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A VLBI STUDY OF H_2O MASER SPOTS ASSOCIATED WITH A MOLECULAR OUTFLOW ρ OPH-EAST

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INTRODUCTION

A molecular outflow is one of the most conspicuous active phenomena associated with protostars, and the kinetic energy of its outflowing mass is as large as that of random motions of ambient molecular cloud, which suggests that outflow has dynamically influence on ambient molecular gas. Possible observational evidence which suggests the existence of dynamical interaction between molecular outflow and ambient molecular cloud has been detected in several star forming regions (Fukui *et al.* 1986; Iwata *et al.* 1988). Recent detections of H_2O maser emission associated with low-mass protostars (e.g. Comoretto *et al.* 1990) also suggest that there still exist active phenomena in the low-mass star forming regions.

Molecular outflow ρ Oph-East, discovered toward a low-mass protostar *IRAS* 16293-2422 (Fukui *et al.* 1986), has been known as a site of dynamical interaction between molecular outflowing gas and ambient molecular cloud by CO and NH_3 observation (Mizuno *et al.* 1990). Existence of several strong H_2O maser spots (Wilking & Claussen 1987; Wotten 1989; Terebey *et al.* 1992) also suggests that active phenomena are occurring in this region. In this paper, we report our result of H_2O maser observation for molecular outflow ρ Oph-East with milli-arcsecond resolution by VLBI.

OBSERVATIONS AND RESULTS

Our VLBI observation has been made for H_2O maser at 22.235 GHz in the 10th KNIFE (= Kashima-Nobeyama Interferometer) experiments using the Japanese domestic mm-wave VLBI network of Kashima 34m , Nobeyama 45m , and Usuda 64m telescopes on May 28, 1991. The east to west baseline of 200 km between Kashima and Nobeyama gives a fringe interval of 14 milli arcsecond which correspond to 2.2 AU at the distance of ρ Oph-east, 160 pc, while the south to

north baseline of 20 km between Nobeyama and Usuda gives a fringe interval of 140 milli arcsecond.. Correlation processing has been made using the simplified correlator, NAOCO (= National Astronomy Observatory Correlator) developed by National Astronomy Observatory. 512 lag of NAOCO gives a frequency resolution of 4 kHz corresponds to a velocity resolution of 0.05 km sec^{-1} for H_2O maser spectra at 22 GHz.

Table 1 indicates that the spectrum obtained with the shorter baseline of Nobeyama and Usuda shows one velocity component peaked at 7.6 km sec^{-1} which is consistent to the strongest VLA component labeled A by Terebey *et al* (1992). On the other hand, our longer baseline of Kashima and Nobeyama resolved the 7.6 km sec^{-1} component into three velocity components of 7.1, 7.5, and 7.8 km sec^{-1}, which are labeled A1 to A3 in Table 1. Visibility phase profiles show that each component has the difference in visibility phase of 40 to 100 degree, which suggests that we resolved the spacial distribution of three velocity components. The simple peak of 7.6 km sec^{-1} by shorter baseline and its resolution by longer baseline suggest that the 7.6 km sec^{-1} component consists of three maser spots with the size of several AU. Distribution of these maser spots in the vicinity of ejective point of the outflowing gas mapped with Nobeyama Millimeter Array (Mizuno *et al.* 1992, in this colloquium) indicates that these maser sources are generated in the activity around the protostar which supply large kinetic energy of out flowing gas. Our results suggest the possible case of evidence for an activity induced by the interaction between outflowing gas and ambient molecular cloud.

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TABLE I The H_2O Maser Sources by KNIFE

source	V_{LSR} (km^{-1})	baseline
A	7.6	Nobeyama - Usuda
A1	7.1	Kashima - Nobeyama
A2	7.5	Kashima - Nobeyama
A3	7.8	Kashima - Nobeyama

REFERENCES

Commoretto G. *et al.* 1990, *A&AS*, **84**, 179.

Fukui, Y., Sugitani, K., Takaba, H., Iwata, T., Mizuno, A., Ogawa, H., & Kawabata, K. 1986, *ApJ*, **311**, L85.

Iwata, T., Fukui, Y., & Ogawa, H. 1988, *ApJ*, **325**, 372.

Mizuno, A., Fukui, Y., Iwata, T. & Nozawa, S. 1990, *ApJ*, **356**, 184.

Terebey, S., Vogel, S. N., & Myers, P. C. 1992, *ApJ*, **390**, 181.

Wilking, B. A. & Claussen, M. J. 1987, *ApJ*, **320**, L133.

Wooten, A. 1989, *ApJ*, **337**, 858.