Analyzing Lens Parameter Distribution: A case study of the Gaia18ajz event

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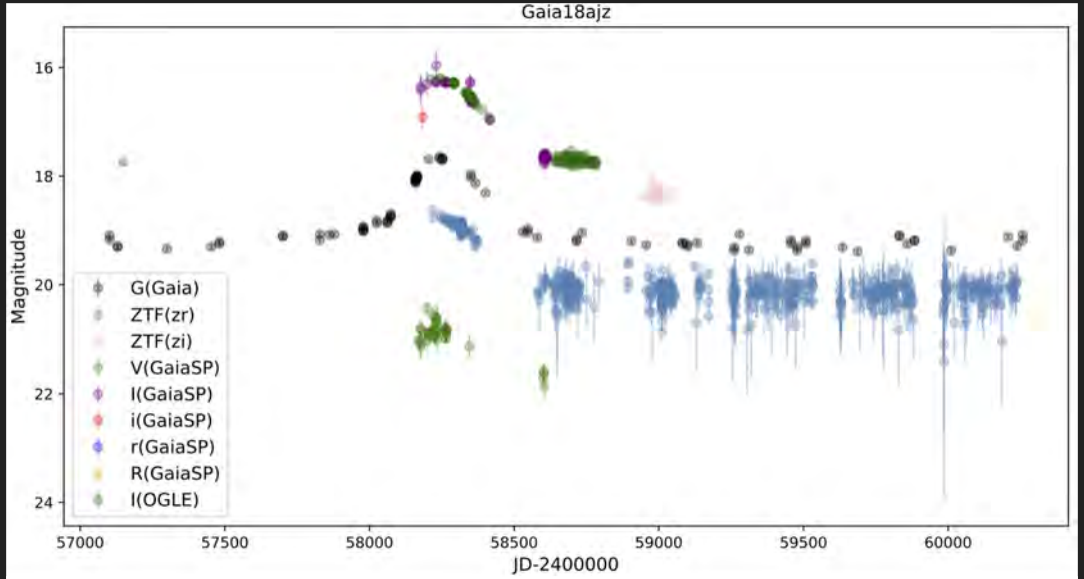
Gaia18ajz

Alert date	14 February 2018
Galactic coordinates	23.20506, 0.92576
Baseline Magnitude (G)	~ 19.25 mag
Peak Magnitude (G)	~ 17.64 mag

Available Photometric Data



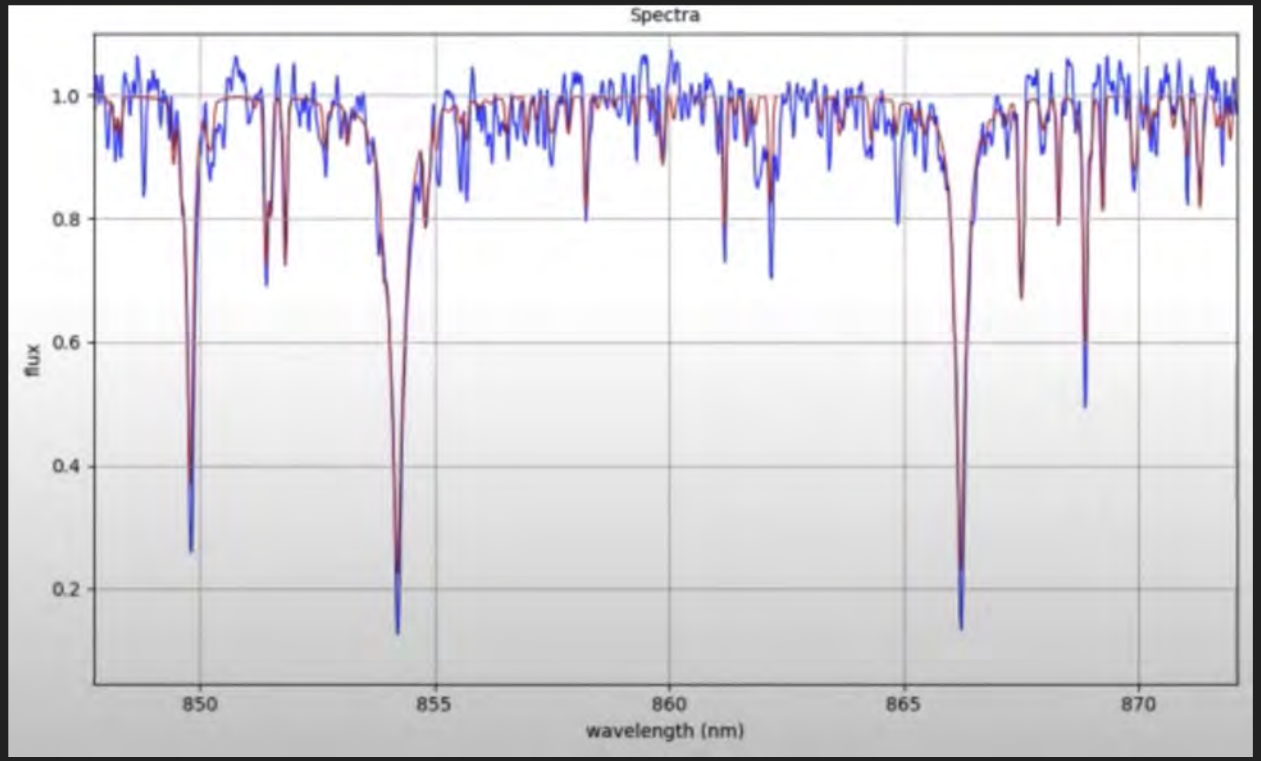
Observatory	Filters (Observed or Standardised to)	Data points	Min.MJD	Max.MJD
ZTF	ZTF(zr), ZTF(zi)	703	58218.47	59993.55
OGLE	I(OGLE)	104	57148.89	58784.54
SMARTS1.3[B]	V(GaiaSP), I(GaiaSP), i(GaiaSP)	103	58171.38	58613.32
Gaia	G(Gaia)	83	57101.37	60010.48
ObsMontsec[B]	I(GaiaSP)	22	58336.98	58374.84
Loiano[B]	I(GaiaSP), R(GaiaSP), V(GaiaSP), r(GaiaSP)	12	58283.99	58312.87
PIRATE[B]	r(GaiaSP)	8	58263.12	58361.95
Terskol[B]	R(GaiaSP), V(GaiaSP), I(GaiaSP)	3	58318.80	58318.80

