Astronomers Map Out Dark Matter in Massive Galaxies

David Pooley
Eureka Scientific
davepooley@me.com
(617) 230-1098

Key collaborators:
Paul Schechter (MIT)
Saul Rappaport (MIT)
Jeffrey Blackburne (Ohio State)

Dark Matter:

- accounts for nearly ¼ of universe
- direct evidence of its existence is scant
- properties and distribution are largely unknown
  - nature of dark matter
  - galaxy evolution

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New technique: Chandra X-ray observations of gravitational lenses

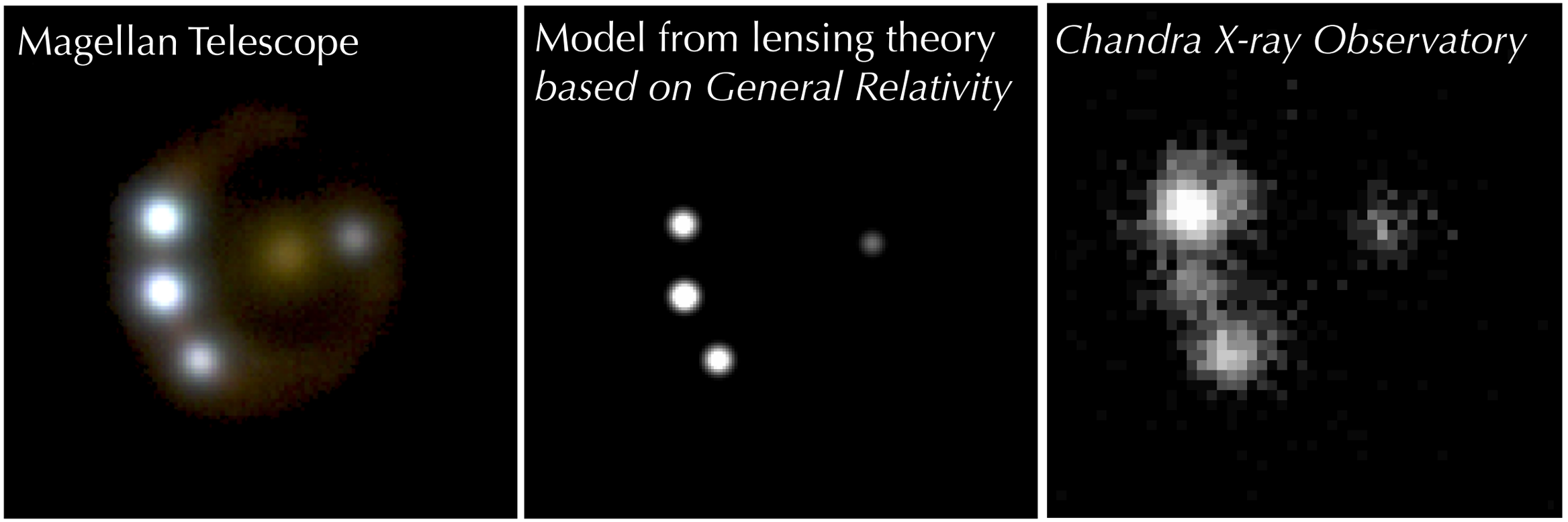
Clean, direct, independent method to measure amount of dark matter at specific locations **within** a galaxy (cf. "weak lensing" helps measure dark matter *between* galaxies in a cluster)

At distances of 15,000 to 25,000 light years (5 to 8 kiloparsecs), these galaxies contain 85% – 95% dark matter (in projection).

