Harvard-Smithsonian
Center for Astrophysics

Mass Measurements for Microlens Planets with WFIRST/AFTA

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Planet mass is not the primary observable

Technique	Primary Observable
Radial Velocity	$m_p \sin i$
Transits	r_p/R_{star}
Direct Imaging	Flux
Microlensing	m_p/M_{star}

Mass Ratio is the Primary Observable

Observable

$$q = m_p / M_{star}$$

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We *must* measure the mass of the lens star to measure the mass of the planet.

Most planetary microlensing events give a mass-distance relation

$$\theta_E^2 = \kappa M_{star}/D_{rel}$$

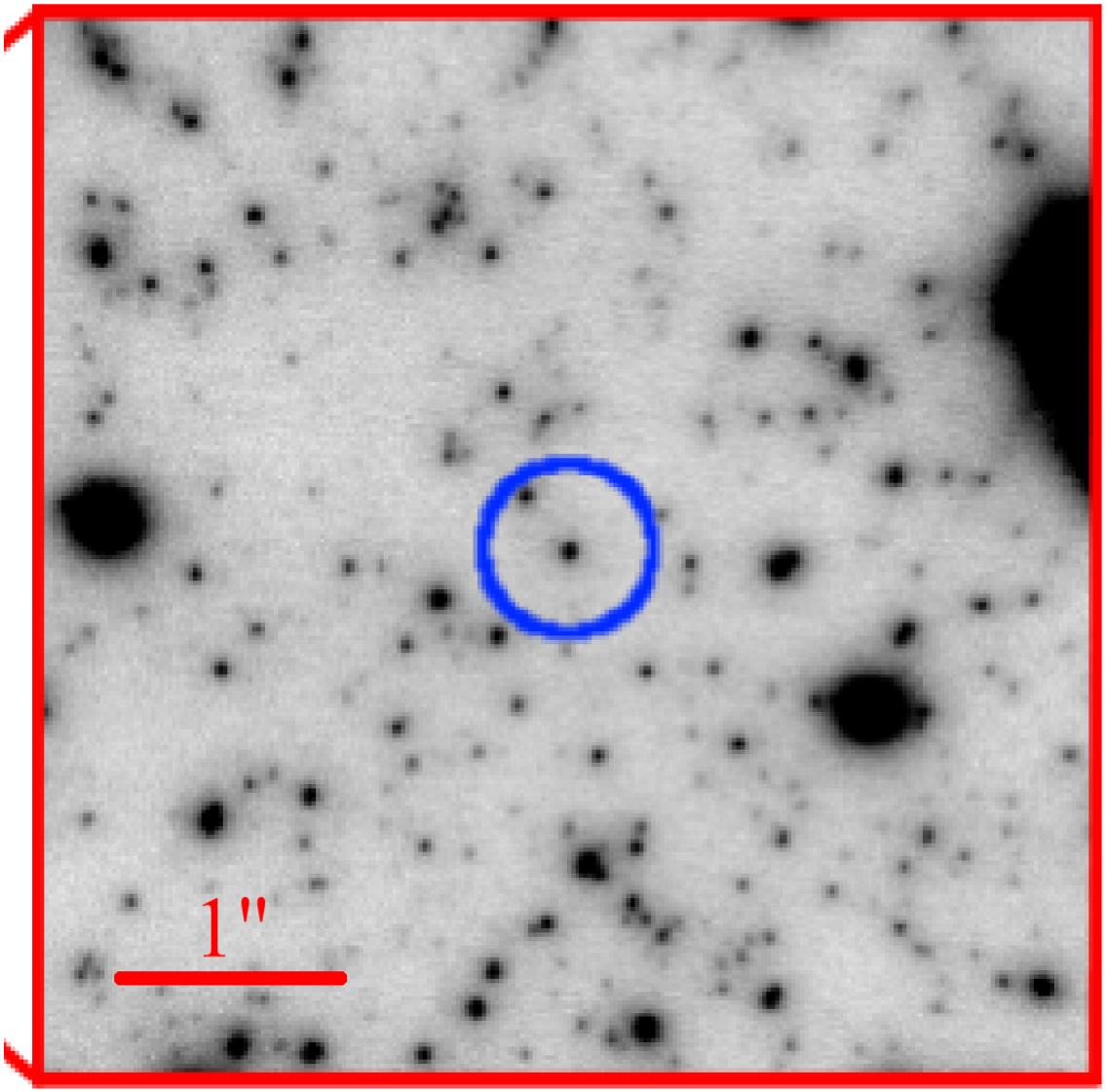
Observable

κ = constant

3 Ways WFIRST will Measure Lens Masses

1. Lens Flux
2. Microlens Parallax
3. Astrometric Microlensing

1. Lens Flux



Batista et al. 2014, ApJ, 780, 54

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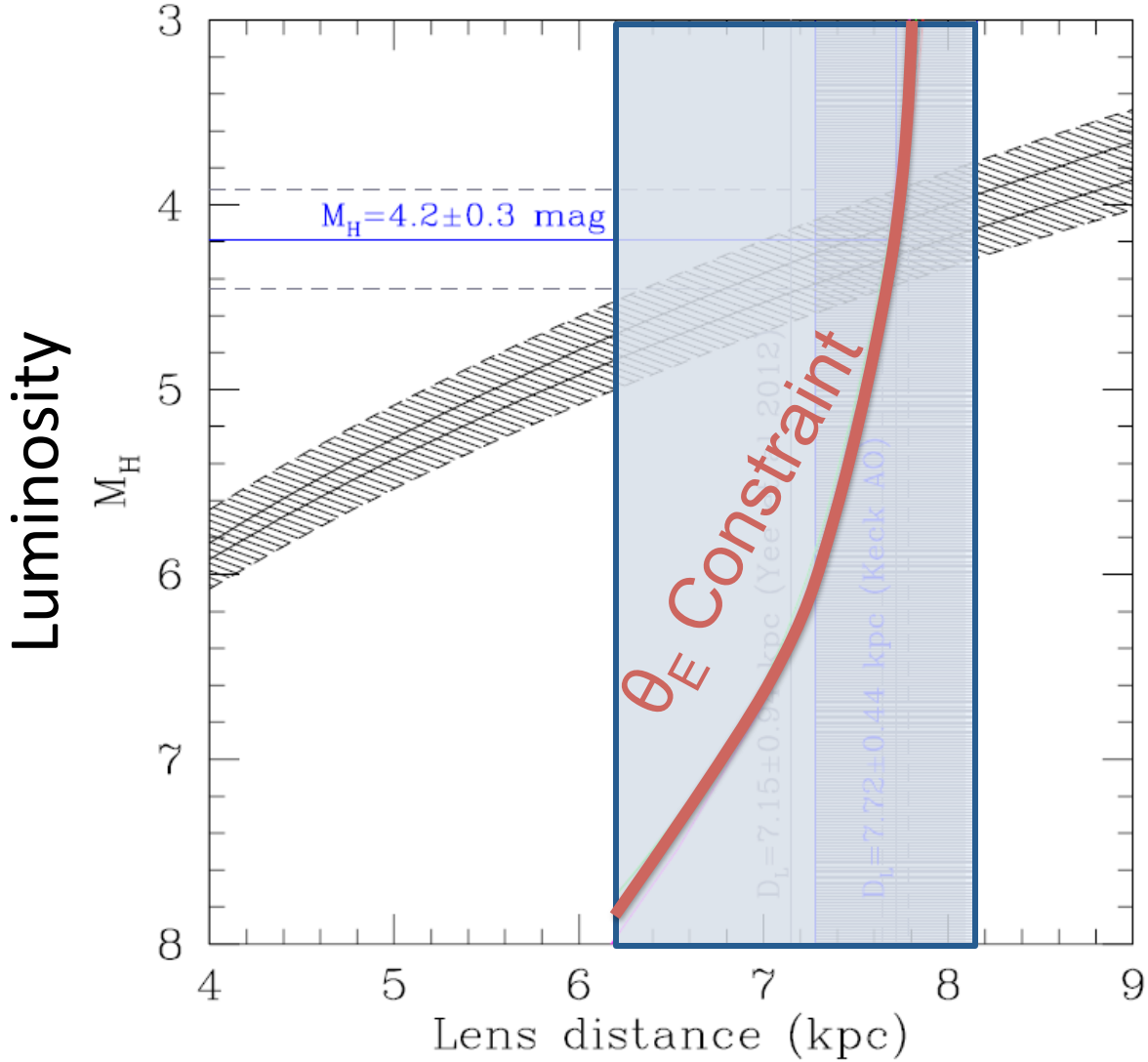

