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MOLECULAR OUTFLOWS IN B335 AND B1

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We present the aperture synthesis observations of the CO molecular outflows associated with the low-mass young stellar objects embedded in B335 and B1. We used the Nobeyama Millimeter Array and obtained the angular resolutions of 8.1" x 5.0" for B335 and 6.5" x 4.4" for B1.

1) B335

B335 is well studied as a typical bipolar outflow source. The high-resolution single-dish maps of CO(J=1-0) (Hirano et al. 1988; Moriarty-Schieven & Snell 1989) reveal that the outflow is of biconical shape and is centered at the cold IRAS source, 19347+0727. B335 is the most suitable object to study the detailed structure of the outflow in the close vicinity of its driving source, because the outflow axis has a small inclination angle (~10°) to the plane of the sky.

In Figure 1 we present the distribution of the blueshifted emission (V_{LSR} = 7.84 km s^{-1}; solid contours), the redshifted emission (V_{LSR} = 9.46 km s^{-1}; dashed contours), and the 2.6 mm continuum emission (gray scale). The blueshifted and redshifted CO emission shows distinct biconical structure. Two prominent peaks are separated by 10" (= 2400 AU) in blueshifted component and 15" (= 3600 AU) in redshifted one. The north-south extent of the outflow at its center is less than 8" (= 2000 AU), indicating that the outflow is focused within ~ 1000 AU of its origin. The 2.6 mm continuum peak whose flux is ~ 80 mJy is located within 4" of the outflow center. The 2.6 mm continuum flux combined with the previous far-infrared and submillimeter measurements (Keene et al. 1983; Gee et al. 1985; Chandler et al. 1990; IRAS Point Source Catalog, Version 2, 1988) suggest that the very dense (> 10^8 cm^{-3}) and massive (1.7 - 2.9 $M_{\odot}$) core is surrounding the young stellar object; such high density material may be responsible for collimating the outflow. In the vicinity of the origin, the flow velocity shows a sudden increase away from the center (see Figure 3 of Hirano et al. 1992). A simple dynamical model of the expanding "snowplowing" shell can explain the velocity field of B335.

2) B1

B1 contains a low-luminosity IRAS source 03301+3057, toward which high-velocity CO emission was detected (Nakayama 1988; Bachiller et al. 1990). The high-velocity emission is confined within ~40" (0.07 pc at the distance of 350 pc) of the IRAS source and is dominated by the blueshifted material. The dynamical timescale of the outflow is estimated to be less than 10^4 yr (Nakayama 1988) or less than 10^3 yr (Bachiller et al. 1990), indicating that the outflow is in the early stage of its growth. Furthermore, detection of the thermal emission lines of SiO (Bachiller et al. 1990; Martin-Pintado, Bachiller, & Fuente 1992; Yamamoto et al. 1992) suggests the existence of some violent activities comparable to those of massive star formation.

The CO emission is detected in the velocity range from -1 to 5.5 km s^{-1}, which is blueshifted relative to the ambient cloud velocity of 6.3 km s^{-1}. No significant emission is seen in the velocity larger than 6.3 km s^{-1}. This indicates that the outflow in B1 is asymmetric in the size of a few thousand AU and is dominated by blueshifted material. Figure 2 shows the total integrated intensity map of CO (J=1-0), superposed on the gray scale map of SiO (J=2-1: Yamamoto et al. 1992). The blueshifted gas shows distinct ring-like structure centered at IRAS 03301+3057. The size of the CO ring is 25" (= 8700 AU) x 14" (= 5000 AU). The central hole of CO(J=1-0) emission well coincide with the IRAS position; this suggests that the observed structure is a nearly pole-on view of the molecular shell swept up by the wind from IRAS 03301+3057. The CO emission ring lies between two clumps of SiO; the distribution of the CO emission appears to be anti-correlate with that of the SiO. The $H^{13}CO^+$ (Yamamoto et al. 1992) and NH_3 (Bachiller et al. 1990) results suggest that the dense gas exists at the southeast of the IRAS source. The morphological relation among the CO outflow, SiO clumps, and dense gas implies that the outflow interacts with the dense gas and causes the strong shock which produce the SiO.

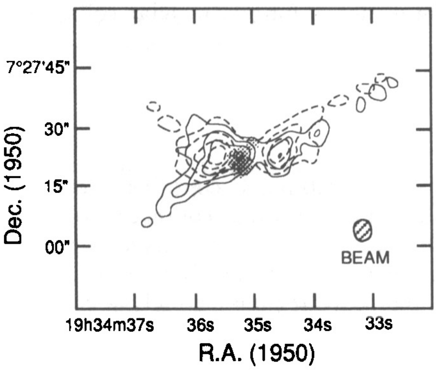

Fig. 1 Contour plots of the blueshifted emission (solid), redshifted emission (dashed), and the 2.6 mm continuum emission (gray scale) of B335.

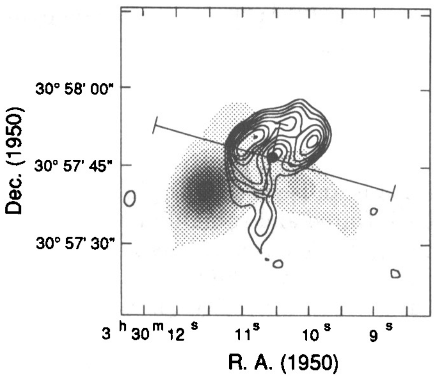

Fig. 2 Integrated intensity map of the CO emission of B1, superposed on the gray scale map of SiO (Yamamoto et al. 1992). The cross mark indicates the IRAS position.

REFERENCES

Bachiller, R., Menten, K.M., & del Rio-Alvarez, S. 1990, A&A, 236, 461
Chandler, C.J. et al. 1990, MNRAS, 243, 330
Gee, G. et al. 1985, MNRAS, 215, 15
Hirano, N., Kameya, O., Nakayama, M., & Takakubo, K. 1988, ApJ, 327, L69
Hirano, N., Kameya, O., Kasuga, T., & Umemoto, T. 1922, ApJ, 390, L85
Keene, J. et al. 1983, ApJ, 274, L43
Martin-Pintado, J., Bachiller, R., & Fuente, A. 1992, A&A, 254, 315
Moriarty-Schieven, G.H., & Snell, R.L. 1989, ApJ, 338, 952
Nakayama, M. 1988, M.S. Thesis, Tohoku University
Yamamoto, S. et al. 1992, PASJ, 44, 459

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