JETS FROM LOW MASS ACCRETING STARS

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There is excellent evidence that jets originate in protostars of low mass ($M \sim M_\odot$). Flow speeds are typically of order a few 100 km s^{-1}; the energy for the motion must be generated close to or below the stellar surface, where the escape velocity is of the same order. Here it will be argued that the origin of the jets is connected with the thermodynamics of the accreted gas as it settles towards equilibrium. At some distance below the photosphere, in a spherically symmetrical star, the opacity of the material becomes so high that the outward flow of radiant energy is too slow to balance the inward convection of thermal energy. Consequently there can be no equilibrium, and the symmetry must be broken. The occurrence of jets can be led back to this effect, and the power required to drive them restores the energy balance.

OBSERVATIONS OF MOLECULAR FLOWS IN S140 AND L723

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ABSTRACT. We have made 15" resolution observations of CO J = 1-0 emission toward L723 and S140 using the Nobeyama 45-m radio telescope. The maps resolved the molecular flow structures clearly. The outflow in the S140 molecular cloud was resolved to be a bipolar structure with its axis being nearly perpendicular to the elongation of the dense core observed in CS emission and to the direction of the infrared polarization. The blueshifted and redshifted components in L723 were resolved into two pairs of bipolar outflows with a point-symmetric structure.

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1. OBSERVATIONS

An energetic molecular outflow from a young stellar object is the most active phenomenon in the star formation process. It is important to investigate the detailed spatial and velocity structures for the discussion of the mechanisms of acceleration, collimation, and evolution of the molecular flow. Here we present the results of high resolution ^{12}CO observations toward L723 and S140.

The ^{12}CO data were taken in April 1984 and April 1985 using the 45-m radio telescope of NRO. The angular resolution, 15", corresponds to a spatial resolution of 0.02 pc for L723 (distance = 300 pc) and 0.07 pc for S140 (distance = 910 pc), respectively. We used the acousto-optical radio spectrometers which give a 250 kHz resolution, corresponding to a velocity of 0.65 km s^{-1}. Both observations were centered on the infrared sources.

2. S140

The distribution of the blueshifted and redshifted wing emissions of CO are offset from each other as shown in Figure 1a. The velocity structure, which will be discussed in detail by Hayashi *et al.* 1986 shows that the position of the emission peak shifts from the south of S140 IRS1 to the northeast with increasing radial velocity. Figure 1b shows the map of the CS J=1-0 emission (Hayashi *et al.* 1985) and the direction of the infrared

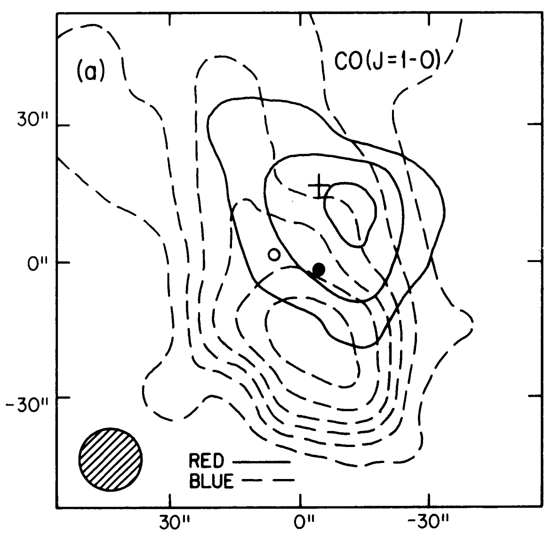

Fig. 1a. The map of the CO emission in the blue (V = -30 to -12 km s^{-1}) and red (V = -3 to 10 km s^{-1}) wings of the S140 molecular cloud. The contour interval is 10 K km s^{-1} with the lowest contour being 20 K km s^{-1}. The map center is $(R.A.\ DEC)_{1950} = (22^h17^m42.0^s, 63°3'45")$ and the central velocity is -7 km s^{-1}.

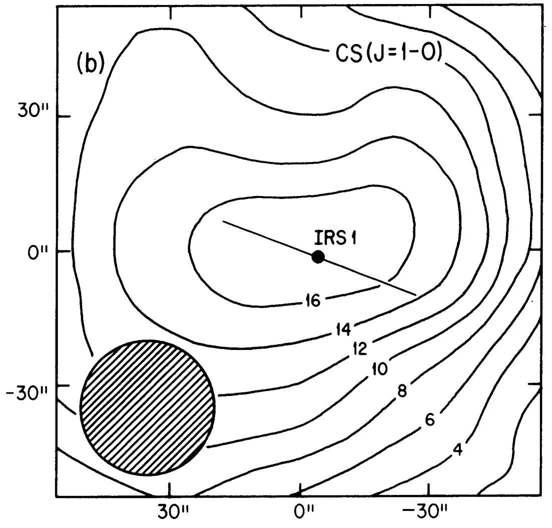

Fig. 1b. The distribution of the integrated intensity of the CS J = 1-0 emission toward the S140 molecular cloud (Hayashi *et al.* 1985). Contour steps are in units of K km s^{-1}. The line across S140 IRS1 shows the direction of the infrared polarization (Dyck and Capps 1978).

polarization (Dyck and Capps 1978). The line connecting the blue and the red lobes of the CO flow is nearly perpendicular to the elongation of the CS core and to the direction of the infrared polarization. Thus the molecular outflow in the S140 cloud has a bipolar nature similar to that of other bipolar sources.