Distance

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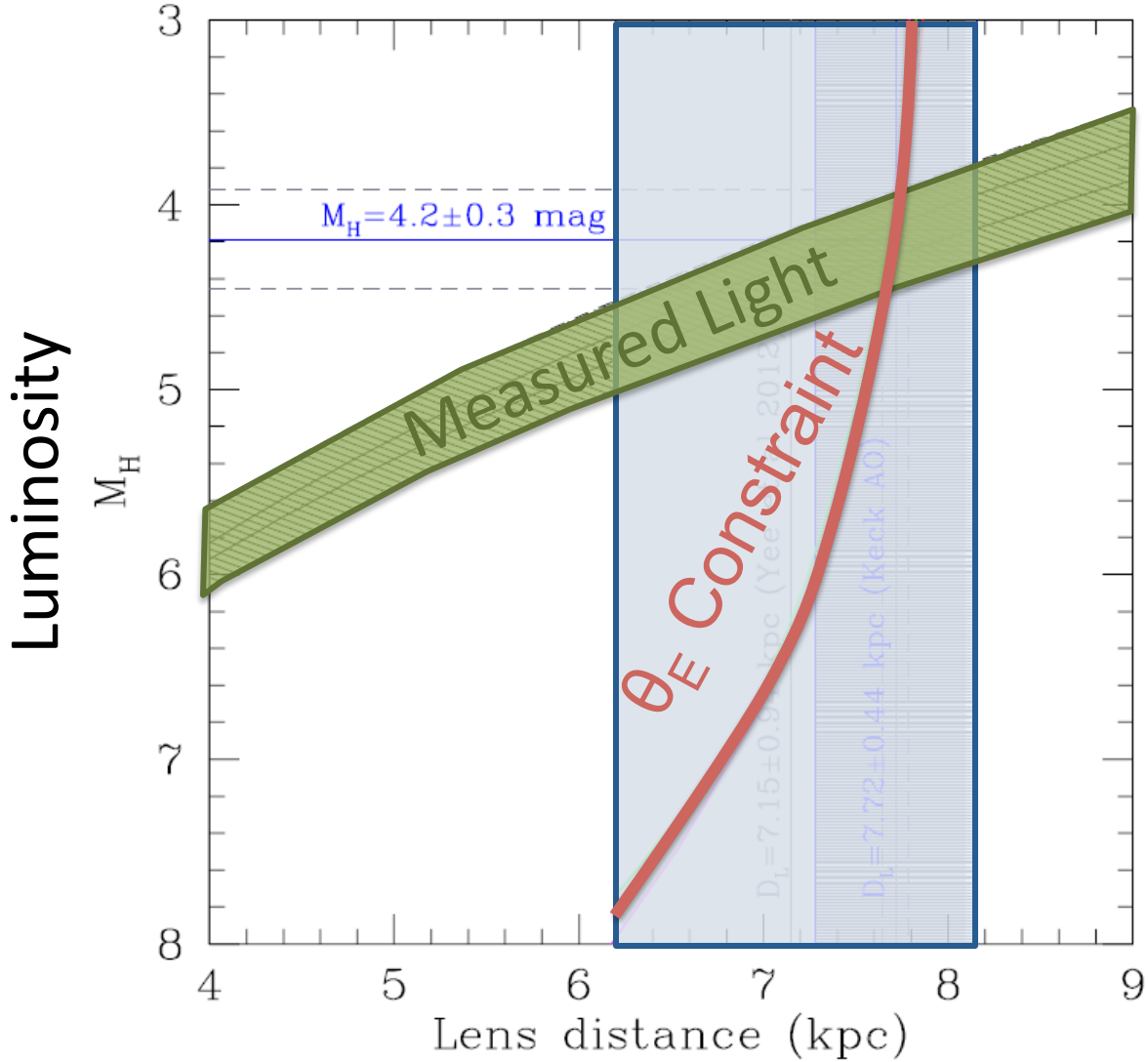

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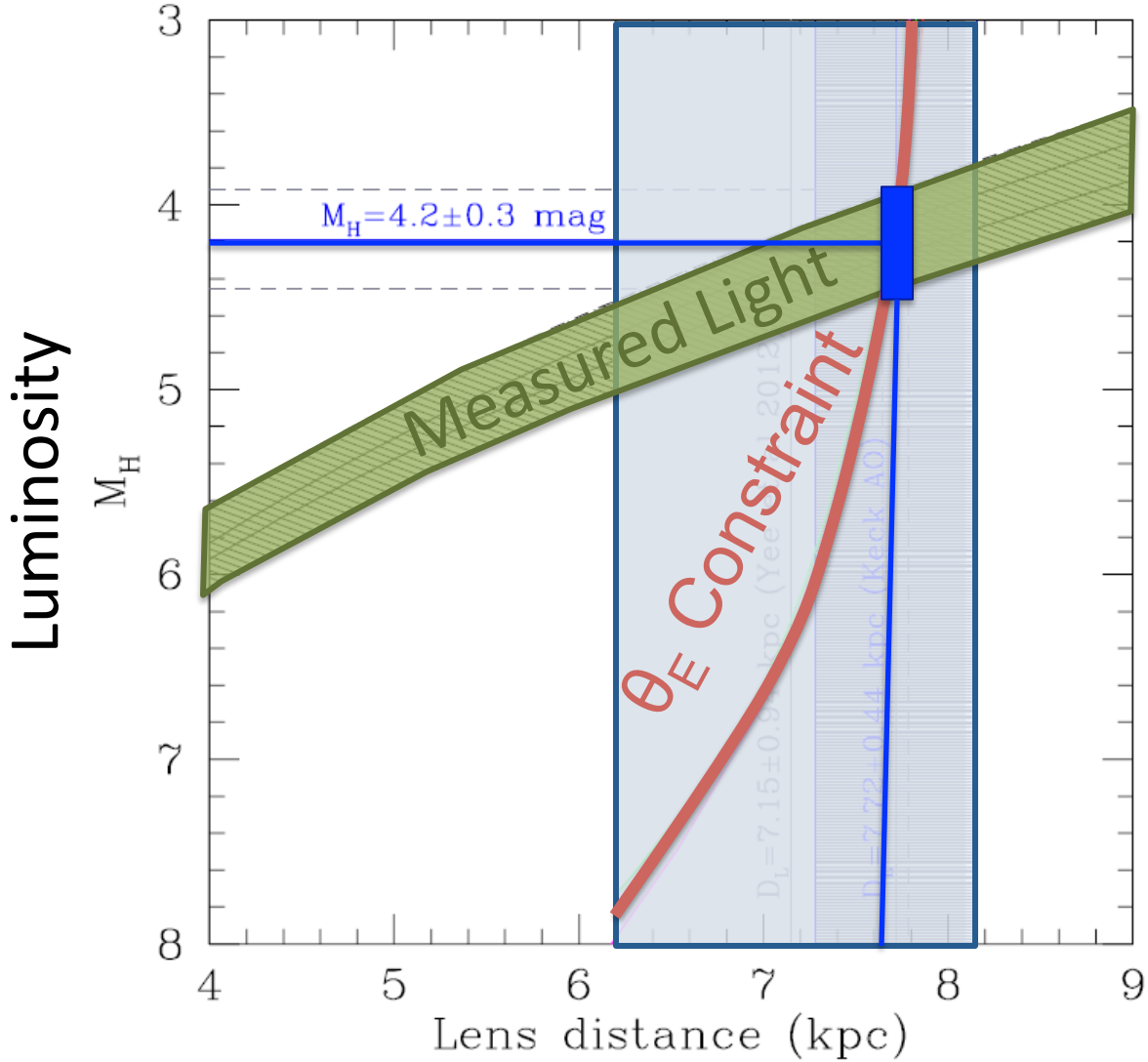

Distance

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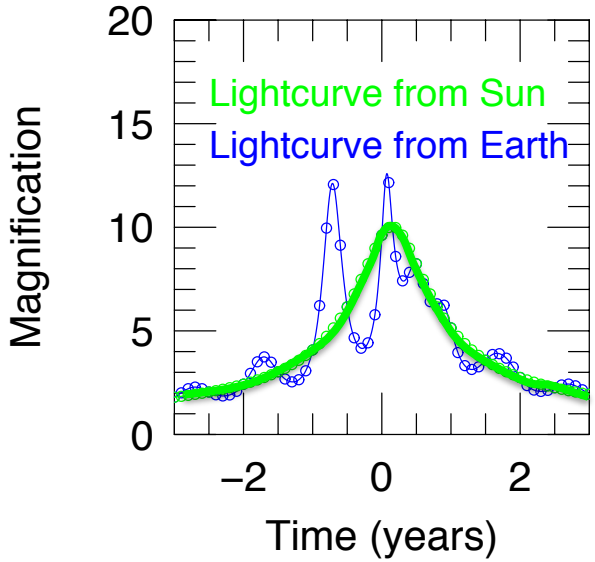
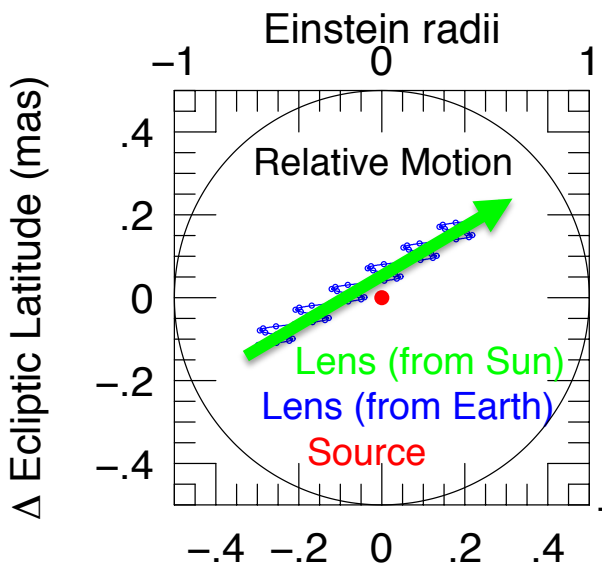
2. Microlens Parallax





