Stage M2, 2019/2020

Weak gravitational lensing: mapping dark-matter on cosmological scales

Context

Weak gravitational lensing, the distortion of the images of high-redshift galaxies due to foreground matter structures on large scales, is one of the most promising tools of cosmology to probe the dark sector of the Universe [1]. Using the lensing distortion patterns we can create maps of the dark-matter distribution on large scales. These maps allow us to measure the mass profile of galaxy clusters and voids. By tracing the dark-matter evolution over cosmic time, we can obtain constraints on dark energy or modified gravity. The maps are also useful to assess lensing magnification of gravitational wave events at high redshift.

To quantify the image distortions we have to measure the shapes of galaxies to very high accuracy. Since typical lensed galaxies at hight redshift are small, faint, and detected with low signal-to-noise ratio, this is one of the biggest challenges for weak lensing. In addition, galaxy images are blurred by the PSF (point-spread function) of the optical imaging system, and suffer from systematic CCD effects related to pixellisation, cosmic rays, etc.

The goal of this M2 stage is to create weak-lensing maps of the dark-matter distribution on large scales. Systematic errors from the PSF and the detector, and their influence on the mass profiles of clusters and voids will be studied. The student will work on wide-field imaging data from CFIS[1] (Canada-France Imaging Survey), and use simulations of the ESA Euclid space mission[2]. The student will use the `python` analysis pipeline that is being developped in our group.

Outline of the project

The tasks and objectives of the internship are as follows.

1. Get familiar with weak-lensing measurements of galaxy shapes, and the influence of the PSF.
2. Assess the PSF uncertainty and its influence on galaxy shape measurement, using CFIS and Euclid simulations. Run the pipeline on both data and simulations. Analyse and interpret the results.
3. Estimate the impact of PSF errors on weak-lensing dark-matter maps.

Methods

During the stage, the student will apply statistical measures such as cross-correlations between different data set. Parameter fitting methods will be used for galaxy shape measurement.

[1] http://www.cfht.hawaii.edu/Science/CFIS/
[2] `http://sci.esa.int/euclid`

Scientific environment

The stage will be carried out in the CosmoStat[3] laboratory at the Département d'Astrophysique[4] (DAp) at CEA Saclay, under the supervision of Martin Kilbinger. CosmoStat hosts a multidisciplinary team whose research includes statistics, signal processing, machine learning, and cosmology. CosmoStat members are working on the weak-lensing analysis of CFIS. The group is strongly involved in the upcoming mission Euclid[5] (launch in 2022), the weak-lensing data processing and likelihood analysis of Euclid data.

This internship work can potentially be continued as a PhD in our group.

Requirements

The candidate should be a Master 2 (or equivalent) student with background in either physics/astrophysics or applied mathematics/signal processing/data science. Experience with python is not required, but would be advantageous.

The application deadline is 15/01/2020. The duration of the internship is 4 – 6 months.

Contact

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References

[1] Kilbinger, M., *Reports on Progress in Physics*, 78(8):086901, 2015.

[3] `http://www.cosmostat.org`
[4] `http://irfu.cea.fr/Sap/`
[5] `http://sci.esa.int/euclid`