Motion of Water Masers Associated with a Star-Forming Region W75N†

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ABSTRACT

Water masers in a star-forming region W75N is observed with VERA in 2007 January and May. The observations were carried out with phase referencing by adopting another target of dual beam, Cyg X-3. Maser spots were detected in VLA-1 and VLA-2 regions. In VLA-1, we cannot confirm the signature of elongated outflow observed with VLBA in 1999, due to lacks of spots in 2007 January. On the contrary, our observation of 2007 May is almost consistent with 1999 VLBA observations: a central object is driving an outflow, expanding in multiple direction.

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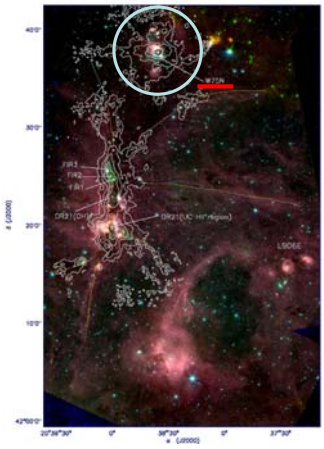


Figure 1: A color image of the full D21/W75 mosaic observed with the Spitzer Space Telescope, composed from image in 3.6㎛ (blue), 4.5㎛(green) and 8㎛ (red). Counters represent the 850㎛ emission mapped using SCUBA and JCMT (Kumar et al,2007,MNRAS).

W75N: Introduction

- W75N region is an area of continuing active star formation of the north-eastern edge of the Cygnus-X complex about 1°.5 to the north-east of the Cygnus -OB2 association.
- W75N is situated close to a compact H II regions and most of W75N region is in a proto-stellar phase based on the present of water, OH and methanol maser .
- It lies at an approximate distance 2kpc.
- In W75N (B), there are three radio continuum sources (VLA-1, VLA-2 and VLA-3) within a region of 1."5.

VLBA Observations of W75N in 1999

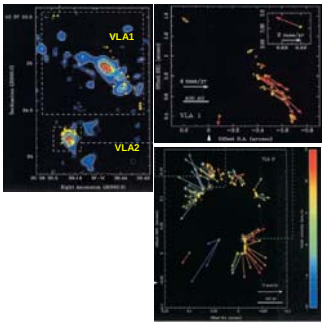


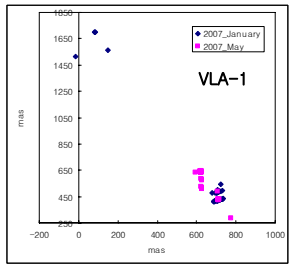
Figure 2. Self-calibrated image of W75N region observed with VLBA (Torrelles et al. ApJ 598, L115, 2003 December 1)

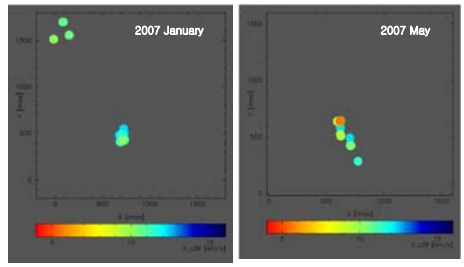
- Active water maser-emitting regions in W75N were observed with VLBA three times in 1999 April, May & June (Torrelles et al. 2003).
- The self-calibration was performed with AIPS.
- Clusters of water masers were setected in VLA-1 and VLA-2 regions. On the contrary, no maser spot was found in VLA-3.
- In total, ~700 spots were detected in VLA1 & VLA2, with 54 spots at all three epochs and 44 in only two epochs.
- The distribution of water masers in VLA-1 are extended to ~1600 AU, and seem to be a collimated outflow parallel to the elongated radio continuum structure, with proper motions of ~2 mas/yr (~19 km/s) for 2 kpc.
- On the contrary, in VLA-2, water masers are distributed on a shell with a radius of ~160 AU, expanding outward from the central source with a mean proper motion of ~3 mas/yr (~28 km/s).

VERA Observation of W75N

- We here present our two VERA observations carried out on 2007 January 20 and May 18, time span of 4 months, for H2O maser ($6^{16} \rightarrow 5^{23}$: v = 22235.080 MHz).
- This time span is set by flare activity in Cyg X-3, another target of the dual-beam with 2.2 degree.
- W75N data was analyzed with phase referencing technique by adopting fringe results of Cyg X-3.

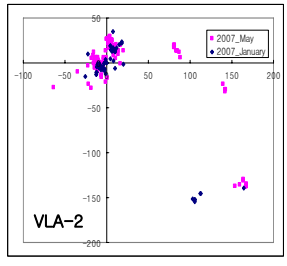
Summary: Maser Features Observed with VERA

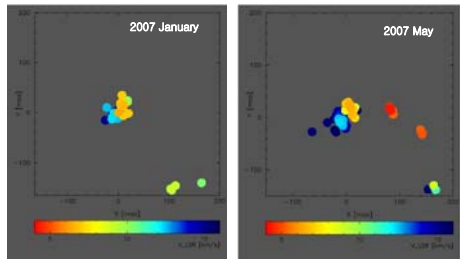




VLA-1:

Water masers were detected within ~800 and ~1,300 mas, similar to 1999 VLBA observations. However, unlike Torrelles et al., we cannot define the pattern of the distribution of spots in VLA-1 due to a small number of spots.
This can be, for example, due to disappearance of number of spots observed in 1999.





VLA-2:

Quite similar to 1999 VLBA observations, a cluster of water masers with radius of ≥150 mas was detected in our observations in 2007.

The feature of expanding shell of spots also look alike, except missing motions of spots in the directions of north-east and south-west from 1999 VLBA observations.

This is probably due to much longer time span of 4 months, enough for spots to change their structure, compared with shorter,1- 1.5 month interval in 1999 VLBA observations.

Discussion & Future works

- Features of water maser spots in W75N we presented here are based on phase referencing with respect to Cyg X-3, another target of the dual-beam. In addition to these observations of 2007 January and May, we also observed W75N in 2007 February, which cannot be done with the phase referencing due to the low flux state of Cyg X-3 under VERA's detection limit.
- Only with a relatively long, five-month, interval of January-May, we could not compare our observation directly to 1999 VLBA observations of Torrelles et al., in particular for VLA-1 region.
- In our observation of 2007 Janaury and May, VLSR ranges from +5 to +15 km/s, while, in Torrelles et al., broader range of VLSR, -10~+15 km/s, were presented in 1999.

- We, therefore, will perform the self-calibration of W75N all for 2007 January, February and May.
- With the January-February interval, it is expected to see the motion of maser spots more clearly than the case of January-May interval we presented here. In addition, the correlation of spots among January, February and May will be clarified.
- Since we have newly adopted two known quasars in the 2008-2009 VERA Open User Observations, we will investigate the proper motion of W75N.