Twisted (Lensed) Quasar Light Curves for Continuum Reverberation Mapping

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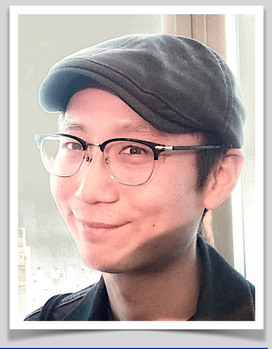
Twisted Transfer: 1909.08638

Microlensing: 2007.14416

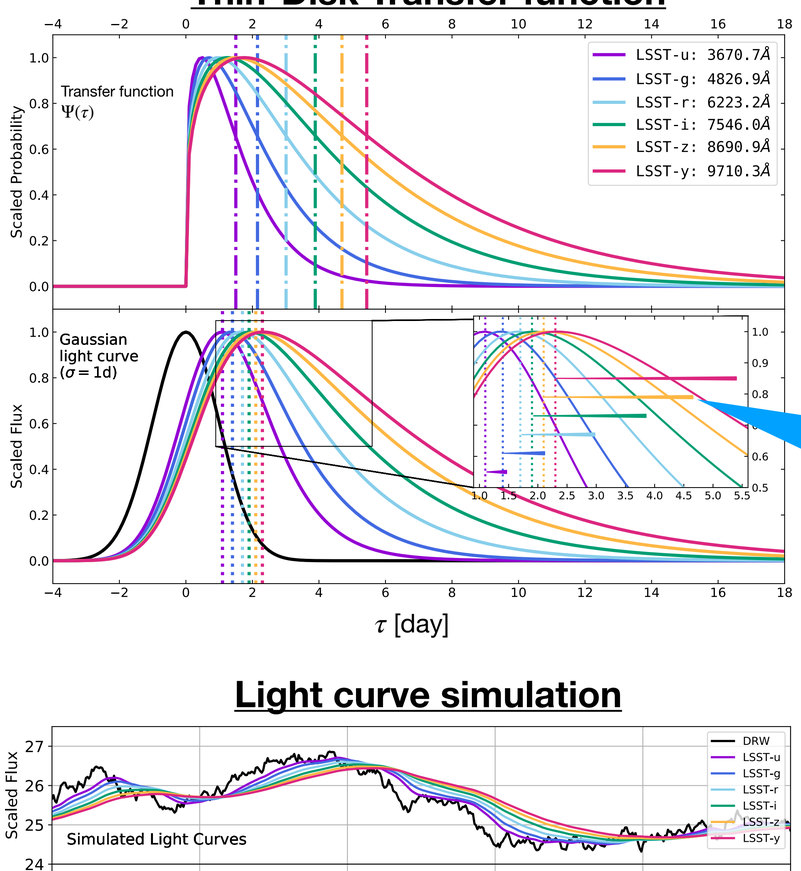


Discrepency in quasar accretion disk

- The accretion disk is larger than predicted by the thin-disk model, by a factor of 2 - 3.
- The traditional reverberation mapping (RM) simplies the transfer function of disk.
- Microlensing induces additional time delay in cosmography, which may bias the Hubble constant (H_0) measurement.

1. Impact of twisted transfer function

Thin-Disk Transfer function



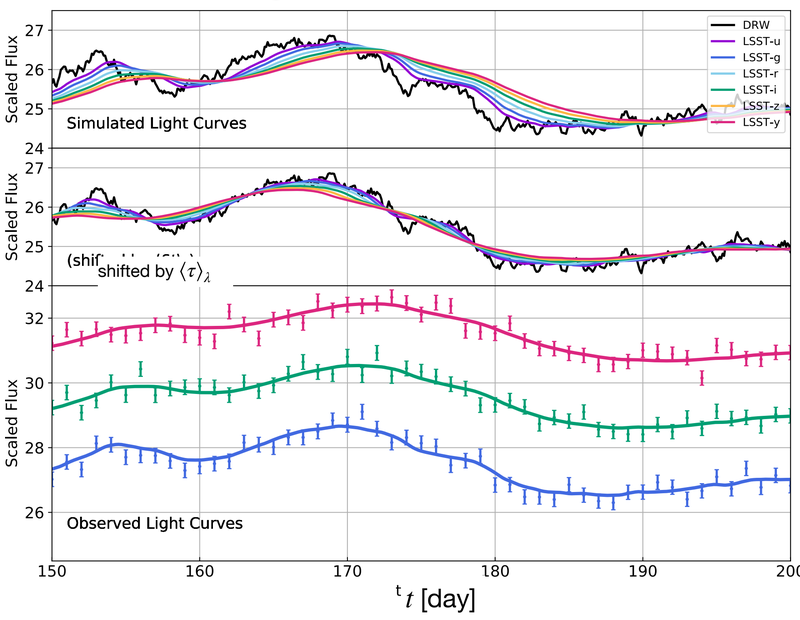
parameters:

