Stage M2, 2018/2019

Cosmology with gravitational waves and galaxy clustering

Context

The recent direct detections of gravitational waves (GW) from mergers of massive compact objects has opened a new window to our Universe. The GW signal allows us to measure the luminosity distance to the merger, from which we can constrain the expansion history of the Universe, including the Hubble constant H_0 and dark-energy properties. However, most GW events are expected to have no detectable electro-magnetic counterpart. We thus have to employ statistical analyses to use these events in a cosmological context. The spatial distribution of galaxies, or galaxy clustering, can help us to infer the redshift of a population of events in a statistical way [1, 2].

Work to date has focused on spectroscopic galaxies. By extending this to galaxy surveys in broad-band photometry the number and limiting magnitude of available galaxies for clustering analysis can be vastly increased. The challenge in this approach is the determination of precise redshifts.

This project aims to estimate the impact of redshift estimation on the clustering analysis of GW events for cosmological parameter inference. Forecasts will be done for current ground-based data coming from LIGO/VIRGO[1] for GW, and optical galaxy surveys such as CFIS[2], as well as for the future space mission LISA[3] and Euclid[4].

Outline of the project

The tasks and objectives of the internship are as follows.

1. Get familiar with the statistical analysis of GW events, and redshift estimation of photometric surveys.
2. Apply and compare different methods of redshift estimation that are developped in the CosmoStat group.
3. Estimate the impact of redshift errors on cosmological analysis of current and future data.

Methods

During the stage, the student will work on various methods of galaxy redshift estimation. This includes photometric redshifts, clustering redshift [3], and machine learning techniques. Statistical methods such as cross-correlations between data sets, parameter inference, and machine learning will be used.

[1] https://www.ligo.org/
[2] http://www.cfht.hawaii.edu/Science/CFIS
[3] https://lsst.org
[4] https://www.euclid-ec.org

Scientific environment
The stage will be carried out in the CosmoStat[5] laboratory at the Département d'Astrophysique[6] (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.

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 28/02/2019. The duration of the internship is 4 – 6 months.

Contact
Martin Kilbinger, `martin.kilbinger@cea.fr`
`http://cosmostat.org/kilbinger`
☎ +33 1 69 08 17 53
CEA/Irfu/Dap, Laboratoire AIM
Orme des Merisiers, Bât 709, office 280
F-91191 Gif-sur-Yvette

References
[1] Petiteau, A., Babak, S., & Sesana, A., *ApJ*, 732:82, 2011.

[2] Nair, R., Bose, S., & Saini, T. D., *Phys. Rev. D*, 98(2):023502, 2018.

[3] Scottez, V., Mellier, Y., Granett, B. R., et al., *MNRAS*, 462:1683–1696, 2016.

[5] `http://www.cosmostat.org`
[6] `http://irfu.cea.fr/Sap/`