Gould & Horne 2013, ApJ, 779, 28

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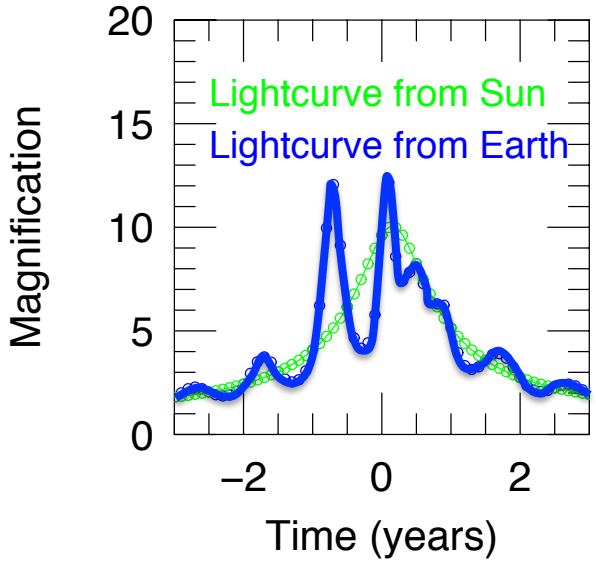

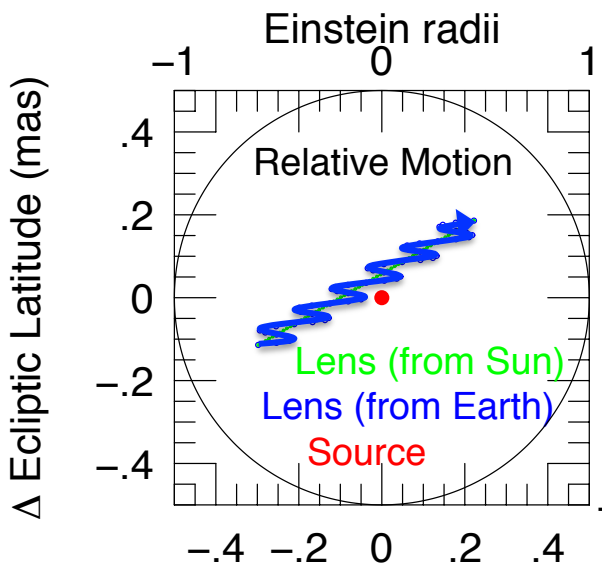

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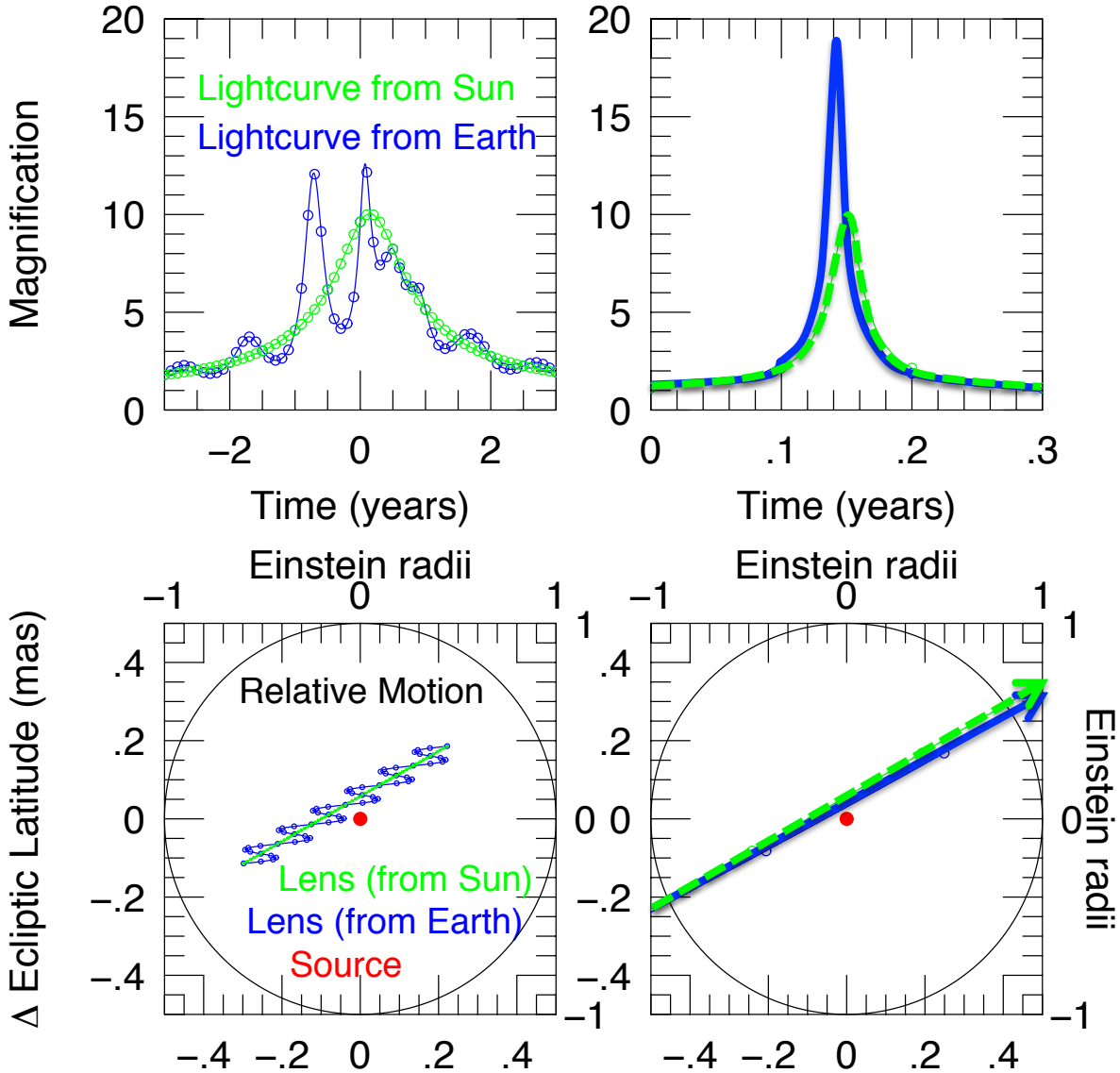

