A Large Scale Survey of Dense Cores and Molecular Outflows in Ophiuchus

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We have been surveying dense molecular cores in Ophiuchus region including ρ Oph, L234, and L43 with the 4m radio telescope at Nagoya University since 1985. We have already mapped ~18° × 12° area with 2′ or 4′ grid spacing in ^{13}CO (J=1-0) spectra. We have identified ~50 dense cores (we call "^{13}CO cores"). Typical mass, density, and size of the ^{13}CO cores are ~20 $M_{\odot}$, ~3×10^3 cm^{-3}, and ~0.3 pc, respectively (Nozawa et al. 1990). We also surveyed molecular outflows in ^{12}CO (J=1-0) spectra toward 13 *IRAS* point sources associated with ^{13}CO cores in Ophiuchus. As a result of the survey, we have found 5 molecular outflows in the filamentary dark clouds and 5 regions exhibiting high velocity wings in the ρ Oph main body.

1. ρ Oph-East

ρ Oph-East (Fukui *et al.* 1986, Mizuno *et al.* 1990a) is the most spectacular one which is associated with IRAS16293-2422, being discovered by Wootten and Loren (1987) independently. It consists of five distinct outflow lobes. Four of them are compact (≲ 3') and apparently form two pairs of bipolar outflows, and the fifth lobe is an extended (~10') monopolar blue-shifted lobe. By NH_3 observations with the 100m telescope at Effelsberg, we found a dense core just toward the eastern edge of the compact blue eastern lobe. The velocity of the dense core is blue-shifted by ~ 0.5 km s^{-1} from the rest of the NH_3 cloud. Calculated momentum of the CO lobe is large enough for causing such a velocity shift if a significant portion of the outflow momentum is transferred to the NH_3 core. This provides the first direct evidence for an outflow to accelerate interstellar molecular gas, strongly suggesting the dynamical importance of outflow in cloud cores where stars are formed.

A high resolution ^{12}CO (J=1-0) map (Figure 1) made with the Nobeyama Millimeter Array (Mizuno et al. 1990b in preparation) reveals the distribution of the high velocity gas near the driving source. The blue-shifted gas is located on the east side and the red-shifted gas on the west side, suggesting that the axis of the bipolar outflow is oriented in the E-W direction. In the vicinity of the IRAS source, the NE-SW bipolar flow is not seen. Taking this result into consideration, we suggest that the NE-SW bipolar flow is formed by some secondary effect such as a dynamical interaction between the high-velocity outflow and the dense ambient cloud.

2. IRAS16285-2356

This outflow was discovered in the ρ Oph northern streamer with the Nobeyama

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45m radio telescope. It has a very short dynamical timescale, ~1×10^4 yr. The outflow is apparently associated with a cirrus type IRAS point source, 16285-2356, detected only in the 100μm band. About 90" north of the IRAS source, another IRAS point source, 16285-2355, is located. 16285-2355 is detected in the 12, 25, and 60μm bands and has a cooler color indices than those of T Tauri stars. Levreault *et al.* (unpublished data) suggested that there is a molecular outflow associated with 16285-2355. However, the high velocity lobes are localized just toward 16285-2356 in our high resolution map with 17" beam and 15" sampling, suggesting that 16235-2356 is preferable to 16285-2355 as a driving source. We think it probable that IRAS16285-2356 is a young and very low-mass (ie. less luminous) protostar, so that the fluxes of 12, 25, and 60μm may be less than the IRAS sensitivity limits.

References

Fukui, Y., Sugitani, K., Takaba, H., Iwata, T., Mizuno, A., Ogawa, H., and Kawabata, K. 1986, *Ap. J. (Letters)*, **325**, L13.

Mizuno, A., Fukui, Y., Iwata, T., Nozawa, S., and Takano, T. 1990, *Ap. J.*, **356**, 184.

Mundy, L. G., Wilking, B. A., and Myers, S. T. 1986, *Ap. J. (Letters)*, **311**, L75

Nozawa, S., Mizuno, A., Teshima, Y., Ogawa, H., and Fukui, Y. 1990, (submitted to *Ap. J. Suppl.*).

Wilking, B. A., Lada, C. J., and Young, E. T. 1989, *Ap. J.*, **340**, 823

Wilking, B. A. and Lada, C. J. 1983, *Ap. J.*, **274**, 698

Wootten, A. and Loren, R. B. 1987, *Ap. J.*, **317**, 220

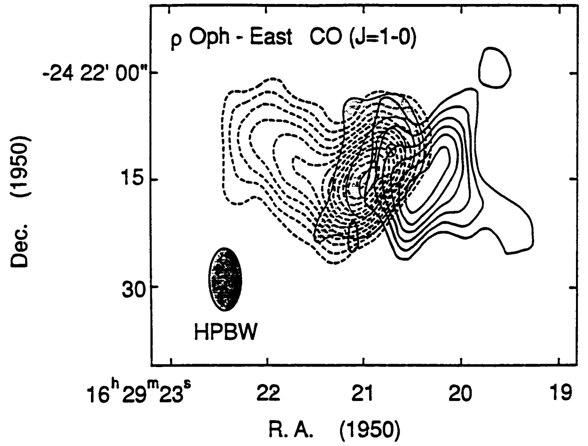

Figure 1 Interferometric map of ρ Oph-East taken with the Nobeyama millimeter array is superposed on the 2.7 mm continuum map (Mundy, Wilking, and Myers 1986). The velocity intervals are 0.4 to 3.2 km s^{-1} (low velocity blue wing) and 8.5 to 12.5 km s^{-1} (high velocity red wing). Contours extend from 2σ rms noise with a 1σ step. 1σ rms noises are 70 mJy $beam^{-1}$.

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