Distance of Solar System from center of Milky Way: ~25,000 light years

Strong anomalies are observed with *Chandra*

RXJ 1131–1231



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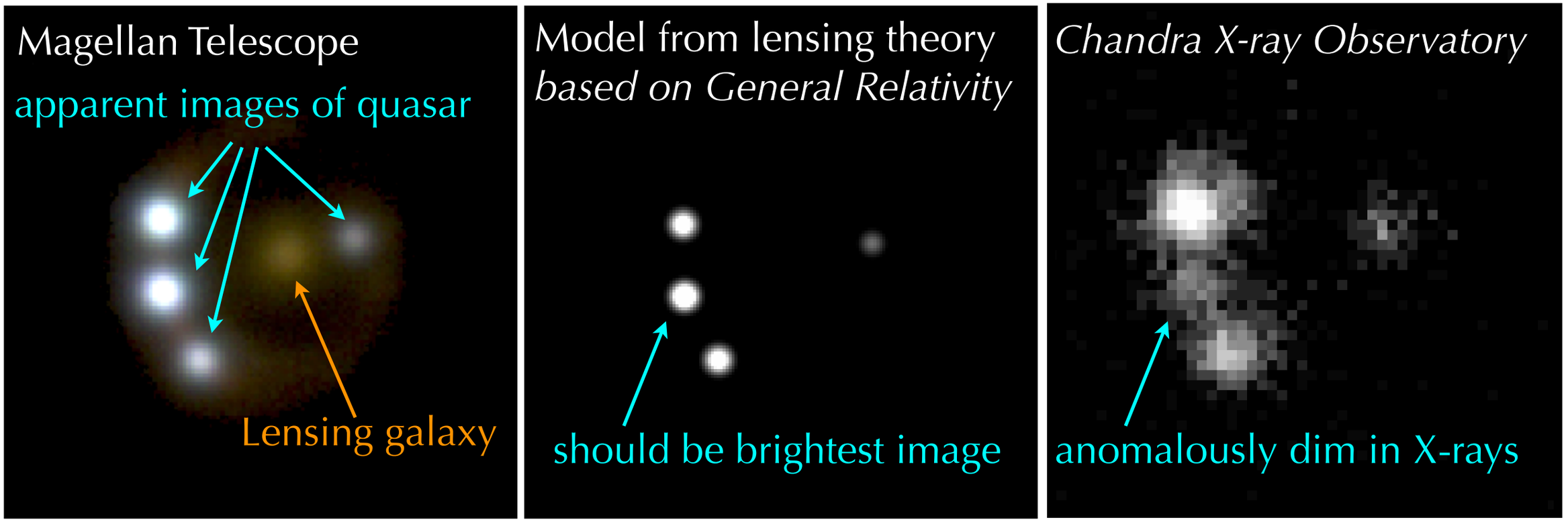


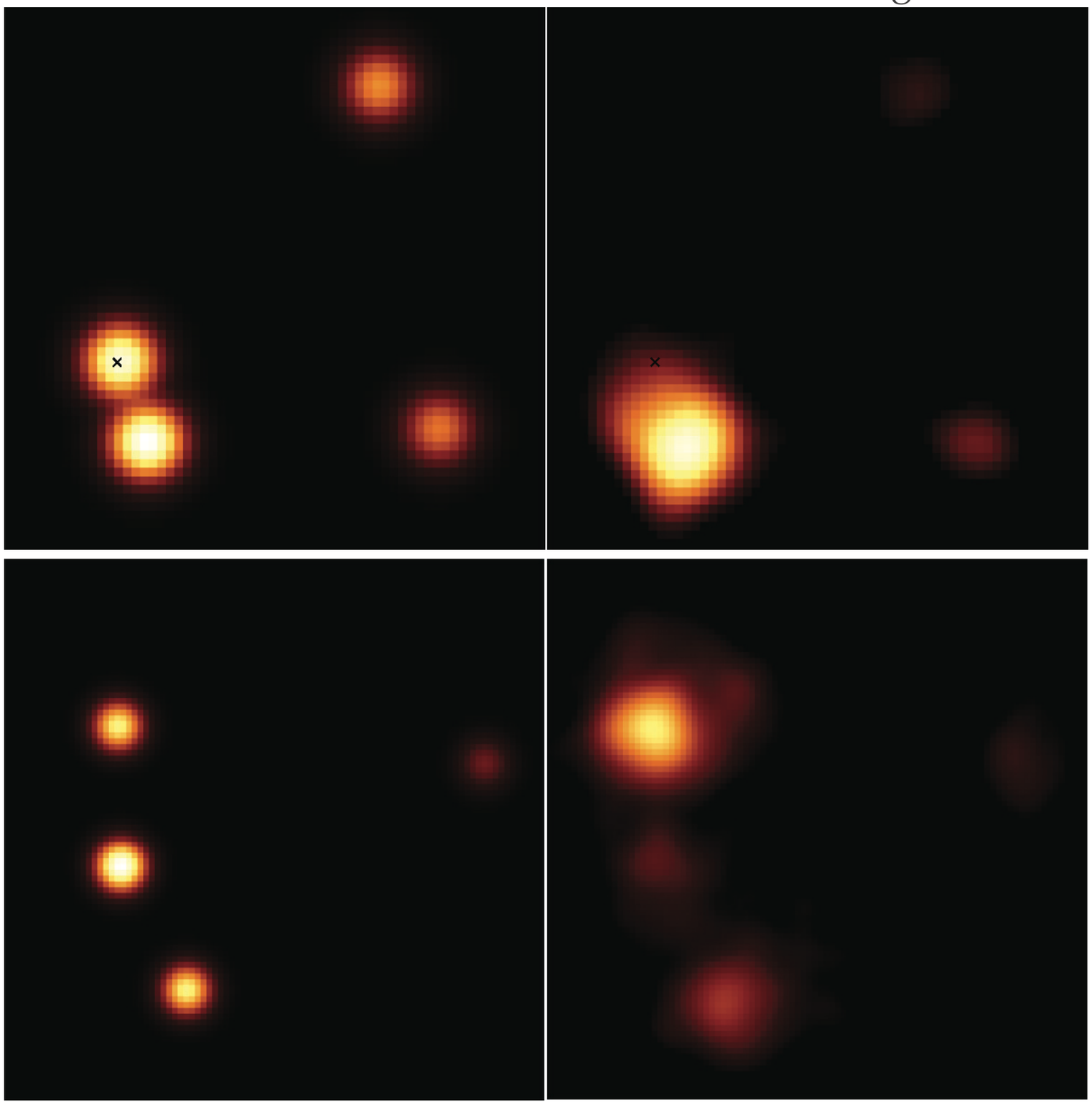
Strong anomalies are observed with *Chandra*

