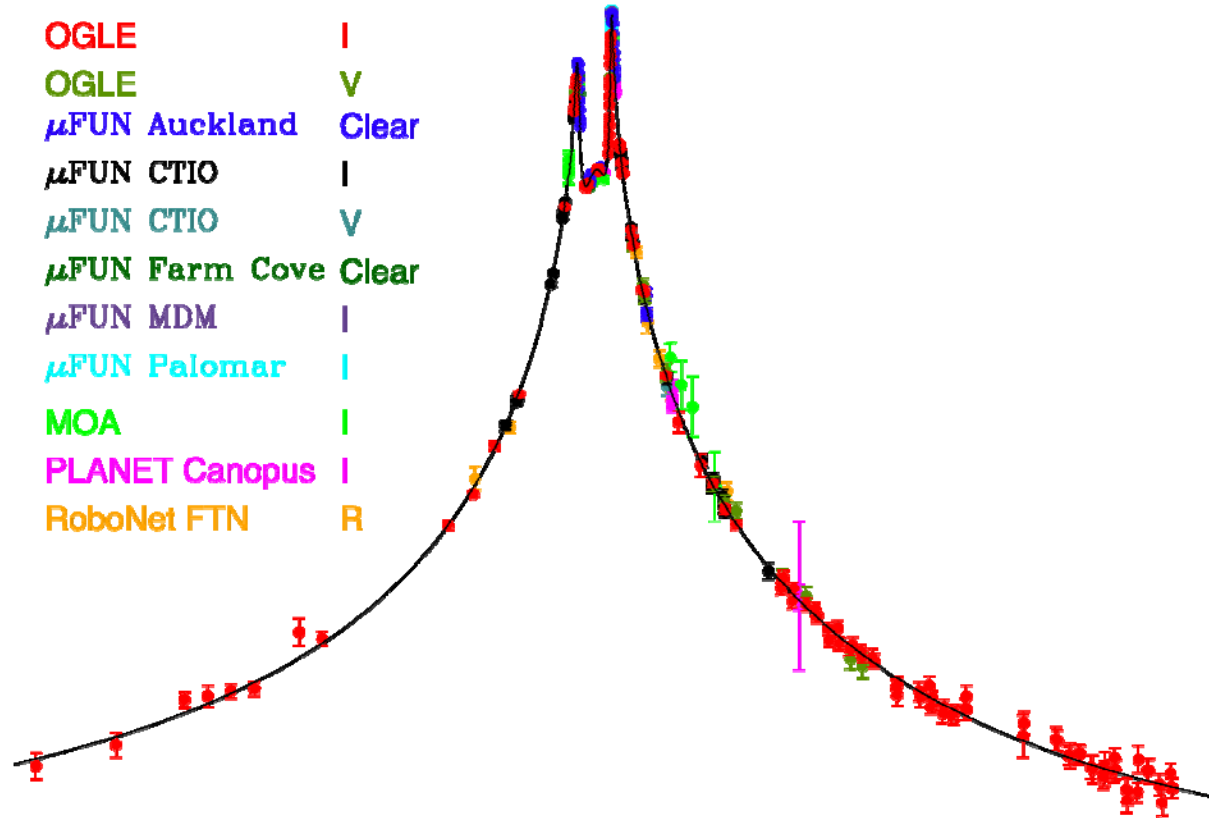


Robust Modeling of 1-Planet Systems

Subo Dong

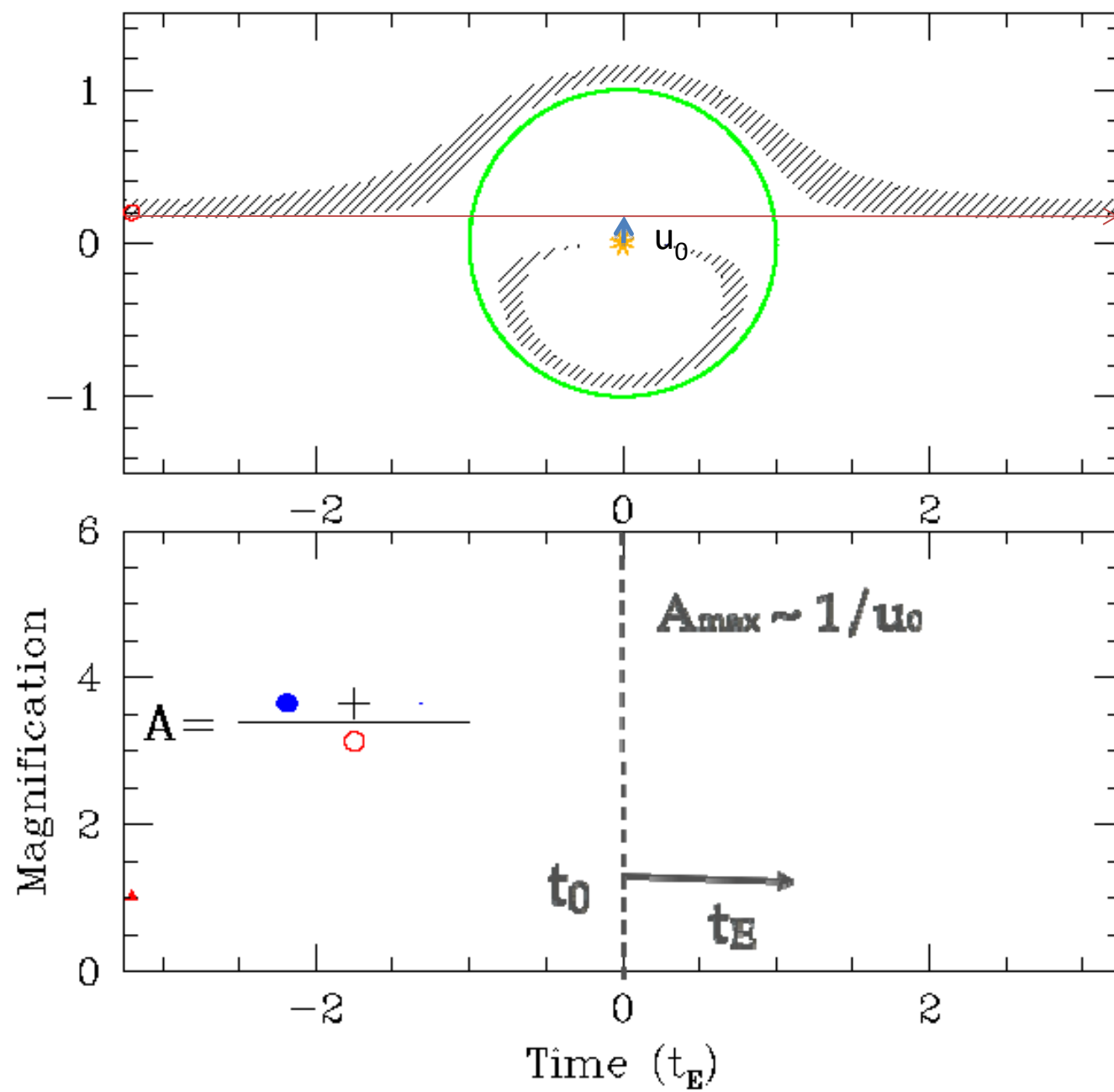
The Ohio State University

