INFRARED SPECTRUM OF H_3^+ NEAR THE GALACTIC CENTER

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The central 150 pc of the Galaxy called the Central Molecular Zone (CMZ) is the hub of astrophysical activities. It has high densities of stars, interstellar matter, supernovae, gravitational and magnetic energies, and emit intense radio and X-rays. A large fraction ($\sim$ 10 %) of molecules in the Galaxy are concentrated in this region. Nevertheless its extinction is small since molecules are concentrated in dense ($\geq 10^4$ cm^{-3}) and massive molecular clouds with a volume filling factor of only $\sim$ 0.01. What kind of gas fills the rest of the CMZ has been a vexed question.

Our observations using infrared spectrum of H_3^+ have revealed a vast amount of low density ($\sim$ 100 cm^{-3}) and high temperature ($\sim$ 250 K) gas with a high volume filling factor.[a] Crucial to this discovery has been the unique characteristics of H_3^+ as a probe based on its simple chemistry and spectroscopy. We use it as a dosimeter, a depth meter, a thermometer, and a densitometer to measure ionization rate ζ, dimensions of the gas L, temperature T, and density n, respectively.[b]

The H_3^+ spectrum in the CMZ first appeared as an enigmatic, intense and broad line toward the brightest star. The line was more than 10 times stronger than any H_3^+ line in the Galactic disk indicating a large amount of H_3^+ but we did not know how to interpret their intricate velocity profile. Our discovery in 2002 of the spectrum of H_3^+ in the $J = K = 3$ metastable rotational level[c] provided the key, which we used as the Rosetta stone to decipher the enigmatic spectrum.

Now observations of H_3^+ toward more than dozen stars from the center to 30 pc to the East and their analyses based on a model calculation of the thermalization of H_3^+[d], have established existence of a large amount of the warm and diffuse gas. The revelation of this new category of gas drastically changes the previous concept of the gas in the CMZ.[e] Its relation with the previously postulated three categories of gas will be discussed.

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[a] T. Oka, T. R. Geballe, M. Goto, T. Usuda, & B. J. McCall, ApJ, 632, 882 (2005)

[b] T. Oka, Proc. Natl. Acad. Sci. USA, 103, 12235 (2006)

[c] M. Goto, B. J. McCall, T. R. Geballe, T. Usuda, N. Kobayashi, H. Terada, & T. Oka, PASJ, 54, 951 (2002)

[d] T. Oka & E. Epp, ApJ, 613, 349 (2004)

[e] Goto, Usuda, Nagata, Geballe, McCall, Indriolo, Suto, Henning, Morong, & Oka, ApJ submitted.