- $M_{\rm BH} = 2 \cdot 10^8\ M_\odot$
- $L/L_{\rm Edd} = 0.1$
- inner radius = 0
- height of corona = 0
- inclination = 0
- $R_{\rm LSST\text{-}u} \approx 0.2$ ld

The peak positions differ from the mean delays $\langle\tau\rangle$:

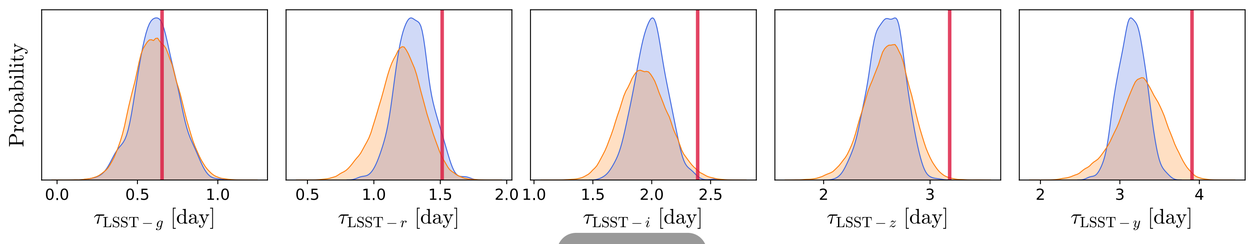
implying an **underestimation** of the time lag using curve-shifting techniques.

Light curve simulation



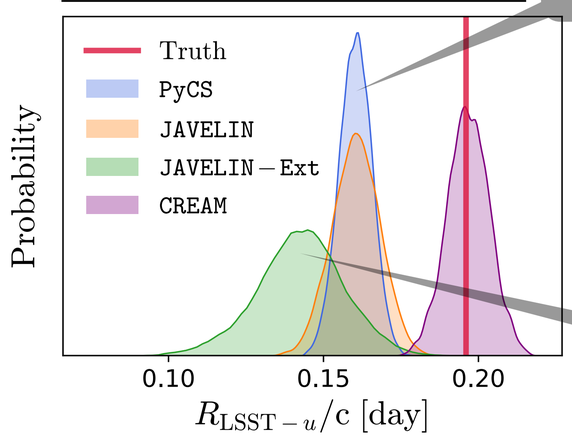
- LSST-like light curves
- driving curve (DRW):
  - $\tau_{\rm rel} = 200$ days,
  - $\mathrm{SF}_\infty = 2$ (arb. unit)
- duration: 1000 days
- error: $\Delta m = 0.01$ mag
- season gaps

Time lag measurement:



Source size measurement:

