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Early Metal Enrichment and Multiphase Interstellar Media in a Galaxy at Redshift 8.312

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Contributed talk

Abstract:
"How and when metal/dust enrichment happened in the epoch of reionization is one of the most fundamental questions in modern astronomy. Recent Planck results suggest an instantaneous reionization redshift of z = 7.7 ± 0.8, and the latest Hubble Space Telescope surveys have revealed strong evolution of the ultraviolet luminosity function from z ~ 10 to ~ 8, implying a rapid increase of the cosmic star-formation rate density within a very short time-scale (< 200 Myr). Hence, characterizing star formation and interstellar medium of galaxies in the heart of the reionization era (z ~ 8) is an important next step to our understanding of the earliest evolution of galaxies.

We present ALMA detections of the [OIII] 88 μm, [CII] 158 μm lines and 850 μm dust continuum emission in a Y-dropout galaxy, MACS0416_Y1. The [OIII] and [CII] detections unambiguously confirm its spectroscopic redshift to be z = 8.312, making this object one of the furthest galaxies ever identified spectroscopically. The ultraviolet-to-far infrared spectral energy distribution (SED) modeling where the [OIII] emissivity model is incorporated suggests the presence of a young (age ~ 4 Myr), star-forming (SFR ~ 60 Msun/yr), moderately metal-polluted (Z ~ 0.2 Zsun) stellar component. An analytic dust mass evolution model with a single episode of star formation does not, however, reproduce the metallicity and the inferred dust mass of 4 × 10^6 Msun in the stellar age, suggesting an underlying evolved stellar component as the origin of the dust mass.

A high [OIII]-to-[CII] luminosity ratio (~ 6) implies that typical H II regions are radiation-bounded, which is consistent with the inferred zero escape fraction of Lyman continuum photons obtained in the SED fits. It also suggests that the bulk of photodissociation regions are 'truncated'and are not terminated by molecular gas, although this would contradict the presence of dust, which should be co-spatial with molecular gas. Thus, a possible explanation for the observed fact is patchy/porous geometry of dusty molecular clouds, photodissociation regions, and highly ionized gas on sub-kpc scales, which are all suggested by state-of-the-art hydrodynamic simulations of galaxy formation."

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