

Dependence of Microlensing on Source Size and Lens Mass

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In gravitational lensed quasars, the magnification of an image depends on the configuration of stars in the lensing galaxy. We study the statistics of the magnification distribution for random star fields. The width of the distribution characterizes the amount by which the observed magnification is likely to differ from models in which the mass is smoothly distributed. We use numerical simulations to explore how the width of the magnification distribution depends on the mass function of stars, and on the size of the source quasar. We then propose a semi-analytic model to describe the distribution width for different source sizes and stellar mass functions.

Modeling and Results

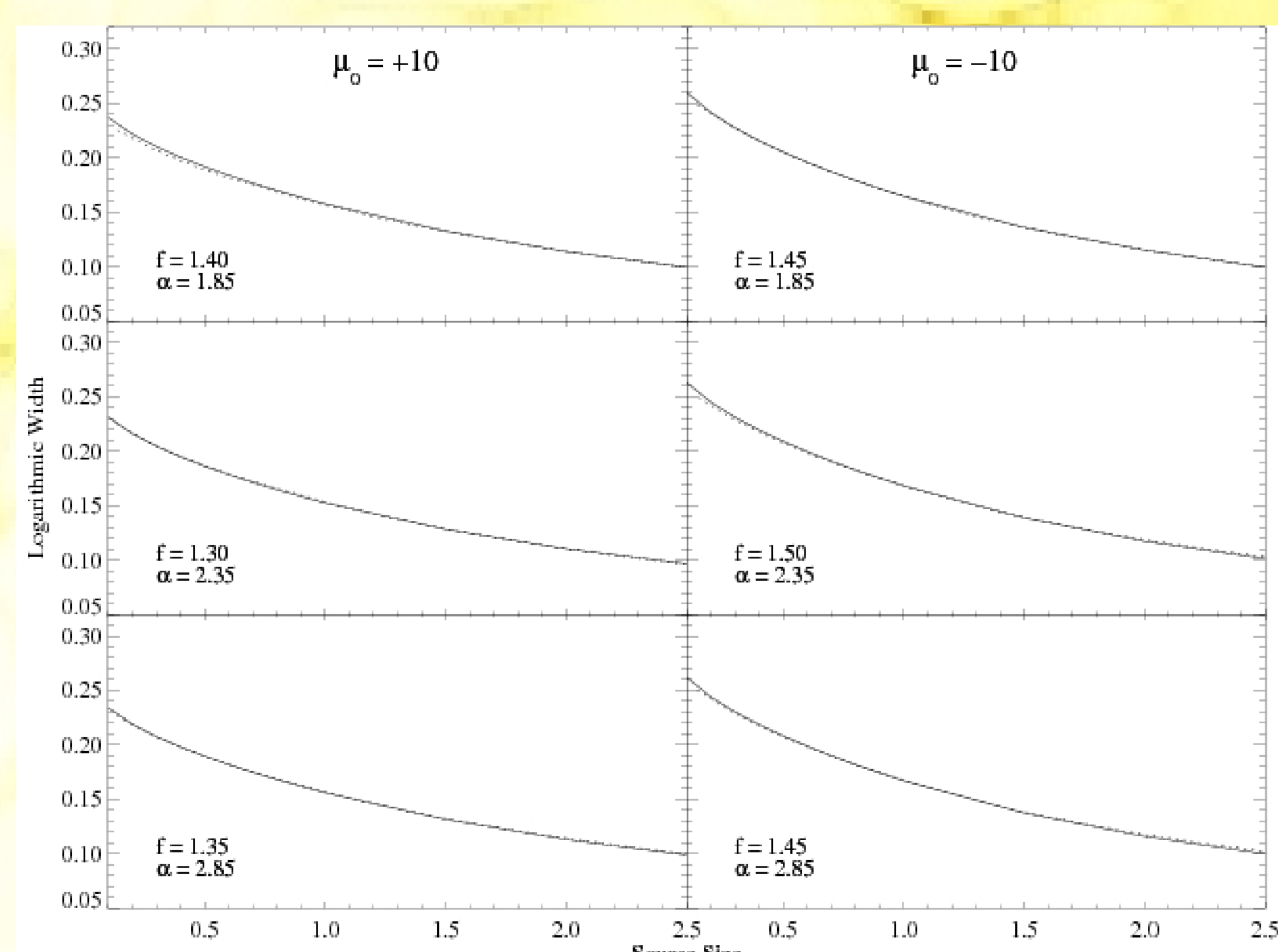
We describe the source by a Gaussian surface brightness profile with given half-light radius.

