Shear calibration for Euclid DR2

Laboratory : LAM

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Title of the thesis subject : Shear calibration for Euclid DR2

Description of the thesis subject :

Context

Euclid is an ESA satellite whose main objective is to understand the accelerating expansion of the Universe using the cosmic shear signal, i.e. the gravitational lensing distortion (called shear) of background galaxies due to the foreground large-scale structures of over 1.5 billion galaxies. These shear distortions are, however, two orders of magnitudes smaller than the distortions imprinted by the telescope optics and are therefore very challenging to measure. The strategy retained by the Euclid Consortium is to calibrate these shear measurement on realistic image simulations. Knowing the input shear values of these simulations one can calculate a correction factor by comparing the output of any shear measurement algorithm to the input of these simulations. Using the same image simulations, one could also train a deep learning algorithm to recognize the shear directly at the image level.

This PhD thesis (2025-2028) follows a twofold purpose. The PhD student will work towards performing the shear calibration for the second data release (DR2) of Euclid. In the meantime he/she will keep developing deep learning approaches for shear measurement building on the expertise developed in PISCO (PIxelS to COsmology).

Shear calibration

Shear calibration is an essential part of any cosmic shear survey, including Euclid. In this section of the thesis the student is expected to lead the production and validation of the calibration simulations. We will re-use some tools we are currently developing for DR1, in particular to verify that galaxy morphologic and photometric properties, as well as survey properties (e.g. local star density, zodiacal light) are accurately reproduced by the simulation pipeline developed in the Science Ground Segment (SGS) of Euclid. The student will also familiarize with the distribution of jobs on large clusters available to the Euclid consortium. In addition, we will need to develop further our understanding of subtle effects that we deem negligible for the precision of DR1 but that will be paramount to reach that of DR2. This includes simulating more realistic galaxy shapes, accounting for color gradient issues and refining the impact of survey properties, especially those which present a time-dependence such as the building of ice on the instrument mirrors and the charge transfer inefficiency due to degradation of the charge coupled device camera by cosmic rays hits.

Deep learning

In parallel, the student will improve the deep learning approach that we have explored. He/She will first focus on the challenge of tomographic galaxy shape measurement. This step divides the distribution of galaxies into redshift slices, which improves the extraction of cosmological information from lensing analyses, particularly concerning dark energy. More specifically, the student will familiarize to and adapt our existing convolution neural networks and training dictionaries to derive shape probability distribution conditional to the galaxies' distances. A second step will consist in linking the training dictionary to the Euclid simulations built for the shear calibration. This will allow us to perfectly mimic the Euclid observations in terms of galaxy and survey properties and systematic biases, and will open the door to the application of deep learning shear measurements to Euclid DR2 as the final chapter of that thesis.

Research environment

The student will benefit greatly from the LAM environment with a large team of experts in galaxy evolution and cosmology and many members of the Euclid Consortium. This thesis is timely: it will start one year before DR1 and ends right at DR2, allowing the PhD student to work on Euclid data from the beginning of the thesis and to make major contributions to the DR2 analysis. The tools developed in this thesis will ensure that the shear calibration is performed with a sufficient accuracy to fully exploit Euclid DR2 data, with foreseen technical revolution through the deep learning exploration. Finally, they can easily be adapted to other future cosmic shear surveys such as the Roman space telescope.

References :