SPECTROSCOPY OF H_3^+ AND CO TOWARD THE GALACTIC CENTER

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Sightlines toward the Central Molecular Zone (CMZ), a region of radius ∼200pc of the Galactic center (GC), contain column densities of H_3^+ on the order of 3 $\times 10^{15}$ cm^{-2}, ten times higher than the most H_3^+-rich sightlines in the Galactic disk. They cross a variety of clouds in the intervening spiral arms and in the CMZ and the spectra show a wide velocity range from ∼ -150 km s^{-1} to 50 km s^{-1} indicating dynamic nature of the gas. It was a surprise when H_3^+ in the $J = K = 3$ metastable rotational level, 361 K above the lowest (1, 1) level, was observed strongly in the CMZ indicating high temperature.[a] Our analyses of the very rich and unusual spectra using the $R(3, 3)^l$ absorption as the Rosetta stone have revealed a vast amount of warm (∼250 K) and diffuse (∼100 cm^{-3}) gas in the CMZ with a large volume filling factor.[b]

In addition to the sightline toward the brightest star GCS 3-2 so far studied in detail,[b] we report results of several sightlines toward young stars near the Galactic nucleus and the super-massive Quintuplet and Arches Clusters within 30 pc from the center. They all indicate the presence of the gas with high temperature and low density demonstrating the ubiquity of the gas. The relationship between the newly revealed warm and diffuse gas and previously known gaseous components in the GC, i.e., the dense and mostly cold (∼50 K) clouds observed by radio spectra of CO and other molecules, the hot (10^4 K) gas with high electron density observed by radio-wave scattering and free-free emission and absorption measurements, and the ultra-hot (10^8 K) gas observed in X-ray emissions is an intriguing question.[c]

In addition the location of the gas in the CMZ and its excitation mechanism are highly controversial. We will discuss some of those issues.

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

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

[c] S. Boldyrev & F. Yusef-Zadeh, ApJ, 637, L101 (2006)