HOT AND DIFFUSE CLOUDS NEAR THE GALACTIC CENTER PROBED BY METASTABLE H_3^+

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We have observed a vast amount of high temperature (T $\sim$ 250 K) and low density (n $\sim$ 100 cm^{-3}) gas with a large velocity dispersion in the Central Molecular Zone (CMZ) of the Galactic center. We used H_3^+ which is a sensitive probe of low density molecular gas. The observed large column density of H_3^+ in the (3, 3) metastable rotational level gives evidence for high temperature, and absence in the (2, 2) level indicates low density. This remarkable non-thermal rotational distribution is caused by metastability of the (3, 3) level and the fast (2, 2) $\rightarrow$ (1, 1) spontaneous emission (27 days)[a].

The strongest absorption component observed toward the bright infrared source GCS 3-2 is at velocity of $\sim$ - 100 km s^{-1}, indicating that about a half of the hot and diffuse gas is associated with the 180 pc Expanding Molecular Ring. The other half with lower velocities of - 50 km s^{-1} and $\sim$ 0 km s^{-1} is closer to the Galactic center. The large H_3^+ column density indicates high ionization rate on the order of 10^{-14} s^{-1} in the CMZ if the C/H ratio is indeed as high as reported. With the hot X-rays and high magnetohydrodynamic activities, such a high value may be reasonable.

The non-thermal rotational distribution of H_3^+ has also been observed toward 7 other infrared sources within 30 pc of the Galactic center indicating that the hot and diffuse gas is ubiquitous in the CMZ. The spectrum toward GC IRS 3 near Sgr A* shows presence of the hot and diffuse gas in the "50 km s^{-1} cloud", the complex of giant molecular clouds which plays a central role in the discussion of Sgr A* and its environment.

Of the observed total H_3^+ column density toward GCS 3-2 of 4.3 $\times$ 10^{15} cm^{-2}, approximately 3.1 $\times$ 10^{15} cm^{-2} is inferred to be in the CMZ while 1.2 $\times$ 10^{15} cm^{-2} is in the intervening spiral arms. Almost all of H_3^+ in the CMZ is in diffuse clouds. This suggests that the previously reported volume filling factor (f $\geq$ 0.1) of dense clouds is an overestimate by at least an order of magnitude.

[a] T. Oka and E. Epp, ApJ, 613, 349 (2004)