Line-of-sight effects in gravitational lensing

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Structure enhanced ray-tracing

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large scale structure numerical simulations do not have the resolution to accurately describe all the structure on small scale relevant for strong gravitational lensing. I describe recent progress in combining N-body simulations describing the large scale structure with semi-analytical enhanced structure ray-tracing bridging the gap between week and strong lensing.

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Detecting low mass haloes with lensed arcs: predictions

Auteur: Giulia Despali[1]

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Strong gravitational lensing is one of the most accurate methods to measure the mass of galaxies and haloes and one of the most promising to investigate the nature of dark matter. It allows us to probe one of the key signatures of warm dark matter models: the lack of small-mass dark clumps with respect to CDM. Low-mass haloes and subhaloes can be detected through their effect on the surface brightness distribution of lensed arcs, but the number of detections that have been claimed so far remains low.
I will present the results of a systematic comparison between mock and real observations with theoretical predictions, with the aim of establishing the sensitivity limits of instruments such as HST, Keck, ALMA, Euclid and JWST and thus determine which instruments and which sample of lenses is the most promising, together with the observational and modelling challenges that will be faced. I will discuss which kind of observations will give the community the best chance of detecting low-mass dark haloes and subhaloes and present forecasts on the sample size that would be needed to confirm or exclude CDM at a significant level.

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Constraining Dark Matter and Shear With Strong Gravitational Lensing

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The cold dark matter (CDM) paradigm makes a prediction of ubiquitous clumps of DM with masses <10^9Msun, which do not form in alternative models of warm or self-interacting DM. Using galaxy-scale strong gravitational lenses, the presence (or lack thereof) of these DM clumps can be inferred by looking for distortions in the lensed source's emission. I present results scanning for DM clumps in HST imaging of over 50 strong lenses, which includes an independent reproduction of a previous detection found in the system SDSSJ0946+1006. Simplifications in the lens galaxy's light and mass models produce false-positive detections of DM clumps and I discuss strategies for mitigating this.To translate these results into constraints on the DM particle I show how properly accounting for scatter in the DM mass-concentration relation significantly improves our ability to distinguish between DM models, by making high concentration low mass DM halos (e.g. <10^9Msun) detectable.

These lens models include an "external"shear term, which is expected to measure the line-of-sight structure surrounding a lens. However, I show that the inferred shear depends on internal assumptions about the lens galaxy's mass and that care is required to distinguish this internal shear from external shear in strong lens samples.

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Line of sight effects in the past light cone of the horizon-AGN hydrodynamical simulation

Auteur: Raphael Gavazzi[1]

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I will present a few original aspects of the small scale properties of the lensing deflection field that arise from the full multiple plane ray-tracing.

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Line-of-sight shear and beyond

Auteur: Pierre Fleury[1]

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I will discuss the theoretical modelling of line-of-sight perturbations in strong gravitational lensing. Two points will be highlighted:
1. There exists a notion of line-of-sight shear that is, in principle, distinguishable from properties of the main lens.
2. Distortions beyond convergence and shear (flexion, etc.) could play an important role.

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From Images to Dark Matter: End-To-End Inference of Substructure From Hundreds of Strong Gravitational Lenses

Auteur: Sebastian Wagner-Carena[1]

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Constraining the distribution of small-scale structure in our universe allows us to probe alternatives to the cold dark matter paradigm. Strong gravitational lensing offers a unique window into small dark matter halos ($< 10^{10} M_{\odot}$) because these halos impart a gravitational lensing signal even if they do not host luminous galaxies. We create large datasets of strong lensing images with realistic low-mass halos, Hubble Space Telescope (HST) observational effects, and galaxy light from HST's COSMOS field. Using a simulation-based inference pipeline, we train a neural posterior estimator of the subhalo mass function (SHMF) and place constraints on populations of lenses generated using a separate set of galaxy sources. We find that by combining our network with a hierarchical inference framework, we can both reliably infer the SHMF across a variety of configurations and scale efficiently to populations with hundreds of lenses. We then explore how the distribution of line-of-sight structure affects our constraints. By conducting precise inference on large and complex simulated datasets, our method lays a foundation for extracting dark matter constraints from the next generation of wide-field optical imaging surveys.

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Subhalos Overview

Auteur: Simona Vegetti[None]

TBD

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Measuring the line-of-sight shear with Einstein rings (TBC)

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Line-of-sight effects in strong-lensing time delays (TBC)