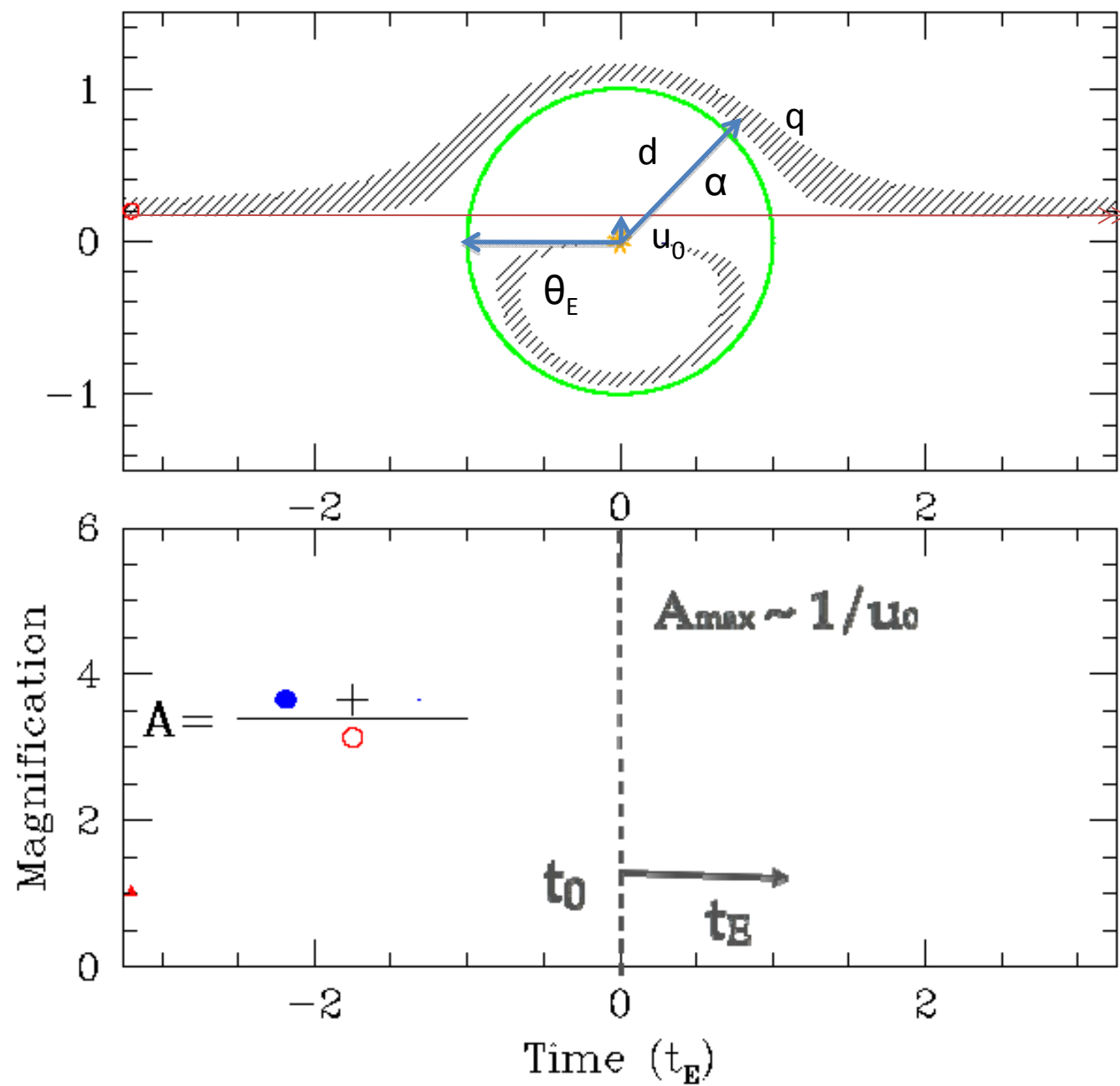
OGLE-2005-BLG-071Lb

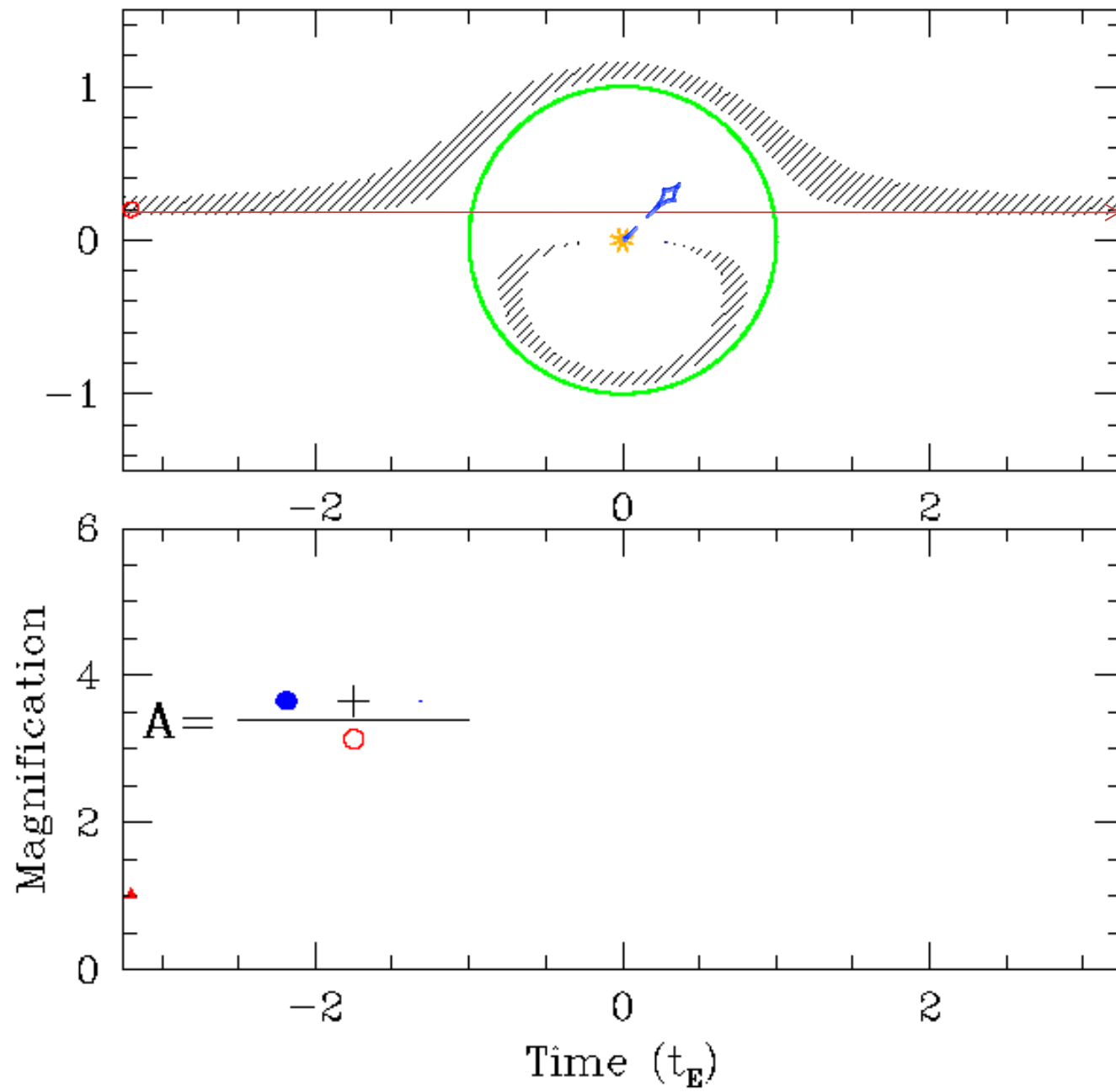


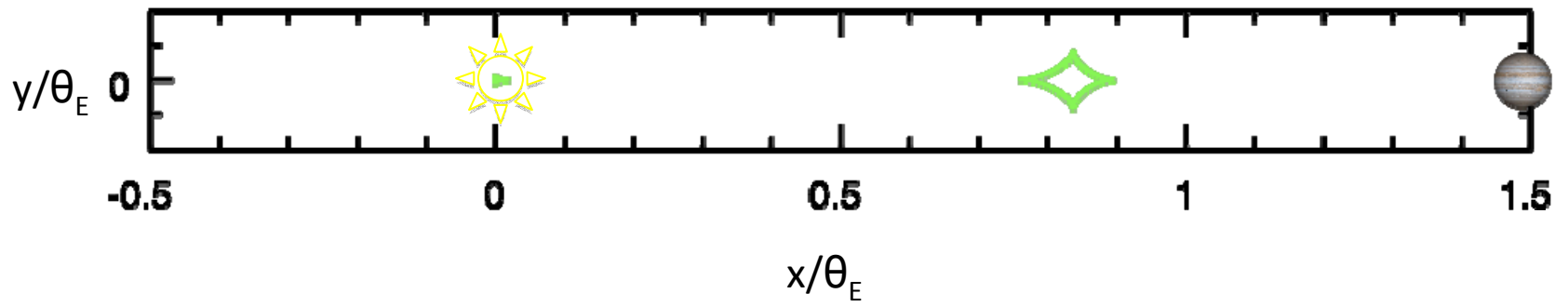
