Strong Lensing Cosmology in the Era of Astronomically Large Data

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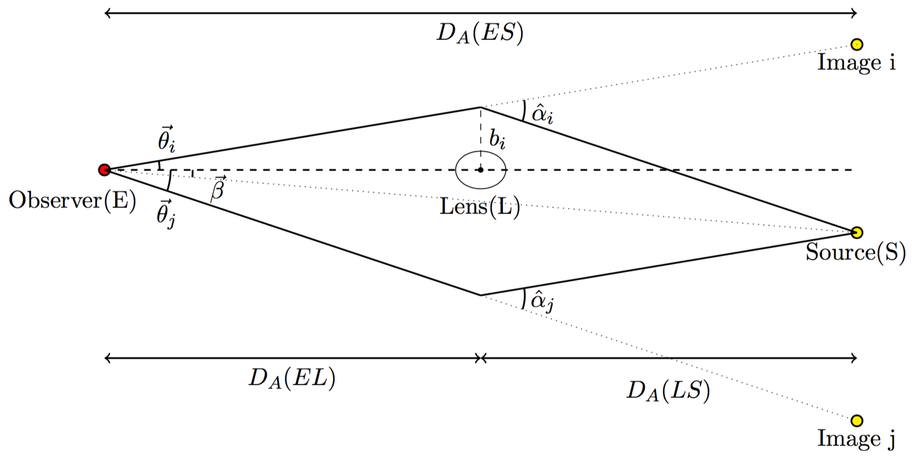
Introduction

Strong gravitational lensing is a probe of both astrophysics and cosmology. Currently, for many statistical studies involving strong lensing systems, the paucity of suitable systems to analyze is a limiting factor. Currently, several hundred lenses have been discovered, either serendipitously or through dedicated surveys. However, ongoing and future surveys are projected to increase the number of known lenses by 1-2 orders of magnitude, greatly increasing the statistical power of strong lenses as cosmic and astrophysical probes.



Schematic diagram of a strong gravitational lensing system (Jee et al. 2015)

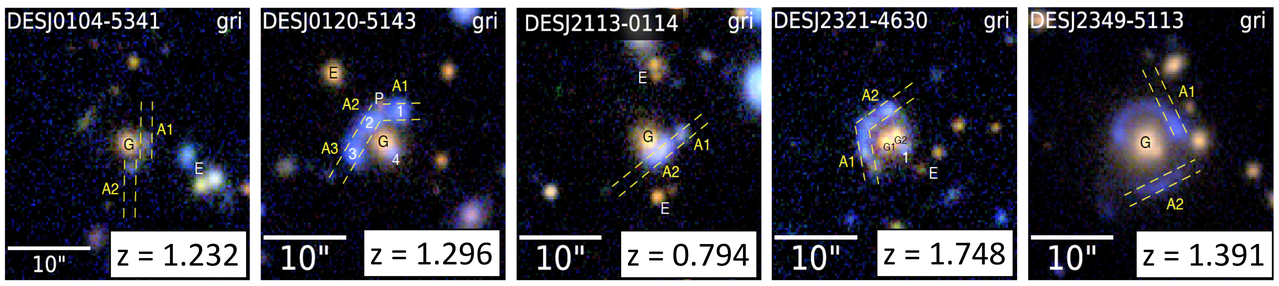
Projections for Current and Future Surveys

Experiment	Galaxy-galaxy	Quasar	Supernovae	Double Source
DES	2400	120	-	10
LSST	120000	3000	130	1500

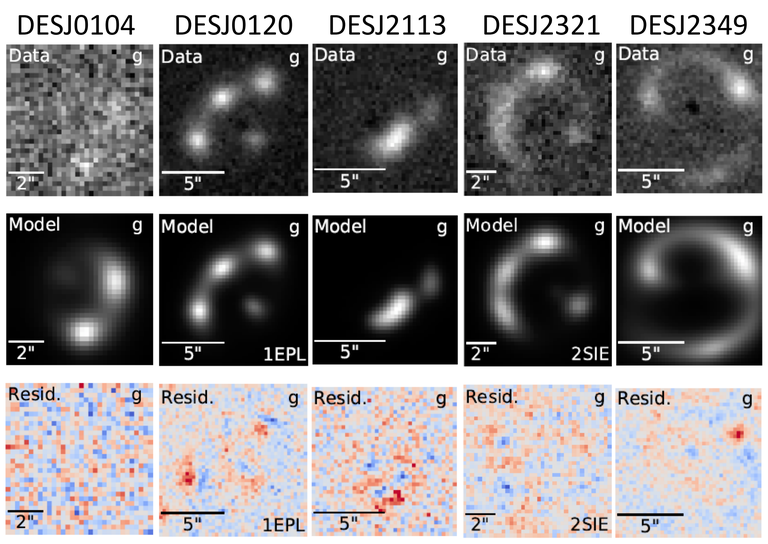
Projections for the number of discoverable lenses of various species in the Dark Energy Survey (DES) and the Large Synoptic Survey Telescope (LSST) Survey (Collett, 2015; Oguri and Marshall, 2010).

