H_3^+ IN DIFFUSE INTERSTELLAR CLOUDS: A TRACER FOR THE COSMIC-RAY IONIZATION RATE

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In the past several years H_3^+ has been detected[a] in diffuse interstellar clouds where it had been predicted to exist in abundances below observable limits. These detections led to several questions about H_3^+ chemistry and the diffuse cloud environment. To answer these questions, further studies of H_3^+ were performed to constrain some uncertain parameters such as the electron recombination rate constant[b]. With new data and some reasonable assumptions it became possible to infer the cosmic-ray ionization rate necessary to produce column densities of H_3^+ observed by the CGS4 spectrometer on the United Kingdom Infrared Telescope (UKIRT). However, the value calculated along the sightline to ζ Per was over an order of magnitude higher than the value found in previous studies using OH[c,d].

Recently, we finished analyzing a survey of H_3^+ in twenty diffuse cloud sightlines. In total, eight of these sightlines yielded positive detections of H_3^+ with another one or two hinting at possible absorption. Using the observed column densities, we calculated the primary cosmic-ray ionization rate and found an average value of $\zeta_p \approx 2 \times 10^{-16}$ sec^{-1}. This is about an order of magnitude larger than what has long been considered the canonical ionization rate. Taking this higher ionization rate into account, some newer models[e] have been proposed to explain both the H_3^+ column densities, as well as the abundances of other species. The observation of H_3^+ along many diffuse cloud sightlines, coupled with the lack of a clear correlation between position and ionization rate, suggests that an enhanced cosmic-ray ionization rate may be a general property of the diffuse interstellar medium.

[a] B. J. McCall, et al., ApJ, 567, 391 (2002)
[b] B. J. McCall, et al., Nature, 422, 500 (2003)
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[e] H. Liszt, A&A, 398, 621 (2003)