A WIDE LATITIUDE CO SURVEY OF MOLECULAR CLOUDS IN THE NORTHERN MILKY WAY

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INTRODUCTION

It is now well established that molecular clouds are an important part of the interstellar medium, containing much or most of the dense, cold component of the gas, and producing the massive stars and supernovae responsible for the diffuse, hot component. It would therefore appear essential in formulating a complete picture of the local interstellar medium to have some knowledge of the distribution and properties of nearby molecular clouds. To this end we have used the Goddard-Columbia 1.2-meter telescope to carry out a wide latitude, low angular resolution survey of CO along most of the first galactic quadrant and a small part of the second. The survey is uniform and fully sampled in galactic longitude from 12° to 100°, and in latitude from -5° to +6°, with extensions to as high as +11° to include specific dark clouds; the total area surveyed, 1128 deg^2, is much larger than any region previously studied in CO or any other interstellar molecule. In order to fully sample such a large area in a reasonable amount of time, angular resolution has been sacrificed to coverage and speed; an angular resolution of 1° was obtained synthetically by simply scanning a square 8 x 8 raster of points separated by 1/8°, the size of the primary beam, and summing the resulting 64 spectra at the end of an observation.

DISCUSSION

Figure 1 is the plane-of-the-sky map which results from numerically integrating the survey over radial velocity. The velocity range of the spectrometer was adequate to include all material in the longitude range of the survey within ~11 kpc of the galactic center for $\ell < 60°$, and within ~19 kpc of the galactic center for $\ell > 60°$. This map is the most direct way to compare CO molecular clouds with continuum radio, IR, and γ-ray surveys, and has been used to study the relation of molecular clouds in the first quadrant to high-energy γ-rays observed by COS-B (Lebrun et al. 1983).

A striking aspect of Figure 1 is the large filling factor of the CO emission - roughly 50% of the total area observed. About half this emission comes from quite local clouds within ~1 kpc; most of the rest is confined to the intense central ridge of emission about 2° thick at $\ell < 45°$. This is the dense concentration of clouds in the distant Scutum and 4-kpc spiral arms that has been called the molecular ring on the assumption that it represents an axisymmetric distribution of clouds with respect to the galactic center. These distant clouds are so heavily obscured by the foreground Rift material

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that the associated H II regions and young stars are almost entirely invisible from the solar system; we can remove them to study the local clouds by restricting the range of the velocity integration.

Figure 2 has been integrated over the range -10 to 34 km s^{-1}, the upper limit chosen to include in the map all major clouds which contribute to the obscuration of the Great Rift. On the same scale we show a wide-angle photograph of the Milky Way with the lowest CO contour overlaid. It is obvious from this comparison that there exists a remarkably good correlation between the low-velocity CO emission and the optical obscuration of the Great Rift. Nearly every dark nebula is a CO molecular cloud and vice versa.

The nature of the Great Rift is a very longstanding problem. In recent times, there have been various attempts to divide the Rift into regions of roughly uniform obscuration, on the assumption that each region corresponds to an individual dust cloud at some fixed distance. With the aid of our CO survey, it is a simple matter to resolve the Rift into discrete molecular clouds, since even clouds which overlap in direction can be distinguished from one another by their radial velocities. The Rift is decomposed into its individual molecular clouds in Figure 3. Distances were determined either kinematically (for some of the more distant clouds), or with the aid of associated Population-I objects, or with graphs of visual absorption vs. distance for stars within the cloud boundaries (Neckel and Klare 1980). The entire Rift system is seen to be composed of a small number of fairly well-defined clouds at distances ranging from 150 pc to more than 2 kpc.

Of particular interest to the study of local matter is the Aquila Rift, the large lane of obscuration between ℓ = 20° and 40° apparently produced by a single cloud containing several 10^4 $M_\odot$ of molecular gas at a distance of about 150 pc. This cloud is probably related to the very extended, cold HI cloud observed by Riegel and Crutcher (1972) (see Crutcher, this volume), seen as an HI self-absorption feature in the region from ℓ = 345° through the galactic center to ℓ = 25°, at $|b| < 10°$. The CO and HI clouds are comparable in angular size, are similarly displaced to postive latitude, have similar narrow linewidths and quite constant velocities; they are estimated to be at nearly the same distance, and partially overlap spatially in the region ℓ = 20° to 25°. The Aquila Rift molecular cloud and the Riegel-Crutcher HI cloud may therefore comprise a single large lane of cold gas extending over 55° of galactic longitude, corresponding to a linear size of 140 pc. Why this object is molecular at one end, and apparently deficient in dust and molecules at the other, as Riegel and Crutcher find, is a puzzle.