Model

Chandra image

PG 1115–080

RXJ 1131–1231



Anomalies are caused by stars in the lensing galaxy

(called “microlensing” in literature)

Model of galaxy based on lensing theory (General Relativity)
tells you **how much** matter, not **what kind**.

Galaxy of 100% dark matter *will not* produce anomalies we see.

Galaxy of 100% stars is *very unlikely* to produce anomalies we see.

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Galaxies are 85% – 95% dark matter at locations of lensed images

(typically 15,000 – 20,000 light years from center of lensing galaxy)

This is over 10× as likely as 97% – 99% dark matter.

This is over 5× as likely as 100% stars (no dark matter).

Based on *Chandra* observations of ensemble of 14 galaxies

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- Cleanest measurement of anomaly with *Chandra*
- Anomaly depends on composition of matter
- 85% – 95% dark matter at these distances
- Independent evidence for **existence** of dark matter

Questions? David Pooley
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This presentation, images, and scientific presentation (403.05) are at
http://www.deadlyastroninja.com/aas217/

Gravitational lenses: special (and rare) systems

A massive galaxy almost directly between us and a distant source.

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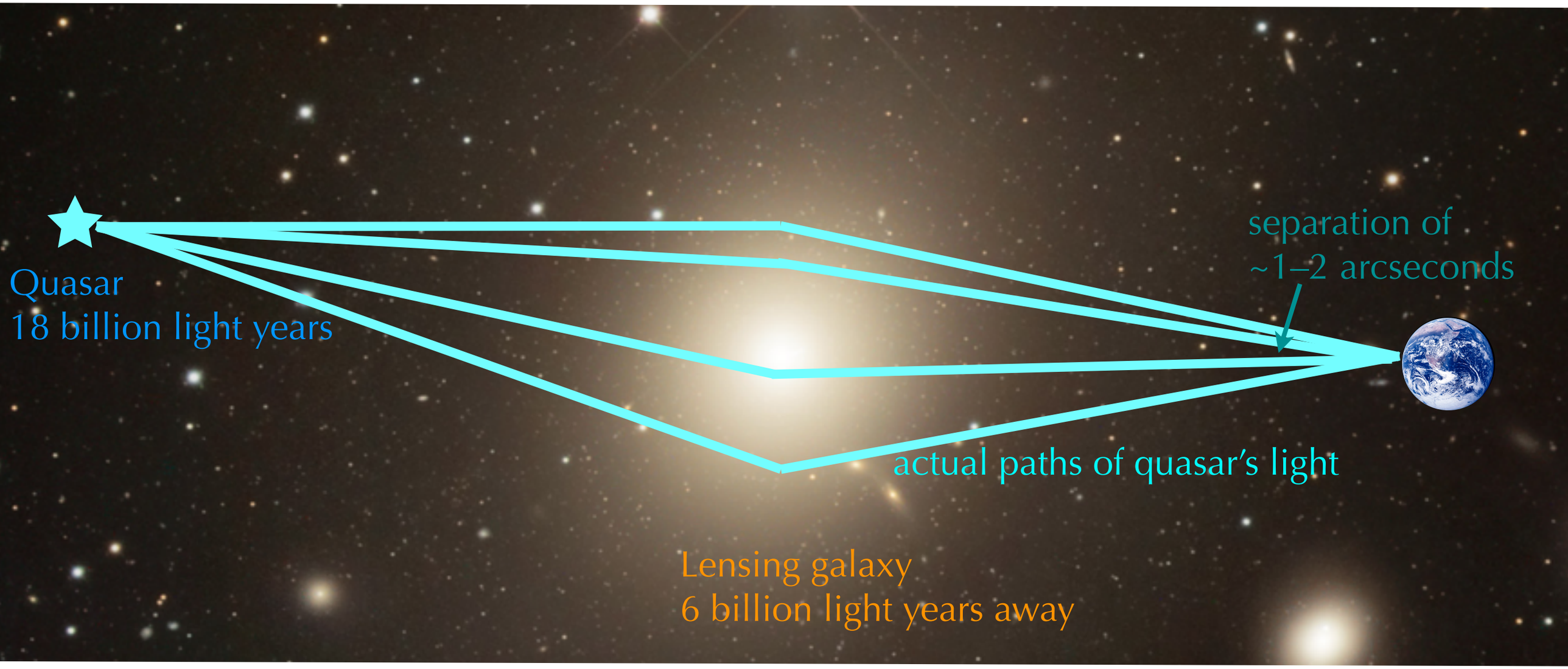

