Probing the physical conditions of the ISM in the quasar host galaxies at z ~6

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The quasars discovered at z ≥ 6 present the first generation of super massive black hole (SMBH) and host galaxy systems. Sub-mm/mm and radio facilities, e.g., Atacama Large Millimeter/submillimeter Array (ALMA), NOrthern Extended Millimeter Array (NOEMA) and the Karl G. Jansky Very Large Array (VLA), with their extraordinary capability, enable us to search for the emission lines from the ionized, atomic, and molecular interstellar medium (ISM). In this conference, I will present our recent results on the multi-phase ISM observations of two FIR bright z~6 quasars (J2310+1855 and J0305-3150) with ALMA and NOEMA. The goal is to understand the physical conditions of the multi-phase ISM and the gas heating mechanisms. I will present the most complete CO spectral line energy distribution (SLED) detected at z~6 towards quasar J2310+1855, with the highest transition CO(13-12) recently detected with NOEMA. Besides, we detected a water line, an OH+ emission and a number of fine structure lines, i.e., [CII] 158um, [NII] 122um, [OI] 146um and [OIII] 88um in this quasar. I will also present spatially resolved CO, [CII] 158um and [CI] observations of J0305-3150. The inconsistency of kinematics with rotation, as revealed by recent super-high resolution [CII] 158um detection of this quasar, may be related to the AGN energy injection into the ISM. With radiative transfer models, we analyze the ISM emissions to probe the physical conditions of the ISM in the two quasars above. Compared to local (U)LIRGs, AGNs, and high redshift SMGs, J2310+1855 exhibits higher CO excitation with strong CO emission line at (J ≥ 8). It also exhibits enhanced H2O/IR, H2O/CO and OH+ /H2O luminosity ratios, suggesting that shocks, cosmic rays or X-rays besides the UV radiation are responsible for the molecular gas heating and ionization.

References

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