Thesis subject

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Subject's title: The Rise of Metals and Dust at z > 8.5 from JWST and Ground-based Spectroscopy (PFS, MOONS)

Subject description:

- The basic constituents of the current Universe are: 73% dark energy, 23% dark matter and 4% baryons. Metals only account for around 2% of baryons. However, they form an essential element acting in many physical processes: they help cool gas clouds for star formation, they are a major component of planetary systems, and they are the building blocks of life.
- Understanding the first phases of the formation of metals, and the link with the first dust grains in the primordial Universe constitutes one of the major astrophysical and cosmological objectives. To meet this objective, we must detect the emission of the first stellar populations to appear in the Universe at very low metallicity, or at zero metallicity (Pop III).
- The main objective of this thesis is to **identify and characterize submetallic galaxies and Pop III galaxies at z > 6, through spectroscopy** (using a new version of CIGALE for spectroscopy).
- CEERS (and other groups) have already identified and begun to analyze submetallic galaxies using JWST (e.g. Arrabal Haro, 2023, Fujimoto, Finkelstein & Burgarella 2023). We have the assurance of producing original results during this thesis, using a homogeneous methodology[1] (Boquien, Burgarella et al. 2019) from the entire JWST spectroscopic sample in the JWST MAST archives.
- We expect these galaxies to be faint low-mass objects. We have started to explore the possibility that some of them could be hidden in the background around NIRSpec's main target (Fig. 1). To this aim, we need to optimize the background subtraction of NIRSpec 2D spectra (the pipeline subtraction is not efficient enough). Tests are very positive (Fig. 1).
- Statistics fromMAST show that the cumulative area[2] to identify pop III galaxies amounts to 1171 arcsec^2 or 9.0e-5 sq. deg. In the corresponding solid angle, various models provide different

[1] From tests carried out with CIGALE-spectro, we can fit 1240 JWST spectra in 20 min to estimate redshifts, and in 1 hr to estimate 6 physical parameters on a 20-core, 128Go-RAM computer.

[2] available at the beginning of the PhD (Fall 2023) and with NIRSpec 2-h exposure time, needed to detect HeII1640, Hβ, and Balmer lines at 8.5 < z < 10.0 (sweet spot, from Sarmento et al. 2018ApJ...854...75S.

predictions for pop III galaxies, from almost none, to about 300, down to $\log_{10}(M_\odot) = 7.5$. **Whatever the observed detection rate of pop III galaxies, we will provide strong constraints for modelling this still elusive first galaxy population**.

- Beyond these direct scientific objectives, the models developed in FIRSTs will be fundamental for predicting observations from projects such as ELT/HARMONI, ELT/MOSAIC, and SKA.

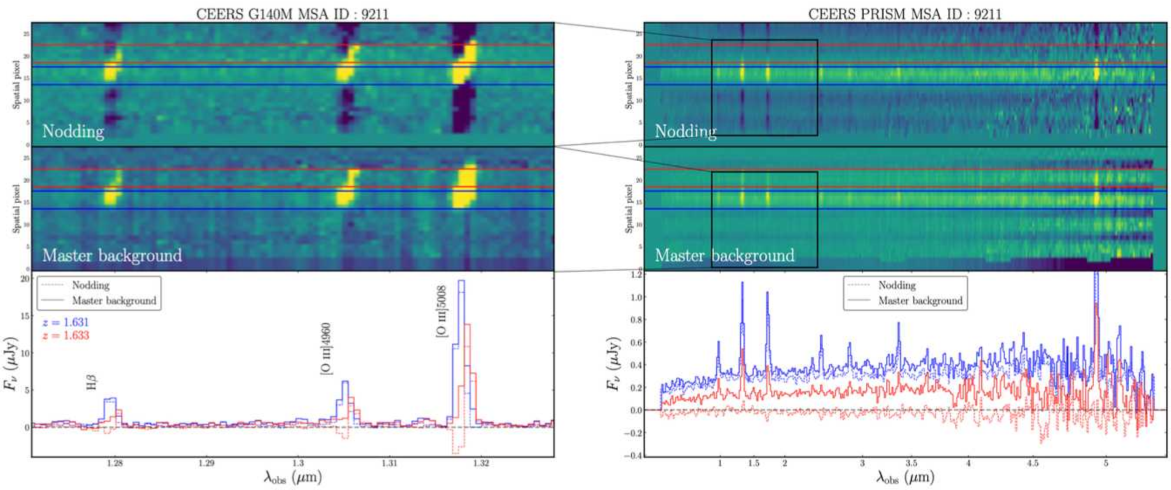

Figure 1: Two examples comparing standard nodded sky subtraction (top 2D) and Master Background Subtraction (bottom 2D) for NIRSpec MOS prism spectra. Nodded subtraction introduces negative traces from bright objects (dark bands in the upper 2D panels), and leads to oversubtraction of extended emission (1D extracted spectra at bottom). Our Master Background Subtraction improves the signal-to-noise ratio, and should allow to detect fainter galaxies.

Bibliography:

- Arrabal Haro, P.; Dickinson, M.; Finkelstein, S.L.; Kartaltepe, J.S.; Donnan, C.T.; Burgarella, D.; et al. 2023Natur.622..707A
- Boquien, Burgarella et al. 2019A&A...622A.103B
- Burgarella et al. 2023A&A...671A.123B
- Fujimoto, Finkelstein & Burgarella 2023ApJ...955..130F
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