REFERENCES

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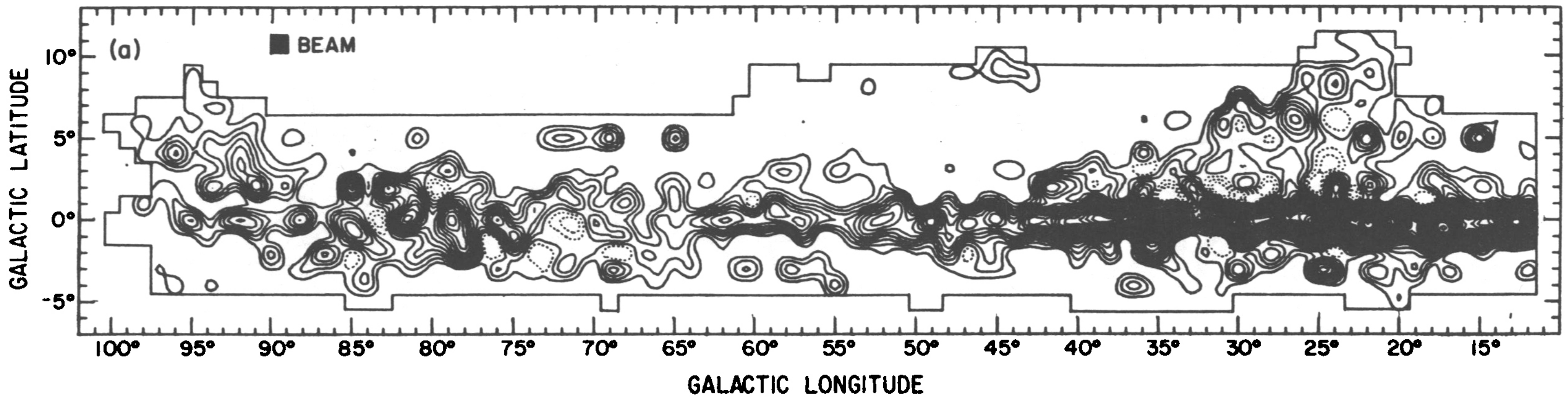

Figure 1. Contour map of the survey integrated over the full velocity range observed. For $|b| \geq 3°$ the velocity range is -83 to $83\ \mathrm{km\ s^{-1}}$, while for $|b| < 3°$ the range is -13 to $153\ \mathrm{km\ s^{-1}}$ at $\ell \leq 60°$, and -113 to $53\ \mathrm{km\ s^{-1}}$ at $\ell > 60°$. The contour interval is $4\ \mathrm{K\ km\ s^{-1}}$.

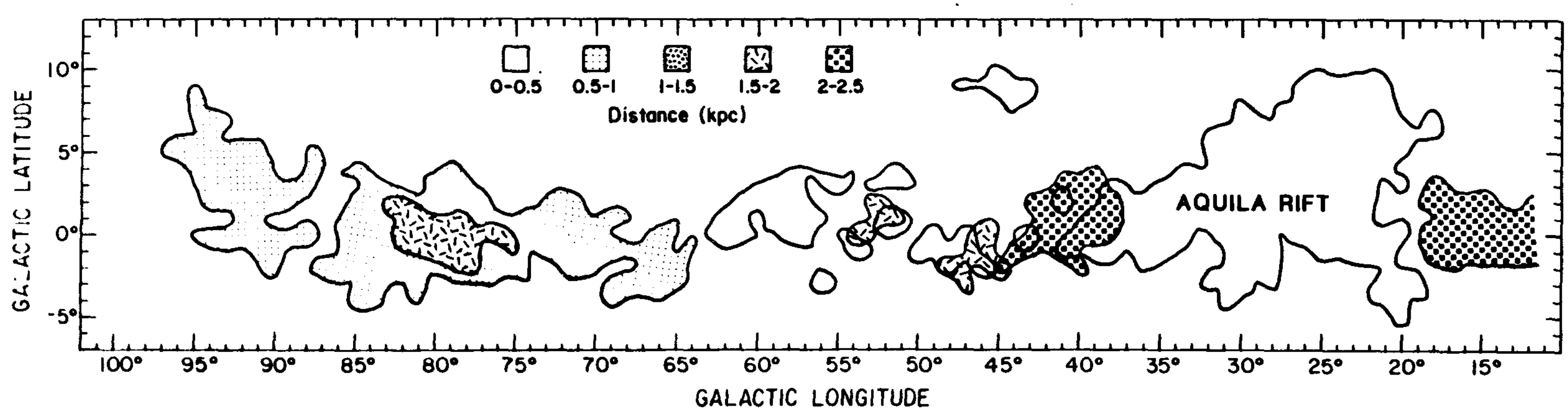

Figure 3. Schematic map of the individual molecular clouds which comprise the Great Rift. The clouds are outlined by their $4\ \mathrm{K\ km\ s^{-1}}$ CO emission contours. Distances are indicated by the shading.

