THE URSA MAJOR MOLECULAR CLOUDS

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1. Introduction

The Ursa Major molecular cloud complex lies in the direction of an expanding HI shell known as the North Celestial Pole loop. The NCP loop, which is centered at $(l, b) \sim (138°,30°)$ and easily seen in IRAS 100 μm emission, is some 60 pc across and 150 pc distant (Meyerdierks et. al 1991). At 100 μm, the Ursa Major clouds appear in projection as "finger" ($l \sim 140, b \sim 38$) which "hangs down" towards the center of the loop and the plane of the Galaxy. Distance estimates to the molecular clouds (Penprase 1993) are consistent with that of the NCP loop, indicating that the clouds are physically associated with the loop.

Figure 1 shows the CO integrated intensity map, (I(CO)), of the Ursa Major complex. The CO spectra ($\sim$ 22000) were obtained with the AT&T Bell Labs 7 m telescope (HPBW = $1'.7$), and were spaced at $1'$. The H_2 mass of the region mapped in CO is about 220 solar masses assuming a relation between I(CO) and H_2 column density $N(H_2)/I(CO) = 2.1\times10^{20}$ (K km/s)$^{-1}$ cm^{-2}. The structure of the Ursa Major complex is dominated by several long ($>$ 2 pc) filaments, some of which are both extremely straight and extremely narrow ($<$ 0.2 pc across). The filaments, clumps, and "bow shocks" seen in the CO maps correlate in detail with features in the IRAS 100 micron flux and opacity maps and, coupled with the general appearance of the atomic gas, suggest a recent shock event. In channel maps (not shown) the lower tip of the CO filaments have a bow shape,

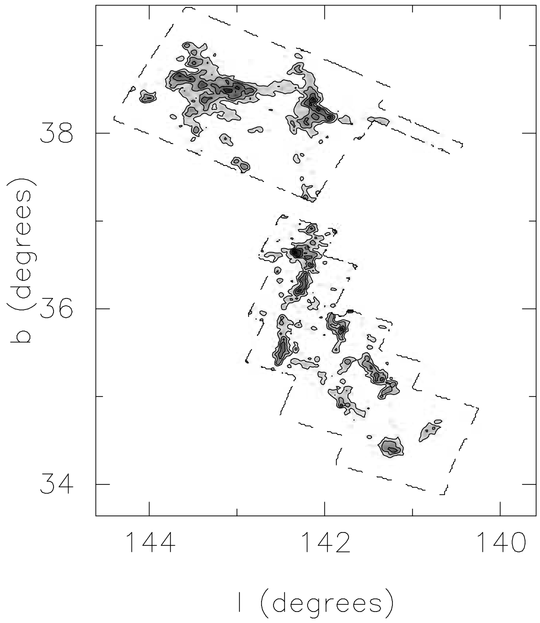

Figure 1. CO integrated intensity I(CO) from $V_{LSR} = -2$ to -3.5 km/s. Contours are 1.5, 3.0, ..., 7.5 K km/s. The data have been smoothed to $4'$.

suggesting the gas is being compressed by a wind from the direction of the Galactic plane.

In HI maps made with the Hat Creek (HPBW = $36'$) and Effelsberg (HPBW = $9'$) telescopes, the atomic gas appears to form a sheath around the CO filaments (see Myers et. al 1995). Figure 2 summarizes the HI and CO kinematic data. In the atomic component (upper plots in Fig. 2), there is a clear correlation of *both* FWHM line width ΔV and LSR velocity with b. In the CO data (lower plot in Fig. 2), the correlations are also present but with much more scatter. These data suggest that the filamentary portion of the Ursa Major complex is arc-shaped when viewed perpendicular to our line of sight, and that this arc is slowly tumbling back down toward the Galactic plane (see Figure 3). A filament rotating as a "solid body" (in the direction of the curved arrows in Fig. 3) would give rise to the observed increase in V_{LSR} with b. Two differing components of the line width, along the filament ("tangential") and across the filament ("radial"), would explain the increase of ΔV with b. Depending on the orientation of the filament with respect to the observer, $\Delta V_{\rm tan} >> \Delta V_{\rm rad}$ (upper picture in Fig. 3) or $\Delta V_{\rm tan} << \Delta V_{\rm rad}$ (lower picture in Fig. 3). Alternatively, the correlation of $V_{\rm LSR}$ with b could be explained by an expanding filament rather than a rotating one. However, the loci of temperature in position-velocity diagrams do not show the curvature that signify expansion.

Figure 2. Summary of HI and CO kinematic data. Symbols represent V_{LSR} range and have same value in each plot. See text for explanation.

Figure 3. Two possible geometries of the HI filament consistent with the data in Figure 2. See text for explanation.