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2. Microlens Parallax

$$M_{star} = \theta_E / (\kappa \pi_E)$$

κ = constant

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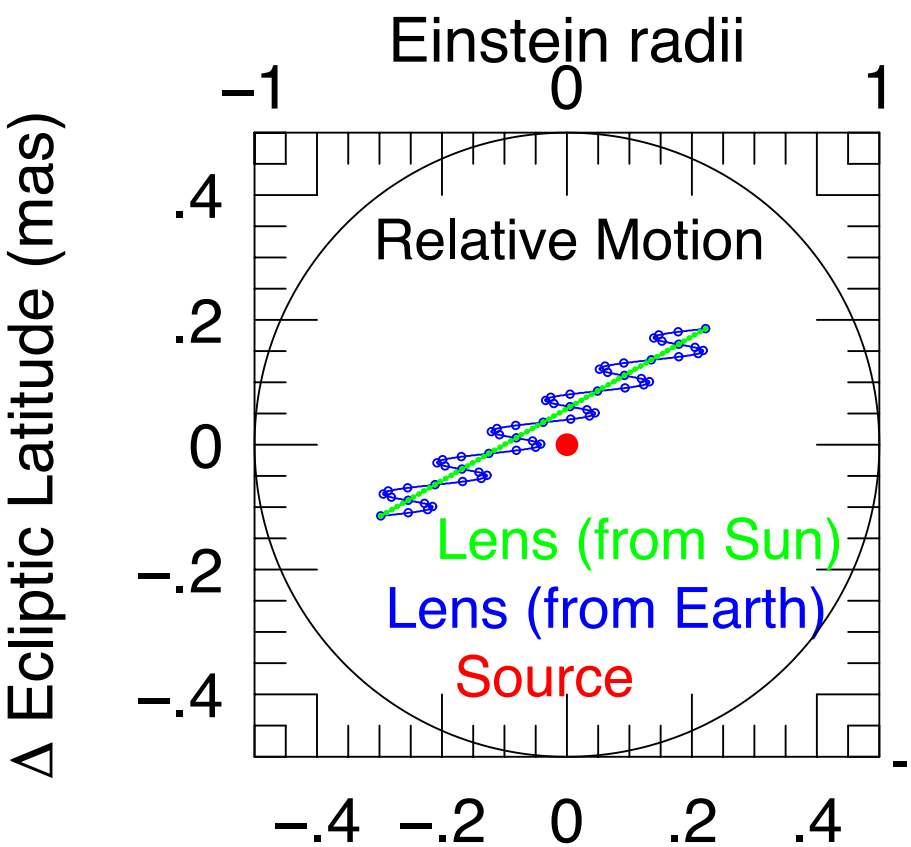
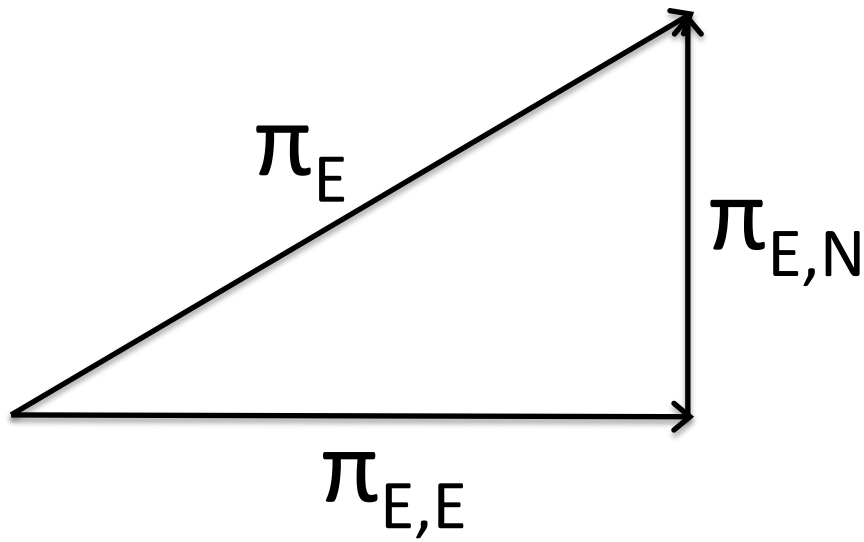
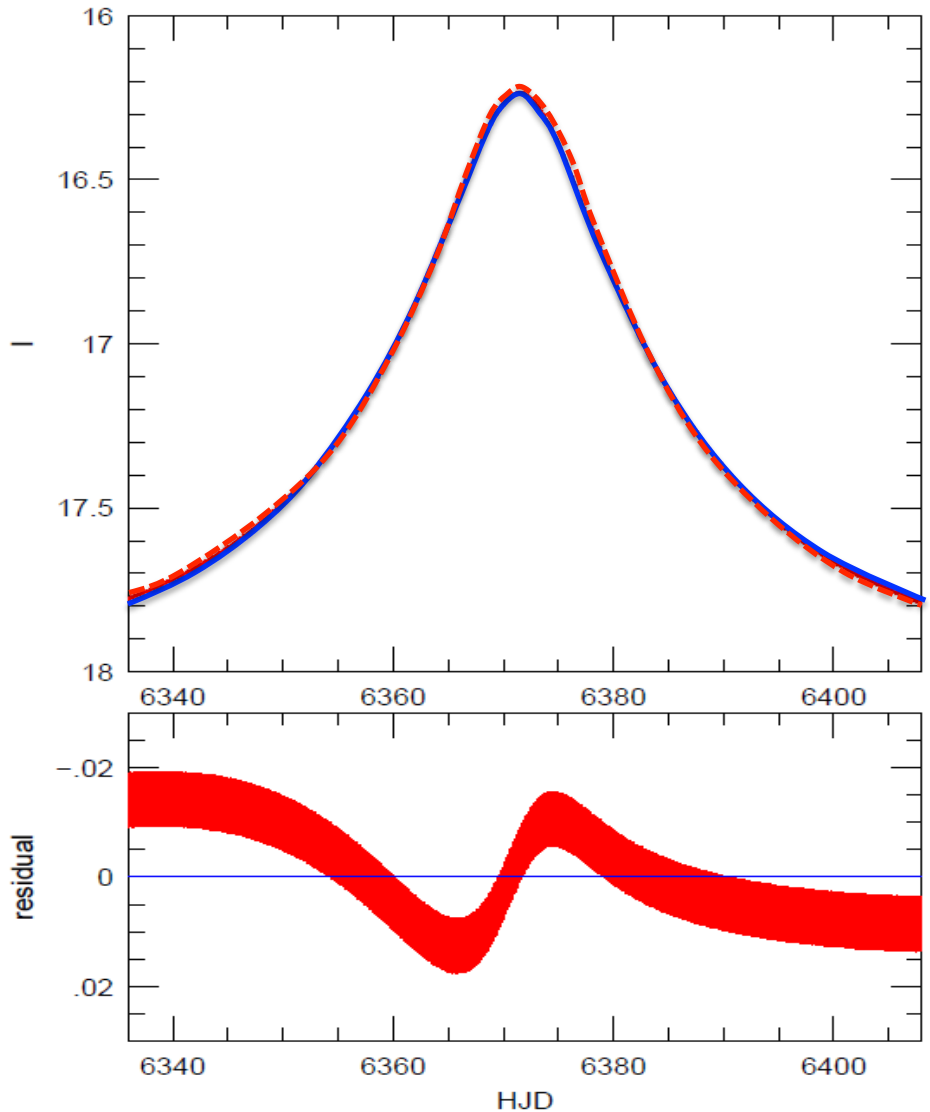
Microlens parallax is a vector.



