Ilaria Risso - PhD first year report

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

Research activity

The subject of my PhD research is the Euclid experiment, a European Space Agency mission about Fundamental Cosmology and Astrophysics. The main goal of Euclid is to put constraints on the cosmological parameters that describe the evolution and content of our Universe, in particular the nature of Dark Energy and a precise estimate of the total neutrino mass. In order to achieve these goals, Euclid will perform an extensive redshift survey, observing more than a billion of galaxies in the visible and near infrared bands. A subset of this statistical sample of galaxies will be also analysed in spectroscopic mode, so that a more robust estimate of their redshifts (and, consequently, their distances) can be derived: one of the main probes of this experiment is in fact the three dimensional distribution of galaxies, which is linked to the total distribution of both baryonic matter and Dark Matter.
A precise determination of the cosmological parameters requires precise measurements of both images and spectra on the focal plane of the telescope: an extensive calibration of all the instrumental and scientific aspects is thus required. During my Master Thesis, I studied the in-flight relative flux self-calibration of a near-infrared spectrometer similar to the one of Euclid and I created an algorithm for its implementation and performance evaluation. In summary, the same astrophysical source in the sky may be measured with a different flux on the focal plane just because it was observed in different regions of the detector: this is not only due to the intrinsic statistical natures of counts, but also to a systematic effect of non-uniform transmission of light introduced by the same telescope optics. This distortion must be reconstructed in order to correct such effect and to obtain the proper photon rates of the observed sources.
The first task of my PhD activity was to extend my studies to the more realistic case of a focal plane split into different sectors, that is made up of a grid of detectors instead of a unique one. This configuration allows to have a greater active area for the collection of the signal, but at the same time there will be “dead areas” corresponding to the inter-detector gaps; moreover, each sector will have slightly different quantum efficiencies and, consequently, the global gains in the counts detection won’t be spatially uniform. The reconstruction algorithm has to account for this further complexity and must be able to give also an estimate of the global QE gains of each sector. The details of this work can be found in the paper at arXiv:2103.15512 and S. Davini, I. Risso *et al* 2021 *PASP* **133** 084501, accepted for publication.
The second task began when the Euclid group of INFN-Genova (and myself in particular) were asked to join the official self-calibration activity within the Euclid collaboration: in particular, we were asked to find the best pointing observation strategy for the self-calibration, so that all the spacial scales of interest are uniformly sampled (in this way, the non-uniformity of the response function on the

focal plane can be properly reconstructed on every scale). We defined some metrics to evaluate this kind of uniformity and we began to apply our self-consistent reconstruction algorithm to the real catalog of sources that Euclid will observe during the self-calibration: we are currently studying the correlation between a uniform coverage of spacial scales and the goodness of the transmission function reconstruction.
I'm also involved in another activity related to the relative flux calibration, that is a possible extension of the monthly periodic self-calibration (the one I studied, made up of a limited set of exposures repeated on the same field on a monthly bases) to the entire survey sources sample. On a theoretical basis, this would allow to infer the time evolution of the transmission function between a self-calibration and another, since there could be effects that modify the transmission of light during the period between a calibration and another (i.e.: outgassing and deposition on the cold telescope optics, with a decrease in light transmission as a consequence). The reference person in this case is Marco Scodeggio from INAF-IASF Milano, with whom I extensively collaborated both during the master thesis and the first year of the PhD.

Attended courses and exams

I attended and I passed the exams of the following courses:

1. *Astrofisica Sperimentale*: Master degree course (entirely followed - equivalent to 2 PhD courses) by Prof. Zerbi and Prof. Landoni (INAF)
2. *Astrophysics of High Energy*: PhD course by Prof. Tavecchio (INAF)

I also attended a PhD school in place of a doctoral course (on which I've not been evaluated yet):

- *ISAPP School on Neutrino Physics, Astrophysics and Cosmology*: July 21-30, 2021, Valencia (virtual meeting).

Publications

1. S. Davini, I. Risso et al, "***Euclid: quantifying the performance of the relative in-flight flux self-calibration for the NISP spectrograph***", approved for publication on *Publications of the Astronomical Society of the Pacific* (arXiv:2103.15512).
2. I. Risso et al, "***Calibrazione in flusso per lo spettrografo a infrarossi dell'esperimento Euclid***" in *Il Nuovo Cimento - Colloquia and Communications in Physics* (currently in publication).

Conference presentations

1. Poster session at "Massively parallel spectroscopy from space. An ATLAS Probe community workshop" - ***A procedure for relative in-flight flux self-calibrations of spectro-photometric instruments for cosmological surveys***, June 21-25, 2021.
2. Panelist for the "XIX International Workshop on Neutrino Telescopes", Flash Talk - ***Preliminary study on the relative in-flight flux self-calibration for the Euclid NISP instrument***, February 18-26, 2021.
3. Speaker at the 106° National Congress of SIF (Italian Society of Physics), September 2020, Italy - ***Calibrazione in flusso per lo spettrografo a infrarossi dell'esperimento Euclid***, Field: Astrophysics.