THE COLDEST MOLECULAR GAS IN OUR GALAXY

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Galactic CO emission surveys such as those carried out by Gordon and Burton (Ap. J., 208, 346, 1976) and references cited therein are sensitive only to CO with J = 1 → 0 excitation temperature $\gtrsim$ 5 K. "Cold" molecular (H_2) gas with CO excitation temperature $\lesssim$ 5 K would go undetected in such surveys. Low T_{ex} could be due to either low kinetic temperature or low H_2 density. Evidence for the possible existence of substantial amounts of cold gas ($T_{ex} \sim 3$ K) towards the galactic center is apparent in spectra of Liszt et al. (Ap. J. 213, 38, 1977 and 198, 537, 1975) in the form of narrow gaps, suggestive of self-absorption, at velocities of 0, -30 and -55 km/s with respect to the LSR.

We have performed two experiments to determine the fraction of the interstellar medium that is too cold to have been accounted for in existing CO surveys. Drs. N. J. Evans, R. H. Rubin, and myself have compared 6-cm H_2CO absorption spectra against distant continuum sources with CO emission spectra in the same directions. The 100-m Bonn and the 5-m Texas antennae were used so that the beamwidths were comparable ($\sim 2\overset{\prime}{.}6$). Cold molecular clouds should show up well in the H_2CO spectra but not in the CO spectra. A preliminary analysis of the data for about 40 clouds detectable in H_2CO does not suggest the existence of a substantial population of cold CO clouds.

The other experiment, carried out with the NRAO 36 ft telescope, involved E.N. Rodriguez Kuiper, T.B.H. Kuiper and myself. We carefully checked a number of the Liszt et al. positions to better determine τ_{CO} and T_{ex} for the CO self-absorption features towards Sgr A and vicinity. By taking great care with the "off" source positions we were able to establish reliable baselines and found $T_{ex} \gtrsim 7$ K for all CO features in all five of the directions we observed.

In summary, there is, at present, no indication of substantial amounts of molecular gas in our galaxy with temperatures colder than the $\sim$ 8 K expected from cosmic ray heating of molecular clouds (Elmegreen B. G. et al., Ap. J., 220, 853, 1978).

W. B. Burton (ed.), The Large-Scale Characteristics of the Galaxy, 285–286.

DISCUSSION

Stark: The millimeter-wave radio astronomy group at Bell Laboratories, Crawford Hill, has observed an absorption feature in Sgr A and Sgr B, in a number of molecules. This feature absorbs from several of the strong continuum sources in this region, in a velocity range 0 → -150 km s^{-1}. The feature is optically thick in HCO^+ and HCN, but is optically thin in $H^{13}CO^+$. The excitation temperature of this gas does not differ significantly from 2.8 K in these molecules. Part of this gas is coincident in position and velocity with the "300-pc expanding ring" seen in CO. The existence of this feature in the galactic nuclear region does not necessarily imply the existence of very cold gas in the galactic disk.

Burstein: Heiles and I have reanalyzed the interrelationships among Shane-Wirtanen galaxy counts, HI column densities, and reddenings, and have resolved many of the problems raised by Heiles (Astrophys. J. 204, 379). These problems were caused by two factors: subtle biases in the reddening data and a variable gas-to-dust ratio in the galaxy. Details of this work have appeared in Burstein, D. and Heiles, C.: 1978, Astrophys J. 225, 40.

Lyngå: If I had had your preprint before my review talk, this could have been updated by your sound interpretation of galaxy counts. However, there is still a disagreement between the values of E_{B-V} at the poles where some determinations give E_{B-V} = $0\overset{m}{.}05$ and others give considerably lower values. Possibly, this can be due to the cloud structure. In any case we cannot disregard the stellar statistical determination that give high E_{B-V} values.

Felten: What can you say about the ratio of visual extinction to reddening, and its variation over the sky?

Burstein: Our value of $R = A_{pg}/E(B-V)$ derived from log NGAL is of course dependent on the value of $\gamma(= -d(\log NGAL)/d(A_{pg}))$ one assumes or derives. If $\gamma = 1$ (Heiles, Ap. J. 204, 379), R ≈ 3.6; i.e., approximately the standard value of R = 4.

de Vaucouleurs: I agree with you that galaxy clustering and patchy extinction combine to present a clear-cut distinction between a constant log N or a cosec b law in the range $|\text{cosec } b| < 1.20$, but the current argument is mainly with the hypothesis of dust-free polar caps extending down to $|b| \simeq 50°-45°$ (cosec $|b| < 1.35-1.4$) where the galaxy counts are adequate to show that the $|\text{cosec } b|$ law holds (for counts to different limiting magnitudes).

An unpublished study of colors of galaxies from the second Reference Catalogue shows that the color excess E(U-V) also obeys the cosec b law right up to both galactic poles within the postulated polar windows.

We find no support in the extragalactic data for the hypothesis that $A_B = 0.0$ at $|b| > 50°$ and no evidence against the adopted value $A_B \cong 0.2$ mag. The possible apparent disagreement with the evidence from stellar data suggesting perhaps $A_B \cong 0.05$ to 0.1 mag at the poles indicates the need for further work.

https://doi.org/10.1017/S0074180900014649 Published online by Cambridge University Press