COLUMBIA CO SURVEY: MOLECULAR CLOUDS AND SPIRAL STRUCTURE

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We have recently completed at Columbia University a survey with a 1.2 meter telescope of 2.6 mm CO emission from the first galactic quadrant. The beamwidth of this telescope - 7.5' at 2.6 mm - is optimal for a large-scale galactic survey: it is as small as that of the best 21-cm surveys but not so small that undersampling is required to finish a survey in a few hundred days of observing. The survey contains more than 3000 spectra between longitudes 12°and 60°and latitudes -1°and +1°. Spectra were taken every beamwidth for $|b| \leq 0.25°$ and every two beamwidths elsewhere. Integration times, which averaged about 8 minutes, were adjusted to give an rms noise level of 0.3 K per 0.5 MHz spectral channel.

With the dense sampling of our survey it is possible for the first time to improve upon the axisymmetric models used in analyzing previous undersampled surveys. (See Solomon et al. (1979) for a summary of previous work.) The so-called molecular ring, visible along the lower right of the longitude-velocity map in figure 1, is now resolved into two distinct parallel lanes. As the figure inset shows, these are the classical Scutum and 4-kpc arms. The other main 21-cm features also have distinct CO counterparts: A and B are the local arm, and C is the Sagittarius arm. The arms are separated by regions largely free of molecular clouds. The holes within the loop of the Sagittarius arm, between the Sagittarius and Scutum arms, and between the Scutum and 4-kpc arms, all represent extensive interarm regions.

The confinement of molecular clouds to spiral arms implies that they are transient objects with lifetimes less than 10^8 years, the time it takes interstellar matter to cross a spiral arm. A corollary, based on simple conservation of mass, is that the molecular clouds cannot represent much more than half the interstellar gas.

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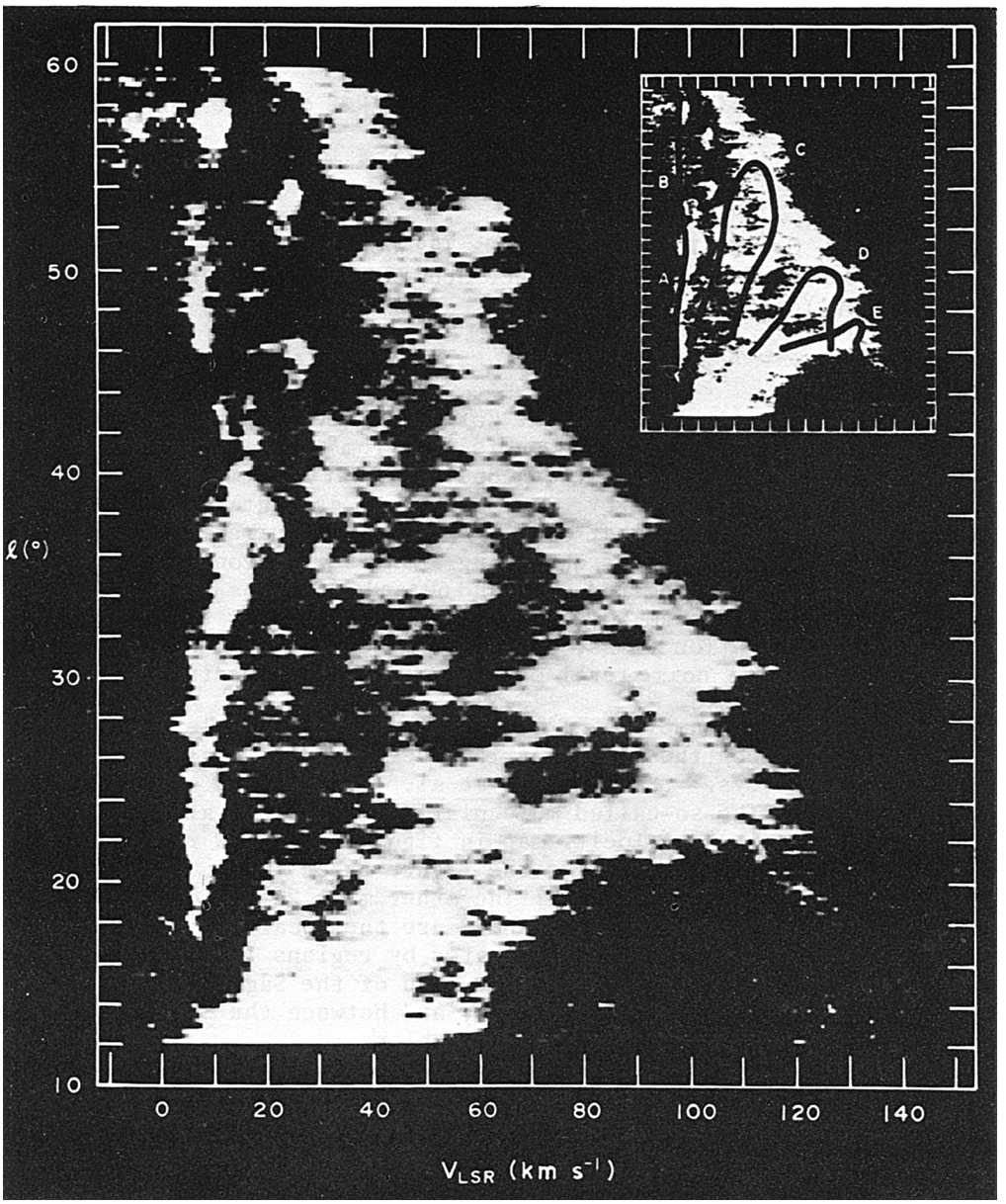

