H_3^+, THE IDEAL PROBE FOR *IN SITU* MEASUREMENT OF GALACTIC COSMIC RAYS

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Cosmic rays are mysterious particles mostly atomic nuclei with extremely high energy from 10^6 eV to 10^{21} eV. Their energy spectra for many nuclei are known in detail from the measurements on the earth. To measure cosmic rays in the Galaxy, however, we need a chemical method using spectroscopy. H_3^+ provides the ideal probe for this purpose because of (1) its ubiquity, (2) simple chemistry, and (3) concise spectrum.

For about 30 years from the classic paper by Spitzer and Tomasko[a], when H^+ was used as the probe, the cosmic ray ionization rate of H_2 was thought to be on the order of $\zeta \sim 10^{-17}$ s^{-1} and uniform throughout the Galaxy. The 1997 discovery of H_3^+ in diffuse clouds and in the Galactic center (GC), however, changed this picture drastically. It is now established that ζ in diffuse clouds is 10 times higher than in dense clouds[b] and ζ in the Central Molecular Zone of the GC is 1000 times higher[c]. The uniformity of cosmic ray energy density throughout the Galaxy which was once thought to be reasonable because of its high penetrability has been negated.

I will analyze these results using the Bethe formula for the cross section of ionization and discuss their implication in astrophysics and astrochemistry.

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[a] Spitzer, Jr, L. and Tomasko, H. G. 1968, ApJ, 152, 972(1968)

[b] Indriolo, N. and McCall, B. J. 2012, ApJ, 745, 91

[c] Oka, T., Geballe, T. R., Goto, M., Usuda, T., McCall, B. J., and Indriolo, N. 2019, ApJ, submitted