martedì 29 settembre 2020

Luca Paganin PhD second year report

My PhD supervisors are INFN staff researcher Stefano Davini, professor Silvano Tosi and professor Marco Pallavicini

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Research activities

- Activities within the Euclid Consortium:

During the second year of my PhD I continued my task in the ESA Euclid Mission, performing spectroscopic simulations in order to validate the official Euclid spectroscopic data reduction pipeline, but I also worked to produce simulated spectra for the Euclid Consortium Legacy Science group. The primary scientific objective of Euclid is fundamental cosmology, in particular to better understand the nature of dark energy, which is the most abundant but still unidentified component of our Universe. However, the Euclid survey will probe approximately one-third of the sky (15000 square degrees), collecting the data of about 1.5 billion of galaxies and thus producing the most extensive galaxy catalogue up to now. These data could also be used for other purposes than fundamental cosmology, which are called legacy science, and include: studying galaxies' formation and evolution, probing primordial Universe objects like quasars and active galactic nuclei (AGN), and many others. In this context I worked for setting up a computational environment on the INFN Pisa cluster ZEFIRO, with the aim to do simulations of the spectra of distant galaxies and active galactic that Euclid is expected to see, and that are needed by the Euclid Legacy Science group for setting up and validate their software pipelines. At the moment I am developing a general software framework in order to perform a forecast of Euclid sensitivity to the main cosmological parameters, studying how these parameters' values and errors can be constrained via the cross-correlation of the photometric and spectroscopic galaxy samples of the Euclid survey. When one talks about "spectroscopic galaxy sample", this means those galaxies (about 50 million) for which the instrument will measure the full spectrum, allowing in this way to measure the galaxy redshift, and therefore the distance, with high precision. Concerning to "photometric galaxy sample", I refer to those galaxies for which Euclid will only provide the photometry, i.e. high resolution images, from which the galaxy redshift can still be inferred, with an error about 50 times greater than the spectroscopic redshift measurement, but with the advantage that these photometric galaxies will be about 1.5 billion. The distributions of the photometric and spectroscopic galaxy samples are correlated, and the aim of my work is to understand if fully exploiting this cross-correlation can provide us more information than the single sample themselves.

- Phenomenological studies for measurements of the Hubble parameter

During 2020 I also joined a project aimed at providing a new method to measure the time delay between multiple images of gravitationally-lensed quasars, to increase the sample used for the determination of the Hubble parameter H0. H0 is a fundamental parameter in cosmology, corresponding in practice to the current expansion rate of the universe, however, current measurements of H0 are in disagreement between one another (with a tension at the 5 standard deviations level). Refinements of the currently-used methods and new methods are highly welcome to better understand the current crisis. Time delays between multiple images of lensed quasars are typically provided by medium-small telescopes after year-long monitoring campaigns: unfortunately the number of lensed quasars that can be angularly resolved by such telescopes is limited. In this work, the team is focused on increasing the sample of usable lensed quasars by providing a method that can derive the time delay even if the multiple images of the quasars are not fully resolved, and at the same time improve the time delay derivations for the fully-resolved cases. The method exploits advanced machine learning techniques in cases where quasars have frequency-range-dependent variations of the light emission. My work consists in providing realistic simulations of light curves of lensed quasars and testing and implementing various machine learning techniques to derive time delays estimates.

Courses and Exams

In the course of the second year I have attended the following courses:

- I attended the Efficient Scientific Computing PhD school (ESC19), which took place in Bertinoro (FC), Italy, from 20th to 26th October 2019;

I passed the following exams:

- Seminar about C++ standard template library for verifying participation to the ESC19 PhD school
- Gravitational Waves (on 29th September 2020)

Conferences and Talks

- Poster session to Euclid Italia Meeting, Bologna, 10/12/2020-12/12/2020: Annual collaboration meeting for the italians involved in ESA Euclid Mission.
- Talk “Simulazioni spettroscopiche per la missione Euclid” at the “106° Congresso Nazionale della Società Italiana di Fisica (SIF)” (virtual).

- Talk “Spectroscopic simulations for the Euclid Survey” in the 5th International Conference on Particle Physics and Astrophysics (virtual): abstract accepted, the conference will take place in the period 5-9 October 2020
- Abstract paper “A data-driven approach for time-delay estimation of non resolved lensed quasars” submitted to the “Machine learning and the physical sciences” workshop, at the 34th Conference on Neural Information Processing Systems (NeurIPS), to be held in December 2020 (virtual).

Publications

- “Cosmological forecasts using Void-Lensing Cross-Correlation with Euclid”, in preparation, currently under internal review by the Euclid consortium
- “Spectroscopic in-flight flux calibrations for near-infrared spectrographs”, in preparation, to be submitted soon

Academic Teaching

- I performed a task of 30 hours of academic teaching support for the course “Fisica Generale I” of the first year of Electrical and Chemical Engineering degree course.
- I am helping student Ilaria Risso with her master degree thesis “Relative flux calibration for the near-infrared spectrograph of the Euclid experiment”

Outreach

- I organized and chaired stages for high school students in January-February 2020, within the PLS (Progetto Lauree Scientifiche).