PhD Thesis Project Proposal
INAF – Osservatorio Astrofisico di Arcetri

Title – Dissecting galaxy evolution through their stellar populations across cosmic time: the power of deep spectroscopic surveys

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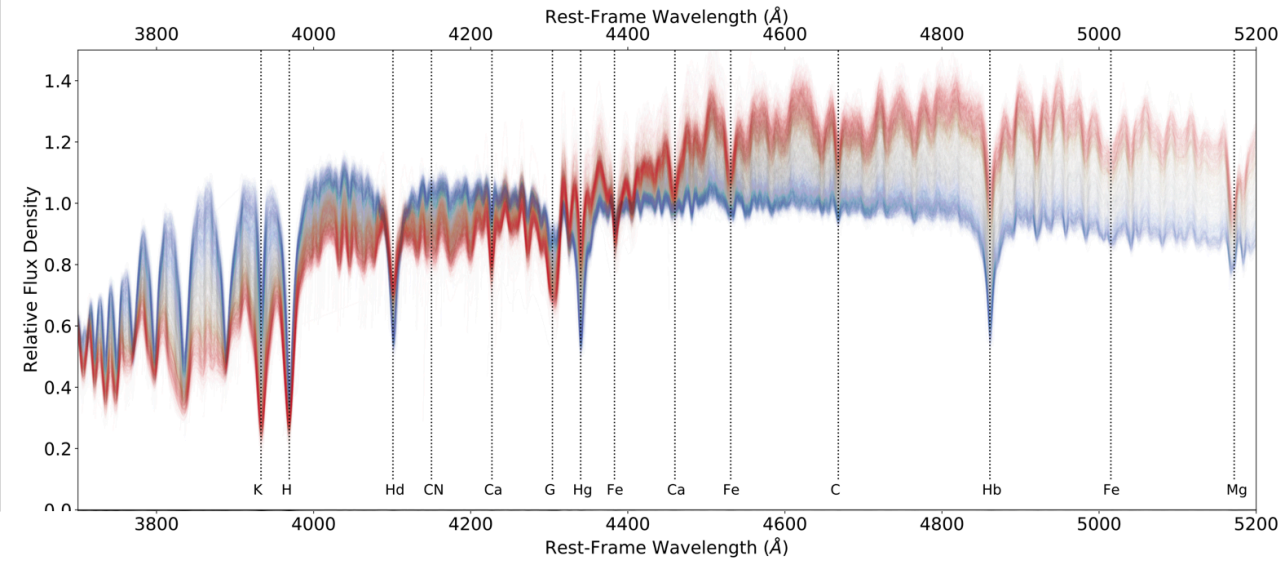
Description –

The redshift interval 0<z<1 covers a significant portion of the Universe's lifetime and witnesses a tremendous amount of transformation in galaxies. ***Direct "look-back" studies*** of galaxy populations have shown a general drop in the star-formation rate (SFR) by almost a factor 10 relative to z=1, with a progressive growth of the massive quiescent galaxy population. To pin down the mechanisms responsible for this global behavior a more detailed characterization of galaxy populations is needed, specifically of the ***physical properties of their stellar populations***.

The metal abundances of galaxy stellar populations are the result of the interplay between star formation, gas recycling and galaxy-environment interactions, integrated over the whole galaxy formation history. Together with stellar ages, they thus constitute a ***fossil record of galaxies' SFHs*** and can inform about the build-up of the massive quiescent population in the local Universe. The so-called ***archaeological approach*** has been extensively adopted at z=0 and, until recently, it has been carried out in a complementary but parallel way to direct look-back studies of the demographics of galaxy populations at different redshifts. *Only a **joint archaeological--look-back approach** can help resolve the early phases of galaxy SFH and metal enrichment history and put constraints to both the SF and assembly histories of galaxies*. This will be key to approach a statistical connection between progenitors and descendants.



Compilation of almost 3000 galaxy spectra from the LEGA-C survey in the redshift range 0.6<z<1. The color code reflects the strength of the Balmer absorption lines (redder->stronger->older galaxies; bluer-> weaker -> younger galaxies). The stellar continuum contains a wealth of absorption features tracing the age and the element abundances of galaxy stellar populations. Credits: van der Wel et al. 2021.

Deep spectroscopic surveys sampling the rest-frame optical of large and representative galaxy samples at high redshift are key to perform such studies. The power of deep spectroscopy for both quiescent and star-forming galaxies at intermediate redshift has been shown in a pioneering work by Gallazzi et al 2014, and it is now entering its full exploitation with recent and planned large deep spectroscopic surveys sampling the redshift range 0<z<1 (LEGA-C with VLT/VIMOS; WEAVE-StePS with WHT/WEAVE and 4MOST-WAVES/StePS with VLT/4MOST).

Objectives –
This PhD project aims at characterizing the histories of star formation and metal enrichment of the stars in galaxies observed in the Universe 8 billion years ago (z~1) and trace their evolution up to the present-day Universe. The stellar populations in galaxies are the fossil record of their past formation history. By studying them the ultimate goal is to understand and constrain the mechanisms of evolution and metal enrichment in galaxies.
The PhD candidate will exploit deep spectroscopic data of *large samples of galaxies at intermediate redshift obtained from the surveys* **LEGA-C** (already completed), **WEAVE-StePS**, which will start observations in 2023, **4MOST-WAVES/StePS** which is planned to start science operations in 2024. The project foresees the development and the application of techniques to interpret the stellar continuum and stellar absorption features in galaxy spectra, ***building upon state-of-the-art statistical techniques and models developed in-house***. The output will be the derivation of estimates of age, metallicity, abundance ratios and star-formation timescales. The thesis objective is to characterize the scaling relations between these parameters and galaxy mass, their dependence on environment, current star formation activity and morphology. The comparison with the relations ***consistently*** obtained at lower redshift will provide constraints on the evolutionary processes of galaxies.
The results obtained and the expertise acquired in this thesis will be an asset for exploiting the data and addressing key science cases of future deep spectroscopic surveys at high redshifts, such as those that will be envisaged for ELT/MOSAIC.

The supervisor and the co-supervisor have a direct involvement in the key surveys mentioned, being Survey Scientist and member of LEGA-C, members of WEAVE-StePS science team, members of the 4MOST-StePS core team, members of the MOSAIC science team. The PhD candidate will benefit from close collaboration with other staff members at INAF-OAA, as well as from the interaction with the other members of the LEGA-C, WEAVE-StePS and 4MOST-WAVES/StePS collaborations, and with our network of international collaborators on population synthesis modelling and massive galaxies at high redshift.