A MOLECULAR WORM IN SCUTUM

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Over the past four years, Pat Thaddeus and I have been using the CfA 1.2 m telescope to carry out a new CO survey of the first Galactic quadrant with a sensitivity per solid angle 3–10 times higher than previous CO surveys of the plane, and 16 times higher than the only previous extensive wide-latitude survey (Dame et al. 1987). Since a preliminary purpose of this survey is the study of molecular gas out of the plane in the inner Galaxy, the observations have so far been confined mainly to several vertical strips across the plane covering a few degrees in Galactic longitude and 6°–8° in Galactic latitude; details of this on-going survey are given in Dame & Thaddeus (1995).

Our survey has revealed faint, filamentary CO emission extending over 200 pc from the plane in many directions; this emission is evidence for a thick, low-density molecular disk in the inner Galaxy ~3 times as wide as that of the dense central H_2 layer and comparable in width to the central H I layer (Dame & Thaddeus 1994). We have also found a number of examples of well-defined molecular clouds at high z which appear to have been ejected from active star-forming regions in the plane. This brief contribution discusses one of the more interesting of these clouds, which appears to lie at the top of a molecular "worm" of the sort long observed in H I (e.g., Koo, Heiles, & Reach 1992), but not observed previously in CO.

Figure 1*a* is a 3-dimensional rendering of a surface of constant T_{mb} in a portion of our CO survey below the plane near $l = 24°$. Although this unusual representation of the data is of little use for quantitative analysis, it displays the large-scale structure and coherence of the high-z feature of interest here better than any single slice or integration through the survey. That feature appears to originate from an intense region near the plane at $l = 23.4°$, $v = 100$ km s^{-1} (arrow) and extends at roughly constant longitude to a well-defined cloud at $b = -1.3°$, $v = 115$ km s^{-1} (labeled). Since this cloud lies ~6 km s^{-1} above the terminal velocity in this direction (Clemens

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1985), we adopt the subcentral distance of 7.8 kpc. That implies a vertical displacement of 177 pc. Figure 1*a* suggests that this high-z cloud may have been ejected from a region of active star formation near the plane. The region marked by the white spot in Figure 1*a* is one of the most intense in CO in the first Galactic quadrant, lying near the peak of the molecular ring and the tangent of the 4-kpc spiral arm. There is also a pronounced concentration of H II regions in this direction, most falling in the range 70-115 km s^{-1} (see Fig. 2 of Lockman 1989). If our cloud has been ejected, then its H_2 mass of $\sim 6 \times 10^4 M_\odot$ and radial velocity $\sim$ 15 km s^{-1} with respect to its parent cloud imply a kinetic energy of $\sim 2 \times 10^{50}$ ergs; its vertical displacement implies a comparable amount of potential energy. With an initial vertical speed of 15 km s^{-1}, the cloud could have reached its present height in $\sim 2 \times 10^7$ yrs. In terms of its mass, vertical displacement, and energetics, this high-z cloud is quite similar to the one discussed by Nyman et al. (1987), but is three times further away.

As Figure 1*b* shows, the H I emission in this region displays a similar vertical structure, one which Koo et al. (1992) have identified as a prominent worm (GW23.0-1.6+100 in their catalog). Although the high-z end of the H I worm is displaced by $\sim 1.5°$ in longitude from the CO feature and extends more than twice as high, the H I worm is inclined to the Galactic plane (see Fig. 13 of Koo et al.) and seems to envelope the CO feature at its base. Further, since the CO and H I structures have nearly identical (forbidden) velocities of $\sim$ 115 km s^{-1}, there seems little doubt that the two are related, and that what we have detected in CO is the molecular counterpart or core of this H I worm.