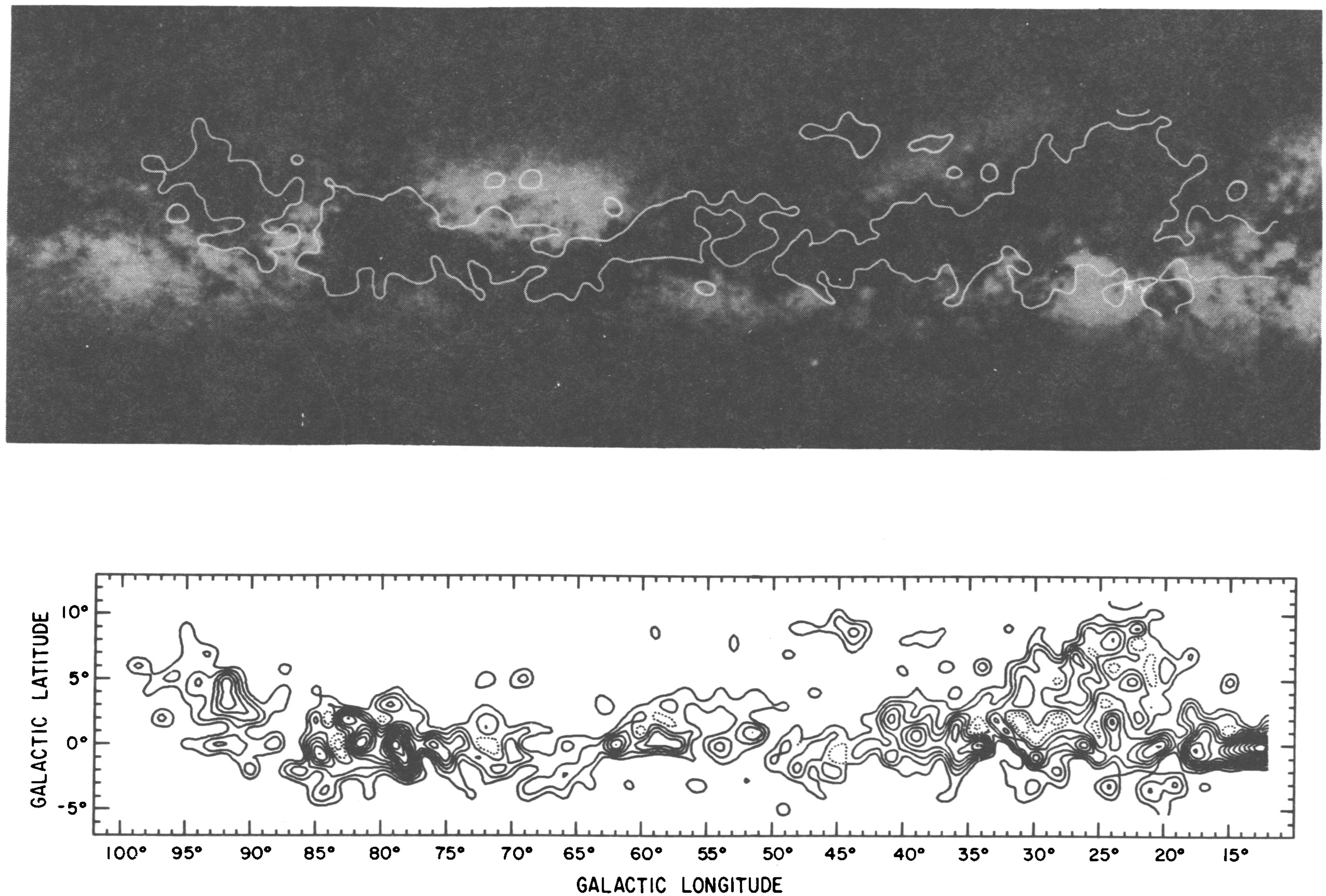

Figure 2. Mt. Wilson mosaic of the Milky Way, with a contour map on the same scale of the CO emission integrated between -10 and 34 km s^{-1}. The contour interval is 4 K km s^{-1}; the lowest contour is overlaid on the photo.