THE DISTRIBUTION OF FORMALDEHYDE IN THE GALAXY

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A deep survey of formaldehyde absorption along the galactic plane has been made using the MkII telescope (beamwidth 9 arcmin). Observations were made with 1° spacing between ℓ = 14° and 36° and 2° spacing elsewhere in the longitude range 8 to 60 . Integration times were typically 7 hr; the rms noise was 4 mK.

A comparison of the H_2CO longitude-velocity distribution with that of neutral hydrogen shows that H_2CO has a more clumpy distribution, although not as clumpy as CO (Burton and Gordon 1978). The major concentrations of H_2CO lie within HI concentrations (spiral arms) and most are coincident with ionized hydrogen features seen in the 166α recombination line ℓ-v diagram of Hart and Pedlar (1976). The radial distribution of H_2CO in the Galaxy was derived using the rotation curve of Burton and Gordon (1978). The H_2CO distribution is similar to that of CO and HII, showing a broad peak between R = 4 and 6.5 kpc. An estimate of the molecular hydrogen content of the Galaxy was made by assuming $N(H_2CO) = 1.25 \times 10^{-9} N(H_2)$ as given by Scoville and Solomon (1973). This leads to a maximum density (at R = 5 kpc) of 1 cm^{-3}, a value about half that suggested by Gordon and Burton (1976). The density at the solar radius is 0.15 cm^{-3}, which compares closely with 0.143 cm^{-3} derived from UV observations.

It should be emphasized that radio observations of different molecules give probes of different density regimes of interstellar molecular hydrogen. CO samples the highest densities (say 10^2 to 10^3 cm^{-3}), H_2CO intermediate densities (say 1 to 100 cm^{-3}), and CH lower densities (say 1-10 cm^{-3}). Observations of a range of molecular species are required to give the full picture.

REFERENCES

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DISCUSSION

Davies: We consider that the main contribution to the background radiation field is the 2.7 K cosmic background. Evidence for this is that the H_2CO absorption is not limited to the regions of highest galactic continuum emission.

Burton: Uncertainties in the galactic rotation curve may result in discrepancies among the radial abundance distributions derived from the various tracers which we have heard discussed today. Although there is not much doubt about the rotation curve at galactocentric distances greater than 4 kpc, at $R < 4$ kpc there are several different curves available in the literature. Numerical experiments show that the differences are reflected in radial abundance derivations.

Davies: We have looked at the H_2CO radial distribution as a function of the assumed rotation curve and found that there is no significant effect for H_2CO. This is possibly because the H_2CO is mainly concentrated at $R < 4$ kpc where the galactic rotation curve is well-determined. Differences in the various model rotation (and expansion) curves occur at $R < 4$ kpc; these affect the derived HI distribution particularly.

Field: You quoted "H_2 densities" even though you noted that H_2CO lines are formed in low-density regions, which are largely HI. Will you clarify this point?

Davies: We observe a formaldehyde density which we convert to a total gas density (atomic plus molecular) by multiplying by 8×10^8. This relation is supported by observations of HI and H_2CO absorption in the direction of strong galactic non-thermal sources. At higher densities (> 100 cm^{-3}, say) the gas may be predominantly molecular.

Cohen: Again, it seems to me that the H_2CO and CO (from the Cohen and Thaddeus survey presented earlier) ℓ,v diagrams are completely consistent.

Davies: I agree.

Solomon: The radial distribution in the galaxy of H_2CO is identical (from your measurements) with the CO distribution that we measure and very different from HI. Therefore, the H_2CO must be sampling regions which are molecular.

Your analysis of abundance and H_2 density assumes absorption only of the 2.7 K background. The continuum from HII regions will add significantly in some locations, leading to an underestimate of τ. The excitation temperature of formaldehyde may also vary.

Davies: I agree that the H_2CO is sampling the H_2 distribution; my point is that although the H_2CO and HI have different radial distributions, the H_2CO concentrations still lie within the main HI spiral features as delineated in the ℓ,v diagram. Our analysis of the H_2CO abundance included the effect of the galactic continuum as well as the 2.7 K background. An excitation temperature of 1.7 K was assumed.

Stecker: First, as a point of clarification, you stated that your derived H_2 abundance in the 5-kpc annulus was about 1/2 that derived by Gordon and Burton. Would that then be about 1/4 of that given by Dr. Solomon this morning? Second, because your survey samples clouds which are less dense than those sampled in the CO surveys, could most of the H_2 be tied up in the CO clouds in the annulus rather than in the less dense H_2CO clouds and could that help account for the apparent disrepancy?

Davies: The answer to the first question is yes, and to the second is possibly yes: there will be some extra contribution from the CO, but I have not calculated how much extra.

Heiles: Instead of absorbing the 3 K background, the H_2CO you observe might just be absorbing only the extra 0.6 K (average) contributed by the HII regions. This would bias your observations because you would see H_2CO only on the front side of HII regions.