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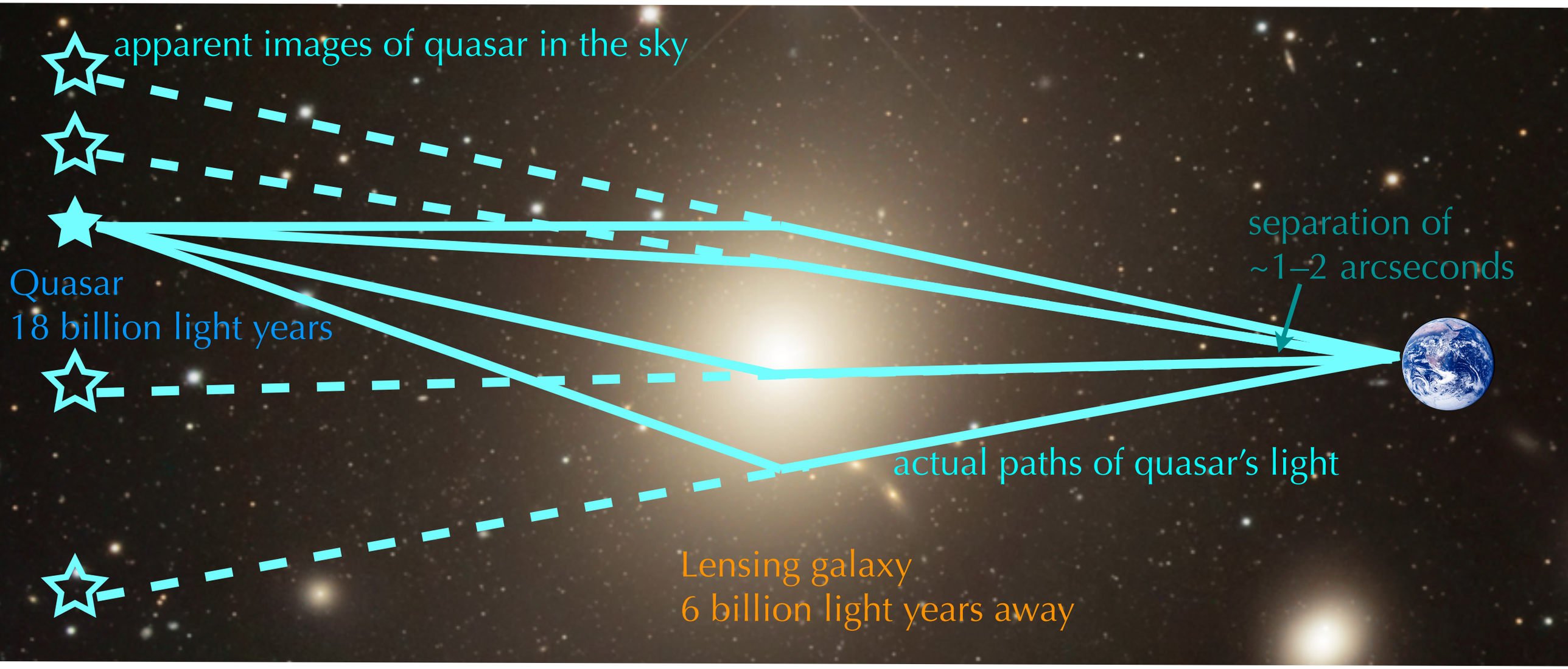