[B] Data from that observatory has been processed and calibrated using BHTOM

Source star

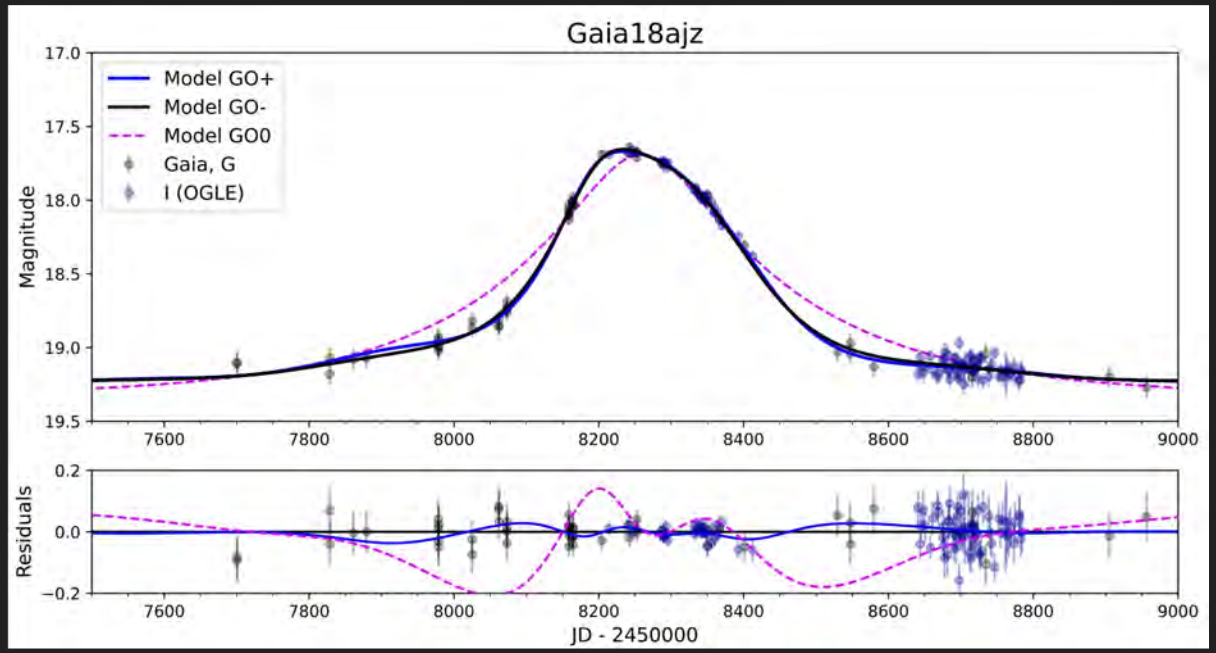
$$D_S = 11.5 \pm 2.9\,\mathrm{kpc}$$

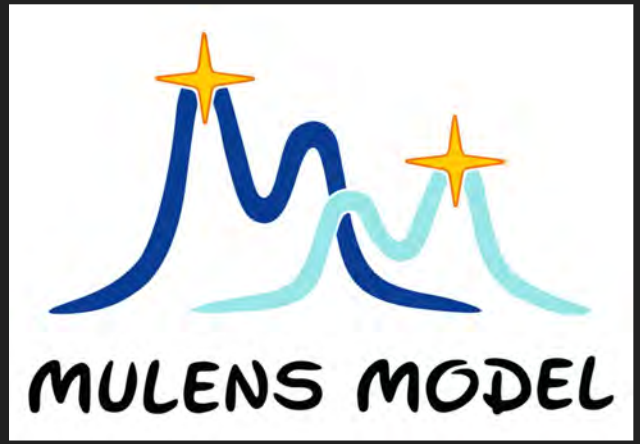
$$A_V = 8.0 \pm 0.1\,\mathrm{mag}$$



X-SHOOTER Spectra, 25.03.2018, 08.08.2018

Model of the microlensing event

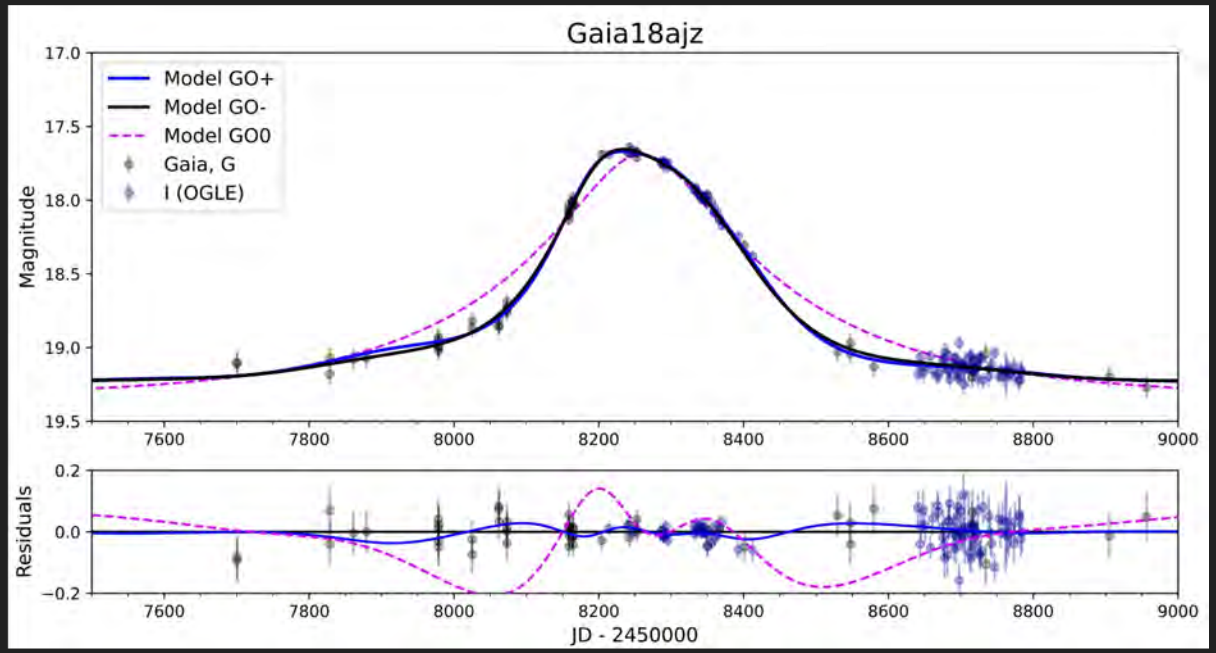




(Poleski & Yee, 2019)

Model of the microlensing event

Two possible solutions



Parallax models:

