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The Structure and Kinematics of Envelope around Red Supergiant AH Sco Traced by SiO Masers

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Abstract. Observations of 43 GHz v =1, J = 1−0 SiO masers in the circumstellar envelope of the M-type semi-regular variable star AH Sco were performed with the Very Long Baseline Array (VLBA) at 2 epochs in March 2004. These high-resolution VLBA images reveal that the distribution of SiO masers is roughly on a persistent elliptical ring with the lengths of the major and minor axes of about 18.5 and 15.8 mas, respectively, along a position angle of 150°. The 3-dimensional kinematics model-fitting for proper motions and spatial distributions of maser features clearly indicates that the SiO maser shell around AH Sco was undergoing an overall contraction to the star at a velocity of 15 km s^{-1} at a distance of 2.26 kpc to AH Sco due to the gravitation of the central star.

Keywords. (Stars:)circumstellar matter – masers – stars: individual (AH Sco)

1. VLBA observations

Late type stars often exhibit circumstellar maser emission in molecules e.g. OH, H_2O, and SiO. The interferometric observations of these masers would be useful in determining the structure and kinematics of the circumstellar envelop (CSE) and understanding the physical circumstance and mass loss procedure for late type stars. In this paper, we present the first VLBI maps of 43 GHz v =1, J = 1−0 SiO maser emission toward red supergiant AH Scorpii (AH Sco). The observations were performed at two epochs on March 8, 2004 (epoch A) and March 20, 2004 (epoch B) with the VLBA. The data were recorded in left circular polarization in an 8 MHz band and correlated with the FX correlator in Socorro, New Mexico. The correlator output data had 256 spectral channels, corresponding to a velocity resolution of 0.22 km s^{-1}.

2. The spatial structure of the SiO masers

The high resolution VLBI images reveal a persistent elliptical structure of SiO masers around AH Sco during an interval of 12 days (Fig. 1). We characterized this morphology by performing a least-squares fit of an ellipse to the distribution of masers weighted by the flux density of each feature for each of two epochs. The lengths of the major and minor axes were found to be 18.6 and 15.7 mas for epoch A, and 18.4 and 15.9 mas for epoch B, respectively, with the major axis of the ellipse oriented similarly at 150° at both epochs. We also notice that the red-shifted SiO masers lie slightly closer to the center than the blue-shifted masers.

3. The kinematics of the SiO masers

By identifying the matched common maser features that appeared in both epochs, we were able to estimate their proper motions (Fig. 2). We can see that the maser shell shows an overall contraction toward the central star. We have made a 3-dimensional kinematics model-fitting for spatial distribution and proper motion of SiO maser features (see details

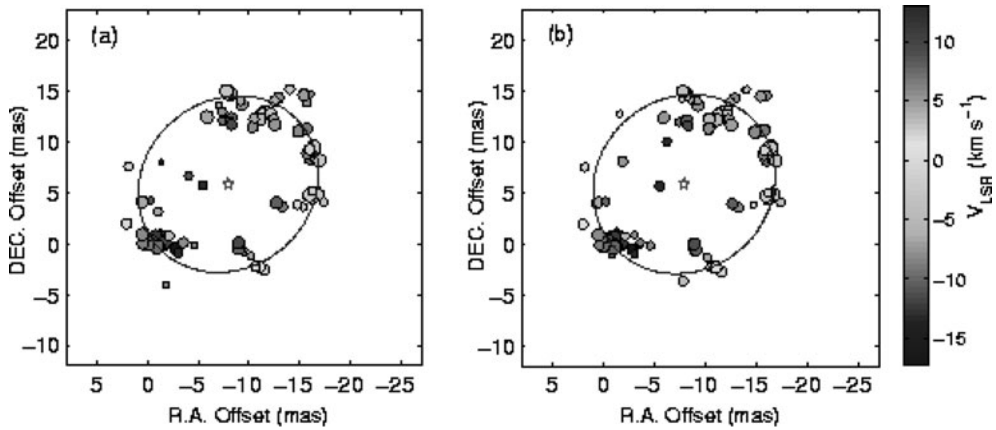

Figure 1. VLBI images of 43 GHz $v = 1$, $J = 1 - 0$ SiO maser emission toward AH Sco at two epochs. The ellipse indicates the least-squares fit to the maser distribution for each epoch. The fitted center of ellipse model is marked by the red star.

in Chen & Shen 2008). The 3-dimensional kinematics model suggested that the SiO maser shell was undergoing an overall contraction to the star at a velocity of 15 km s^{-1} at a distance of 2.26 kpc to AH Sco due to the gravitation of the central star.

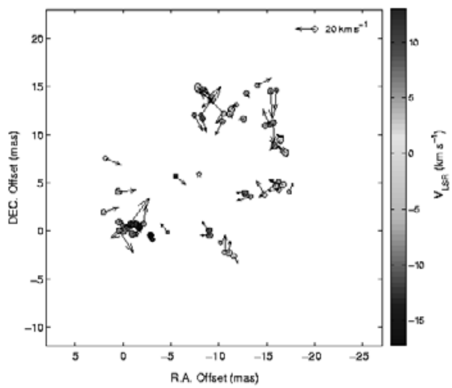

Figure 2. Distribution of proper motion velocity vectors of the matched maser features at a distance of 2.26 kpc.

Interestingly, the optical phase at which the SiO maser shell around the red supergiants contracts is nearly the same as that seen in Mira variables: red supergiant AH Sco ($\phi \approx 0.55$; Chen & Shen 2008); red supergiant VX Sgr ($\phi = 0.75 - 0.80$; Chen et al. 2006), Mira variable R Aqr ($\phi = 0.78 - 0.04$; Boboltz, Diamond & Kemball 1997), Mira variable TX Cam ($\phi = 0.50 - 0.65$; Diamond & Kemball 2003). This infers that the contraction of the SiO maser shell would occur during an optical stellar phase of 0.5-1, which agrees with the theoretical kinematical model results of Humphreys *et al.* (2002).

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References

Boboltz, D. A., Diamond, P. J., & Kemball, A. J. 1997, *ApJ*, 487, L147
Chen, X. & Shen, Z.-Q. 2008, *ApJ*, (in press); astro-ph/08031690
Chen, X., Shen, Z.-Q., Imai, H., *et al.* 2006, *ApJ*, 640, 982
Diamond, P. J. & Kemball, A. J. 2003, *ApJ*, 599, 1372
Humphreys, E. M. L., Gray, M. D., Yates, J. A., *et al.* 2002, *A&A*, 386, 256

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