# Thesis subject

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HDR: yes

Subject's title: Gaseous galaxy environment and its role in galaxy formation

Subject description:

Understanding how galaxies form is one the major motivating factors that drive modern astrophysics and cosmology. The epoch around z=2 is of critical importance since this is the era where the Universe assembles most of its stars. The story of how the universe arrives at this star formation peak is the story of how galaxies acquire the gaseous fuel for star formation from large-scale collapse and how this acquisition is regulated by outflows caused by star formation. To tell this story, we must come to understand the properties of galactic environments on all scales, through the study of gas outside galaxies (the intergalactic medium, IGM). Within galaxies' gravitational sphere of influence is the interface between the intergalactic medium and the galaxy, known as the circumgalactic medium (CGM). In order to pick apart the voyage from IGM, to CGM, to galaxy and potentially back again we must develop the necessary tools to disentangle gas properties and build the datasets necessary. This means that we must reconstruct representative volumes of the cosmic web, and sampling-well all possible environments: nodes, filaments, sheets and voids.

The student will explore the tomographic mapping of the cosmic web using foreground absorption along the line of sight to bright background quasars and galaxies. The student will further classify and analyse the Lyman-alpha forest and associated metal absorption by galaxy proximity, and placement within the cosmic web filament to draw inferences about galaxy formation.

Increasing source densities and the extension of wide-area galaxy surveys to beyond z>2 mean that activity in IGM tomography and the study of the CGM is growing rapidly. The student will work within the ANR supported projects WEAVEQSO-JPAS and HZ-3D-MAP and make use of quasar spectra from SDSS-IV (in hand), DESI (being acquired) and WEAVE-QSO (will begin to arrive before the starting date). Furthermore, data of line-of-sight absorption towards galaxies for mapping and CGM sampling will grow rapidly via DESI ancillary programs, PFS and DESI-Ib during the doctorate program. Further galaxies for CGM studies will be provided by Over the next decade and beyond MOSAIC, DESI II, MSE and WLT will all exploit the methods developed in this program. LAM astronomers have key roles in these present and future projects.

**Bibliography:**

Japelj et al (2019), “Simulating MOS science on the ELT: Ly-alpha forest tomography” https://ui.adsabs.harvard.edu/abs/arXiv:1911.00021
Jin et al (2022) “The wide-field, multiplexed, spectroscopic facility WEAVE: Survey design, overview, and simulated implementation” https://arxiv.org/abs/2212.03981
Kraljic et al 2022 “Forecasts for WEAVE-QSO: 3D clustering and connectivity of critical points with Lyman-α tomography” https://ui.adsabs.harvard.edu/abs/2022MNRAS.514.1359K/abstract
Pieri et al (2014) “Probing the circumgalactic medium at high-redshift using composite BOSS spectra of strong Lyman α forest absorbers” https://ui.adsabs.harvard.edu/abs/2014MNRAS.441.1718P/abstract
Pieri et al (2016), “WEAVE-QSO: A Massive Intergalactic Medium Survey for the William Herschel Telescope” https://arxiv.org/abs/1611.09388
Ravoux et al (2020) “A tomographic map of the large-scale matter distribution using the eBOSS—Stripe 82 Lyα forest” https://ui.adsabs.harvard.edu/abs/2020JCAP...07..010R/abstract

**Please provide a brief justification of the scientific importance of the subject and/or its strategic interest for LAM:**

This studentship is part of a strategy to exploit IGM tomography starting now and spanning various large projects to which LAM has made significant technical and/or management investment. In chronological order these are DESI (spectrograph development and Pieri’s science team leadership), WEAVE-QSO (Pieri’s survey leadership), PFS (spectrographs integration and survey management), DESI-Ib/DESI-II (Pieri’s target selection, proposals and exploitation feasibility), MOSAIC (PI and Pieri as IGM-tomography-related working group chair). Note that a wide z>2 galaxy survey will be one of the two major science goals of both DESI-II (and it’s pilot survey DESI-Ib) and we are well-placed to play a key role.

**Please provide a brief explanation about why the proposed subject is timely, and include an indication of the expected scientific landscape within 3 to 5 years after the defense:**

Until now, we have mainly been able to study the properties of the universe as it builds towards its star formation rate peak through the properties of gas in absorption. Samples of z>2 galaxies have been small and under-sample the statistics of galaxy formation, given the diversity of environmental factors connected to the acquisition of gaseous fuel. Adding 3D mapping sample rates and galaxy populations to this optimal epoch for intervening absorption will be transformative over the next decade. Within 3 to 5 years of the defense (2029 to 2032) WEAVE-QSO, DESI and PFS will be complete, as will the DESI-II pilot DESI-Ib. DESI-II will be underway. MOSAIC will be approaching, with IGM tomography a major science goal. WSJ may also aim to make grow the datasets to be exploited for this science. A student defending in 2026 will have a wide variety of continuing opportunities in this field over many years.

**Please provide a brief description of the work environment (resources, collaborations…) of the thesis:**
Two new ANR projects will have started by Sept 2023: WEAVEQSO-JPAS (PI Pieri) and HZ-3D-MAP. A postdoc has been recruited at LAM for each and are expected to remain in post for the first year of the doctoral students. In addition to collaborative support, ample travel funds will be available and the means to buy computer equipment through the.

**Please indicate if other (co-) funding has been requested/accepted for this subject:**
No

**Please provide information about ongoing and past (over a 10 years period) supervision(s):**

Pieri has not supervised a student with ED funds. Sean Morrison was funded through ANR funds between 2016-2020 and Ramona Augustin was co-supervised with a German partner and CNES. Duarte Munoz Santos is in his final year and is co-funded by the above ANR and the ED.