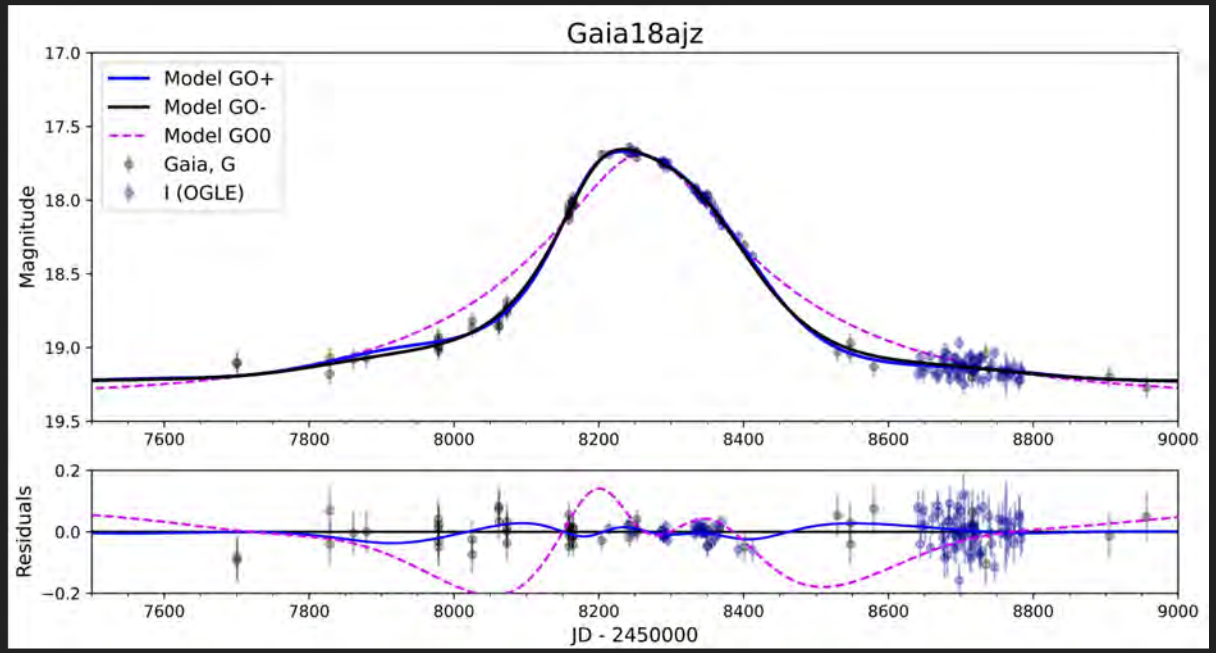
GO+: Gaia + OGLE, u0 > 0
GO-: Gaia + OGLE, u0 < 0

Standard model:

GO0: Gaia+ OGLE

Model of the microlensing event

Two possible solutions



Parameter	GO+	GO-
u_0	$0.196^{+0.030}_{-0.026}$	$-0.228^{+0.023}_{-0.017}$
t_E [days]	316^{+36}_{-30}	346^{+30}_{-20}
π_{EN}	$0.145^{+0.022}_{-0.026}$	$-0.0232^{+0.0069}_{-0.0069}$
π_{EE}	$0.060^{+0.015}_{-0.010}$	$0.0865^{+0.0066}_{-0.0063}$
$f_{s,G(\mathrm{Gaia})}$	$0.79^{+0.15}_{-0.12}$	$0.96^{+0.09}_{-0.11}$
$f_{s,I(\mathrm{OGLE})}$	$0.82^{+0.15}_{-0.12}$	$1.02^{+0.09}_{-0.12}$

Model of the microlensing event

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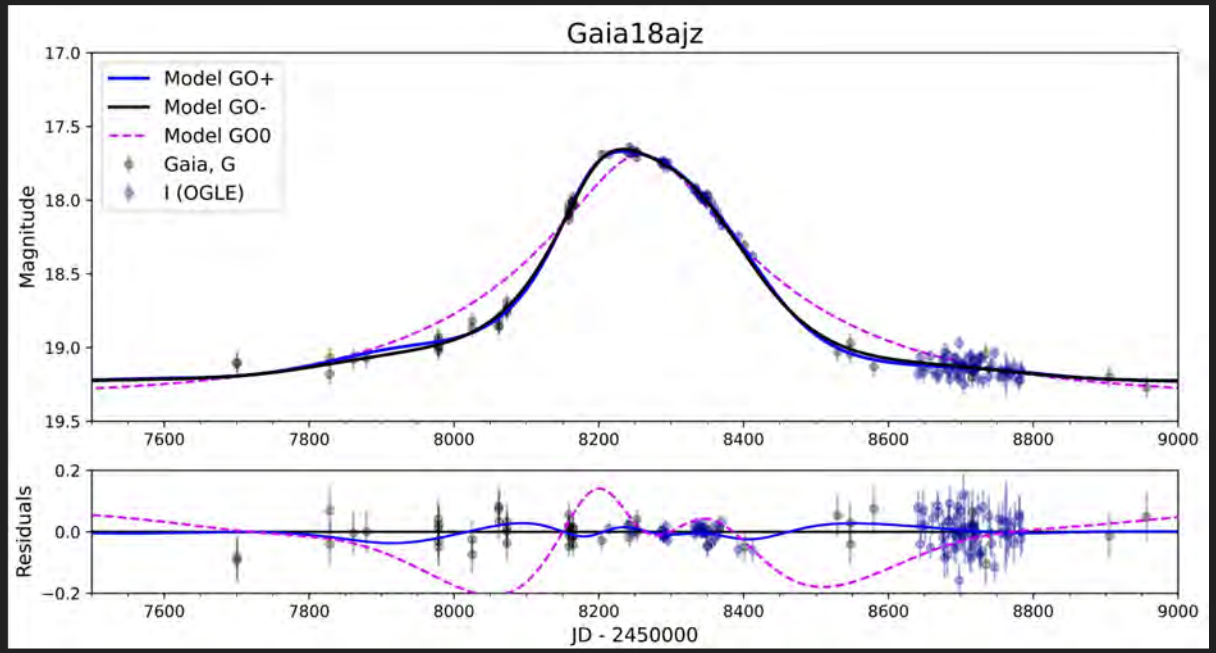

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What now?