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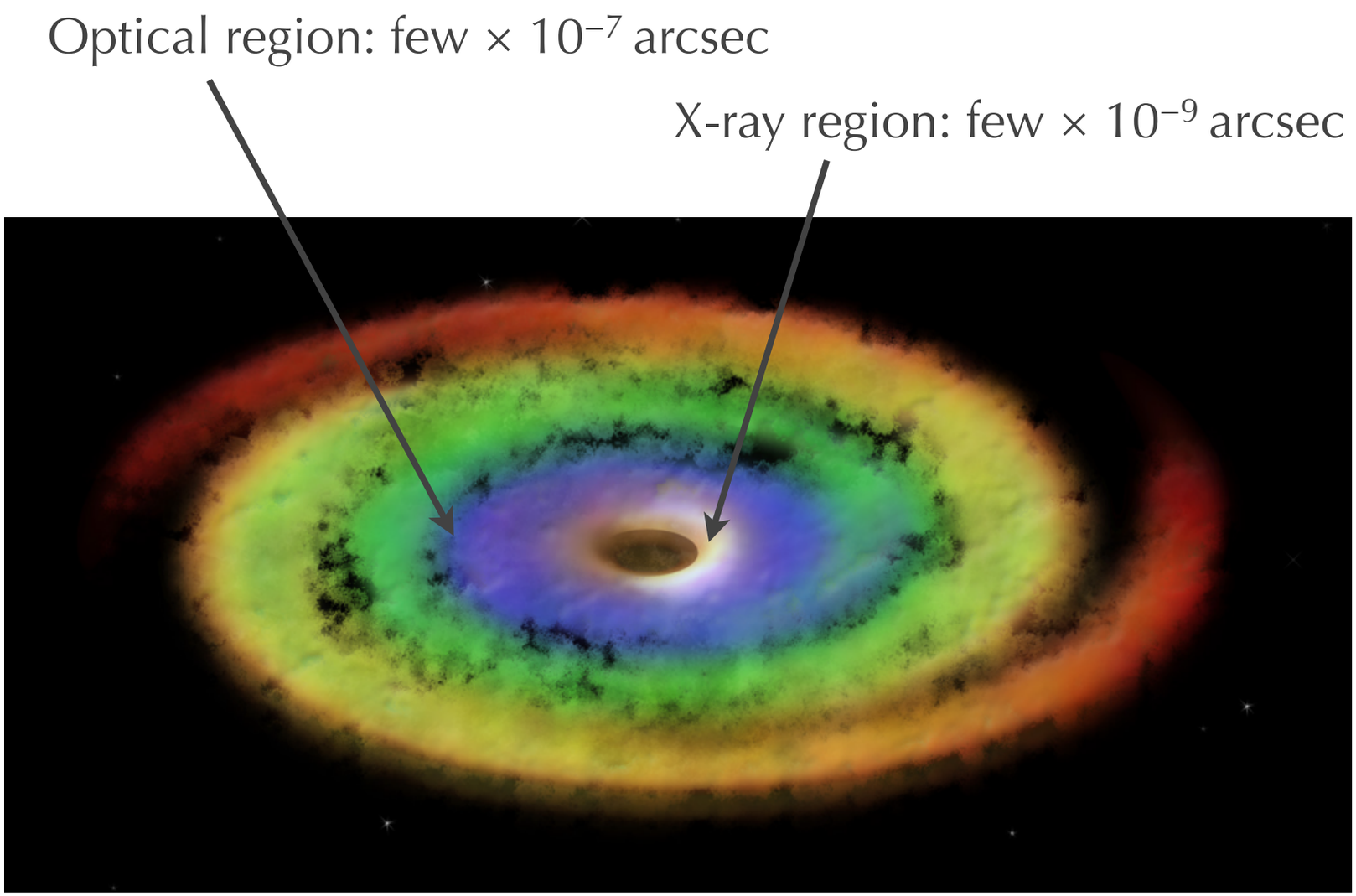
X-rays give cleanest microlensing signal



