Thesis subject

Name of the laboratory: Laboratoire d'Astrophysique de Marseille

Thesis advisor: Matthew M Pieri
Email and address: matthew.pieri@lam.fr
Tel: +33-(0)4-91-05-69-87

Co-advisor: None

Subject's title: **Modelling large astrophysical surveys of the Lyman-alpha forest**

Subject description:
The 'Lyman-α forest' refers to the crowded series of hydrogen absorption lines imprinted in the spectrum of a bright source (typically quasars emitting in the first quarter of the history of the Universe or 'z>2') on its long voyage to Earth. This intergalactic gas fills the universe between galaxies and traces density in the universe. WEAVE-QSO and DESI are massive spectroscopic surveys that are providing more than a million Ly-α forest quasar spectra. We use this richly informative phenomenon to measure and reconstruct the 3-dimensional cosmic "web" of structure. This allows us to study many processes including the expansion rate of the universe (and so mysterious acceleration due to dark energy), and the formation of galaxies feeding from this gas. In order to understand our analysis we need to simulate the entire observed universe many times over. We call simulations of this type "mocks". Forest mocks exist but they lack a realistic implementation of galaxies in absorption and galaxies imaged in other surveys studying the same volumes of the universe. In order to simultaneously exploit the intergalactic medium, the gas around galaxies (the circumgalactic medium) and galaxy surveys we need a new generation of mocks.

The successful applicant will work within the WEAVE-QSO and DESI teams to develop this next generation of mock Lyman-α forests with our own measurements of the circumgalactic medium in absorption and metals in the intergalactic medium. The applicant will also work towards the simulation of galaxy surveys J-PAS, PFS, Euclid and HETDEX for the extension to galaxy surveys and exploiting team expertise at using machine learning to generate realistic galaxy samples, with a longer term extension to the Extremely Large Telescope instrument MOSAIC.

Bibliography:

- "LyaCoLoRe: synthetic datasets for current and future Lyman-α forest BAO surveys" Farr et al 2020, JCAP, 03, 068
- "CoLoRe: fast cosmological realisations over large volumes with multiple tracers " Ramirez-Perez et al 2022, JCAP, 05, 002
- "A Strong Blend in the Morning: Studying the Circumgalactic Medium Before Cosmic Noon with Strong, Blended Lyman-α Forest Systems" Morrison, Som, Pieri et al 2023, arXiv:2309.06813
- "WEAVE-QSO: A Massive Intergalactic Medium Survey for the William Herschel Telescope" Pieri et al, 2016,sf2a conf, 259
- "3D correlations in the Lyman-α forest from early DESI data" Gordon et 2023,JCAP, 11, 045