

Luca Paganin PhD first year report

My PhD supervisors are professor Marco Pallavicini and INFN staff researcher Stefano Davini.

Research subject

My PhD research falls within the context of the Euclid mission, at the intersection of Fundamental Cosmology and Astrophysics. Euclid is a ESA space mission which aims to measure the expansion history of the Universe with a precision that allows to set major constraints on the nature of Dark Energy, and provide a more precise estimate of neutrino masses. In order to do this, a large survey of about a billion galaxies will be done. The survey will be performed using two instruments installed on the spacecraft, VIS (Visual Imager) and NISP (Near Infrared Spectrometer and imaging Photometer). VIS will acquire the shape of the galaxies, measuring the gravitational lensing due to the intervening mass distribution, and thus having an indirect measure of this mass. NISP will instead acquire galaxies' spectra, with the aim of measuring their redshifts. Of course, in order to extract meaningful physical information from these images it is necessary to take into account the instrumental noise affecting the detector, performing what it is called astronomic data reduction. My thesis is focused on the spectroscopic observations: the data reduction is a pipeline of operations performed on the image, aimed at producing a calibrated plot of the spectral intensity for each galaxy in the image. This allows to obtain all the physical information about chemical composition and redshift of the galaxy itself. It is clear that before the spacecraft launch there will not be real images available on which testing and validating the data reduction pipeline. This clearly justifies the need for software simulations, aimed at reproducing in the most detailed possible way the spectroscopic images which will be acquired by the detector once it will have been launched. As said, my activity is focused on the spectroscopic simulations: in cooperation with a research group from Milan INAF section, I am helping developing and testing a simulation software with the principal aim of evaluating all the background and detector effects of the NISP spectroscopic instrument. These effects include both optical and detector effects. One of the most critical optical effect is due to astrometric distortions, i.e. non-linear conversions between angular celestial coordinates of the objects and pixel coordinates on the focal plane. Detector effects include quantum efficiency, dark current, and readout noise. In this first year I learned how to use the simulation tool, which is about 60k lines of Python and 45k lines of C, and I wrote scripts to automate instrumental effects separation and simulation runs. I learned the Physics behind the simulations, in particular the basics of near-infrared slitless spectroscopy, near-infrared radiation detection and measurement, and I learned how a code for simulating a

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spectroscopic redshift survey is written. Finally I have contributed to a Euclid analysis project aimed to provide constraints on cosmological parameters, in particular neutrino masses and dark energy equation of state, using the cross-correlation between cosmic void abundance and weak gravitational lensing. In the context of this analysis I wrote a Python code for automating the run of cosmological simulations with an arbitrary number of parameters, submitting the jobs in parallel to the local computing facility.

Courses and Exams

In the course of this first year I have attended the following courses:

- Gravitational Waves (G. Gemme, A. Chincarini, F. Sorrentino): I followed two modules (34 hours) of the Master degree course;
- Introduction to AdS/CFT and its applications (A. Amoretti): PhD course
- Cosmology (N. Maggiore): PhD course
- Renormalization Group a la Wilson Polchinsky (C. Imbimbo): PhD course
- Statistics for Data Analysis (F. Parodi, S. Passaggio, V. Kulikovskiy): PhD course

Among these I gave three exams:

- Introduction to AdS/CFT and its applications (A. Amoretti)
- Statistics for Data Analysis (F. Parodi, S. Passaggio, V. Kulikovskiy)
- Cosmology (N. Maggiore)

Attended Conferences and Meetings

- Universum, Milan, 03/04/2019-05/04/2019: conference about the state of the art of cosmology research in Italy. No talk, only participation;
- Euclid Annual Meeting, Helsinki, 04/06/2019-07/06/2019: Annual collaboration meeting for the ESA Euclid Mission. No talk, only participation.