80%



70%

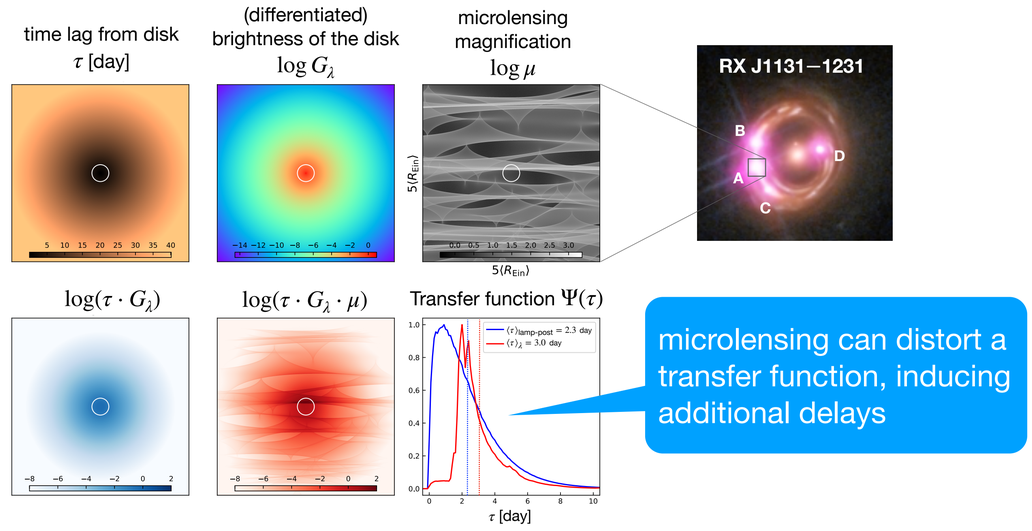
- PYCS: splines estimator
- JAVELIN: DRW + Top-hat
- JAVELIN-Ext: JAVELIN + $\tau \propto \lambda^{4/3}$
- CREAM: Fourier ω + Thin-Disk + Lamp-post

- The transfer function of thin-disk model is asymmetric.
- Curve-shifting techniques that are sensitive to sharp features, underestimate multi-band time delays by up to 20%.
- JAVELIN-Ext may not perform better, with fitted size being 30% smaller.
- The proper transfer functions need to be taken into account, such as CREAM.

3. Future prospect

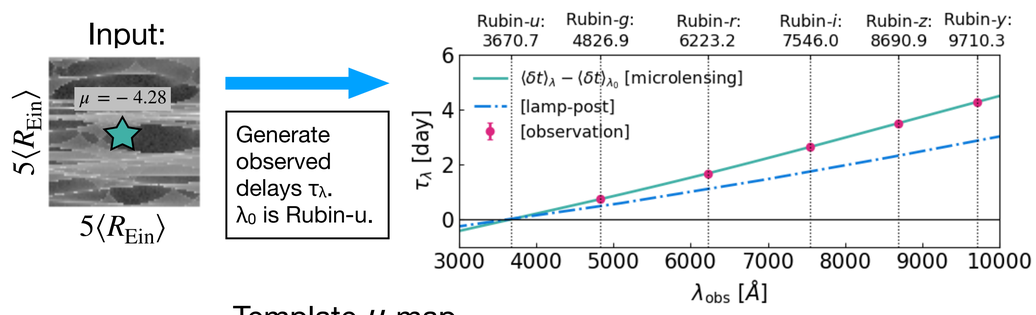
- more sophiscated disk models: inner radius, height of corona, inclination angle, temperature slope, etc.
- better techniques for time lag measurements, with and without microlensing.
- LSST (microlensing) light curves.

