Particle Based Lensing (PBL)

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Abstract

Combining weak and strong (W+S) lensing is becoming an important tool in mass measurements of clusters. Determining mass maps of clusters using W+S analysis can be challenging because of the difference in length scales associated with the different signals. Traditionally researchers have used grid based methods to reconstruct the density fields. In this paper we develop a particle based method that incorporates these two scales without the necessity of regularization. The accuracy of the method is determined by the smoothing scale used. We apply the particle based method to do mass reconstruction using ellipticities only. This can be easily generalized to include strong lensing information as well. There are also complexities with images in the semi strong or semi weak regimes which is resolved by smoothing the ellipticity function. We apply these techniques to a number of test cases and find excellent agreement between the reconstructed and input mass distribution.

Introduction

Gravitational lensing is the bending of light rays from distant sources by intervening massive bodies.

Weak Lensing

Weak Lensing is the statistical distortion of background galaxies by foreground lens, like a galaxy cluster. Lensing of images changes differentially aligned tangentially to a lens, as illustrated in Fig. 2.

Strong Lensing: Parity

When a background source and the lens are very nearly aligned, the source may be multiply imaged.

Weak+Strong Lensing

Recent studies of weak+strong lensing have produced some excellent results. The mass reconstruction is done via a \( \chi^2 \) minimization process. Finite differencing methods are used for calculating derivatives.

Weak lensing occurs within a few arc-seconds of the lens center whereas weak lensing resolution is larger than \( \sim 30^\circ \). Regularization schemes are used to smooth the result in weak regime and resolve the strong lensing structure. Though these methods have been very successful in reconstructing the cluster cores the choice of the regularization is arbitrary.

More Information !!!

- Flux Ratios:
- Ellipticity Differences: \( \varepsilon_{ij} \)

Interpolated Ellipticities

The ellipticities are defined by two different functions inside and outside the critical curve (cc). The functions are continuous at the cc but their derivatives are not. This makes fitting to the ellipticity via \( \chi^2 \) difficult. We have replaced this gaspy ellipticity function with a smooth function. This helps us to avoid getting stuck at a local minimum close to the global minimum.

Particle Based Lensing

We introduce a new method Particle Based Lensing (PBL) which combines the disparate scales of weak and strong lensing with the help of a smoothing scale \( w_g \). This is a variant of SPH in which the potential field is defined at the position of each lensed galaxy. \( \{w_i\} \). In order to make the field as continuous as possible, we may expand the local potential field around that point to arbitrary order.

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References


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Website: http://www.physics.drexel.edu/~debl/PBL.htm