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$$D_L = \left(\theta_E \pi_E + \frac{1}{D_S}\right)^{-1}$$

- To find the mass we have to find the θ_E
- We can't find the θ_E without the astrometric data

Solution 1: Simulation of the astrometry

Astrometry

Gaia astrometric parameters for the source star in Gaia18ajz.

Parameter	GDR2	GDR3	
ϖ [mas]	3.24 ± 0.59	1.52 ± 0.54	!
μ_α [mas yr^{-1}]	-7.76 ± 1.36	-5.37 ± 0.59	
μ_δ [mas yr^{-1}]	-4.27 ± 1.46	-6.69 ± 0.51	
RUWE	1.49	1.53	!

What now?

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Solution 1: Simulation of the astrometry (but not in this case 😔)

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Solution 1: Simulation of the astrometry (but not in this case 😔)

Solution 2: DarkLensCode!

DarkLensCode

MCMC samples + Set of priors

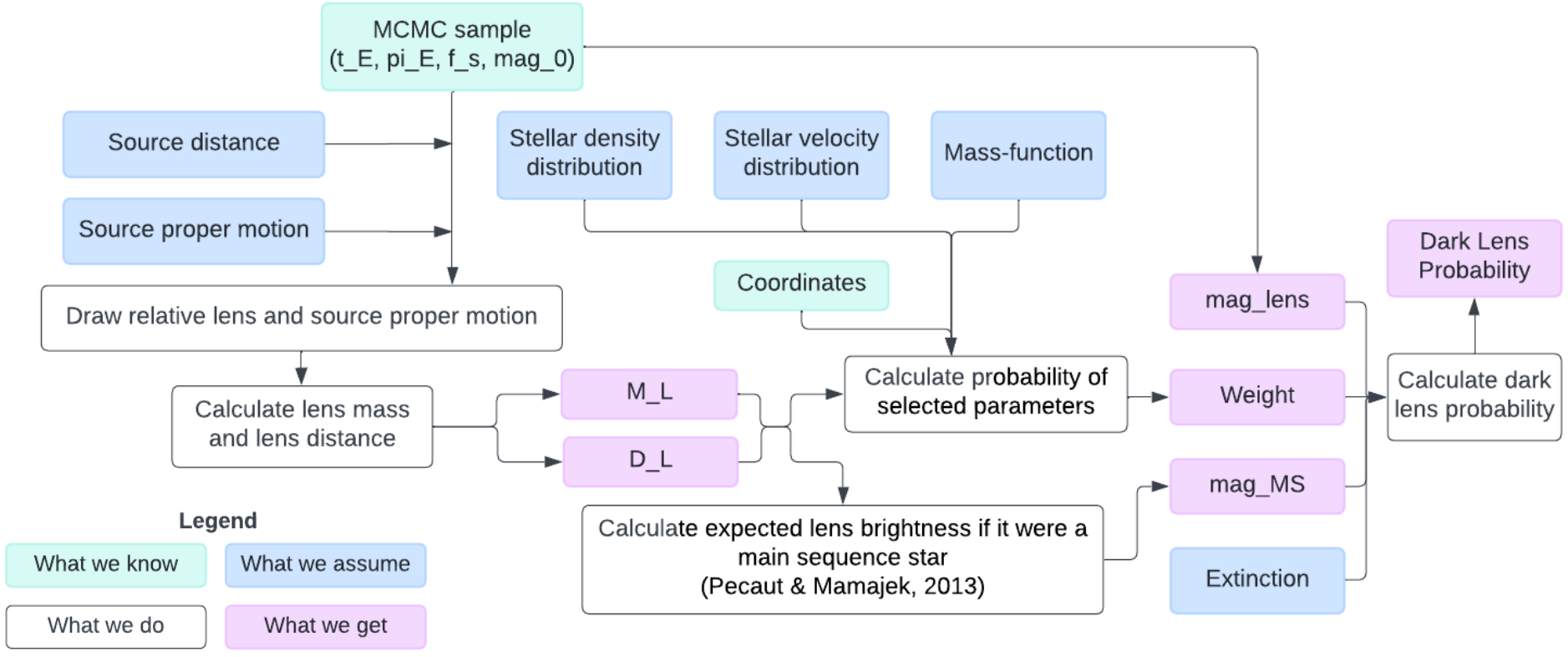
=

Lens mass and distance + dark lens probability

Previously used in:

Kruszyńska et al. (2024, in review),
Maskoliūnas et al. (2023, in review),
Kaczmarek et al. (2022),
Kruszyńska et al. (2022),
Mróz, Wyrzykowski, (2021),
Wyrzykowski, (2020),
Wyrzykowski, (2016)