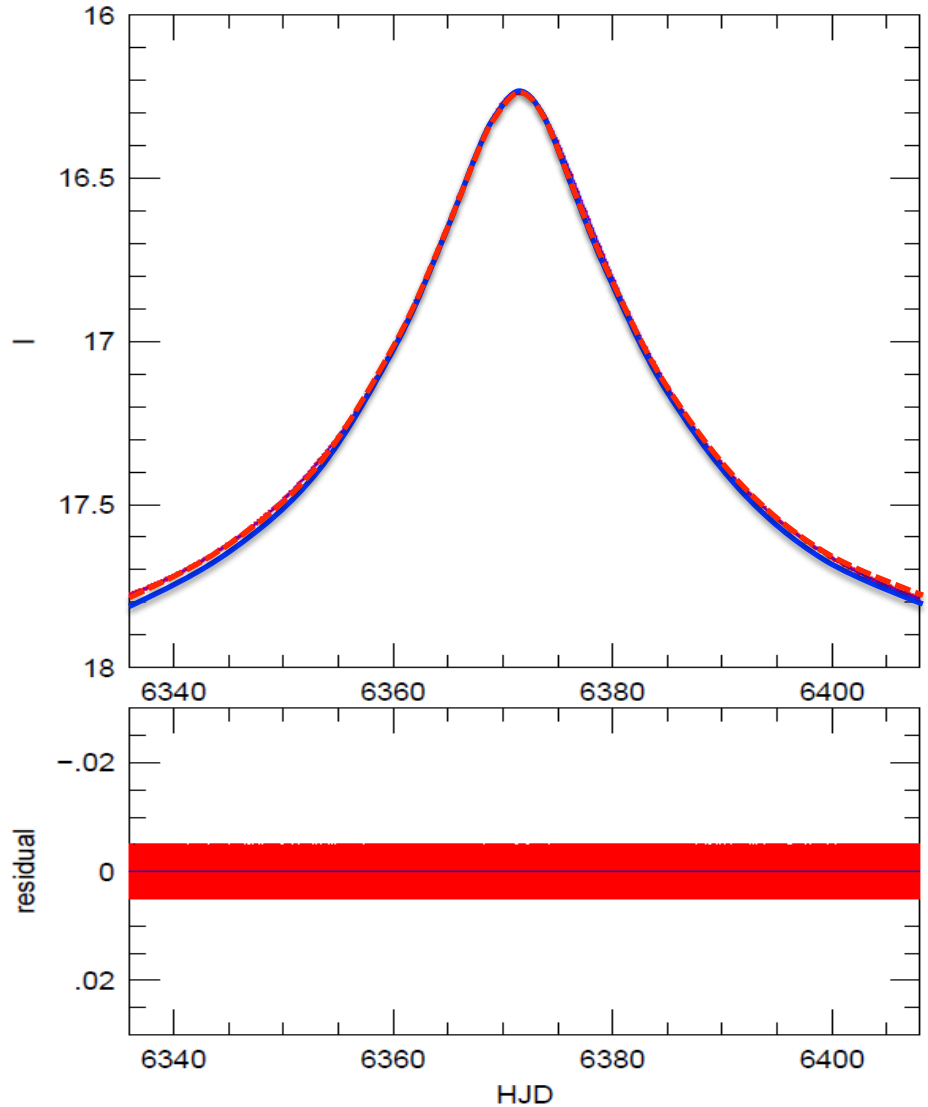


Gould & Horne 2013, ApJ, 779, 28

Component PARALLEL to Sun ➔ ASYMMETRIC Distortion

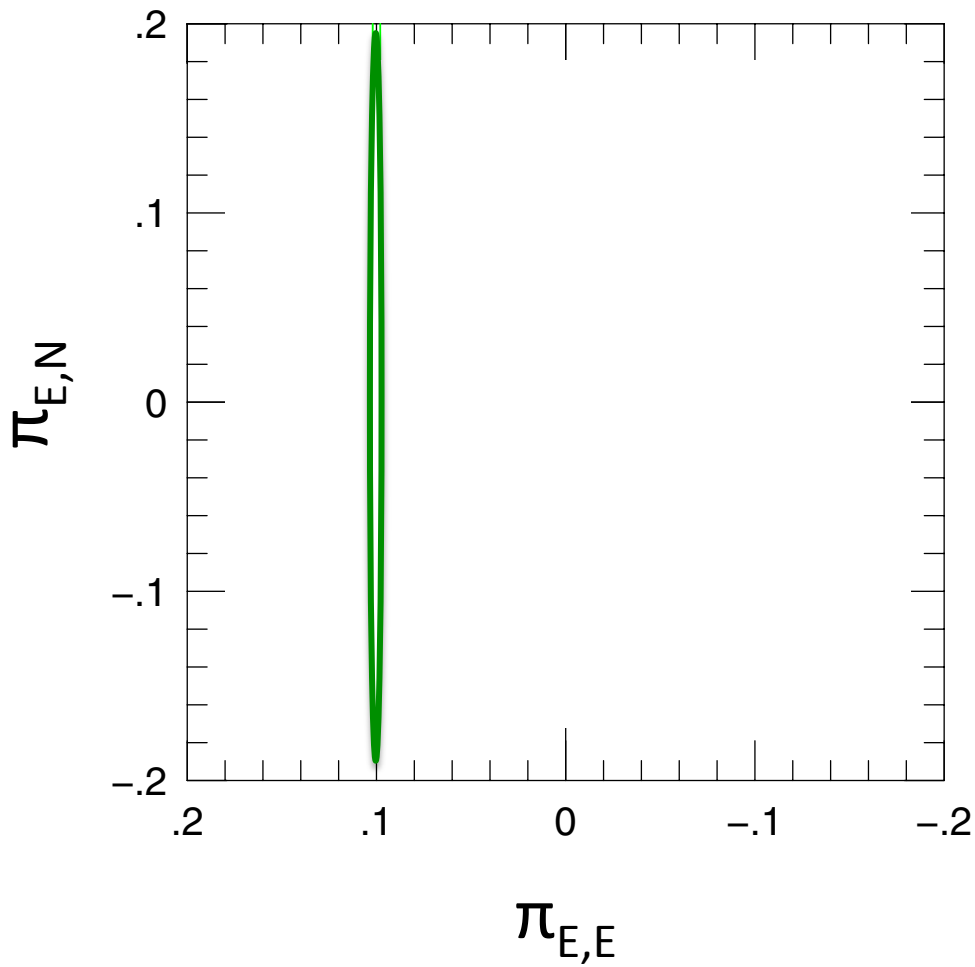


Component PERPENDICULAR to the Sun ➔ SYMMETRIC Distortion



2. Microlens Parallax

$\pi_{E,E}$ is much better measured than $\pi_{E,N}$.



Gould 2013, ApJL, 763, 35

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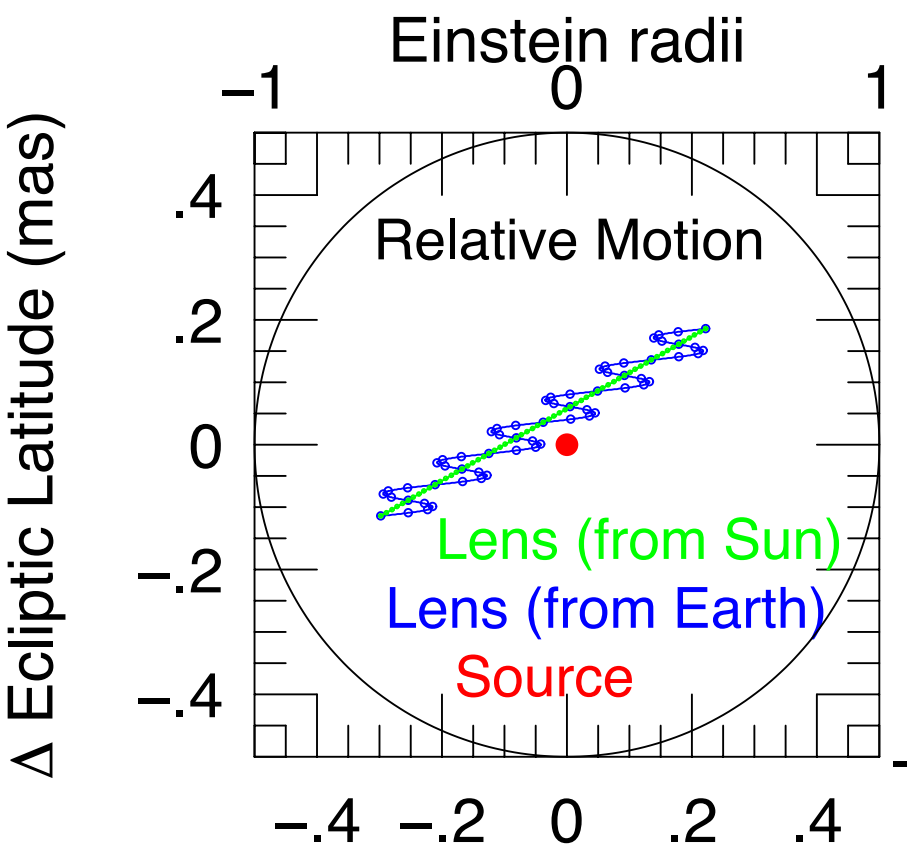

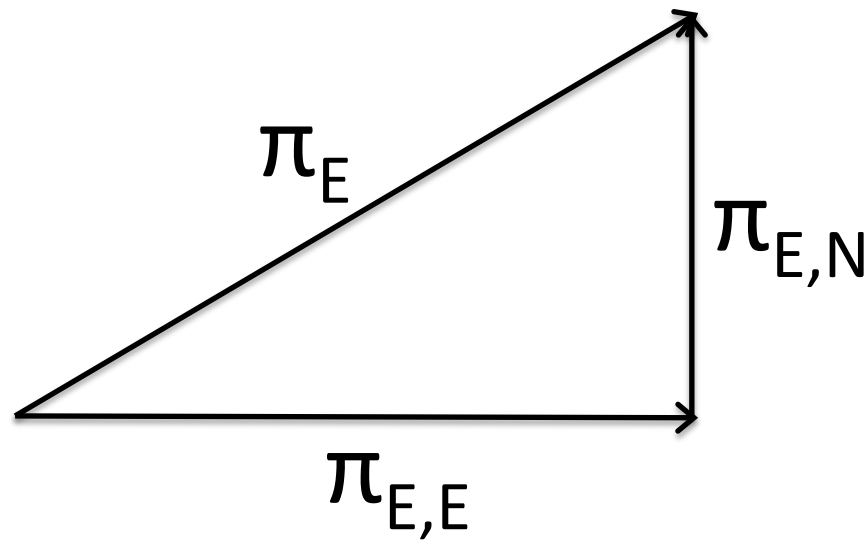

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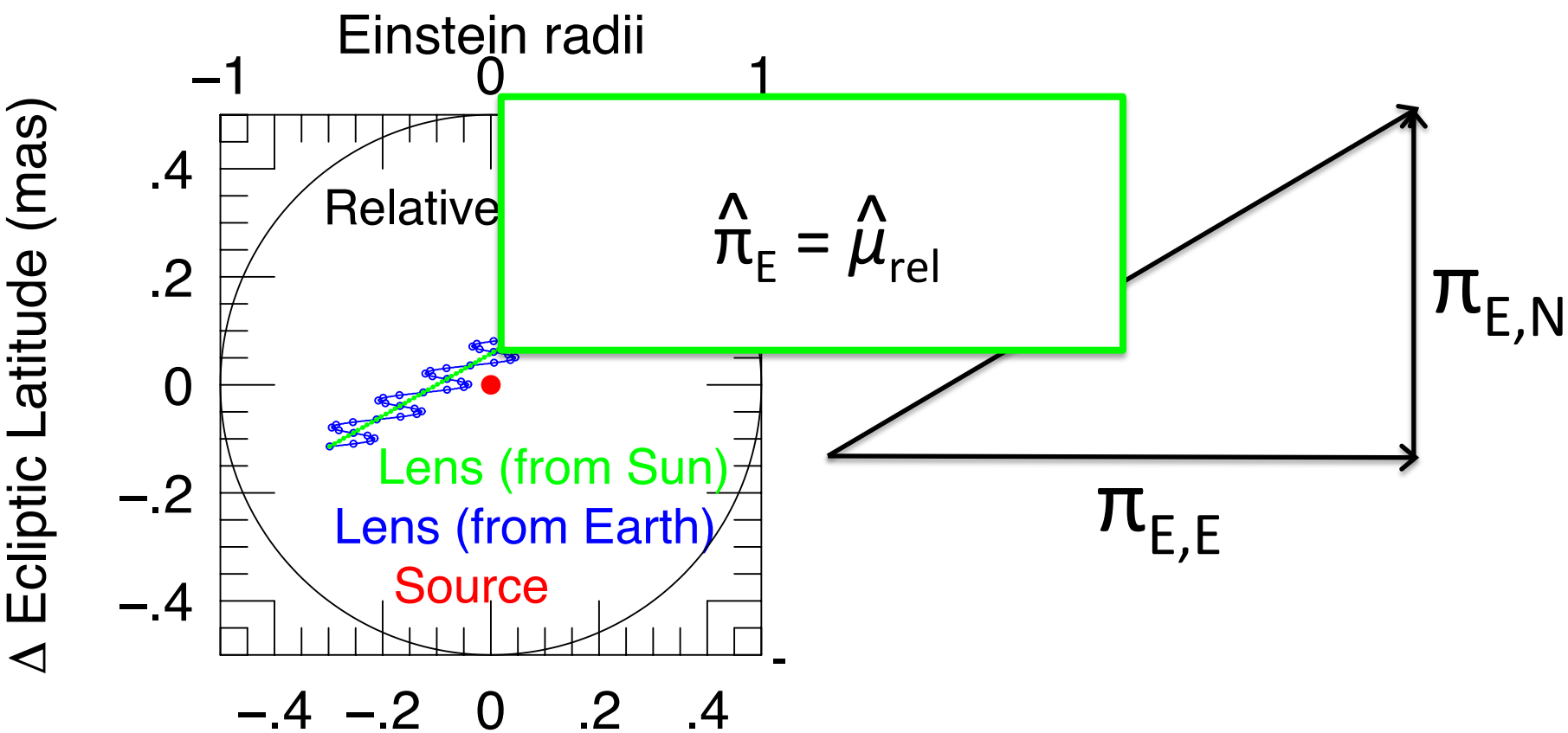

