Thesis subject

Name of the laboratory: **Laboratoire d'Astrophysique de Marseille**

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Subject's title: **New insights on the environment of primeval galaxies**

Subject description: *Recent cosmological hydrodynamic simulations suggest that primeval galaxies typically inhabit proto-clusters (e.g., Yajima et al. 2022), constituting the initial large-scale structures of the Universe. The central region of these formations likely harbors the most massive galaxy hosting an Active Galactic Nucleus (AGN – Gatica et al. 2024). These structures have been well-characterized up to z~2 (e.g., Ando et al. 2020), with their evolution aligning with observations in the local universe. Notably, the inaugural observations from the James Webb Space Telescope (JWST) indicate the potential existence of proto-clusters of galaxies at redshifts as high as z∼10 (Castellano et al. 2023). However, findings at z≥6 primarily rely on photometric data; thus, spectroscopic follow-ups are imperative to initially confirm the nature and properties of these structures, encompassing dark matter halo mass, spatial extent, the nature of central massive galaxies, and more.*

The primary objectives of this project are to characterize the first large-scale structure of the Universe by (i) determining the physical properties of proto-cluster members, including the protocluster core, and (ii) studying the physical extent of these structures. The thesis will unfold in two parts. In the first year, the student will identify proto-clusters of galaxies at z≥6 in the initial deep surveys obtained with JWST (PRIMER, CEERS, JADES) by employing a combination of SED-fitting and Voronoi tessellation analysis. Subsequently, the research will encompass spectroscopic follow-up observations utilizing ongoing multi-object spectrographs as part of the GTO (MOONS/VLT- end 2024, PFS/Subaru – beginning 2025, EMIR/GTC – on going), along with utilizing open time at the VLT, ALMA and JWST.

The principal outcomes of this thesis will include (i) the first statistical analysis of proto-clusters at z≥6 concerning density, physical properties, and evolution over cosmic time; and (ii) the initial analysis of proto-cluster core properties, focusing on massive star-forming galaxies or AGNs. These results will be systematically compared with state-of-the-art hydrodynamical simulations to reinforce our conclusions (Bennett et al. 2024). The thesis will draw upon the involvement of LAM members in related projects (MOONS, PFS, CEERS, PRIMER) and foster collaboration with experts in simulations of the early Universe.

Bibliography:
Ando et al. 2020, MNRAS, 496, 3169 · Bennett et al. 2024, MNRAS, 527, 1033 · Castellano et al. 2023, ApJ, 948, 14 · Gatica et al. 2024, MNRAS, 527, 3006 · Yajima et al. 2022, MNRAS, 509, 4037