Stage M2, 2019/2020

Cosmological analysis of peaks in weak gravitational lensing maps

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]. From lensing distortion patterns we can create maps of the dark-matter distribution on large scales. Peaks in these maps correspond to highly non-linear and non-Gaussian over-dense regions in the cosmic web, and their distribution contains a wealth of information about cosmology. Lensing peaks can contribute to measure the dark-matter content of the Universe, to constrain properties of dark energy, and to place limits on the neutrino mass.

The goal of this M2 stage is to derive constraints on cosmological parameters from state-of-the-art weak-lensing catalogues. The student will work on wide-field imaging data from CFIS[1] (Canada-France Imaging Survey). This ongoing survey will cover $5,000$ deg^2 in the Northern sky, of which around one third has been analysed for weak lensing in our group.

Using analytical models of weak-lensing peak counts that have been developped in CosmoStat [2], and numerical simulations [3], the student will derive posterior distributions of cosmological parameters. Likelihood-free method such as ABC (Approximate Bayesian Computation), recently developped for cosmology [4], and machine-learning techniques [5] will be applied to obtain constraints on cosmological parameters while accounting for the non-Gaussian nature of the peak count observables.

Outline of the project

The tasks and objectives of the internship are as follows.

1. Get familiar with the theory and measurement of weak-lensing peak counts.
2. Measure peak counts in CFIS weak-lensing maps.
3. Use analytical and/or numerical models to derive parameter constraints.

Methods

During the stage, the student will extract statistical information from large weak-lensing catalogues and images. They will apply advanced Bayesian likelihood-free parameter inference methods, use analytical modelling and work with numerical simulations.

[1] http://www.cfht.hawaii.edu/Science/CFIS/

Scientific environment
The stage will be carried out in the CosmoStat[2] laboratory at the Département d'Astrophysique[3] (DAp) at CEA Saclay, under the supervision of Martin Kilbinger, co-supervised by Valeria Pettorino and Virginia Ajani. CosmoStat hosts a multidisciplinary team whose research includes statistics, signal processing, machine learning, astrophysics, and cosmology.

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.

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

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

[3] Liu, J., Bird, S., Zorrilla Matilla, J. M., et al., *JCAP*, 2018(3):049, 2018.

[4] Lin, C.-A. & Kilbinger, M., *A&A*, 583:A70, 2015.

[5] Alsing, J., Charnock, T., Feeney, S., & Wandelt, B., *MNRAS*, 488(3):4440–4458, 2019.

[2] `http://www.cosmostat.org`
[3] `http://irfu.cea.fr/Sap/`