3. L723

The clear bipolar structure in the East-West direction was first shown by Goldsmith *et al.* (1984). The present results, as shown in Figures 2a-d, resolved the blueshifted and redshifted components into four components with a strikingly symmetric distribution around the FIRS (Davidson 1983). The East and West ridges are prominent at the lower velocity range, whereas the North and South peaks are more evident at higher velocities. There are two possibilities for explaining these configurations:

1) The North and East as well as the South and West peaks delineate a pair of arc-like structures. These may be interpreted as parts of the shell produced by the bipolar flow.

2) There are two pairs of outflows: the North and South pair and the East and West pair. They may arise from two outflow sources or from the precession of a single outflow.

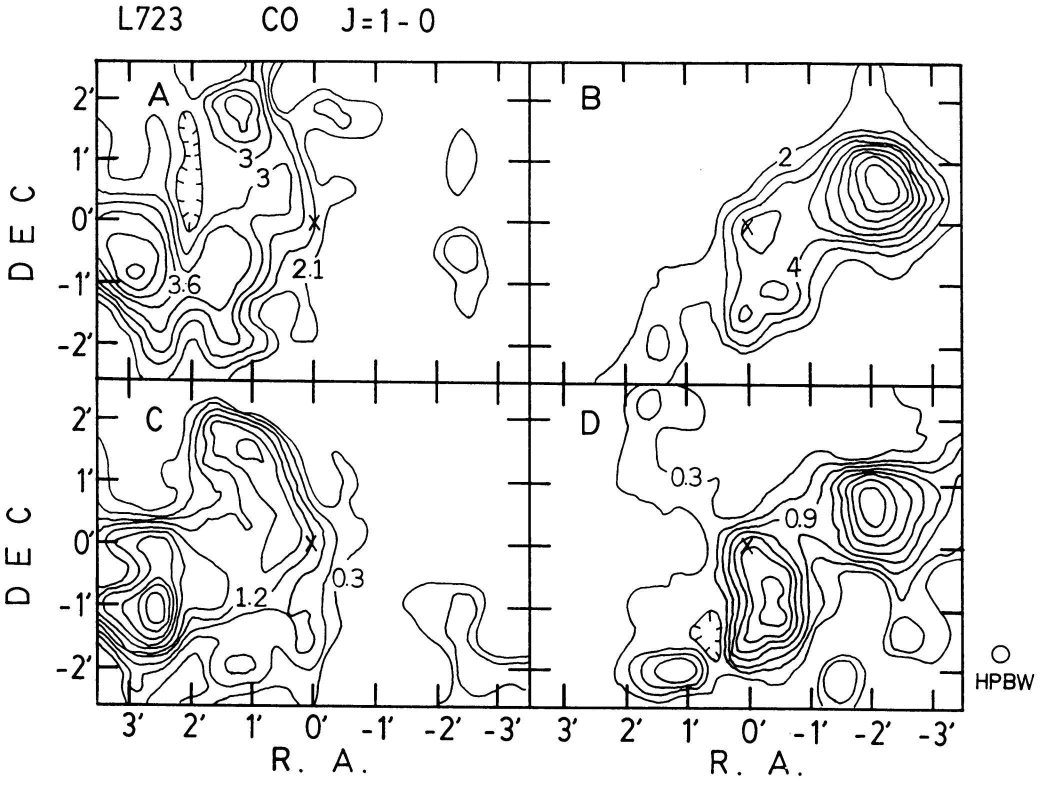

Fig. 2 (a-d). The maps of the integrated ^{12}CO emission from the wings of L723. The map center is the position of FIRS from Davidson (1983) and the central velocity is 10 km s^{-1}.

(a) v = 5 to 9 km s^{-1}; contour unit = 0.5 K km s^{-1}.
(b) v = 12 to 16 km s^{-1}; contour unit = 1.0 K km s^{-1}.
(c) v = 1 to 5 km s^{-1}; contour unit = 0.5 K km s^{-1}.
(d) v = 16 to 20 km s^{-1}; contour unit = 0.5 K km s^{-1}.

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