We model the stellar population of the lensing galaxy by a power-law mass function with varying slope and mass range, i.e.,

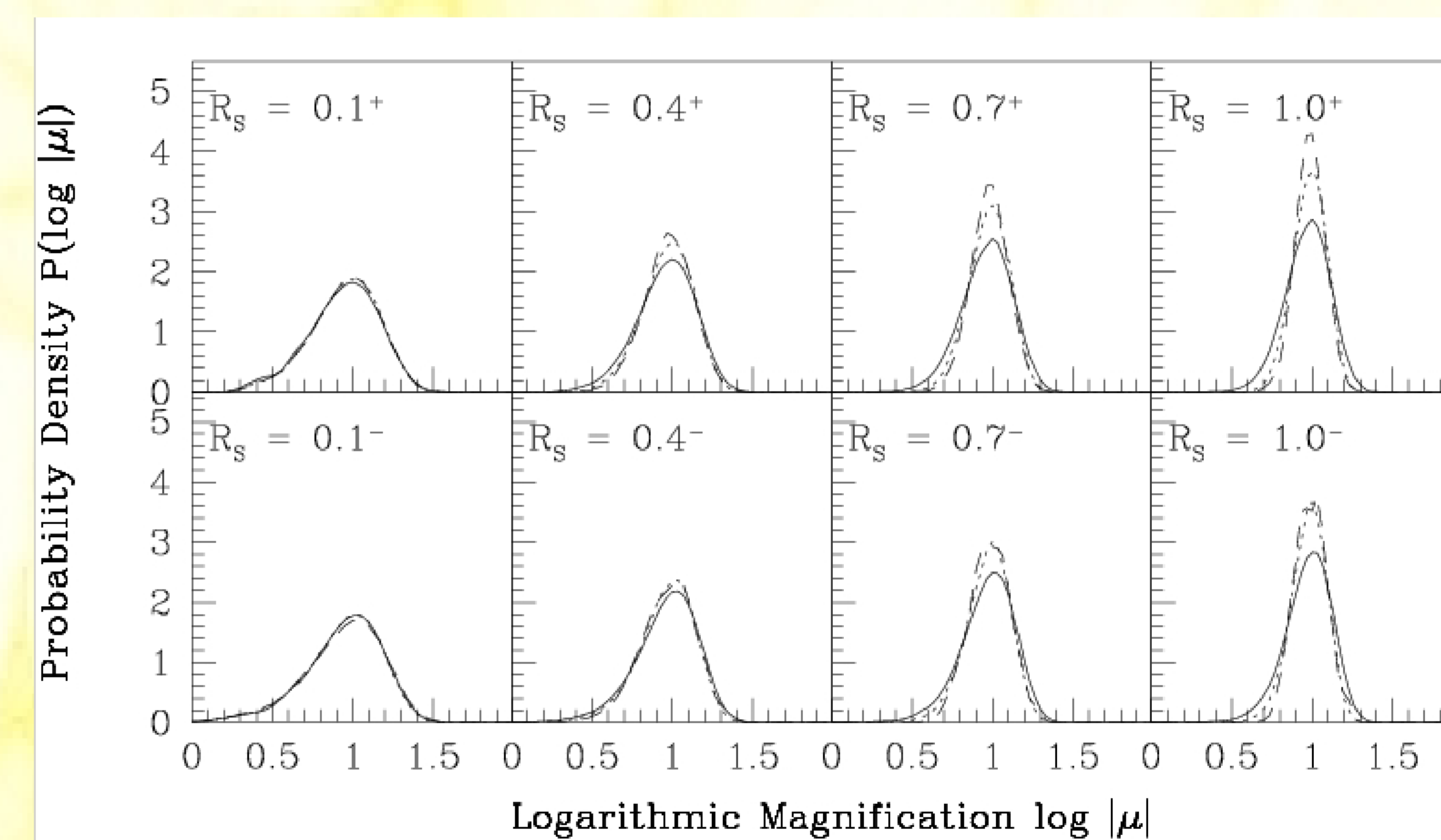
$$\frac{dN}{dM} \propto M^{-\alpha} \quad (M_1 \leq M \leq M_2)$$

We use the microlensing software of Wambsganss (1999) to construct magnification distributions.

The width of the distribution decreases with increasing source size and decreasing lower mass limit (see figure at right).



Comparison of the width derived from simulations (solid curves) with our semi-analytic method (dotted curves).



