Strong Lensing Cosmography with Euclid and HST Frontier Fields

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Subject's title: Strong Lensing Cosmography with Euclid and HST Frontier Fields

Subject description:

Scientific context

Several cosmological probes are used to distinguish different cosmological models. Amongst them, strong lensing by massive galaxies or galaxy clusters appear to be very powerful (Collett et al., 2015, Jullo et al. 2010, Acebron et al. 2017). This method provides orthogonal constraints to other probes (see Fig. 1). In order to increase efficiency, redshifts must be measured for both the lens and the source, **since the dependence on cosmological parameters is encapsulated in the relative distances between the lens, the source and the observer**. Lens modeling of galaxy clusters and individual galaxies is commonly performed with the public code we maintain and develop at LAM, LENSTOOL, widely used in our community (e.g. Kneib 1996, Jullo et al. 2007, Richard et al. 2014, Sharon & Johnson 2015, Limousin et al. 2017). During the next decade, EUCLID will survey 15,000 deg2 in imaging and spectroscopy to characterize the nature of dark energy and dark matter. Several 100s and 1000s of galaxy clusters and individual lens galaxies will be observed. The EUCLID consortium is presently preparing the detection of these galaxies, but we still need to prepare their analysis to test dark energy and dark matter models.

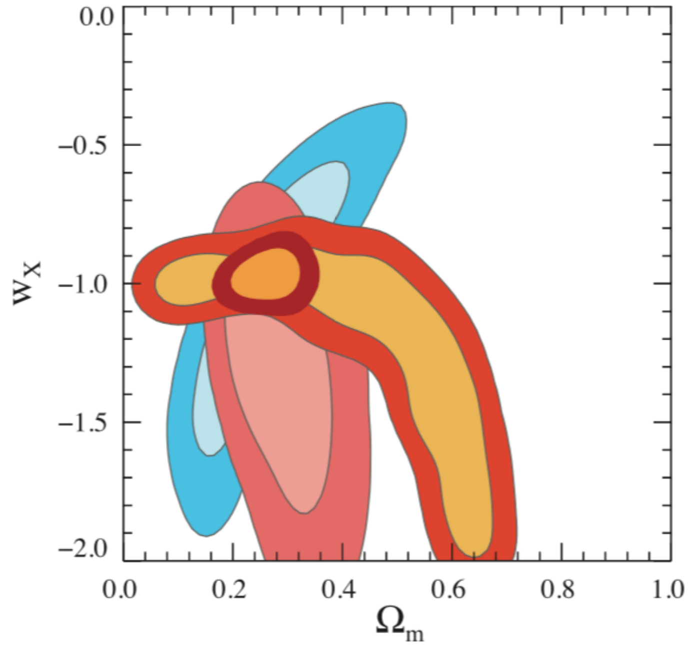

Fig. 1: Cosmological constraints obtained with strong-lensing (orange) in a single galaxy cluster (Jullo et al. 2010), compared to constraints obtained with X-ray masses and WMAP5 (blue). Strong lensing contours are orthogonal contours derived from other probes.

Scientific objectives

The objective of this thesis is to improve this cosmography technique by combining several clusters in a joint fit of the cosmological parameters. Recently, 6 massive galaxy clusters of the HST Frontier Fields program have been observed up to magnitude ~29, unveiling several 100s of new strong lensing constraints. In addition, MUSE deep observations of the cluster cores have measured redshifts from these new arcs. All the data are therefore ready to perform the cosmography analysis. The main difficulty is understanding the systematic errors in our models.

Building on our latest works on systematic analysis in strong lensing clusters (Acebron et al. 2017) and the evolution of galaxies in cluster environment (Niemiec et al. 2018), we will update in LENSTOOL the current and simple mass to light ratio to a better stellar to subhalo mass relations. We will also use mock

catalogues of strong lensing events in clusters (based on MOKA tool, Giocoli et al. 2012) to derive parametric covariance matrices, to be used in the fit. Finally, we will use this new model to improve the current mass distribution of the 6 HFF clusters and derive cosmological parameters. This work will have a strong impact on the study of high redshift objects in these fields.

In contrast to the HFF, Euclid will confirm the existence of many clusters, but will be too shallow to discover many strong-lensing events per cluster. In this thesis, we will apply the techniques described above to Euclid simulated clusters being produced by the Strong Lensing SWG. We will try several approaches of combination, among which the joint fit of multiple clusters in parallel on a supercomputer.

This PhD project will provide excellent training and experience on the EUCLID data just on time for the scientific exploitation of the mission, making it easy for the successful PhD candidate to apply for fellowships and postdoctoral positions. **The future of strong lensing clusters is extremely bright and it is timely and relevant to train young researchers in this area. In the recent years, more than 1600 HST orbits have been granted to observe strong lensing clusters (CLASH, HFF, RELICS and BUFFALO), clearly demonstrating that this class of objects are essential to our understanding of the Universe.**

Schedule. 2019-2020

The PhD student will start by getting used with the modeling of simulated lens galaxy clusters. He/She will extend the work done in Acebron et al. 2017 to improve the models in LENSTOOL. Next, he/she will focus on the analysis of the HST Frontier Fields (HFF) clusters.

2020-2022

In the second part of the thesis, he/she will develop a tool to combine clusters to estimate cosmological parameters. A publication about Euclid cosmological forecasts obtained with this method will be published.

Bibliography:

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