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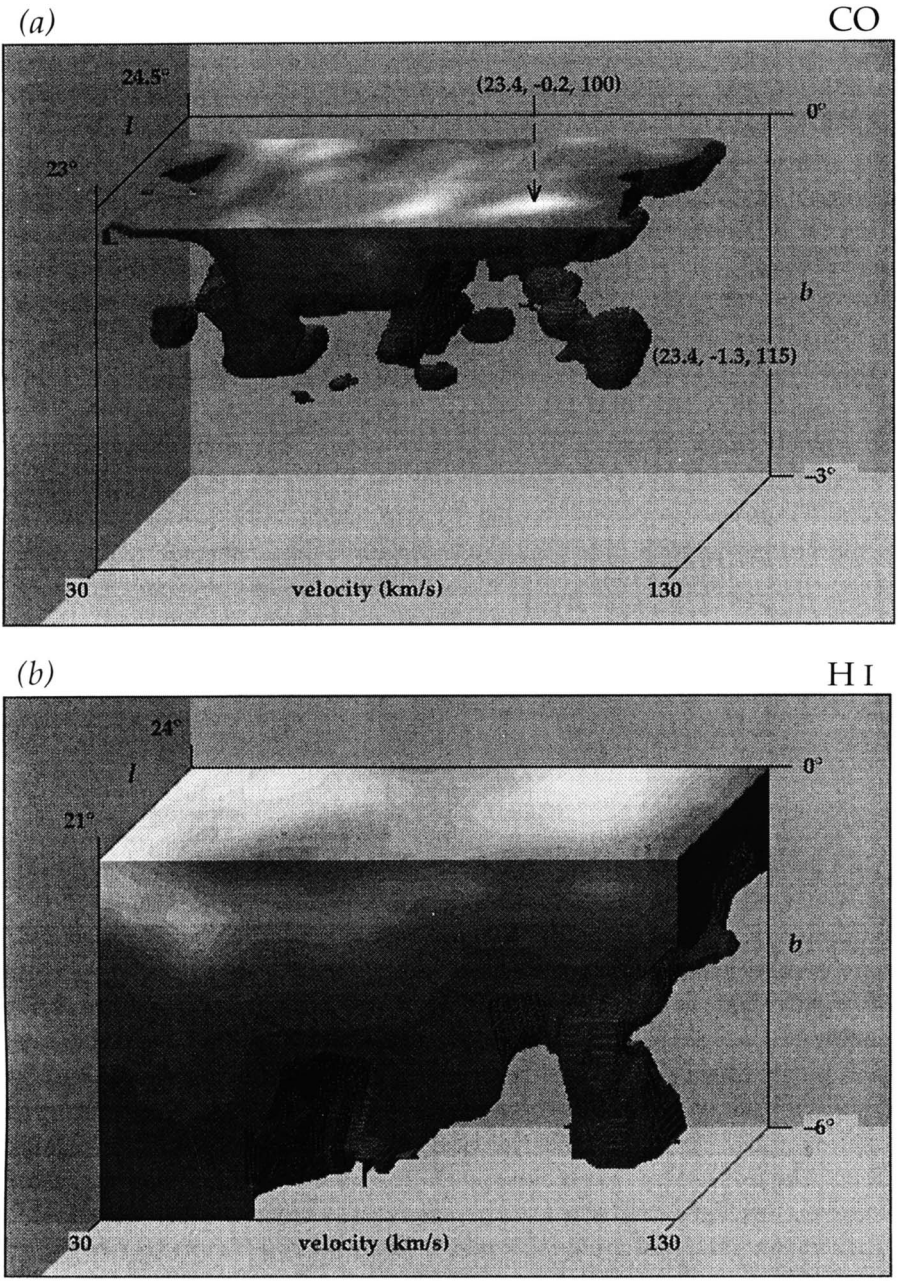

Figure 1. (a) A shaded isosurface at T_{mb} = 0.28 K from a CO survey of the region l = 23° to 24.5°, b = –3° to –0.2°, and v = 30 to 130 km s^{-1}. At the edges of the survey, higher intensities inside the isosurface are represented by a black-to-white grayscale, the brightest point (*white*) at 6.5 K. An intense region near the plane and the high-z cloud are labeled with (l, b, v). *(b)* A similar isosurface at T_b = 2.35 K from the H I survey of Hartmann & Burton (1995), but covering about twice the range of Galactic longitude and latitude.

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