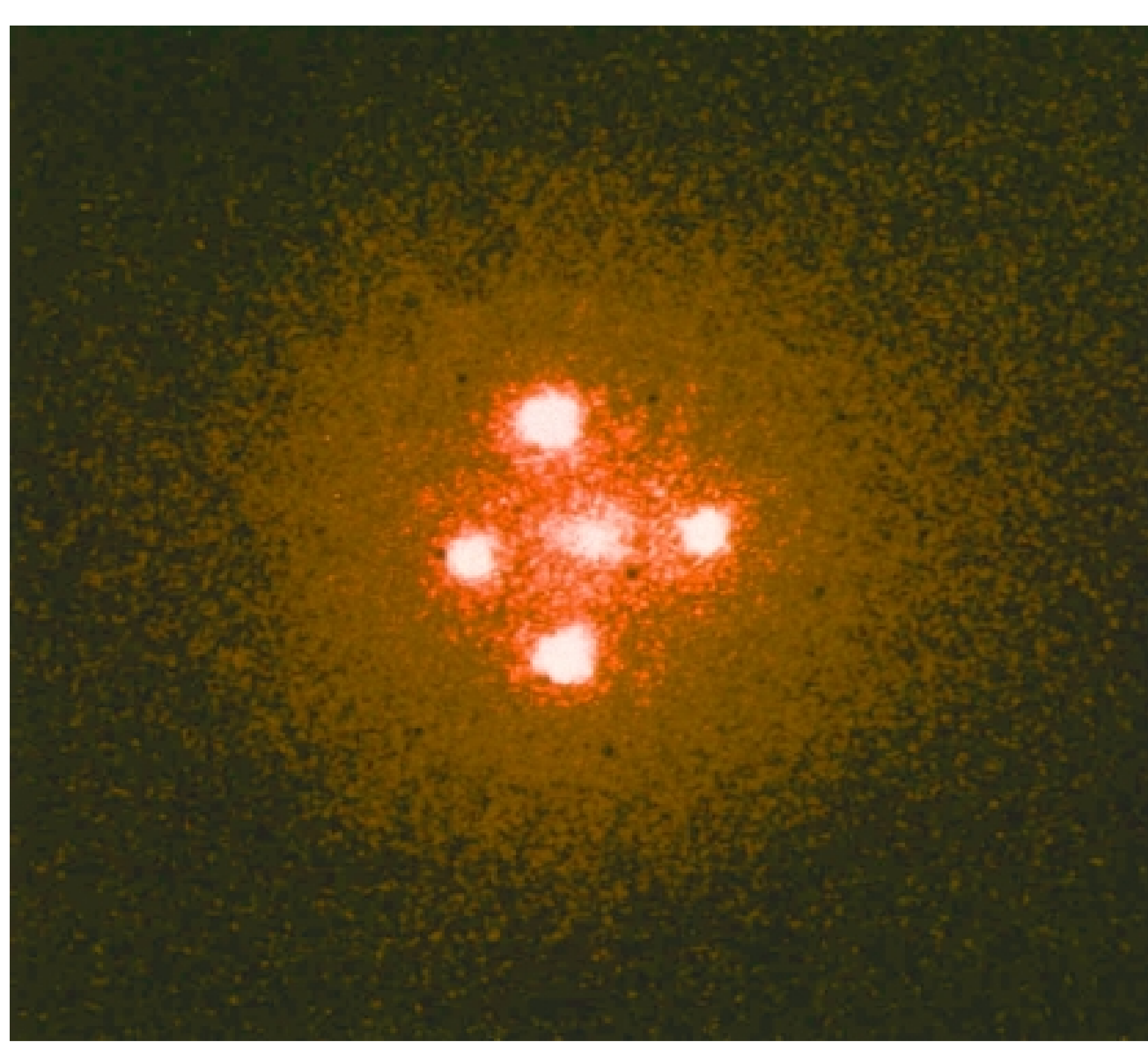
Magnification distributions for different source sizes and mass functions. Source sizes are measured in solar Einstein radii. All curves are for mass functions with slopes of 2.35 and upper limits of one solar mass. The solid, dotted, and dashed curves have lower limits of 1, 0.1, and 0.03 solar masses.

We quantify the effects of source size and lens mass by writing the width as a weighted integral of the mass function, ignoring nonlinear effects as a first approximation:

$$\sigma(r_s) = \int_{M_1}^{M_2} n(M) W \left(r_s \sqrt{\frac{M}{M}} \right) dM,$$

where sources are measured in units of the mean-mass Einstein radius. We compare this result with simulations in the figure at left.

We conclude that microlensing becomes unimportant for large sources and small masses. However, there is no clear break between the regimes where microlensing plays a role and where it does not.



