# INVESTIGATING THE COSMIC-RAY IONIZATION RATE IN THE GALACTIC ISM WITH $H_3^+$ OBSERVATIONS

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Observations of $H_3^+$ in the Galactic diffuse interstellar medium (ISM) have led to various surprising results, including the conclusion that the cosmic-ray ionization rate ($\zeta_2$) is variable by over 1 order of magnitude between different diffuse cloud sight lines, with values as high as $8 \times 10^{-16}$ s$^{-1}$, and $3\sigma$ upper limits as low as $0.7 \times 10^{-16}$ s$^{-1}$. This variation is interesting, as it contradicts the typical assumption that the cosmic-ray spectrum is relatively uniform throughout the Galaxy. Instead, the flux of low-energy cosmic rays responsible for ionizing $H_2$ must be decreased in some regions due to particle propagations effects, and increased in other regions by local acceleration sites. Whether or not acceleration in and propagation from supernova remnants (thought to be the primary accelerators of Galactic cosmic rays) alone can account for such variability remains unknown.

At present, the survey of $H_3^+$ in diffuse clouds consists of observations toward 52 sight lines, with detections in 20 of those. In an attempt to understand variations in the inferred ionization rates, I have studied the environments through which all of these sight lines pass. I have also observed $H_3^+$ in 6 sight lines that probe gas in close proximity to the supernova remnant IC 443. Ionization rates inferred in 2 of these sight lines are about $20 \times 10^{-16}$ s$^{-1}$, indicating a high flux of low-energy particles, but the other 4 sight lines do not show absorption from $H_3^+$, so the high ionization rate and particle flux seems very localized. Combining these results near a supernova remnant to those in the general ISM further enhances the variability seen in the cosmic-ray ionization rate, and requires that the concept of a uniform cosmic-ray spectrum be reviewed.