

R18a Neutral gas conditions and C/CO abundance in nearby AGN probed by ALMA [C I] ($^3P_2 - ^3P_1$) observations

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Active galactic nuclei (AGN) harbor a multiphase, parsec-scale gas torus that facilitates activity via inflows toward the supermassive black hole. Since neutral gas is a dominant phase inside the torus, it is important to place observational constraints on its properties. In particular, the abundance of atomic carbon (C) is expected to be enhanced relative to CO due to AGN feedback, but observational evidence of this is inconclusive. In order to investigate the C/CO abundance ratio and physical conditions of neutral gas, we conducted the first high-resolution (~ 10 pc) observations of [C I] ($^3P_2 - ^3P_1$) toward the nuclei of nearby Seyfert-2 galaxies NGC 613 and NGC 1808 with Atacama Large Millimeter/submillimeter Array. [C I] ($^3P_2 - ^3P_1$), CO ($J = 7-6$), and 800-GHz continuum were detected toward the torii of both galaxies. We compared the [C I] ($^3P_2 - ^3P_1$) line intensity with previously observed [C I] ($^3P_1 - ^3P_0$), and obtained excitation temperatures and column densities of $T_{\text{ex}} \sim 10-24$ K and $N_{\text{CI}} \sim (0.3-1) \times 10^{19} \text{ cm}^{-2}$ in the central 100-pc region under the approximation of local thermodynamic equilibrium (LTE). The [C I] (2-1)/(1-0) line intensity ratio (~ 1), T_{ex} , and N_{CI} are maximum at the AGN. We also performed a non-LTE analysis using all available [C I] and CO lines. The results constrain the H₂ gas conditions to relatively high density ($n_{\text{H}_2} > 1 \times 10^3 \text{ cm}^{-3}$) and kinetic temperature ($T_{\text{k}} > 50$ K), and suggest a high C/CO abundance ratio of $\sim 0.5-1$ in the central $r < 30$ pc.