Q2237+0305
(hubblesite.org)

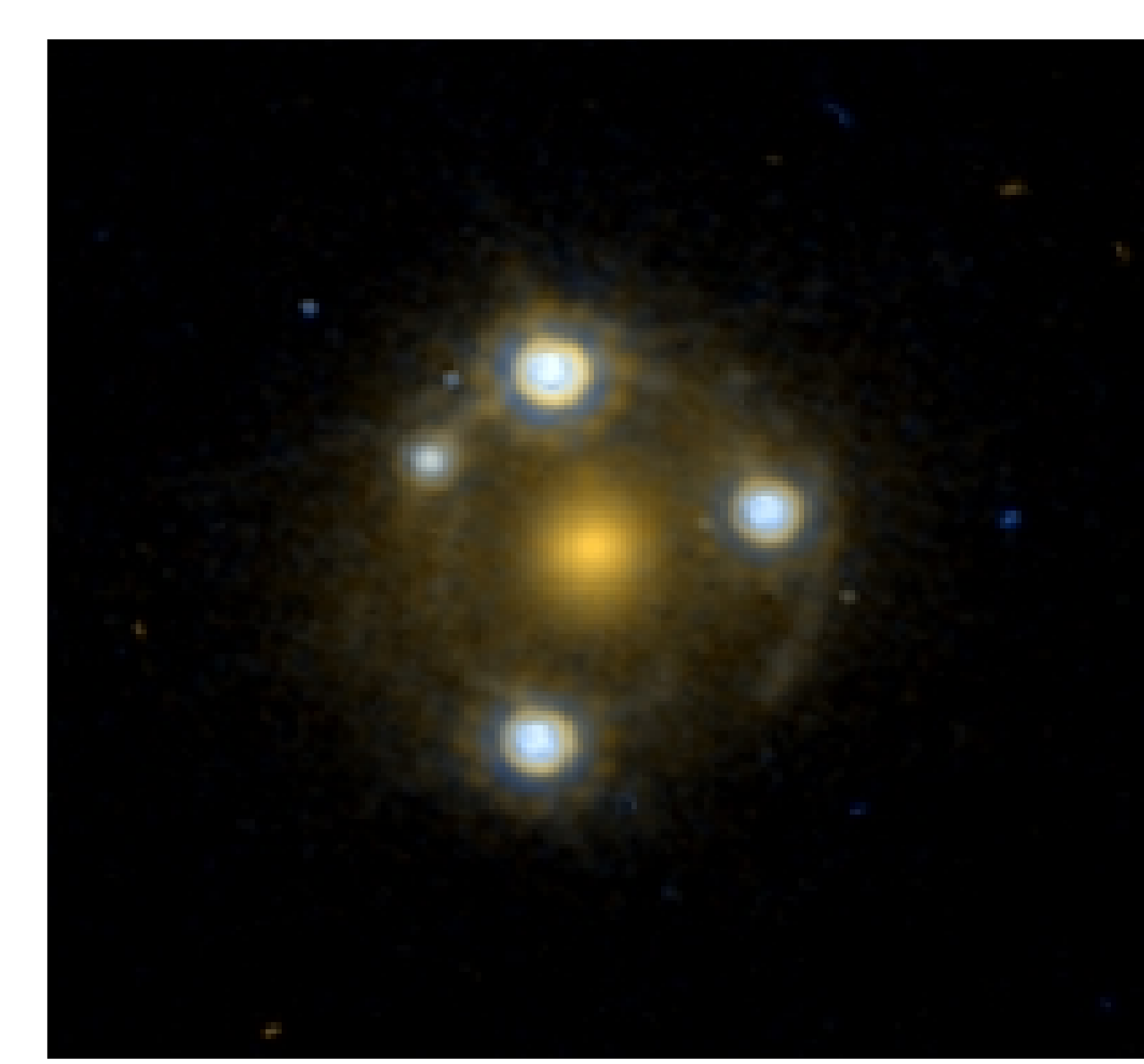
Background

Smooth mass models reproduce the observed image positions.

"Microlensing" by stars in the lens galaxy can perturb the image magnifications (relative to smooth models).

Observations of microlensing are used to constrain the structure of the source quasar and/or the population of stars in the lens galaxy.

Microlensing is stochastic, so the natural theoretical quantity is the magnification distribution. The width of the distribution quantifies the strength of microlensing.



SDSS0924+0219
(Keeton et al. 2006)

Previous Work

Wyithe & Turner (2001) show that microlensing of a point source is insensitive to stellar mass functions with typical ranges.

Schechter & Wambsganss (2002) show that microlensing of an extended source by a uniform mass distribution is greater for models with dark matter.

Lewis & Gil-Merino (2006) analyze microlensing of an extended source by a bimodal mass distribution and show that low-mass objects act like a smooth component.

Previous authors have not simultaneously considered an extended source and power-law mass function.