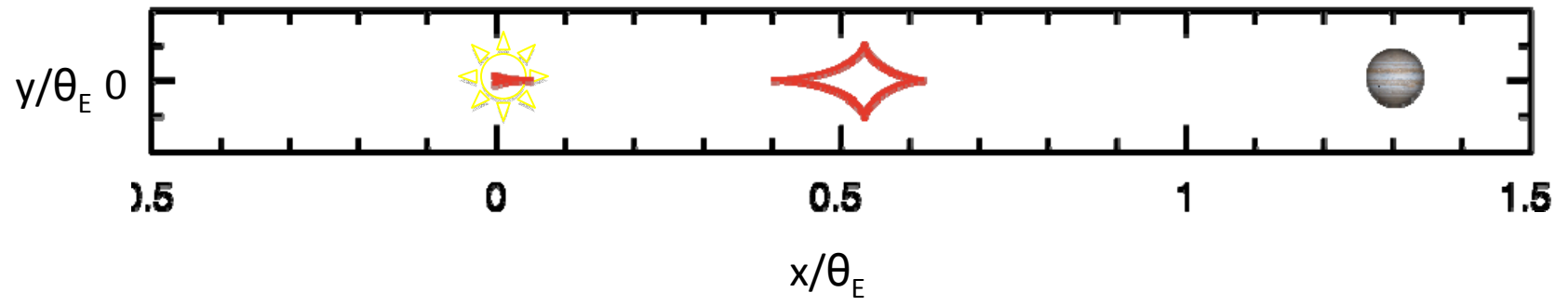
- OGLE I
- OGLE V
- μFUN Auckland Clear
- μFUN CTIO I
- μFUN CTIO V
- μFUN Farm Cove Clear
- μFUN MDM I
- μFUN Palomar I
