Full of Orions? A 200-pc resolution mapping of ISM in a z~3 dusty galaxy

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Sub-millimeter galaxies (SMGs) at redshift z=2-4 represent the most extreme star-forming environments, with star formation rates 1 – 2 dex higher than in z~0 starbursts. Studies of physical conditions of their star-forming ISM have been largely restricted to unresolved observations. However, there is a mounting evidence than the key ISM tracers ([CII], CO lines, dust continuum) in SMGs are not co-spatial, potentially biasing the ISM properties derived from unresolved, source-averaged observations.

To understand the spatial distribution of individual tracers in SMGs, and the variation of the ISM properties on sub-kpc scales, we map the ISM conditions on sub-kpc scales in a z=3.04 strongly lensed SMG SDP.81, using archival ALMA imaging of the FIR continuum and CO(5-4), (8-7) and (10-9) data [1], with new observations of the CO(3-2) and [CII] lines, and rest-frame 160-um continuum – a total of 40 hours on ALMA. Using a visibility-plane lens modelling code [2], we map the individual tracers with a median source-plane resolution of ~200 pc. We make our high-resolution maps publicly available with the aim to facilitate further studies of this unique dataset.

Our results show that the CO, [CII] and FIR continuum have dramatically different spatial distributions, with only ~50% of the [CII] emission associated with the FIR-bright starburst. Using photon-dominated models [2] to derive the ISM properties on 200-pc scales, we find strong gradients in FUV field strength and gas temperature on sub-kpc scales. Comparing our results to present-day star-forming regions, the molecular gas properties in SDP.81 averaged over 200-pc scales are comparable to those in the vicinity of the Trapezium cluster [4]. We are now complementing this extensive dataset by resolved maps of dense-gas tracers (HCN, HCO^+) and radio continuum

References

[1] ALMA Partnership, 2015, ApJL 808, L4
[2] Rybak et al., 2015; MNRAS 451, L40
[3] Kaufman et al., 2006, ApJ 644, 283
[4] Goicoechea et al., 2015, ApJ 812, 75