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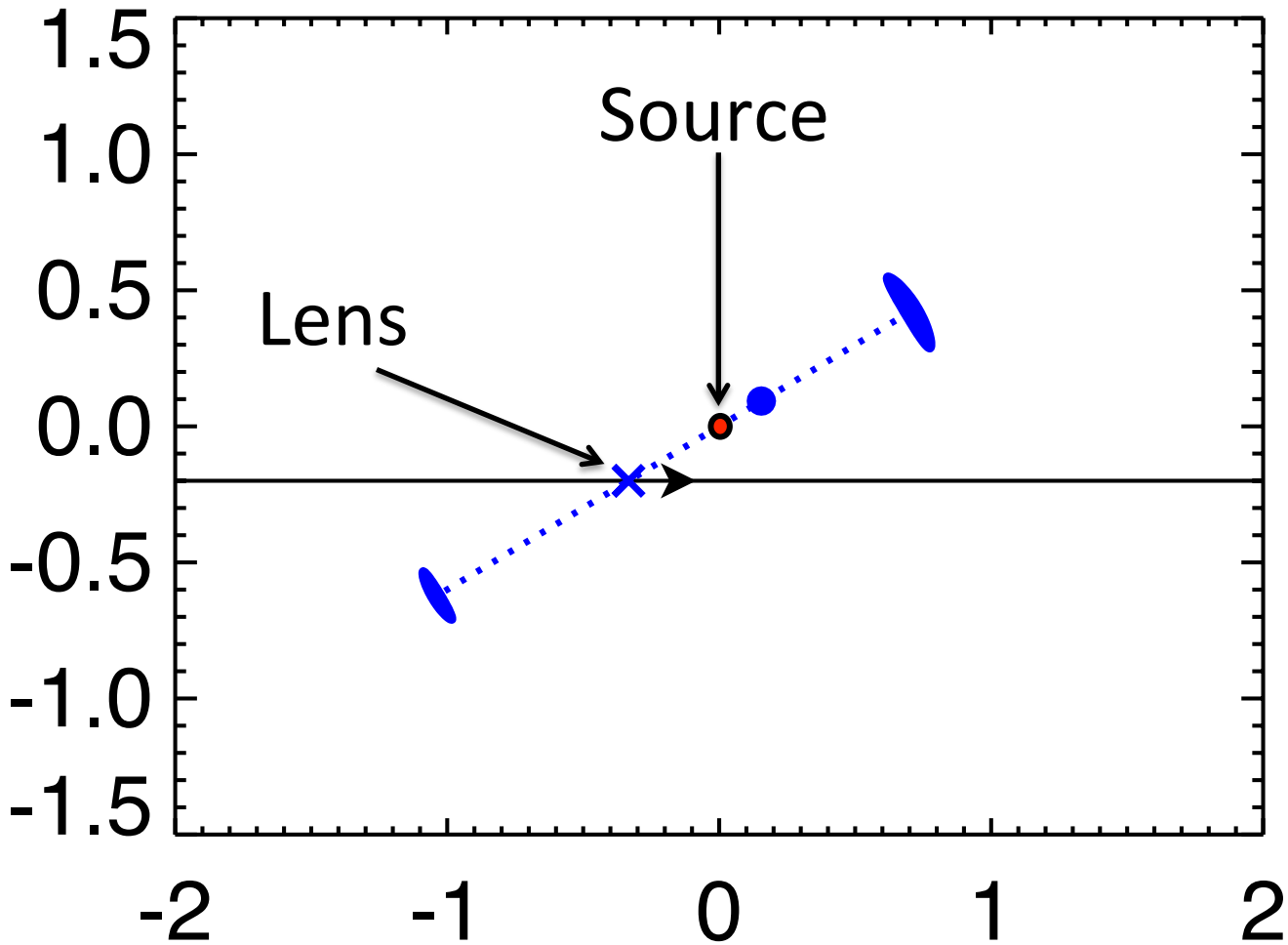
3. Astrometric Microlensing



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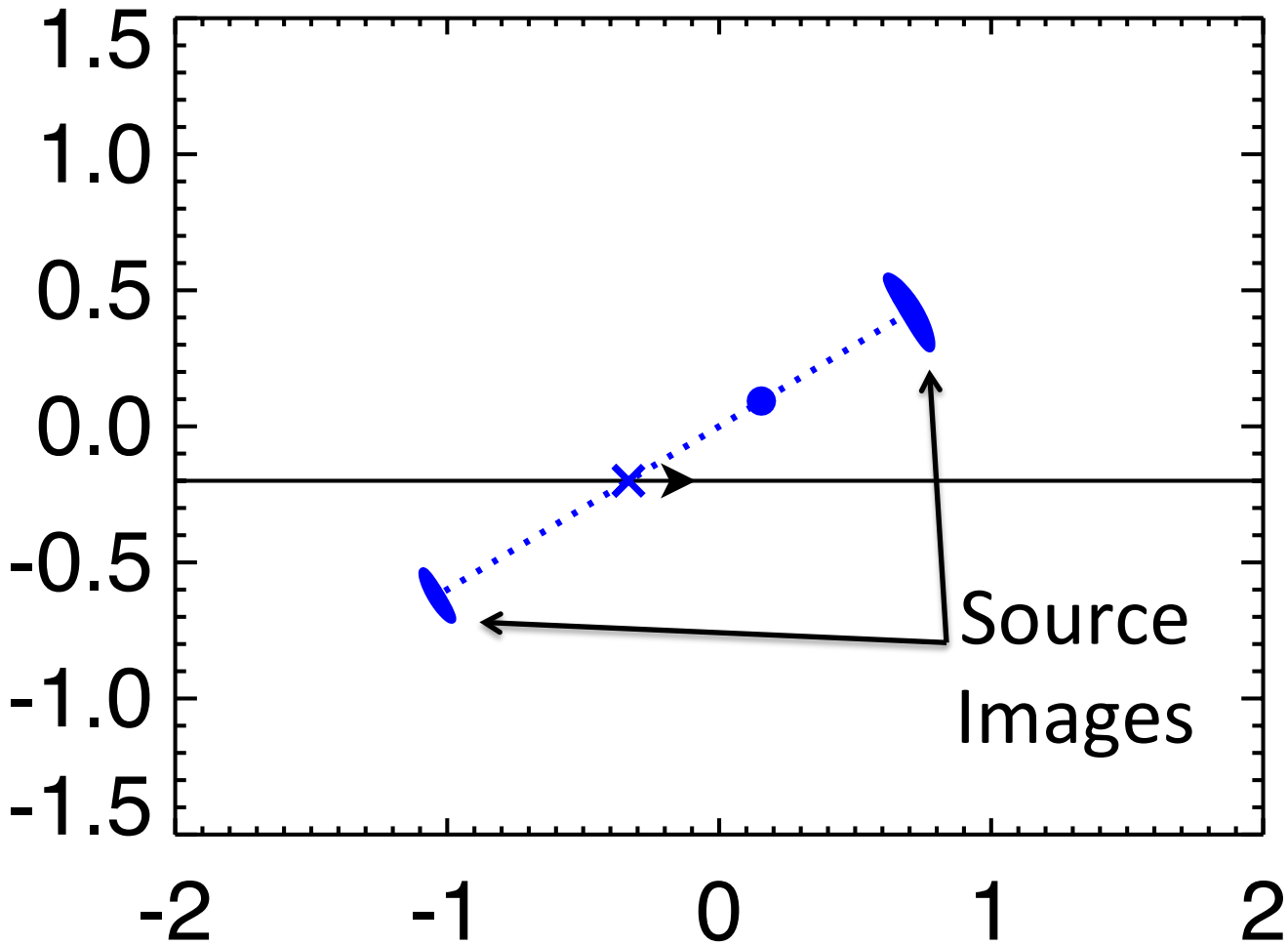

