"Spiral Arms and Massive Star Formation: Analysis of the CO Face-on Pictures of the Galaxy"

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The face-on distribution of molecular gas in the first Galactic quadrant, derived from the Massachusetts-Stony Brook Galactic Plane CO Survey (Clemens, Sanders, Scoville 1986), was compared to the Galactic distribution of giant radio HII regions (see Figure 1 below). The HII regions were found to preferentially select gas regions of higher than average density (more than twice the mean) and showed a strong correlation with the second power of the gas density. Systematic effects were tested with a Monte Carlo simulated HII region distribution and found to be negligible.

The 135 HII regions were selected from the radio catalogs of Downes et al. (1980) and Wink et al. (1982). The HII regions were required to be within the CO survey l and b limits, within the solar circle, and not part of the 3 kpc expanding arm. The velocities of the HII regions were tabulated by the catalog authors and obvious associations with known objects and H_2CO absorptions were used by them to assign distances. The distance assignments were here grouped into two catagories; A) those HII regions with definite distance assignments (85 objects); and B) those HII regions with less secure distance assignments and those for which no near-far assignment was possible (50 objects).

The mean H_2 gas density associated with each of the HII regions was found by forming the average of the face-on gas properties within a 300 pc x 300 pc box surrounding each HII region. The $\langle N(H_2)\rangle$, $\langle Z_o\rangle$, and $\langle dZ\rangle$ values were combined to yield $\langle n(H_2;Z)\rangle$, where the Z used was appropriate to the HII region.

Additionally, a sample of pseudo-HII region locations was generated with a Monte Carlo routine. The Monte Carlo HII regions were chosen to match the R and Z distributions of the real HII regions, but to have random Galactic azimuth assignments. From this sample a total of 840 pseudo-HII regions within the survey limits were tabulated inside of R_o.

The mean molecular hydrogen density found (as averaged over 300 pc) for the (R,Z) Monte Carlo run was 1.21 ± 0.03 H_2 cm^{-3}. However, the real HII regions gave a higher value of 1.72 ± 0.10 H_2 cm^{-3}. To quantify the dependence of HII region density on molecular cloud density, the HII regions were binned according to the value of their associated molecular gas density. The number of HII regions reaches a peak around 1-1.5 H_2 cm^{-3}. However, the volume of the Galaxy at each density shows a strong decrease with increasing density. Thus, the number of HII regions per unit volume associated with each density rises from 0 to 4 H_2 cm^{-3}. If the number of HII regions per unit volume N is assumed to obey a power law dependence with associated molecular gas density as: $N = c\,\langle n(H_2;Z)\rangle^{alpha}$, then the slope of the plot of ln(N) versus ln(n(H_2;Z)) (Figure 2, below) indicates the value of the power index, alpha. The group A sample is characterized by an alpha of 1.91 ± 0.16. The Monte Carlo value of 1.14 ± 0.05 shows that although the proper (R,Z) HII region distributions will tend to select high density gas, a random azimuth assignment selects both lower density gas and a lower power law on gas density than the real HII

regions.

The power law index relates the star formation efficiency for massive OB stars (those forming giant radio HII regions) to the mean H_2 gas density. A power law index of zero would imply that star formation is uncorrelated with molecular hydrogen clouds; an index of unity (c.f., Young and Scoville 1982) implies that star formation rates depend on no properties other than the presence of molecular gas. However, an index of two (Schmidt 1959; Dopita 1985) implies that other factors, such as cooling or ambient pressure or cloud collisions (Scoville, Sanders, and Clemens 1986) play a role in triggering massive star formation.

References:

Clemens, D.P., Sanders, D.B., and Scoville, N.Z. 1986, Ap. J., submitted.

Dopita, M.A. 1985, Ap. J. (Letters), 295, L5.

Downes, D., Wilson, T.L., Beiging, J., and Wink, J. 1980, Astr.Ap. Suppl., 40, 379.

Schmidt, M. 1959, Ap. J., 129, 243.

Scoville, N.Z., Sanders, D.B., and Clemens, D.P. 1986, Ap. J. (Letters), submitted.

Wink, J.E., Altenhoff, W.J., and Mezger, P.G. 1982, Astr. Ap., 108, 227.

