Maser Observations in VY CMa with VERA

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ABSTRACT

We present the results of multi-epoch VERA(VLBI Exploration of Radio Astrometry) observations of 22GHz H_2O and 43GHz SiO masers in the supergiant VY CMa(VY Canis Majoris). We estimated the inner motion of H_2O masers over 6 months and that of SiO masers over 1 month. We also compared the distribution of SiO J=1-0 v=1 masers with J=1-0 v=2 masers in VY CMa using the simultaneous VERA observation.

INTRODUCTION

Red supergiants have a high mass-loss rate and are often surrounded by a shell of gas and dust. H_2O and SiO masers are found in circumstellar envelopes(CSE) of the supergiants. These masers are important tool to study the structure and the dynamics of CSE, the mass-loss process, and the evolution of these stars.

OBSERVATIONS

- VERA 4 stations in Japan

Date	Transition	Duration	Beam size (mas)
2003. 05. 20	H_2O (6_{16}-5_{23})	8 hours	2.16 ×0.77
2003. 10. 23		6 hours	2.24 ×0.80
2003. 12. 18		8 hours	2.06 ×0.80
2006. 04. 23	^{28}SiO J=1-0 v=1 and v=2	7 hours	1.02 ×0.40
2006. 05. 26		7 hours	1.06 ×0.40

Correlation: Mitaka FX correlator

RESULTS

22GHz H_2O Maser Distribution

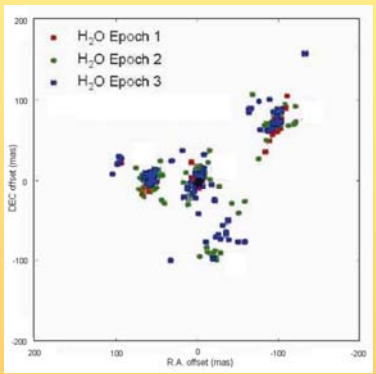

Figure 1.(b) The distribution of H_2O masers over three epochs.

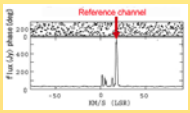

Figure 1.(a) The spectrum of H_2O masers

To align three maps , we assume the position of the strongest maser component at each epoch is the same over three epochs. In order to investigate the inner motions, maser components which are detected at all three epochs have been chosen.

For chosen components, we have investigated the inner motions over six months between epoch 1 and epoch 3. Figure 2 shows the movement of these components. The arrows on the Figure 2 indicate the direction of the inner motions, but the length of the arrows do not relate the amount of movement.

The movement of the maser components are 0.55 mas in R.A. and 0.7 mas in DEC on the average.

Using these inner motions, we estimated the statistical parallax. The statistical parallax method assume the standard deviation of the radial velocities and that of the inner motions are the same. The distance to VY CMa we estimated is 1.88 kpc.

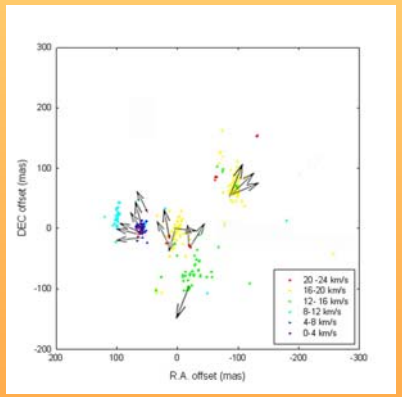

Figure 2. The inner motion of H_2O masers for six months

43GHz SiO Maser Distribution

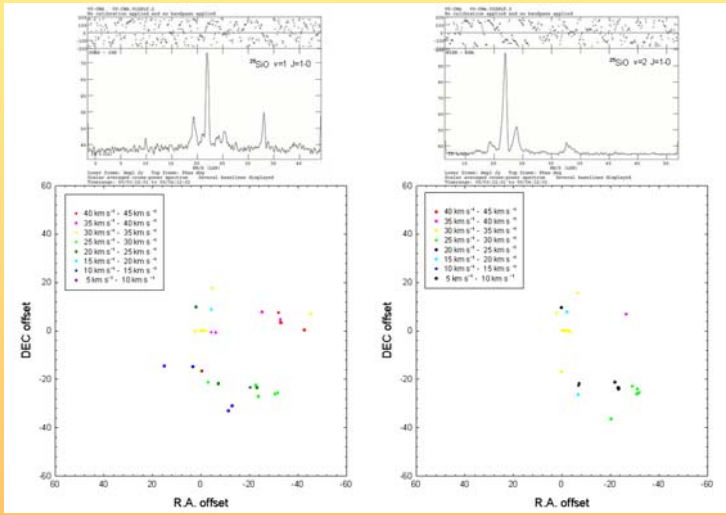

Figure 3. (top) SiO maser spectrum for v=1 J=1–0 (left) and for v=2 J=1–0 (right) (bottom) SiO maser distributions for v=1 J=1–0 (left) and for v=2 J=1–0 (right)

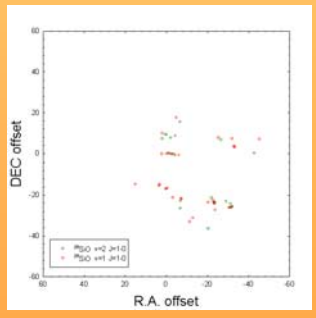

Figure 4. The aligned map of v=1 and v=2

We aligned both v=1 and v=2 maps with the maser component which has the V_{LSR}=22.0 km s^{-1}. For the same velocity components, the difference of the positions is 0.45 mas in R.A. and 0.19 mas in DEC on the average.

For the transition of J=1-0 v=1 ^{28}SiO masers, we estimated the preliminary inner motion for one month. The distance to VY VMa is 1.18 kpc assuming the statistical parallax. This result is underestimated to the previous studies(1.5kpc, Lada & Reid, 1978).

DISCUSSION

We estimated the statistical parallax for both H_2O and SiO masers. Compared with the result from H_2O masers, the distance is underestimated from the inner motion of SiO masers. The possible reason is that the inner motions are overestimated because of the short time scale.

The adopted physical value of the model for VY CMa's circumstellar geometry is R_*=13 AU (Smith et al. 2001), and it is 6.91 mas at 1.88 kpc and 11.01 mas at 1.18 kpc. When we assume the distribution of SiO masers is the ring as shown Figure. 5, the diameter is approximately 40 mas. Therefore we obtain R_{SiO} ~ 1.81-2.89 R_*, and this result is consistent with that the SiO maser emit at typical distances of 2–4 stellar radii toward Mira variables and supergiants (Boboltz et al. 1997).

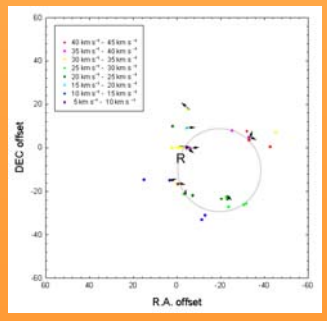

Figure 5. The preliminary inner motion of v=1 J=1-0 SiO masers

REFERENCE

Boboltz, D. A., Diamond, P. J., & Kemball, A. J. 1997, ApJ, 487, L147

Lada, C. J., & Reid, M. J. 1978, ApJ, 219, 95

Smith et al. 2001, AJ, 121, 1111