- MOA I
- PLANET Canopus I
- RoboNet FTN R

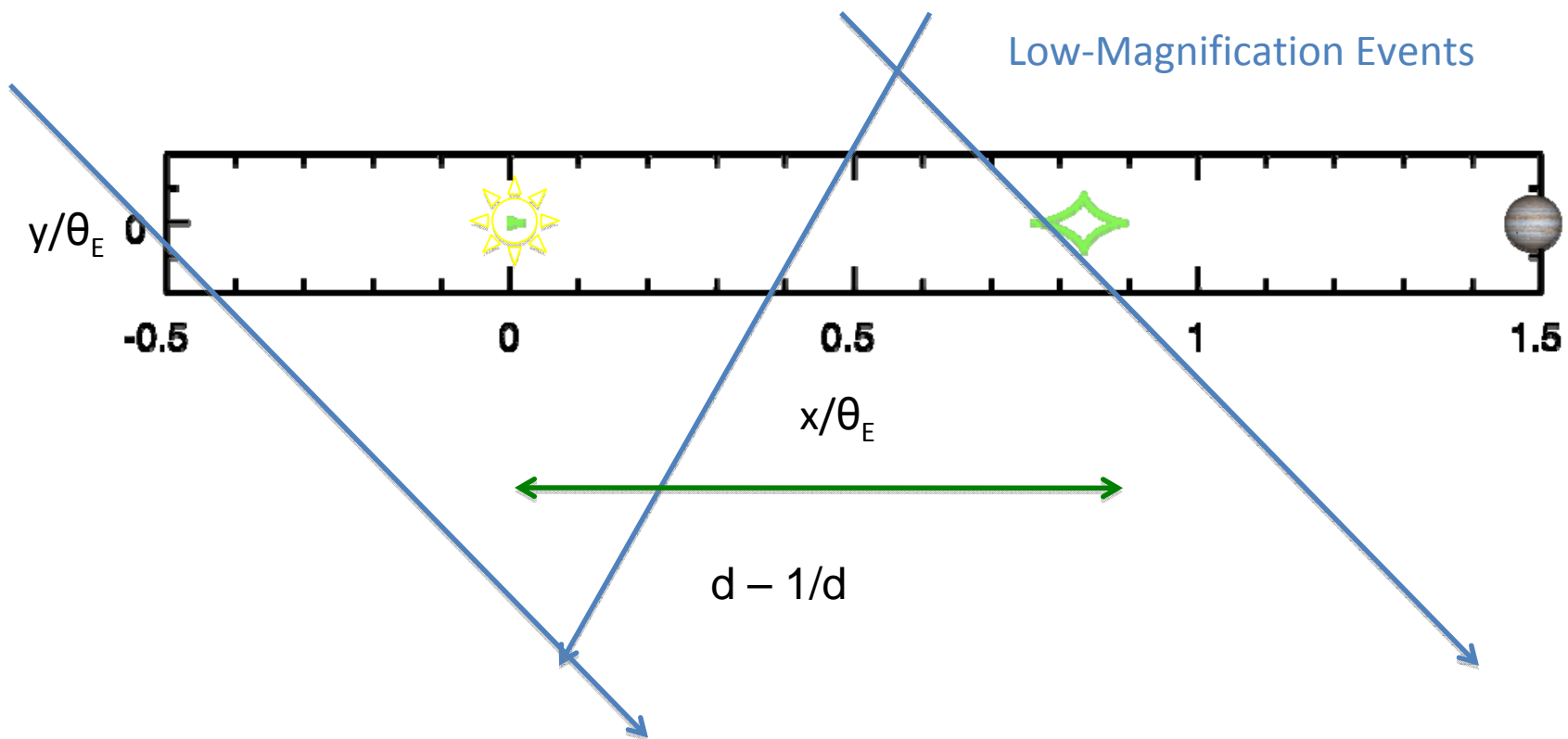
Model	t_0	u_0	t_E	b	q	α	ρ	$\pi_{E,N}$	$\pi_{E,E}$	ω	b/b	I_s	I_b	V_s	V_b