DarkLensCode



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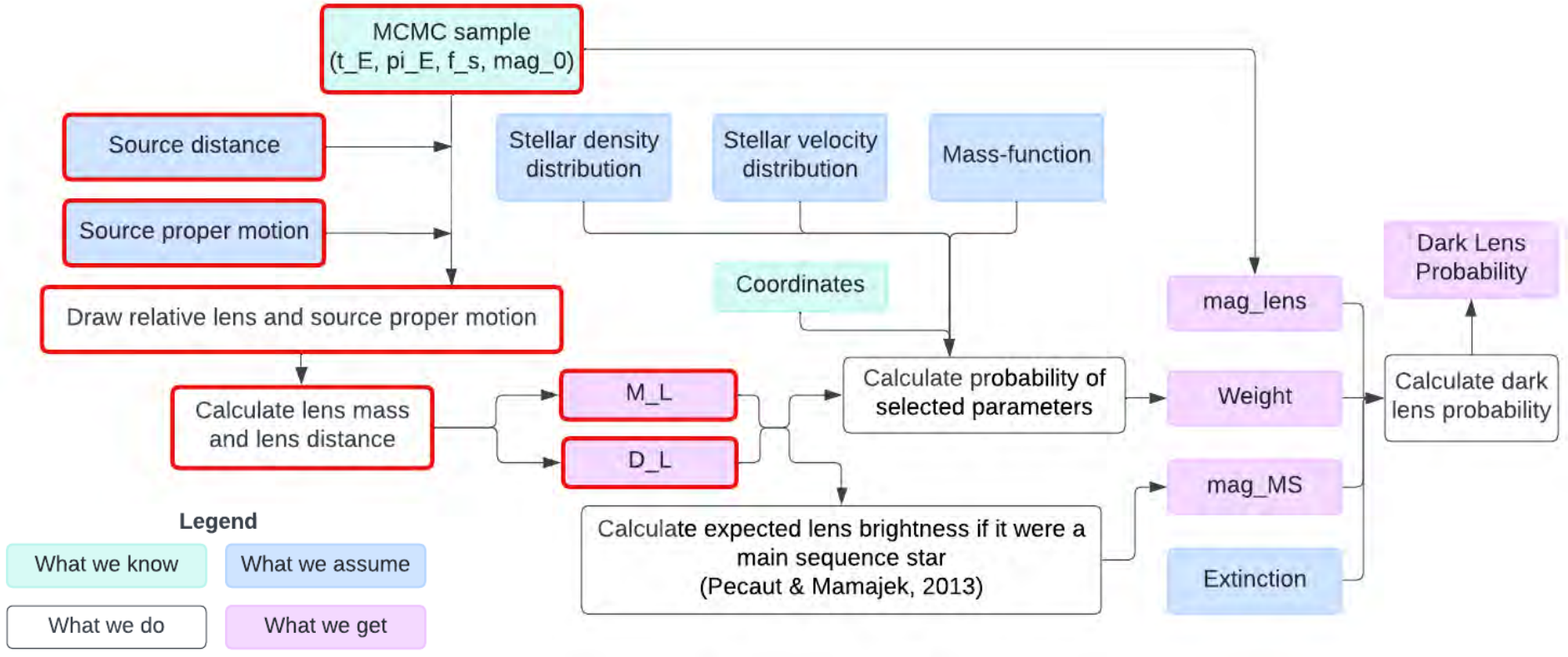