Young, J.S., and Scoville, N.Z. 1982, Ap. J. (Letters) 260, L11.

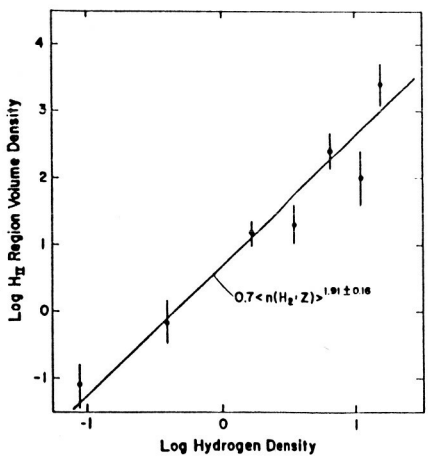

Figure 2: Log HII region volume density vs. molecular hydrogen gas density. Straight line has slope alpha = 1.91±0.16.

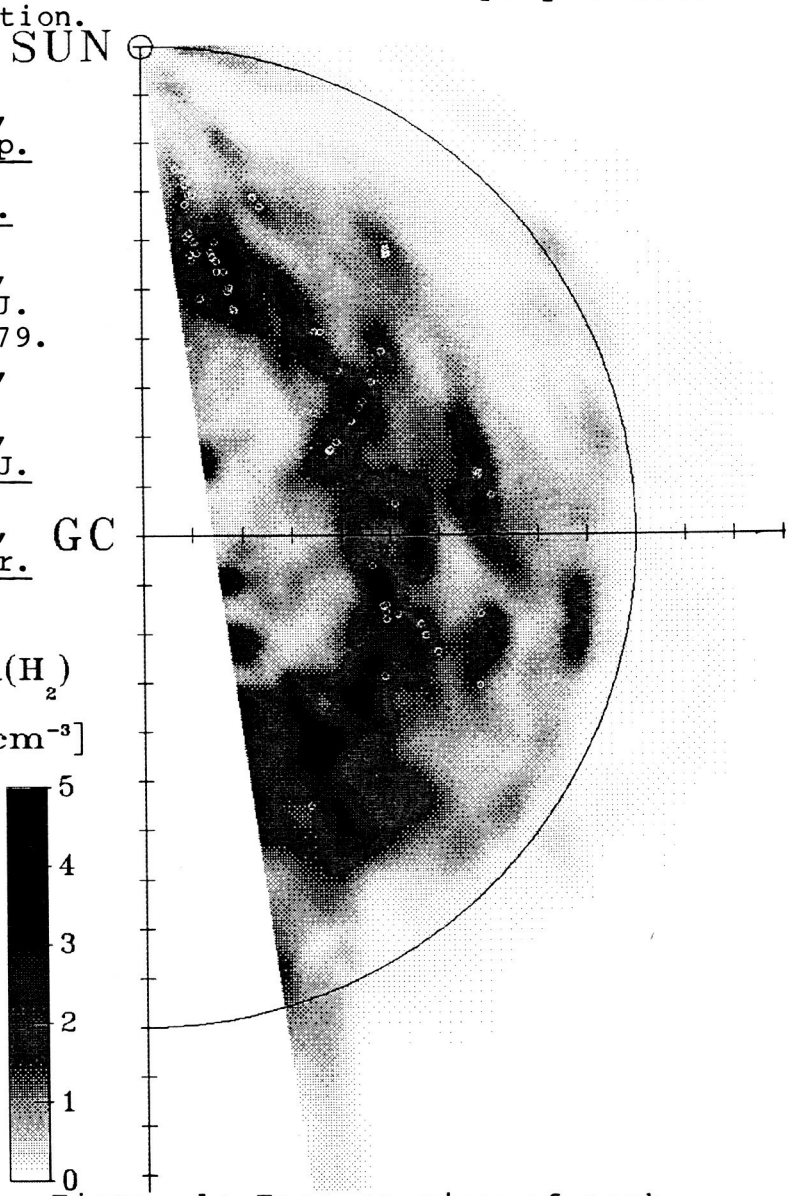

Figure 1: Face-on view of peak molecular hydrogen volume density for the first quadrant as viewed from the North Galactic Pole. Small white circles indicate group A HII region locations.