A Compact Obscured AGN Host at z = 3.386: A Possible Precursor of a Hot Dust-Obscured Galaxy

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Dust-obscured, optically faint galaxies provide important laboratories for understanding the co-evolution of galaxies and supermassive black holes. In particular, Hot Dust-Obscured Galaxies (Hot DOGs) are thought to represent a short-lived but crucial phase of rapid black hole growth, although their formation pathway remains poorly understood.

Archival ALMA Band 3 observations led to the serendipitous discovery of an 850 μm continuum source (~0.2 mJy) located only 6″ from the Cloverleaf quasar (z = 2.54). The source exhibits a well-detected (6.7σ) double-peaked emission line at 105 GHz. Subsequent ALMA observations confirmed its spectroscopic redshift of z = 3.386 ± 0.005 through the detection of CO(6–5). The object is not associated with any previously known galaxy in the Cloverleaf field and remains undetected in deep HST optical and near-infrared imaging (>24 mag), indicating that it is an extremely dust-obscured system.

Comparison of its submillimeter and X-ray luminosities suggests that the source hosts both vigorous star formation and significant black-hole accretion activity, placing it between typical star-forming galaxies and luminous quasars. Furthermore, previous low-resolution spatial observations hint at multiple structural components, potentially indicating an ongoing merger.

In this work, we revisit the physical nature of this source, using ALMA, NOEMA, VLA, and JWST/MIRI observations. In particular, we aim to improve constraints on its stellar mass using new JWST measurements and compare its stellar and black-hole masses with those of other galaxy populations. This analysis allows us to investigate whether this source represents a transitional phase linking dusty star-forming galaxies, obscured AGN, and Hot DOGs within the broader framework of galaxy–black hole co-evolution.