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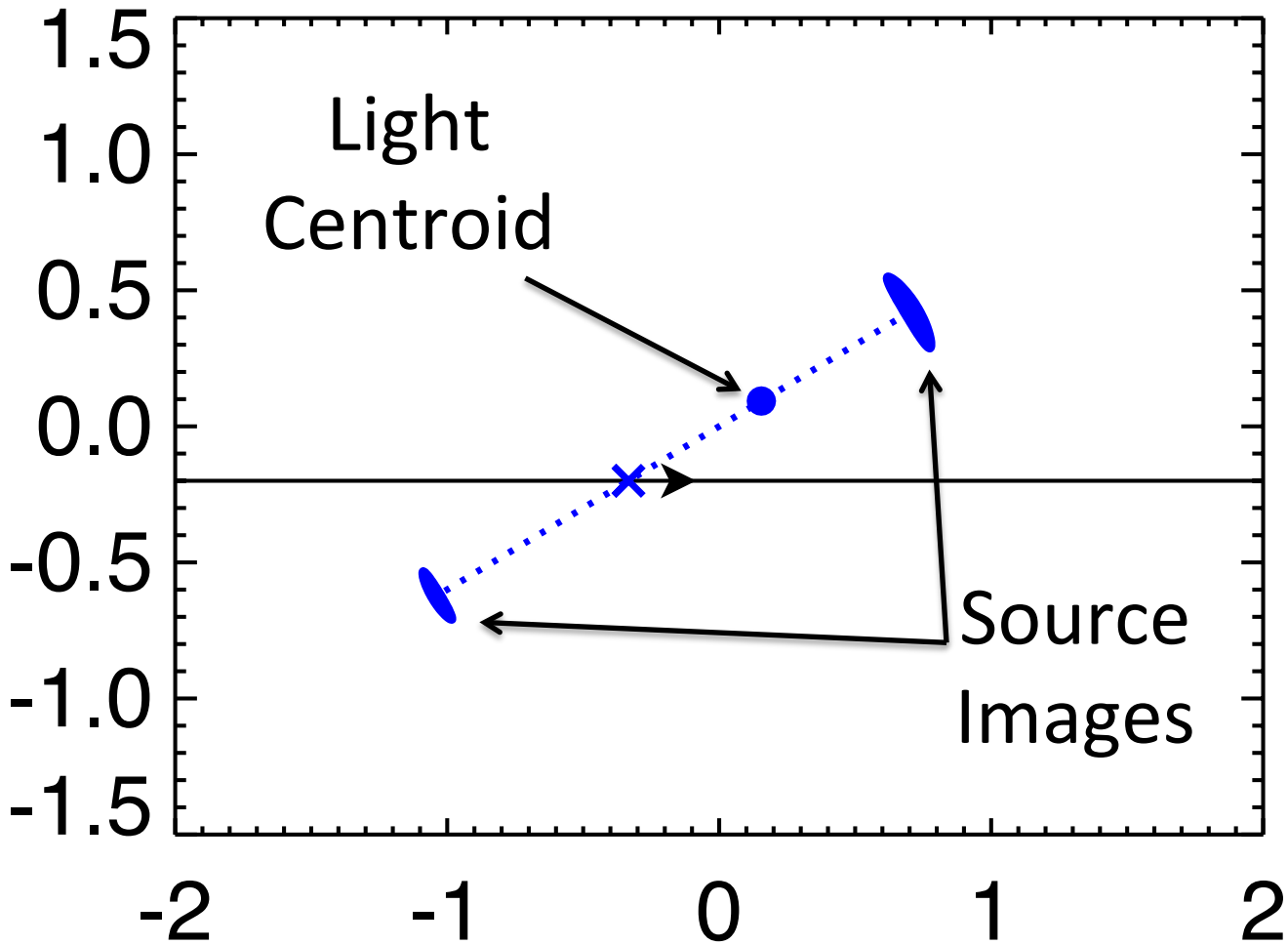

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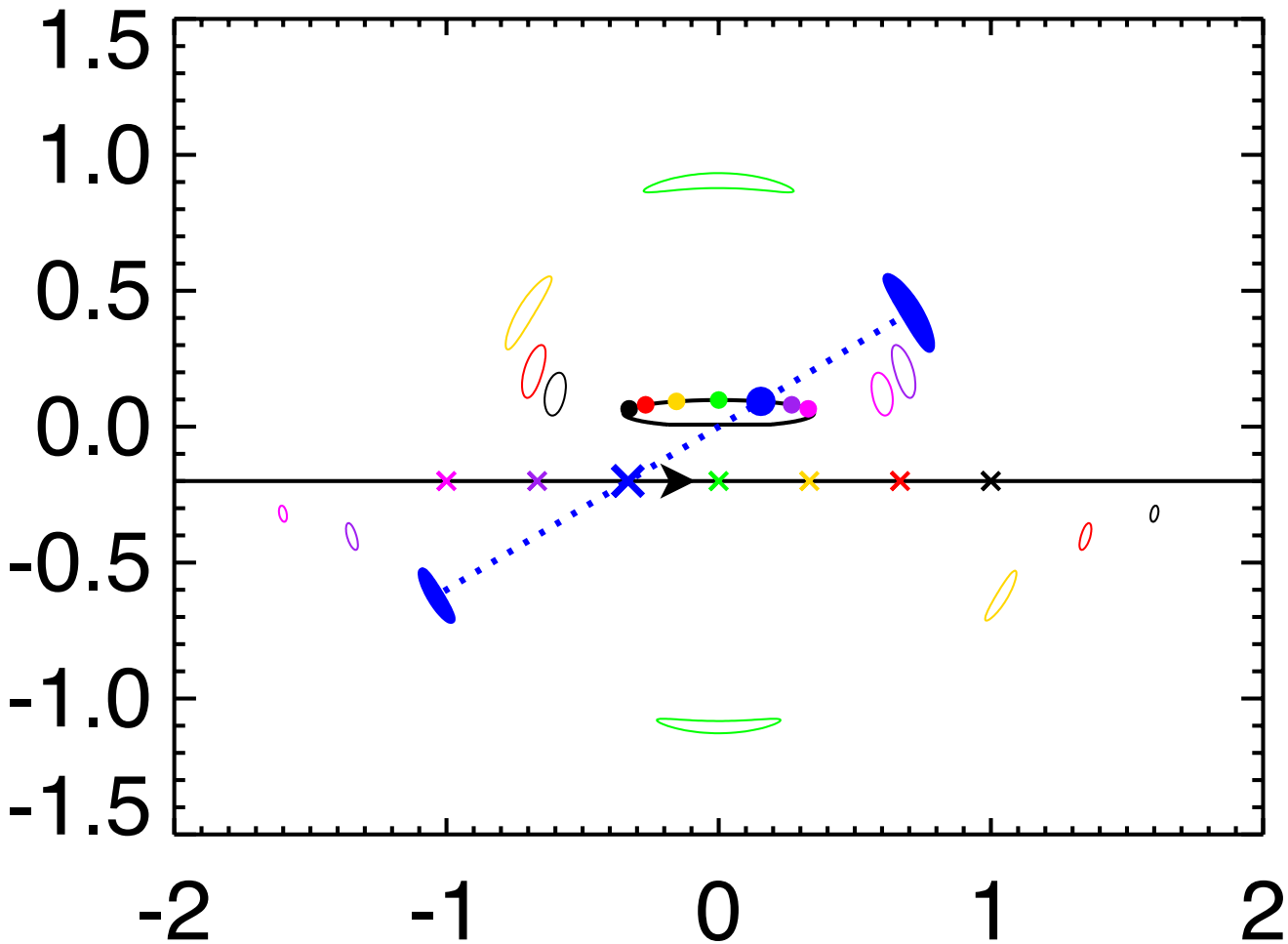

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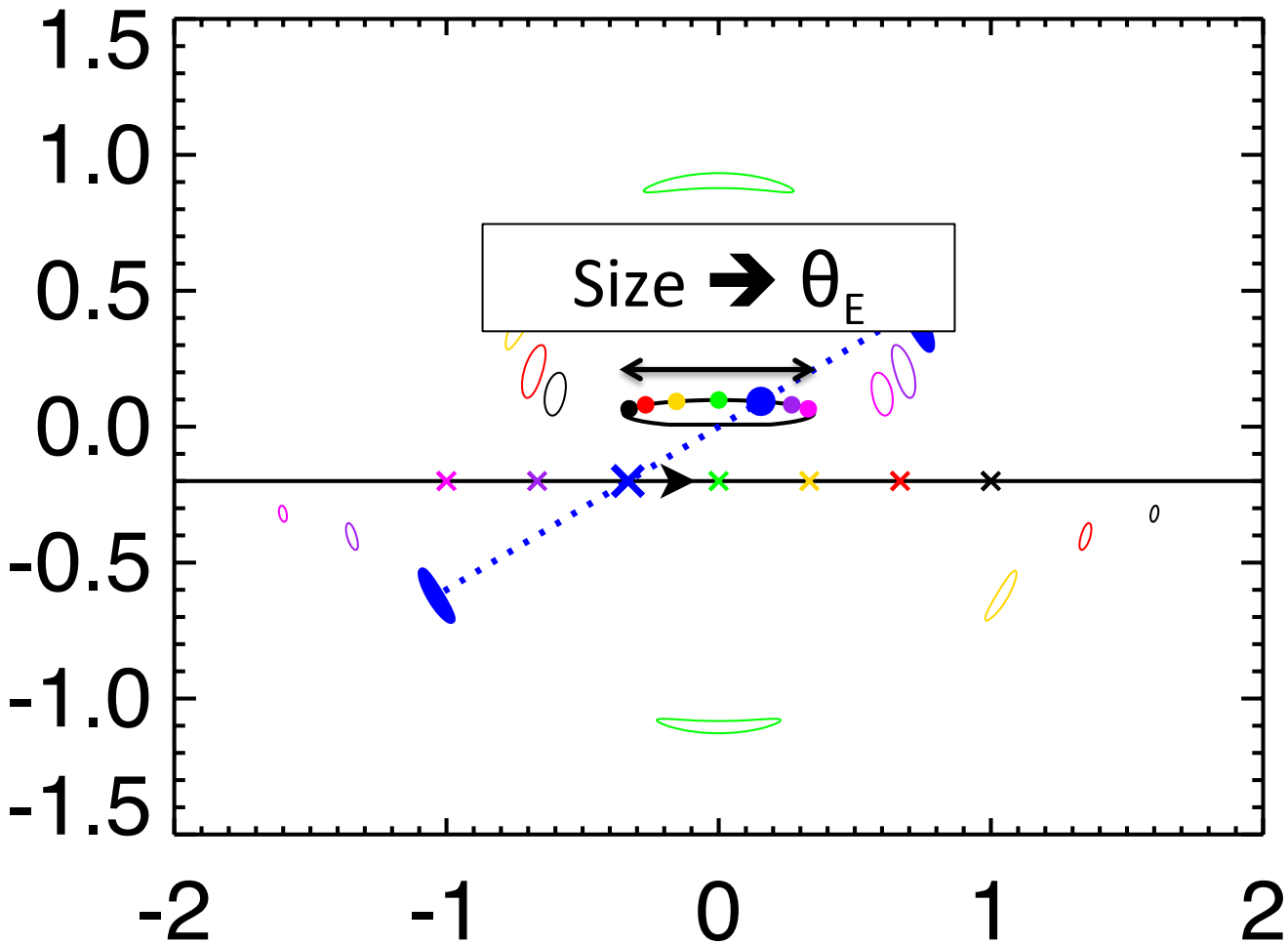

