A MULTI WAVELENGTH VIEW ON MASSIVE STAR FORMING COMPANION GALAXIES TO HIGH-REDSHIFT QUASARS


1 Max Planck Institute for Astronomy, Heidelberg, Germany; 2 INAF Bologna, Italy; 3 University of California, Santa Barbara, USA; 4 Carnegie Observatories, Pasadena, USA; 5 Princeton University, USA; 6 University of Bonn, Germany; 7 Cornell University, Ithaca, USA; 8 Steward Observatory, Tucson, USA; 9 Kavli Institute, Beijing, China

OBJECTIVE
High-redshift quasars, z > 6, i.e. < 1 Gyr from the Big Bang, are predicted to be found in the high-density peaks of the dark matter distribution, surrounded by overdensities of galaxies[10]. UV-based observational studies have reported inconclusive evidence so far[11]. Previous ALMA observations of the cool gas and dust in a sample of quasars unveiled the presence of additional ([CII]- and far infrared (FIR)-bright companion galaxies (LIR < few 10^10 Lsun, L[CII] < few 10^9 Lsun), at a mere projected distance of < 60 kpc and velocity distance of < 450 km/s[12]. These galaxies are probably undergoing a gravitational interaction with the quasars, and pin-point highly rich regions of the early universe.

Here, we aim at characterizing the spectral energy distribution (SED) of four galaxies adjacent to four 6 < z < 6.6 quasars, through newly acquired, sensitive, multi-wavelength imaging follow-up observations.

DATASET
We use archival ALMA Band 6 observations of the dust continuum and [CII] emission line[10], new dedicated Spitzer/IRAC[3,4] and [6] deep imaging, probing the bulk of the galactic stellar population, and HST/WFC3 imaging in the F40W filter, sampling the emission from young stars.

SED AND GALACTIC PROPERTIES MODELING
We compare the SEDs of the companion galaxies to those of representative local star-forming/star-bursting/ultraluminous infrared (ULIRG) galaxies (Fig 1). We also fit the SED of the companion to PJ67 with the software MAGPHYS-highz[13], from which we derive its stellar mass (Fig 1, upper right).

We derive the properties of the companion galaxies:

- **Obscured Star Formation Rate**, i.e. the stellar reprocessed by dust (SFRd), sampled with ALMA. We convert the total infrared luminosity (integrated within 3-1000 μm) to a SFR following [3].
- **Unobscured Star Formation Rate**, i.e. the emission of 10-200 Myr old stars (SFRu), sampled with HST/WFC3. We convert the monochromatic ultraviolet luminosity to a SFR using the scaling relation from [4].
- **Stellar Mass** limits on the companions to J0842, PJ231 and J1200, using the dynamical and gas masses derived from the ALMA measurements from [4].

CONTEXT OF THE HIGH-REDSHIFT GALAXIES POPULATION

TAKE HOME 1: The SEDs of three companion galaxies to quasars at z > 6 are consistent with an Arp 220-, i.e. ULIRG-, like template, vestigial of a recent massive gas-rich merger.

TAKE HOME 2: Three companion galaxies to z > 6 quasars present an obscured SFR (~ 100-700 Msun/yr) > 100 x unobscured SFR (2-3 Msun/yr).

The galaxy adjacent to PJ167 presents a lower SFR obscured fraction of ~ 0.7.

TAKE HOME 3: The galaxies adjacent to high-redshift quasars are consistent with being on the main sequence of starforming galaxies. Future observations with, e.g. JWST, will be fundamental in characterizing these sources and their stellar masses.

References: