THE RELATIVE DENSITY OF H, OH AND H_2CO IN INTERSTELLAR CLOUDS

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I have attempted to obtain an answer to the question "In which gas (neutral hydrogen) clouds do we find molecules?" By limiting the investigation to those clouds which might be considered normal (i.e. specifically excluding the class of clouds which emit by maser action) it is possible to obtain a definitive answer to the question namely, those clouds which have the highest gas concentration. Further data on the correlation between the distribution of neutral hydrogen and of different molecules can be found.

The clouds which are seen in absorption against background radio sources are most ideally suited for this purpose and I have used the absorption spectra of neutral hydrogen (21 cm wavelength), of the OH radical (18 cm, the 1667 MHz line) and the formaldehyde molecule (6 cm). Only the absorption spectra of the three strongest non-thermal sources (Cas A, Cyg A, and Tau A) were used because only these have unambiguous neutral hydrogen absorption spectra and also because they, unlike the H II regions, do not have 1667 MHz OH spectra which may be confused by anomalous emission. In the absorption spectra of these three sources individual clouds at specific velocities can be recognized on the H, OH and H_2CO spectra. We can then investigate the OH and H_2CO content of each cloud relative to its neutral hydrogen content.

Data for the neutral hydrogen absorption spectra of the three sources and the OH absorption spectrum of Cas A were obtained at Jodrell Bank. The OH absorption spectra used for Cyg A and Tau A were those of Goss (1968) and the H_2CO absorption spectra were from Zuckerman *et al.* (1970). The parameter which can be directly compared for each cloud is the integral of the absorption profile expressed as an optical depth $\times$ velocity $= \tau_0 \Delta v$. The ratio, x, of this integral for different species gives the ratio of line of sight integral of density of each species through the cloud multiplied by a factor which is the inverse ratio of the (excitation) temperature of the species. If we make the reasonable assumption that this latter factor is constant on average then we can directly compare the integrals and draw conclusions about the relative contents of the various species in each cloud.

The main conclusion of this analysis is that the relative abundance of H, OH and H_2CO varies from cloud to cloud in a systematic way. It is found that the ratio of OH to H or H_2CO to H increases as the neutral hydrogen density increases. For the OH data, which at present is more definitive than the H_2CO data, the ratio $x(\mathrm{OH}) = 2.1 \pm 0.2$. Another way of describing the results is to say that with the data available for this study OH is only seen in those clouds which contain $\gtrsim 2 \times 10^{20}$ neutral hydrogen atoms per cm^2. The corresponding neutral hydrogen density is $\sim 30\ \mathrm{cm}^{-3}$.

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At densities less than this there is no evidence from the present data that OH molecules are formed.

These results apply to the general interstellar medium in the vicinity of the Sun and include clouds in both the Orion and Perseus arms. They are probably quite different from the (peculiar?) conditions in the galactic centre region for example, but are most likely more typical of the conditions which apply generally in the Galaxy.

References

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