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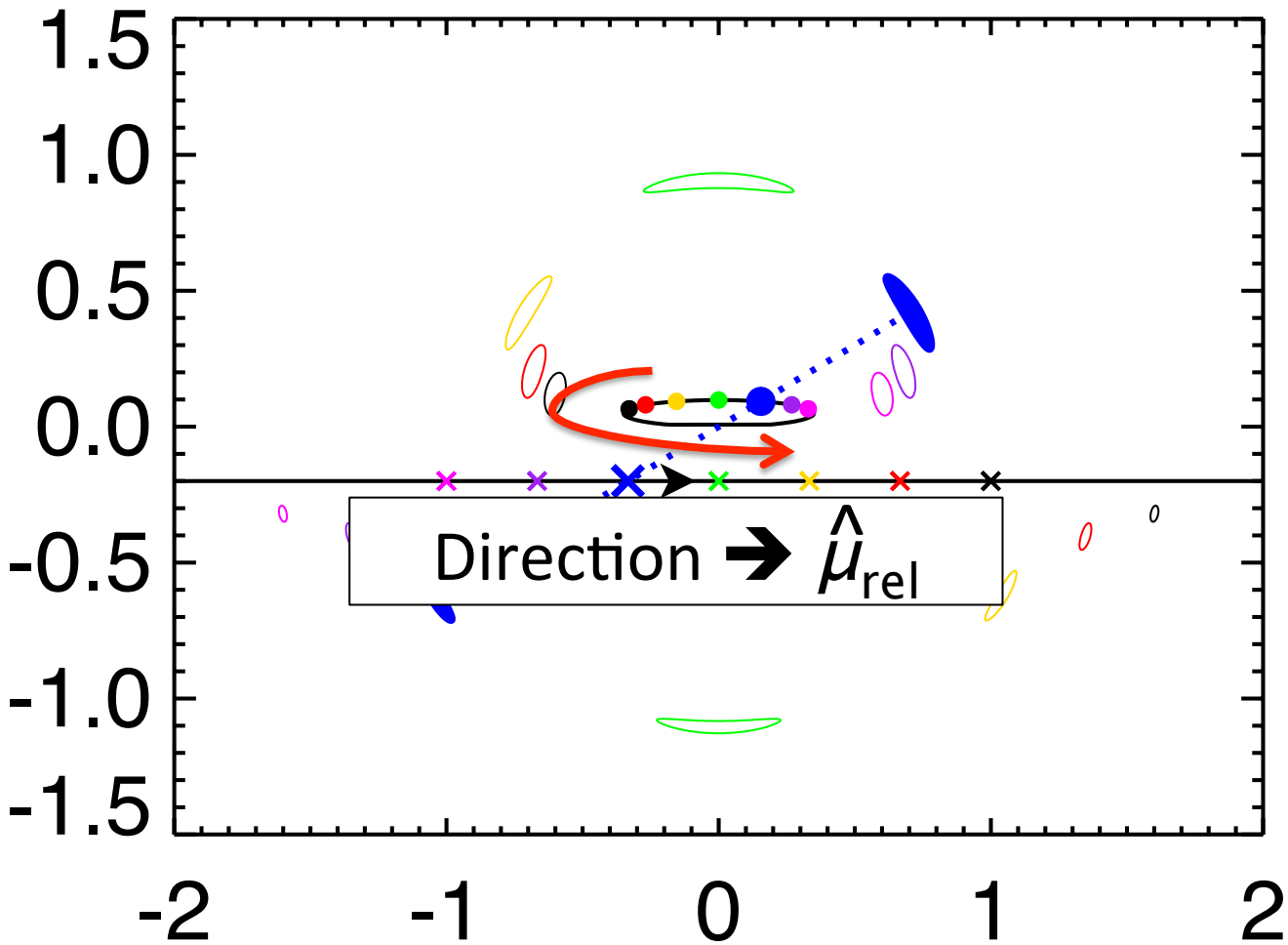
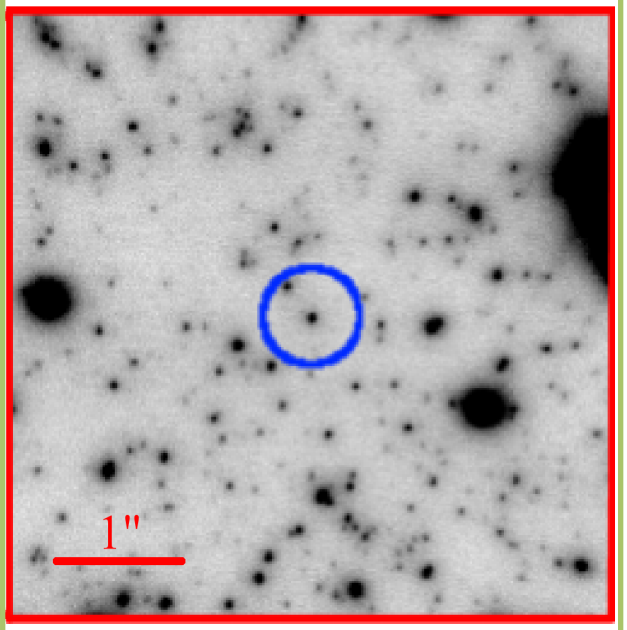
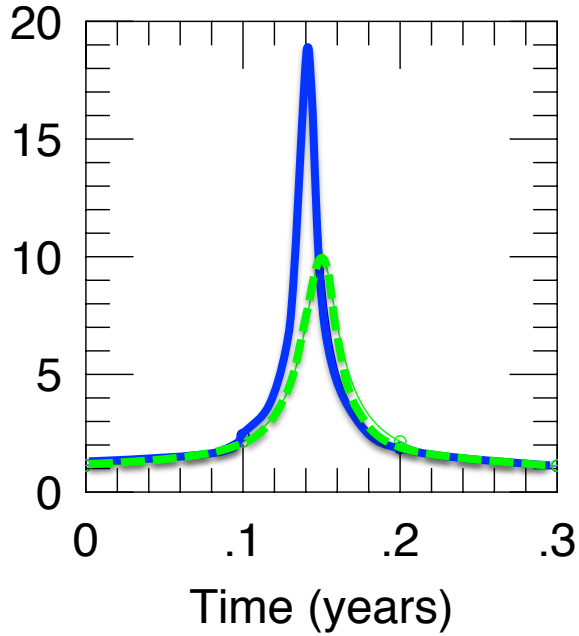


Three Techniques to Measure Mass

Lens Flux



Parallax



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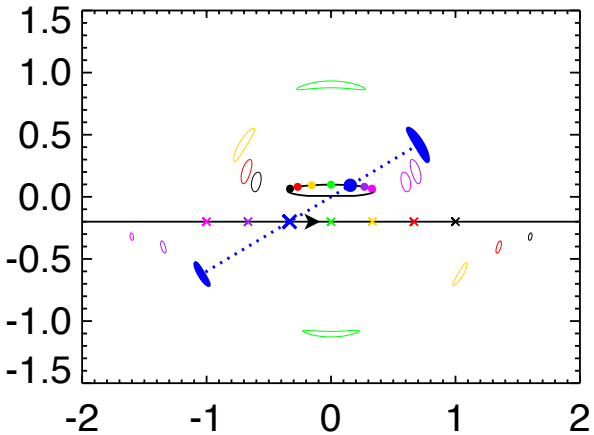

Uses for Lens Mass Measurements

- Measuring true planet masses
- Measuring masses for faint or dark objects (e.g. brown dwarfs and black holes)
- Measuring the galactic distribution of planets (measured lens masses also give distances to the lens systems)