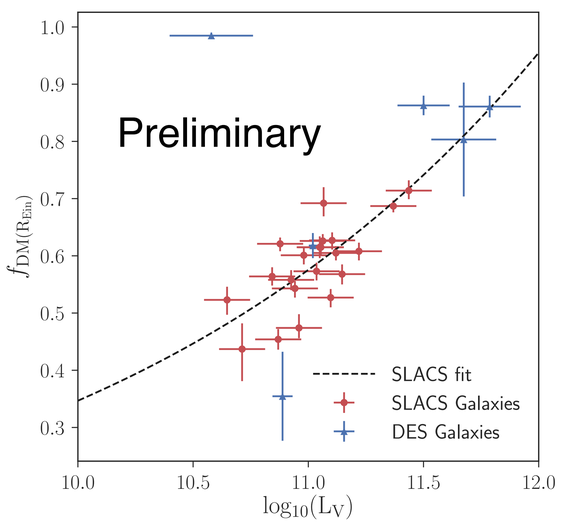
Strong Lensing as a Probe of Dark Matter

Strong gravitational lensing is an established probe of the matter distribution in galaxies. By reconstructing the image morphology through forward modeling, mass and light profiles of the lens galaxies can be precisely inferred. Here, we model five spectroscopically confirmed early-type galaxy lenses in DES data and infer their dark matter mass fractions and density slope.



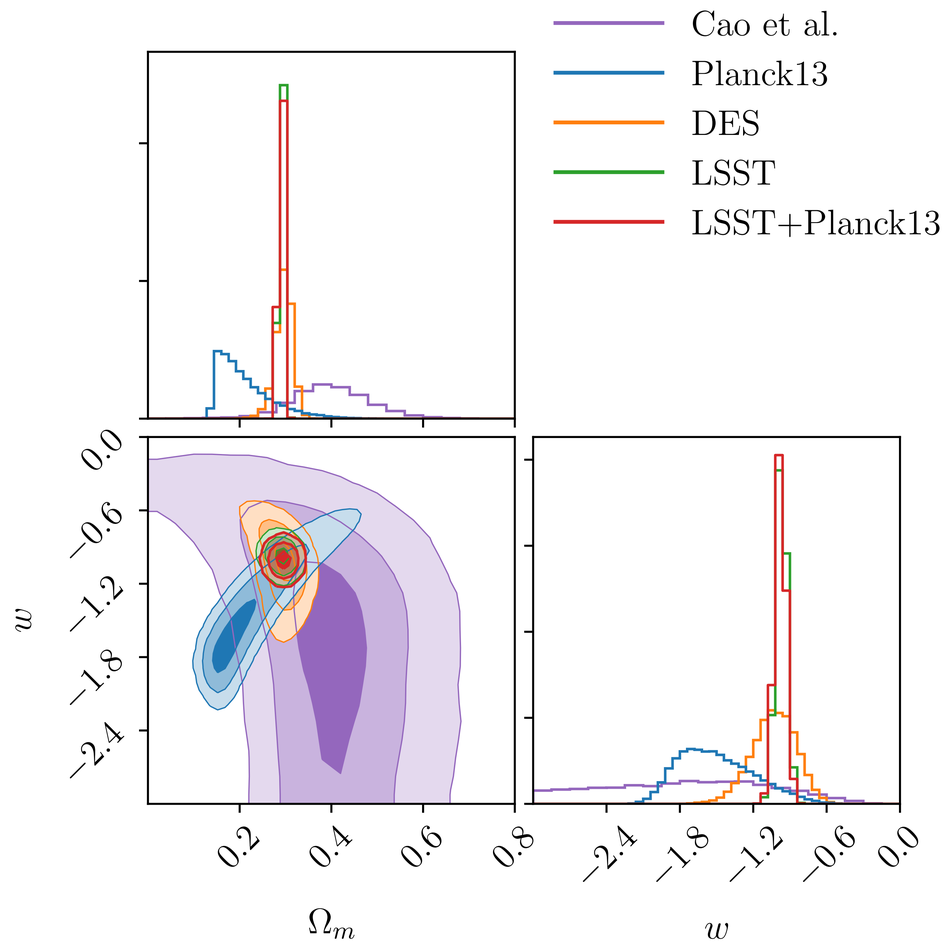
gri-band composite images of 5 spectroscopically-confirmed galaxy-scale lensing systems in DES data.





Left: g-band cutouts of DES images, reconstructed model images and residuals. Right: Dark matter mass fraction of DES galaxy-scale lenses as a function of luminosity, compared to the Sloan Lens ACS Survey (SLACS) lens sample.

Strong Lensing as a Probe of Dark Energy



Constraints on flat wCDM cosmology from 118 known lenses (Cao et al., 2015), Planck 2013, and realistic populations of discoverable lenses from the DES and LSST surveys.

Strong lensing has been long-recognized as a potential probe of cosmology. However, it is only recently, with the growing number of known lenses, as well as better understanding of the underlying systematics of different strong lensing probes, that strong lensing approaches maturity as a cosmic probe. We explore the use of the distance ratio probe $\mathbf{D_{LS}/D_{ES}}$, inferred from measurements of the Einstein radii and lens velocity dispersions of a sufficiently large catalog of galaxy-scale lenses, to constrain cosmological models. We forecast constraints on cosmology from realistic catalogs of galaxy-scale lenses discoverable in ongoing and future surveys.

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