MOLECULAR-CLOUD CLUSTERS AND CHAINS

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We report some preliminary results from the Massachusetts - Stony Brook CO survey of the first galactic quadrant using the 14-meter millimeterwave telescope of the Five College Radio Astronomy Observatory. The survey contains approximately 50 000 observations spaced every 3 arcminutes in l and b between longitudes 0° and 90° and latitudes -1° and 1°. We have mapped emission from giant molecular clouds (GMC) which we identified, in earlier more limited strip surveys of the galactic plane (Solomon, Sanders and Scoville 1979; Sanders 1981), on size scales from a few parsecs to hundreds of parsecs, in order to determine the degree of clustering and organization into large-scale features. In addition to the characteristic size of 20 - 60 pc for individual GMC, we find clustering of clouds on a scale of from 100 to 300 pc.

Figure 1 (these Proceedings, page 3) shows approximately 40 percent of the survey data in the form of l,b strip maps between longitudes 20° and 50°, representing the integrated emission in 5 km s^{-1} velocity bins. Approximately 1500 emission features have been identified in this longitude range, and maps of a few hundred GMC known to be located on the near side of the tangent point have been analyzed. Several of the more prominent nearby clusters of clouds revealed by the survey can easily be seen at G35-0.6 (W44), v = 35-60 km s^{-1}; G49.5-0.4 (W51), v = 45-70 km s^{-1}; G42-0.4, v = 55-75 km s^{-1}; G28.3+0, v = 70-90 km s^{-1}; G24.5+0, v = 45-65 km s^{-1}. Clearly not all molecular clouds are contained in such clusters, but a full analysis of the degree of clustering and correlation lengths will be presented elsewhere.

Figure 2 (page 4) shows the relatively nearby cluster of GMC's near the supernova remnant W44. The cluster contains at least eight clouds with diameters larger than 20 pc and has a total diameter of approximately 110 pc. The cluster is nearly circular in projection and appears to have an ordered internal velocity structure, where the higher-velocity clouds are found at the largest radii and the central-velocity material is near the cluster center. The total velocity width is 25 km s^{-1}. We obtain a mass for the entire cluster of about 2×10^6 $M_\odot$. Larger clusters

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such as the 300-pc object near longitude 31° shown in Figure 3 (page 5) tend to be elongated in the plane; their width in the z direction is typically <150 pc, similar to the full width at half-maximum of the molecular disk as a whole.

Clouds on the far side of the tangent point typically subtend only one-tenth to one-twentieth the solid angle of nearby clouds at the same velocity, hence are more difficult to pick out from Figure 1. However, our 3-arcminute sampling, with a spatial resolution of 12 pc at a distance of 14 kpc, is adequate to easily resolve individual giant clouds and cloud clusters even at the most distant parts of the inner Galaxy. For example, one of the largest structures identified in the survey is the chain of molecular clouds nearly 2.2 kpc in length shown in Figure 3 (page 5). Over 70 distinct features with diameters larger than 12 pc can be identified, and at least 30 are GMC's with diameters larger than 20 pc. Three cloud clusters can be seen with sizes larger than 100 pc. At a distance of 14 kpc the entire chain can be characterized by a width perpendicular to the galactic plane of 100 pc (FWHM) with an H_2 mass of 2 × 10^7 $M_\odot$, approximately 1 percent of the total mass of molecular hydrogen in the galactic disk. We note that the low-resolution GISS CO survey reported by Dame (these proceedings) has also identified some of the largest molecular clusters seen by us, but their report apparently has missed a large fraction of the strong emission, particularly from the far side of the tangent point which contains most of the area of the inner Galaxy. For example, the cloud cluster at l = 31° in Figure 3 is identified, but missed is the remaining two-thirds of the strong emission, including at least 25 clouds with diameters larger than 25 pc, each more massive than 10^5 $M_\odot$.

The cloud chain in Figure 3 is similar in length and number of clouds to two large, local galactic features: the Perseus Arm at longitudes 105° to 145°, and the M17-M8-NGC6334 cloud chain usually referred to as the Sagittarius-Carina spiral-arm segment. The origin of these molecular-cloud chains may be due to two-fluid gravitational instabilities as discussed by Jog and Solomon (1984) and Jog (these proceedings). They suggest that such instabilities "... may represent spiral-arm segments each of typical wavelength 2-3 kpc". In this view, many of the spiral features in our Galaxy are material arms, that is, randomly occurring sheared two-fluid gravitational instabilities.

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