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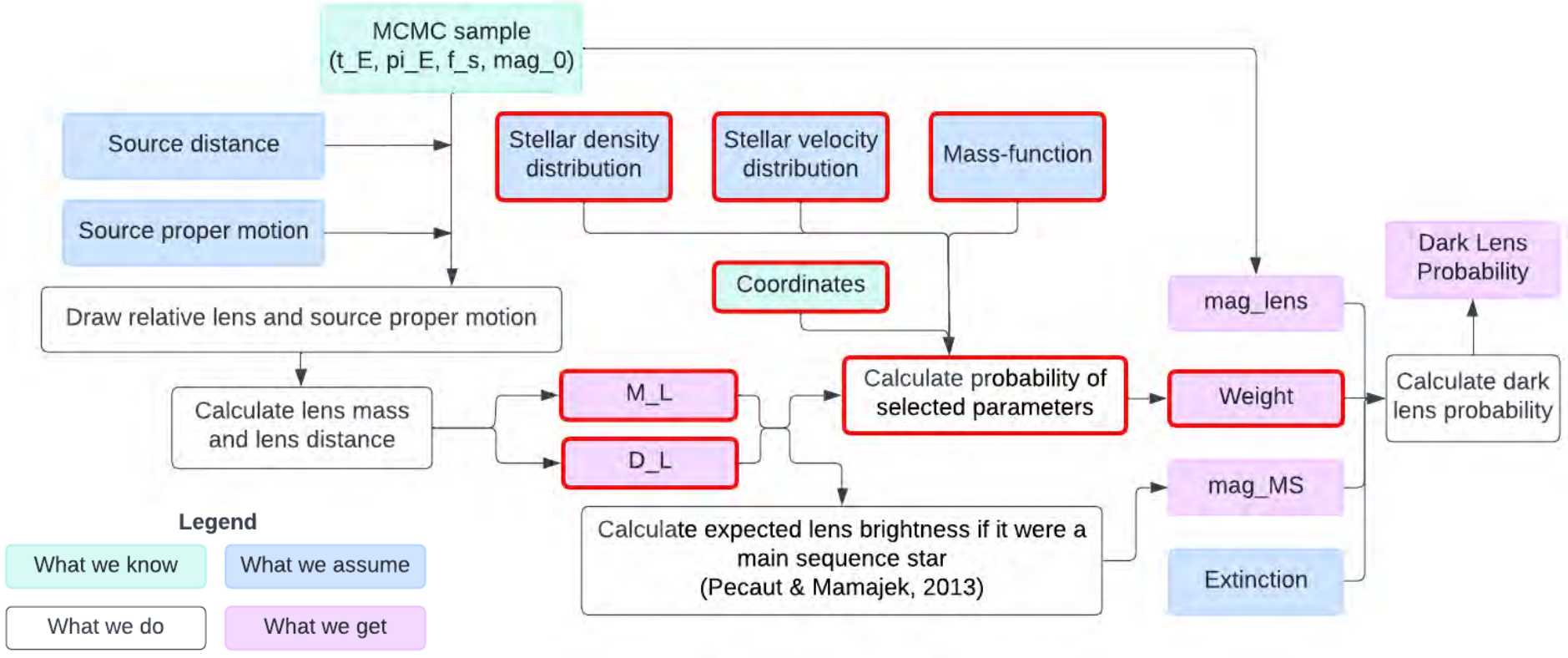