χ^2	(HJD')		(day)		$\times 10^3$	(deg)	$\times 10^4$			(yr^{-1})	(yr^{-1})	(mag)	(mag)	(mag)	(mag)
Wide+	3480.6885	0.0277	69.4	1.283	7.0	274.26	5.5	-0.34	-0.26	0.408	-0.363	19.51	21.34	20.84	23.18
1330.3	+0.0071 -0.0049	+0.0009 -0.0010	+2.4 -2.1	+0.008 -0.006	± 0.3	+0.24 -0.28	± 1.2	+0.24 -0.25	± 0.05	+0.539 -0.571	+0.141 -0.122	± 0.03	+0.21 -0.19	± 0.04	+0.42 -0.28



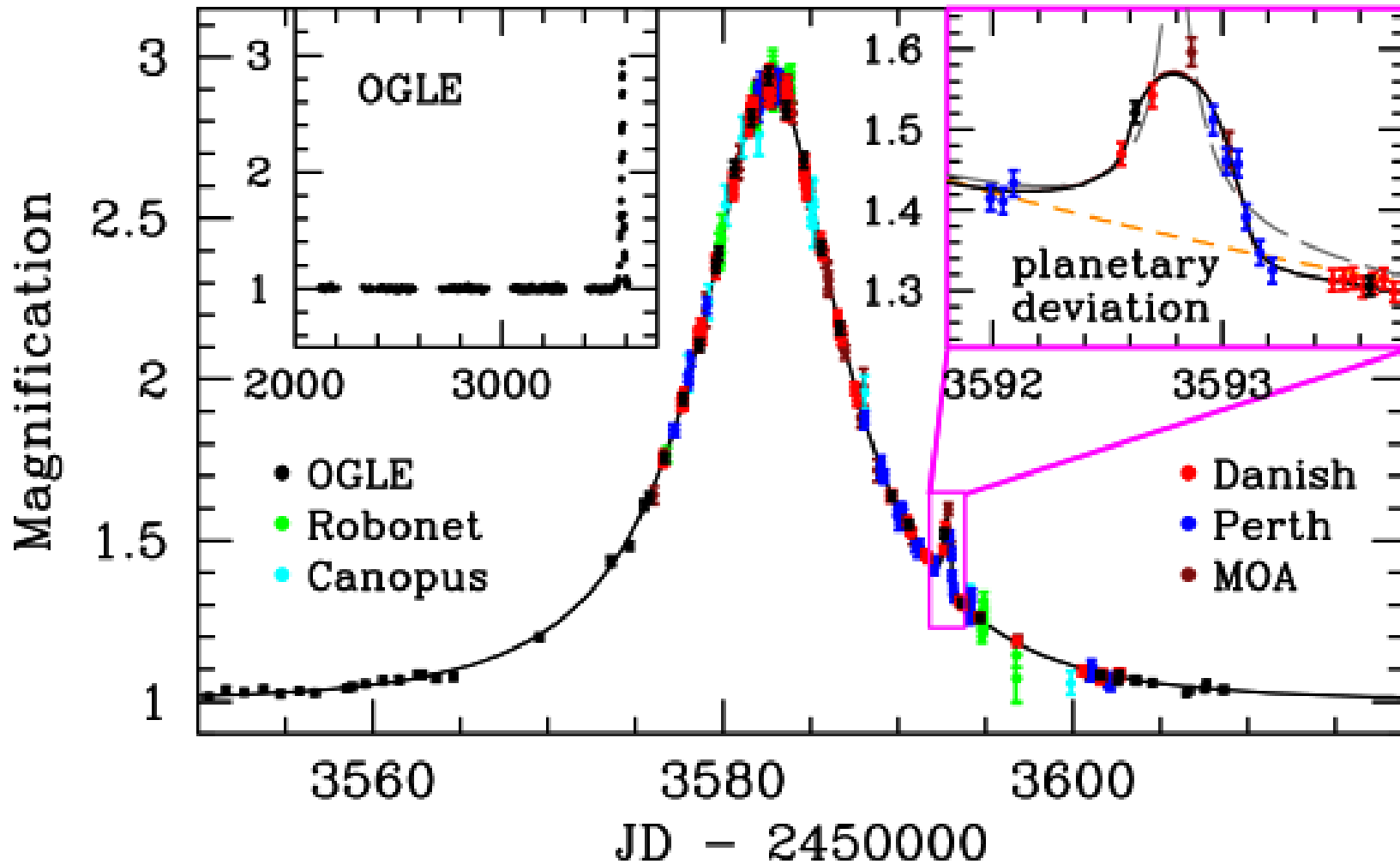




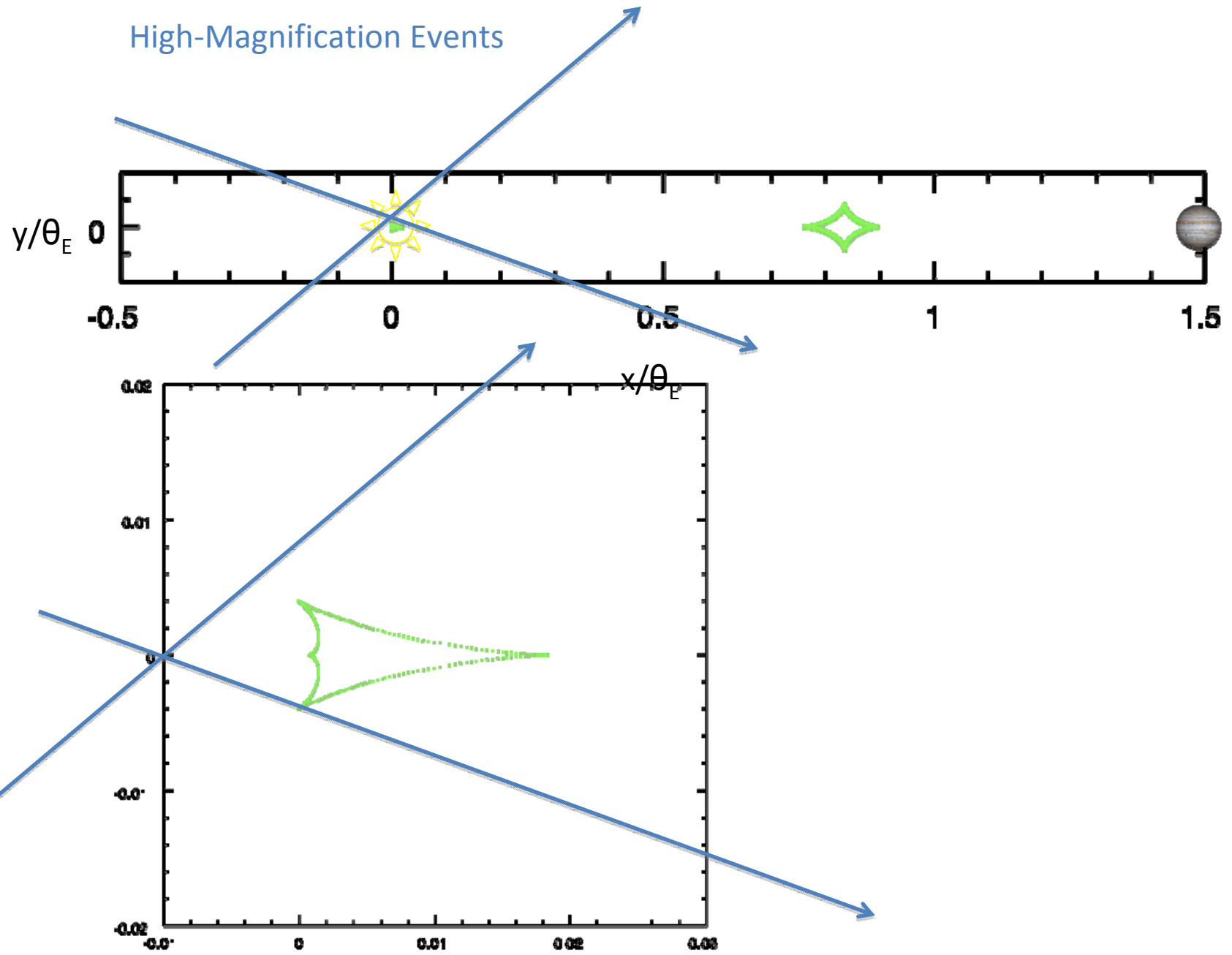