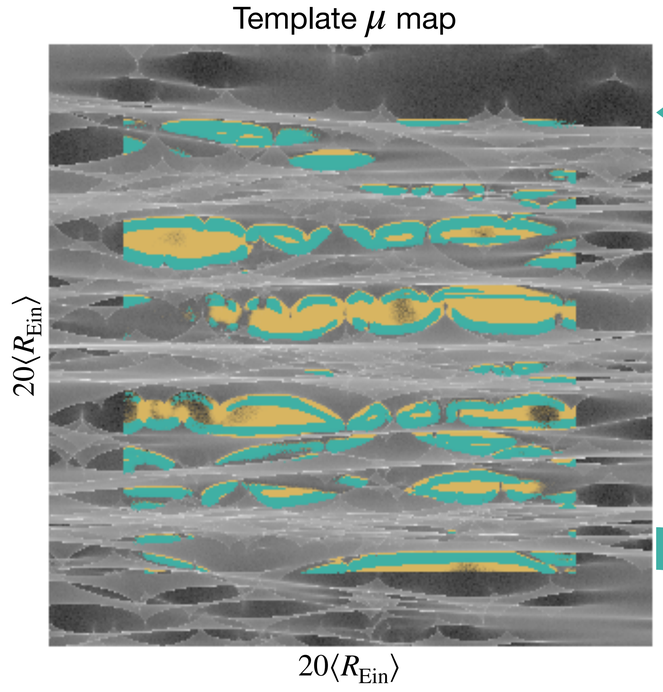
2. Microlensing light curves for RM



microlensing can distort a transfer function, inducing additional delays

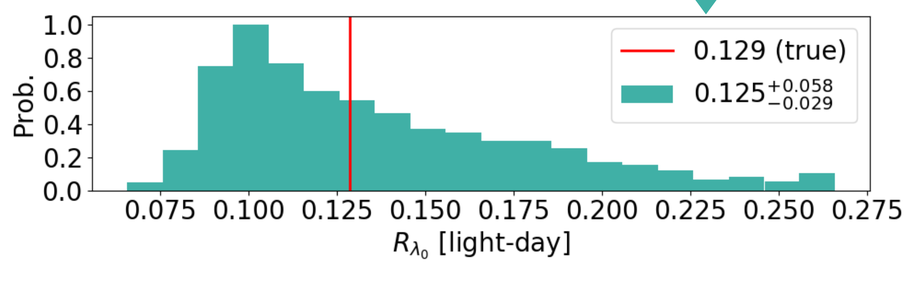
New method to estimate the accretion disk size



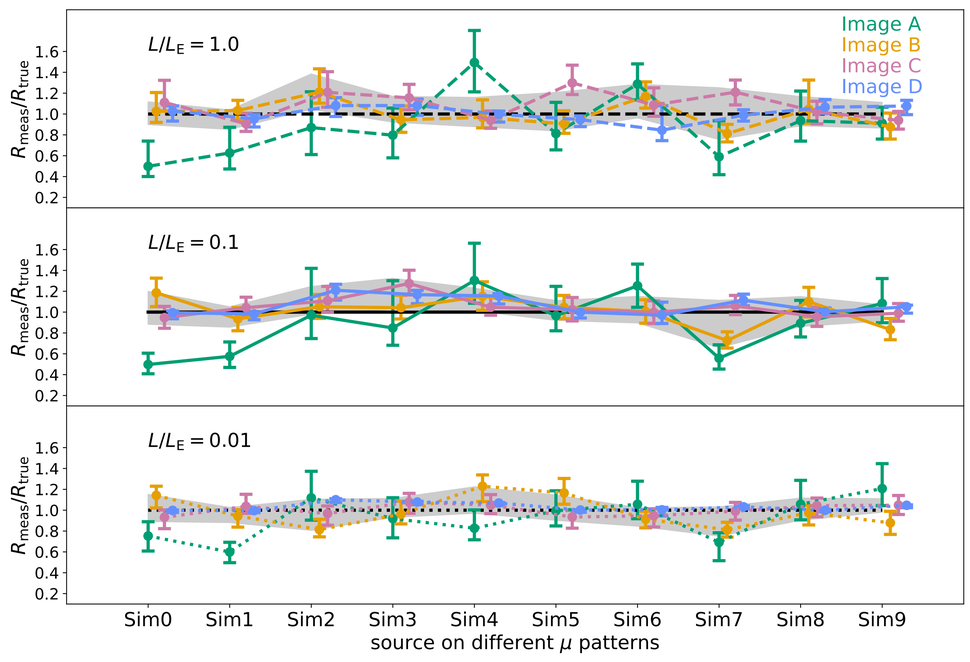


Method:
Use template μ map to fit the source size R_{λ_0} via the brute-force search.
"○" is the location with magnification error of 25%. ($3.21 < |\mu| < 5.35$)

"○" is the location when $\chi^2 < 1$.



Combining disk measurments from multiple lensed images



- Disk sizes can be recovered to within a factor of 2 (using one lensed image)
- When four lensed images are used, our method is able to achieve an unbiased source measurement within error of the order of 20%.