# Ilaria Risso - PhD second year report

## AA: 2021/2022

**Tutors**: Stefano Davini (INFN Genova) and Silvano Tosi (Unige & INFN Genova)

### Research activity

During my second year of PhD, I kept on working on Cosmology within the Euclid Consortium, an ESA mission, both continuing and developing my previous activities and starting new ones.

Last year, the Euclid group of INFN-Genova (and myself in particular) were asked to lead the effort to define the best pointing sequence for the Euclid in-flight Self-Calibration. This specific kind of calibration is necessary to account for the reduction in the signal transmission once the instrument in the space environment, such as radiation damage, dust deposition or presence of ice on the optics and on the detectors. Because of all these effects, the same object observed at different positions on the focal plane yields different count rates. The self-calibration procedure takes advantage of multiple observations of the same sources, performed through different partially-overlapping exposures in the sky, in order to reconstruct the illumination variation across the focal plane. I provided the Euclid Consortium with the sequence of pointings that maximizes the sampling of all the spatial scales of interests, so that the illumination variation can be properly reconstructed at those scales. The optimal pointing sequence has been chosen among a statistical sample of self-calibration-like surveys derived from a Monte Carlo approach and based on a geometrical analysis.

Once the Self-Calibration sequence was chosen, we wondered if we could give an estimate on the accuracy of the reconstructed illumination variation, accounting for all the systematic effects and noise introduced by the instrumentation. During my master thesis, I developed an algorithm for the illumination variation reconstruction: however, it was based on simplified assumptions and models of the telescope and detectors. We decided to validate the algorithm making realistic simulations of the Self-Calibration procedure, using the optimal pointing sequence that we had previously selected. We exploited the official Euclid spectroscopic image simulator, called SIM TIPS, and the official pipeline for the spectra extraction and reconstruction, the SIR Pipeline. In this way, all the instrumental and systematic effects were included and the reconstruction procedure became as difficult as it will be in the reality. Simulations are still running, since a lot of technical issues appeared: I'm going to keep on working on this task during my last year of PhD.
One of the issues I have to face, related to the Self-Calibration, is the decontamination procedure. It may happen that the spectra of two sources that are close in the sky overlap on the focal plane. The Euclid survey is designed to disentangle the two spectra, slightly changing the dispersion direction between an exposure and the following one. Also, the officiale pipeline has a dedicated algorithm for the disentanglement of two overlapping spectra and fro their correct reconstruction. Anyway, this procedure needs to be optimized. I've been working on this topic since the end of this second year of Phd.

Finally, I joined a new activity more focused on the measurements of cosmology that Euclid will provide. Euclid is going  to determine the redshift of more than 50 millions of galaxy through spectroscopic measurements. The SIR Pipeline will extract the 1D spectra, starting from the 2D galaxy spectrograms on the focal plane; the SPE Pipeline will extract the redshift of those galaxies, starting from the SIR output 1D spectra and looking for the $H_\alpha$emission line. However, there can be mistakes in the redshift determination, both for physical and

computational reasons. Since the redshift is directly related to the galaxy distance from us, this means that the 3D mapping of the inhomogeneities in the Universe (which is one of the main probes of the Euclid mission) could be wrong, leading to an incorrect determination of the cosmological parameters related to the Euclid observables. In particular, the galaxies whose redshift is not correctly derived are called interlopers, and their fraction with respect to the total observed galaxies is called purity. In this work, I run simulations of the 2-point correlation function (that is, the statistics that is used to quantify the galaxy clustering) assuming different types and fractions of interlopers, in order to see how much Euclid results will be affected by low purity unlucky scenarios. In order to provide realistic estimates, one should run end to end simulations, from the sources in the sky to their redshift extraction, in order to understand in which way the concatenation of all the pipelines worsen the redshift determination. The decontamination task for the Self-Calibration is also part of this activity: the goal is to automatize the end to end realistic simulations, parametrizing the error function related to the redshift determination, and using it to simulate the interlopers and their effect on the Galaxy Clustering statistics.

**Attended courses, schools and exams**

I attended and I passed the exam of:

- *Applicazioni della matematica all'astrofisica*, by Prof. Anna Maria Massone and Prof. Michele Piana (at DIMA).

Note: I still have to be examined on the School I followed in place of a PhD exam. Also, I'm going to attend one last course this year (*Fisica delle strutture cosmiche* by Prof. Marco Raveri).

I attend the *Advanced Euclid School* in Les Houches (France) from June 20th to July 1st.

**Publications**

1. Both the "currently in progress" publications that I mentioned last year were officially published and can be found at:

- https://iopscience.iop.org/article/10.1088/1538-3873/ac102e
- https://www.sif.it/riviste/sif/ncc/econtents/2021/044/02-03/article/71

2. Currently in preparation: paper on the Self-Calibration sequence selection

**Conference presentations**

1. Poster at International Conference of High Energy Physics - *The pointing strategy for the Self-Calibration of the Euclid mission*, Bologna, July 8, 2022.

**Outreach activities**

2. Lecture about "Telescopes on satellite" for "Università della terza età" in Genova, May 23, 2022.
3. Organization of stages for high school students on cosmology
4. Talk for *Giornata Nazionale dello Spazio*, INFN-Genova YouTube channel https://www.youtube.com/watch?v=ZboYpx_r1GQ&ab_channel=INFNGenovaDivulgazione, December 16, 2021.

**Teaching activities**

Tutor of general physics for 1st year FARM and CTF students.