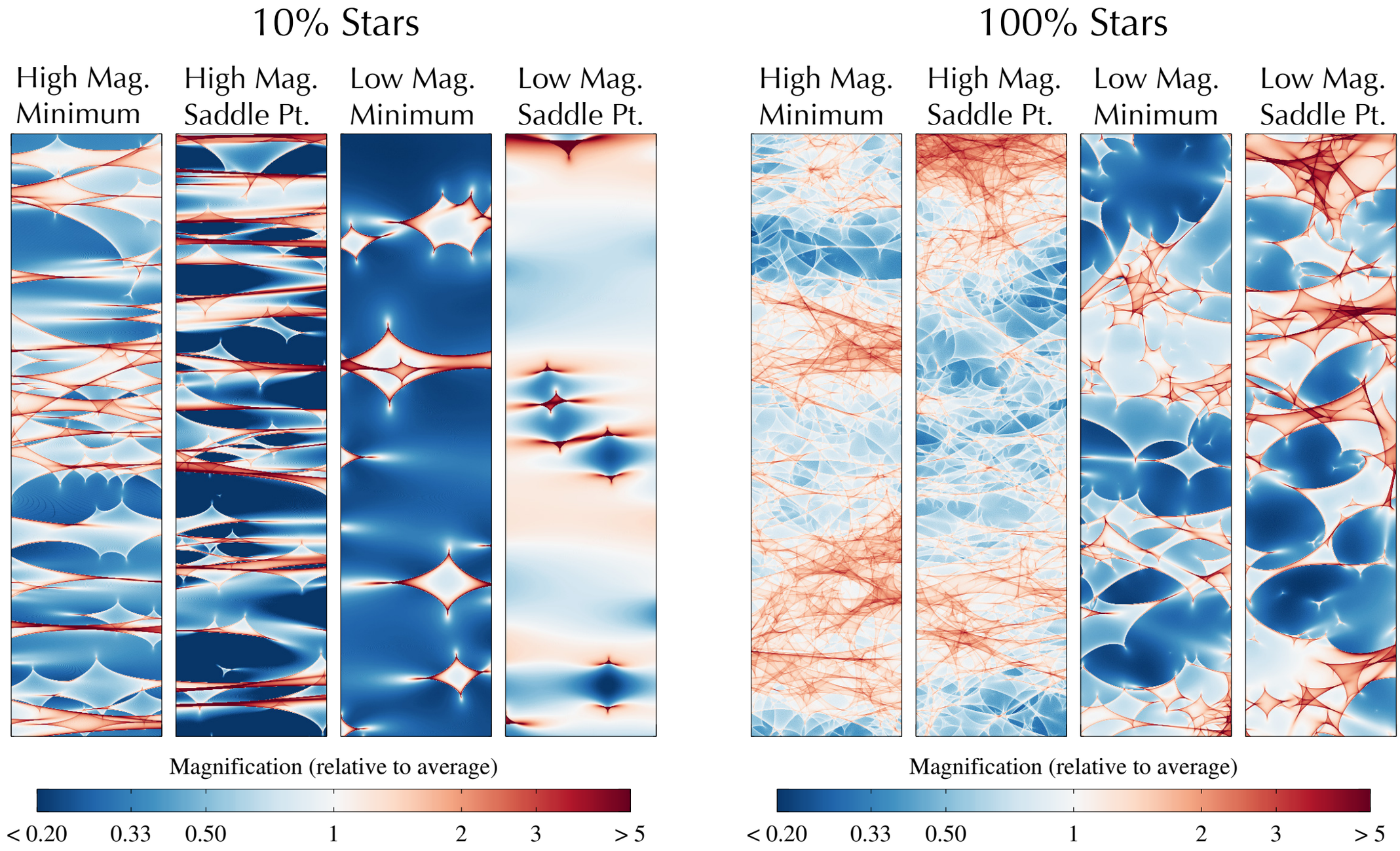
Schematic of quasar accretion disk

Einstein radius of star in typical lensing galaxy:

$\sim 3 \sqrt{(m/M_\odot)} \times 10^{-6}$ arcsec

Probability of microlensing depends on dark/stellar ratio

Custom microlensing maps are made for each system for a variety of dark/stellar ratios.
Strong demagnifications are unlikely for very high (100%) and very low (1%) stellar fractions.



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