THE IONIZATION RATE IN DENSE INTERSTELLAR CLOUDS

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ABSTRACT. Measurements of the abundances of OH, HCO^+ and DCO^+ are employed to derive the ionization rate in molecular clouds.

The ionization rate is a crucial parameter in the determination of the ionization and thermal structure of dense interstellar clouds. It has been derived for diffuse clouds from studies of hydrogen recombination lines (Shaver 1976, Shaver et al. 1976, Payne et al. 1984) and from studies of the HD and OH chemistries (Black and Dalgarno 1973, Black, Hartquist and Dalgarno 1978, van Dishoeck and Black 1986). The recombination line studies yielded upper limits to the ionization frequency of 0.4 to $1.6\times10^{-16}s^{-1}$ and the most recent chemical studies a probable upper limit of $7\times10^{-17}s^{-1}$.

We present here a procedure for determining the ionization rate, and the abundance of H_3^+ ions, in dark clouds where observations of OH, DCO^+ and HCO^+ have been carried out.

Cosmic rays produce H_2^+ ions which are immediately transformed to H_3^+ ions. The H_3^+ ions react with atomic oxygen to initiate a sequence of reactions which terminates in the production of OH and H_2O. The OH molecules are usually removed most efficiently by reactions with oxygen atoms. In interstellar clouds, the OH molecules are in their lowest rotational state and the rate coefficient remains high at low temperatures (Clary and Werner 1984). The equation equating the formation and destruction can be reduced to give the simple relationship $n(H_3^+) = 0.2n(OH)$, correct probably to within a factor of two.

To determine ζ we need the destruction rate of H_3^+ ions. The destruction rate enters as a parameter in the fractionation chemistry of DCO^+/HCO^+ abundance ratio. The ζ is obtained by equating the formation and destruction rates of H_3^+, the H_3^+ abundance having been derived from the measured OH abundance.

For the dark clouds L134N and Bok B335 we obtain $\zeta = 0.8\times10^{-17}s^{-1}$ and 1.1×10^{-17}, respectively.

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