

Mapping Out Substructure in Galaxy Clusters using Strong Lensing

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Abstract

In the last fifteen years Hubble Space Telescope has observed many galaxy clusters that host multiple images of background strongly lensed galaxies. The precision of HST's astrometry and the depth of its photometry are often necessary to identify and characterize the faint images of galaxy sources. These data have been used by many workers to model the projected mass distribution in clusters with the goal of deducing the properties of dark matter based on its observed clumping. However, most of the mass reconstruction work has been done using parametric mass models. Such models presuppose a close relationship between the distribution of the dark matter and that of light. The upshot is that the parameter space of solutions is not fully explored, and also, the observed image positions need not be well fit by the model. In order to utilize the high precision of HST data, I propose to use a free-form, or non-parametric mass modeling technique to reconstruct the detailed mass distribution in two clusters, SDSS J1004+4112 (14 images; $z=0.68$), and Abell 1689 (106 images; $z=0.18$), both observed with the HST in the last few years. The method fits the observed image positions exactly, does not impose restrictive assumptions on the mass, and explores the whole parameter space of mass models that are consistent with the observed lensing data. The method is thus able to see variable mass-to-light ratios of cluster galaxies, sizes of dark matter halos of galaxies, variations of the galaxy halo properties with the distance from the cluster center, and misalignments between mass and light centroids of clusters. In order to characterize the uncertainties of the method I will perform reconstructions on synthetic lenses whose mass distribution is known.

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