Sujet de stage M2, 2016

Weak gravitational lensing: measurement of galaxy shapes for cosmology

Cosmology, weak lensing, and galaxy shape measurement

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]. Weak cosmological lensing has been used to constrain cosmological parameters such as the matter density Ω_m, the dark-energy equation of state w, and has put limits on modifications of general relativity.

To quantify the distortions induced on background galaxy images by matter structures, we have to accurately measure their shapes. Shape measurements to a few percent accuracy of typically small, faint, and low-SNR galaxy images that are blurred by the PSF (point-spread function) of the optical imaging system is one of the biggest challenges of weak gravitational lensing.

A weak lensing pipeline

Our group is developing a new weak-lensing shape measurement pipeline. We finished in the winning group of the challenge `great3`[1] [2], and we will participate in the next challenge (`great4`), which will start in 2016 and end in 2017.

The goal of this stage M2 is to contribute to the weak-lensing analysis on optical wide-field imaging data, and to use the measured shapes of background galaxies to obtain weak-lensing maps of the mass on very large scales. The analysis will be carried out on the state-of-the-art data set from the survey CFHTLenS, with 154 deg^2 one of the largest weak lensing surveys to date. Results from the analysis carried out during the stage will be compared to existing publications. The measured galaxy shapes can then be used for cosmological analyses, for example using weak-lensing peak counts developed in our group [3]. This work could be continued as a PhD in our group.

Methods

During their stage, the student will work on astronomical optical images of faint galaxies and use image processing techniques such as PSF (de-)convolution, object detection, image noise estimation, measurement of galaxy shapes, detection of image artifacts such as cosmic rays, dead columns, saturated pixels, or satellite trails. Further, the student will familiarize themselves with the modeling of galaxy properties, such as their light, color, and shape distribution for different galaxy types. Models of galaxy light profiles will be fitted to pixel data, including error estimation and calibration of the measurement using image simulations.

The codes used in the pipeline are written in python and C++.

[1] `www.great3challenge.info`

Scientific environment

The stage will be carried out in the CosmoStat[2] laboratory at the Service d'Astrophysique (SAp)[3] at CEA Saclay, under the supervision of Martin Kilbinger. CosmoStat hosts a multidisciplinary team whose research includes statistics, signal processing and cosmology. The CosmoStat group is stongly involved in the upcoming ESO space-based mission Euclid[4] (launch in 2020), and manages the weak-lensing data processing of Euclid data. Kilbinger is co-leader of the weak-lensing science working group (WLSWG).

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[3] Lin, C.-A. & Kilbinger, M., *A&A*, 576:A24, 2015.

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