) are listed in Table 1.

Table 1. Stellar position relative to a tracking center

Date	Relat. RA (mas)	Relat. DEC (mas)	Diam. (mas)
23 Dec. 2004	136.7 (1.8)	-132.7 (0.7)	19.2
24 Dec. 2005	167.1 (0.6)	-162 (2.0)	14.5

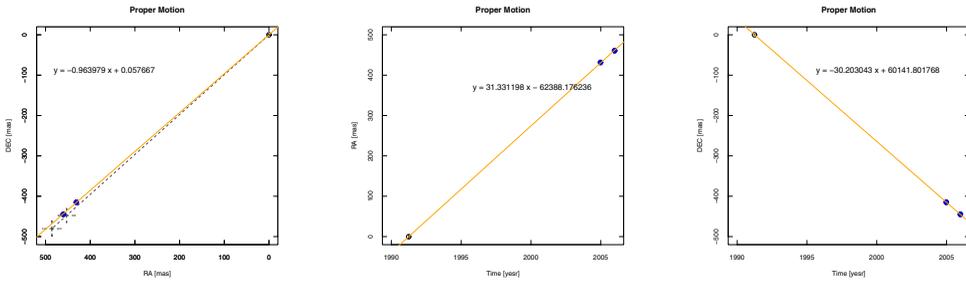


Figure 1. The proper motion of R Aqr. The origin of these figures is $(\alpha_{J2000} = 23^{\text{h}} 43^{\text{m}} 49^{\text{s}}.440, \delta_{J2000} = -15^{\circ} 17' 03''.9)$. Cross-dotted marks show the positions that are estimated from the proper motion reported by HST at each epochs. *Left:* Dec vs. RA *Center:* RA vs. time *Right:* Dec vs. time.

3. Discussion

3.1. Proper motion

We compare the position obtained from our observations with the astrometric position (Figure 1) identified by Hipparcos on 1991.25 (Perryman *et al.* 1997). Figure 1 also shows the positions estimated from the proper motion which is reported by the Hipparcos in each epochs. The positions we have obtained are different from the estimated positions by about 40 mas. We find a linear variation of our positions and the Hipparcos astrometric position at 1991.25. We have obtained a linear fit yielding a proper motion of $(\mu_{\alpha}, \mu_{\delta}) = (31.33 \pm 0.12, -30.20 \pm 0.12)[\text{mas yr}^{-1}]$. The differences of proper motions between our observation and the HST observation are -1.65 mas for RA, and 2.41 mas for Dec.

3.2. Orbital motion

From 2004.98 to 2005.98, the star move 29.3 ± 2.0 mas in RA and -30.0 ± 2.1 mas in Declination. This motion is consistent with the proper motion between 1991.25 and 2005.98 within the error. We could not detect an orbital motion for R Aqr. Hollis *et al.* (1997) proposed orbital elements of this system of $(P, a, e, T, i, \Omega, \omega, K) = (44 \text{ yr}, 2.54 \times 10^{14} \text{ cm}, 0.8, 2442100.0 \text{ JD}, 70^{\circ}, \sim 90^{\circ}, -90^{\circ}, 7.2 \text{ km s}^{-1})$. The position of R Aqr shifted 23.0 mas to the east and 0.9 mas to the south. The motion is consistent with $-1.56 \text{ mas yr}^{-1}$ in RA and 0.06 mas yr^{-1} in Dec. Positional shifts due to the orbital motion between 2004.98 and 2005.98 are -1.5 mas in RA and 0.6 mas in Dec. The difference of the orbital motion between these epochs is so small that we think we could not detect the motion in the observation.

4. Summary

We have observed SiO maser emissions towards the symbiotic star R Aqr using the VERA. We have obtained a proper motion of the star from 1991.25 to 2005.98. The proper motion is different from that reported from the HST observation. Proper motions between 1991.25 and 2005.98 and between 2004.98 and 2005.98 coincide with each other within the error. This result supports the orbital elements proposed by Hollis *et al.* (1997).

References

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