Thesis subject

Laboratory : Laboratoire d'Astrophysique de Marseille

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Title of the thesis subject : New observational insights on primeval galaxies

Description of the thesis subject :

One of the most key questions of modern extragalactic astronomy is the quest for Cosmic Dawn, which marks the transition from a dark Universe to an enlightened one. This process is linked to the formation of the first stars and galaxies some 300 million years after the Big-Bang (for a review see Bromm and Larson 2004). In July 2022, with the release of the first images obtained with the James Webb Space Telescope (JWST), this quest took a turn: never before has mankind been able to directly observe galaxies within the first 400 million years. In less than a week, dozens of galaxies with redshift as high as z=17 have been announced (e.g., Donnan et al. 2023, Castellano et al. 2023, Finkelstein et al. 2023).

Among the first results of the JWST, one is very surprising: the number of massive galaxies in the early Universe has been underestimated (Labbe et al. 2023). Several hypotheses are currently being discussed to explain this discovery. One of them suggests that galaxies could have formed more rapidly than we thought, transforming their gas more efficiently into stars (the so-called star formation efficiency - SFE). This parameter is key to understanding the formation and evolution of the first generation of galaxies. Methods have been developed to either directly measure (e.g., Pavesi et al. 2019) or model this parameter (e.g., Sipple & Lids 2024, Harikane et al. 2022).

We propose to determine the star-formation efficiency of a sample of z>6 galaxies built as follows: (i) up to z<7, targets will be selected from the MUSE/VLT GTO catalog and will have the advantages of having robust detection of Lyman-alpha and being magnified and (ii) at z>7, targets will be photometrically selected from JWST public images. For the 6<z<7 samples, ALMA observations will be performed to directly measure the Star-Formation Efficiency (with the detections of CO, CII, and NII lines as well as the dust emission). At higher redshift, the dark matter halo mass of our candidates will be estimated from SED-fitting (including/excluding binary models) and will give a first estimate of the SFE. The brightest galaxies in this sample will then be followed by spectroscopy with PFS/Subaru, MOONS/VLT, and EMIR/GTC as part of the GTO. The evolution of the SFE will then be compared with the evolution of the galaxy's stellar mass and the age of the stellar population.

Several key results will be obtained after this study:

- the first study of the age distribution at z>6 that could confirm (or refute) early JWST

results,

- the first robust determination of the evolution of the SFE at z>6,
- an updated version of current templates being used in SED-fitting including binaries stars (BPASS models)

References :

Bromm & Larson 2004,ARA&A, 42, 79
Castellano et al. 2023, ApJ, 938, 15
Donnan et al. 2023, MNRAS, 518, 6011
Finkelstein et al. 2023, ApJ, 946, 13
Harikane et al. 2022, ApJS, 259, 20
Labbe et al. 2023, Nature, 616, 266
Pavesi et al. 2019, ApJ, 882, 68
Sipple & Lids, 2024, ApJ 961, 50

NOTE: ***We already have a co-financing for this thesis subject from VAST (Hanoi, Vietnam), in case the retained candidate comes from Vietnam.***