Figure 1. The ℓ, v diagram obtained when our survey is integrated across the galactic plane from b=-1° to +1° and smoothed by 0.25° in ℓ. The insert locates the main 21-cm arms with respect to our CO ℓ, v diagram. A and B are Lindblad's local ring (Burton and Shane 1970; Lindblad et al. 1973); C is the Sagittarius arm (Burton and Shane 1970); D and E are the Scutum and 4-kpc arms(Shane 1972).

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DISCUSSION FOLLOWING COHEN

Sanders: You have used the term "spiral arms" in describing the large ordered features that seem to be present in your plot of ^{12}CO emission in the longitude-velocity plane in the area $12° \leq \ell \leq 60°$, $|b| \leq 0°.25$. The apparent correlation with HI 21-cm emission-contour ridges was also mentioned as further evidence of "arms", yet no clear spiral structure has emerged from extensive analysis of the HI data. Are you saying that the ^{12}CO data gives a more clear picture of spiral structure?

Cohen: Of course there are many difficulties in going from the ℓ-v diagram to real space. The point is that the large 21-cm objects that have been traditionally called spiral arms are seen as well or better in CO. It remains an open question whether these can be connected into a "grand design" of spiral structure.

Silk: Could the evidence you have found for spiral features correspond to the spiral structure noted by Solomon in the hotter CO clouds? In other words, is your sensitivity lower than his?

Cohen: Our sensitivities are about the same. The real difference is in coverage; we have taken spectra every beamwidth or every other beamwidth over the molecular disk, while the small beam of the NRAO 36-foot telescope forces its users to undersample area by a factor of about 100.

Gordon: Comparison of a 2-arm density wave model with our CO observations shows some agreement (see the side-by-side illustrations by Gordon and Burton, Scientific American, May 1979). However, even more striking is the large discrepancy still remaining. Evidently the arrangement of molecular clouds in our galaxy is much more complicated than simple spirals, either in physical or velocity space. In this regard our computer analysis agrees quite well with the results of Sanders and Solomon.

Cohen: There are certainly some molecular clouds between the arms, but I think the data show that molecules are even more concentrated in the arms than is HI.

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