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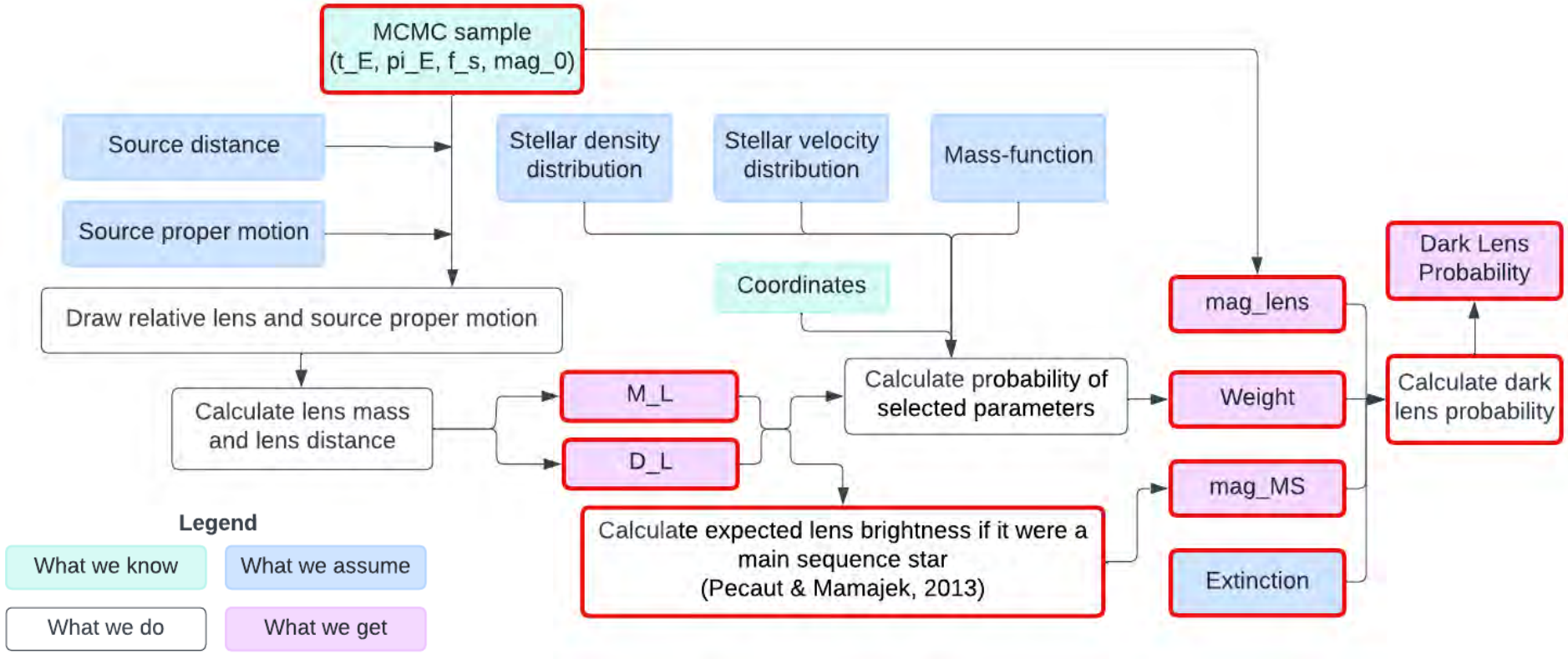
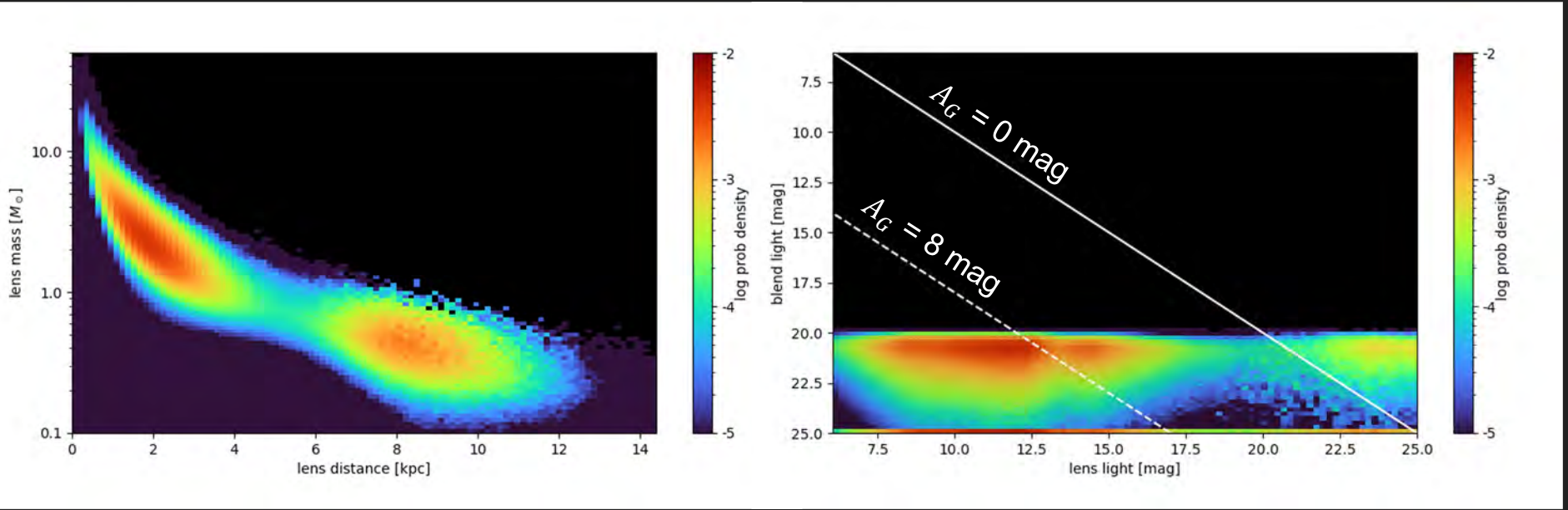


DLC: Our assumptions

- Distance: $D_S = 11.5 \pm 2.9\,\mathrm{kpc}$
- Extinction: $A_G \in [0.0;\, 8.0]\,\mathrm{mag}$
- Proper motion of the source: $\mu_{\alpha*} = -5.37\,\mathrm{mas/yr}$, $\mu_\delta = -6.69\,\mathrm{mas/yr}$ (From Gaia DR3)
- Mass function: (Kroupa, 2001), (Mróz et al. 2021)

DLC: Results



Results for GO- model. Mass function: (Kroupa, 2001)

DLC: Results

Parameter	Dark remnant	Star
M_L $[M_\odot]$	$12.1^{+14.8}_{-5.4}$	$1.16^{+0.36}_{-0.30}$
D_L [kpc]	$1.18^{+0.82}_{-0.62}$	$8.7^{+1.2}_{-1.0}$
θ_E [mas]	$9.0^{+10.9}_{-3.93}$	$0.89^{+0.23}_{-0.21}$
Dark lens probability	$99.5\% - 100.0\%$	$5.0\% - 98.0\%$
Solution probability	30%	70%

For GO- Model

Parameter	Dark remnant	Star
M_L $[M_\odot]$	$5.4^{+7.6}_{-2.6}$	$0.48^{+0.21}_{-0.15}$
D_L [kpc]	$1.03^{+0.77}_{-0.59}$	$8.3^{+1.3}_{-1.2}$
θ_E [mas]	$7.1^{+9.8}_{-3.2}$	$0.64^{+0.20}_{-0.16}$
Dark lens probability	$79.6\% - 100.0\%$	$0.1\% - 32.7\%$
Solution probability	89%	11%

For GO+ Model

Thank you!

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