ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

DIPARTIMENTO DI FISICA E ASTRONOMIA
Department of Physics and Astronomy - DIFA

# PhD projects in ASTROPHYSICS

**Title of the Project:** *Searching for high-redshift progenitors of massive galaxies*
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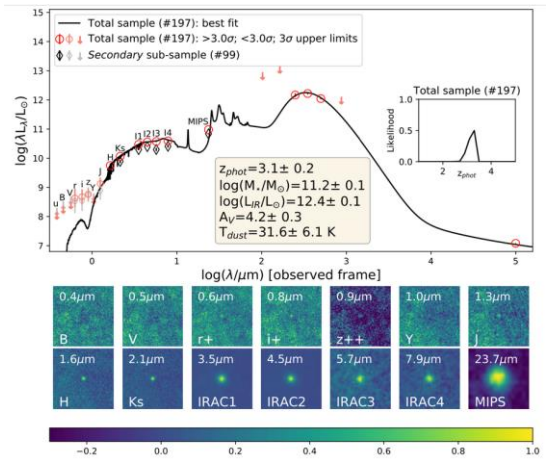
**Collaborators:** M. Talia (UNIBO- DIFA), F. Pozzi (UNIBO-DIFA), C. Gruppioni (INAF-OAS), and the cosmology/galaxy evolution groups at UNIBO-DIFA, INAF-OAS and INAF-IRA.

## Scientific Case

Several questions are still open on galaxy formation within the cosmological context. One of the major mysteries is *when and how massive galaxies formed*. In the present-day Universe, massive galaxies ($M_* > 10^{11}\ M_\odot$) are spheroidal systems (early-type galaxies, ETGs) with old/metal-rich stars and no star formation (see the right-hand figure for an example of an ETG at redshift z~0). Their properties (old stellar ages, metallicities and reconstructed star formation histories) indicate that massive ETGs formed at high redshifts (z>2-3) through a major and short (<0.5 Gyr) gravitational collapse characterized by very high star formation rates. However, the *progenitors* of present-day ETGs are still unknown, and it remains a mystery how such systems formed so rapidly when the universe was still so young. Moreover, understanding ETG formation is also crucial to shed light on the relations with supermassive black holes and the role of AGN feedback in shutting-off the star formation of these galaxies in the early Universe.

## Outline of the project




The objective of the project will be to search for high-redshift progenitors of present-day massive ETGs. Our group has an extended experience and is involved in international projects. The PhD student will benefit from our expert guidance. The project will consist of the following steps.
**(1)** Searching for star-forming galaxies at z>3 missed in previous surveys due to heavy dust obscuration (*UV-dark galaxies*). Being invisible in the optical, these systems will be identified in IR/submm/mm/radio data. The figure (bottom panel) shows an example of a galaxy at z=3.1 visible only at λ>1.3μm (Talia et al. 2020). This search will make use of data from *Spitzer*, *Herschel*, ALMA, VLA, MeerKAT and in the optical/near-IR (e.g. COSMOS). Observing proposals (ALMA, NOEMA, JWST) will be submitted to perform follow-up studies of the selected galaxies. **(2)** Estimating redshift and physical properties ($L_{IR}$, SFR, stellar mass, extinction, $T_{dust}$) of the selected galaxies with SED fitting (see previous figure, top panel). **(3)** Estimating the obscured cosmic star formation density at z>3 (still poorly known) and comparison with theoretical models (*Illustris*, *Millennium*) to investigate the evolutionary links with present-day ETGs.
The PhD student will learn how to make the best use of multi-λ data and to interpret them to constrain galaxy physics and evolution. Moreover, she/he will gain expertise in observing proposal writing and will visit the institutes or universities abroad that are part of our collaboration network. Overall, the PhD student will acquire the scientific expertise and independence needed to continue her/his career successfully at international level.