COMPARING THE ORTHO-TO-PARA RATIOS OF H$_2$ AND H$_3^+$ IN DIFFUSE INTERSTELLAR CLOUDS

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The ratio between the populations of the two lowest rotational levels of H$_2$, $J = 0$ and $J = 1$, can be used to determine the temperature of interstellar gas (referred to as $T_{01}$). Likewise, a temperature can be inferred from the populations of the $(J, K) = (1, 0)$ and $(J, K) = (1, 1)$ states of H$_3^+$. However, the average temperatures derived from these methods ($T_{01} \approx 60$ K, $T(H_3^+) \approx 30$ K) do not agree. Theories predict that the deviation from a Boltzmann distribution in both species is due to collisions between H$_2$ and H$_3^+$ which can change the spin alignment. Recent laboratory results confirm this deviation from a thermal distribution and provide a relationship between the $(1,0)/(1,1)$ ratio of H$_3^+$ and the $(1)/(0)$ ratio of H$_2$. We have made observations searching for H$_3^+$ in several sight lines with measured H$_2$ abundances for the purpose of determining this relationship in interstellar clouds. With such a relationship, we then show that IR observations probing the $(1,0)$ and $(1,1)$ states of H$_3^+$ can be used to estimate the H$_2$ temperature in highly extincted sight lines where UV spectroscopy is not possible.