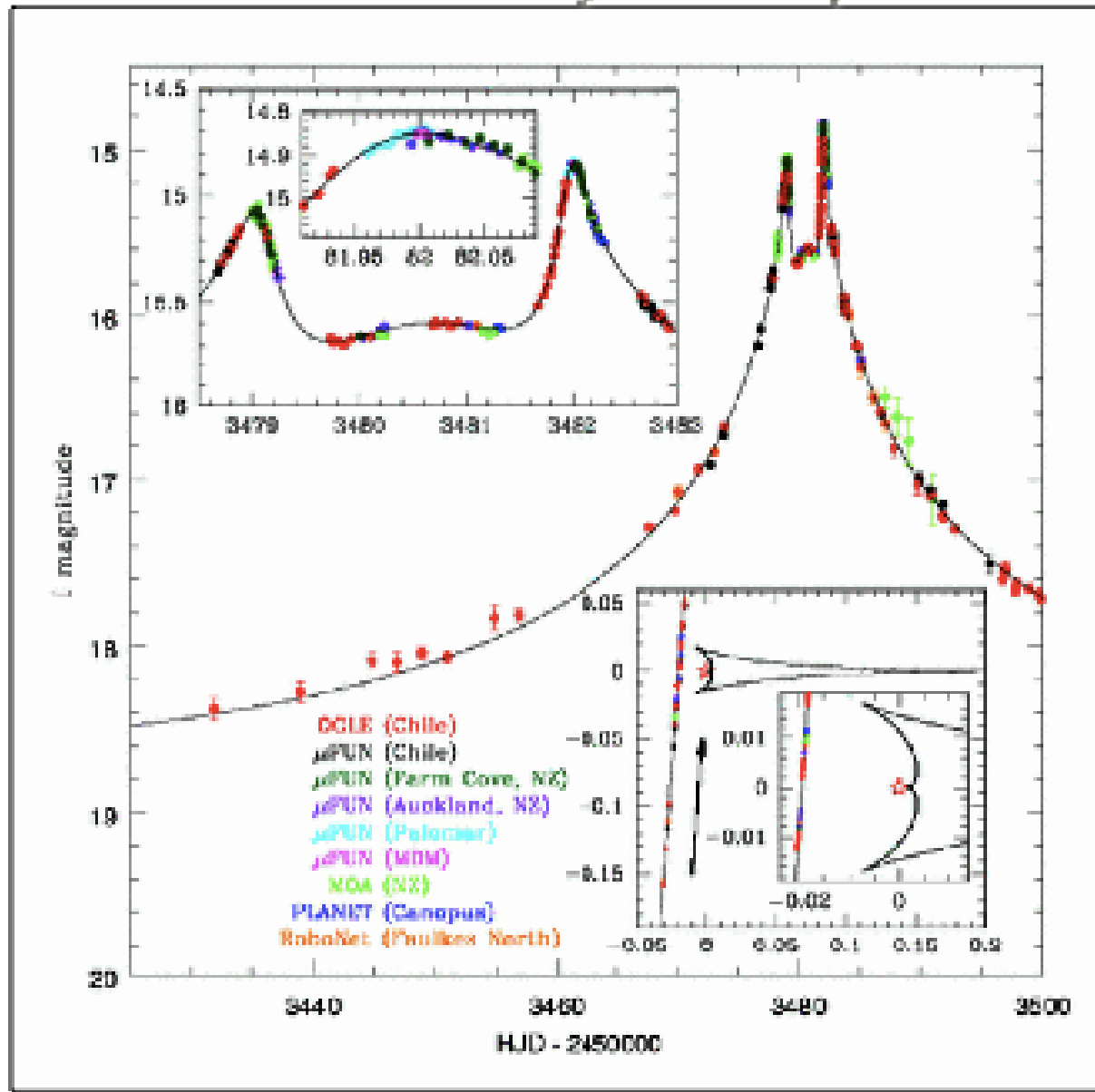
OGLE-2005-BLG-390Lb



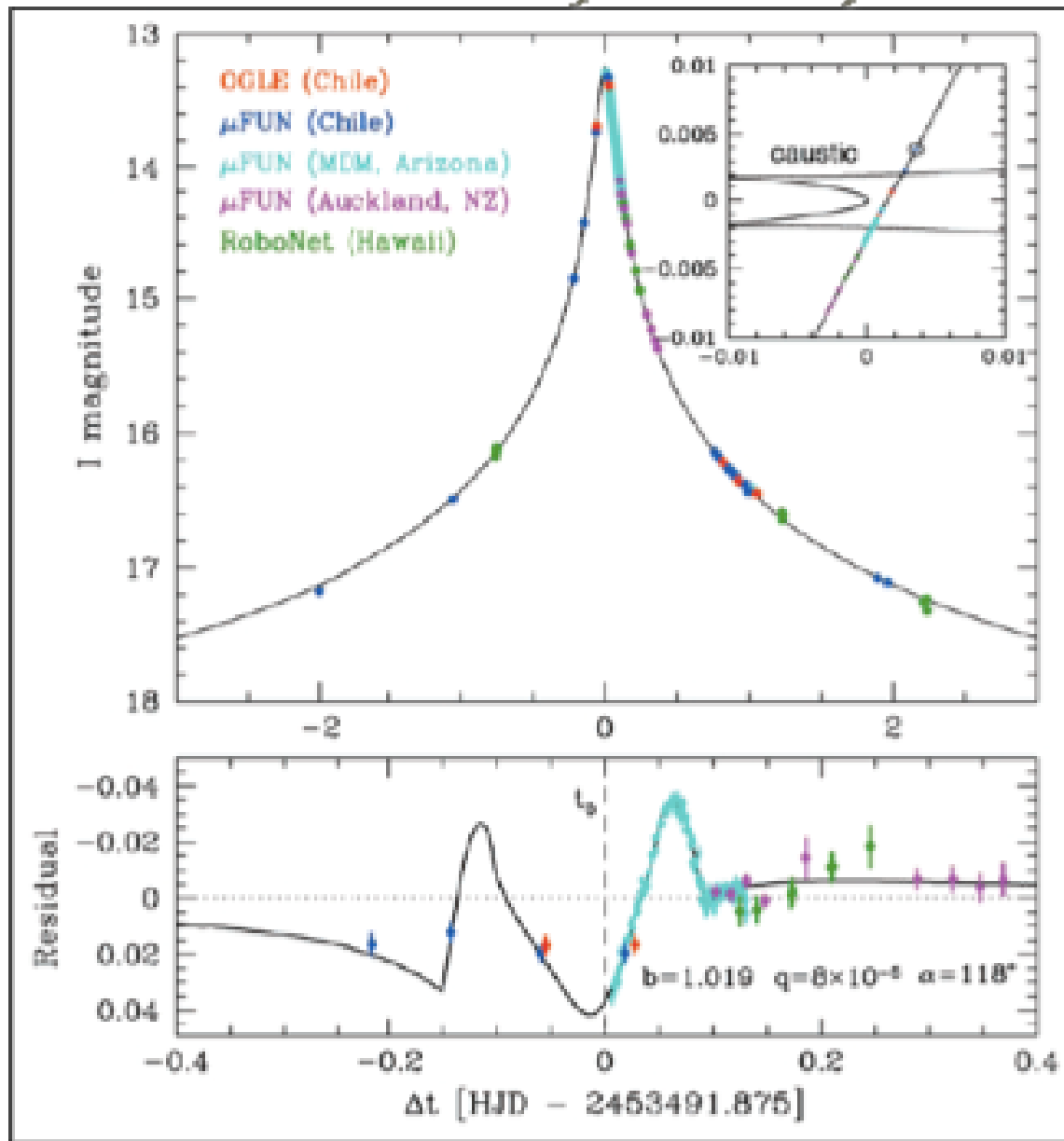
High-Magnification Events



OGLE-2005-BLG-071

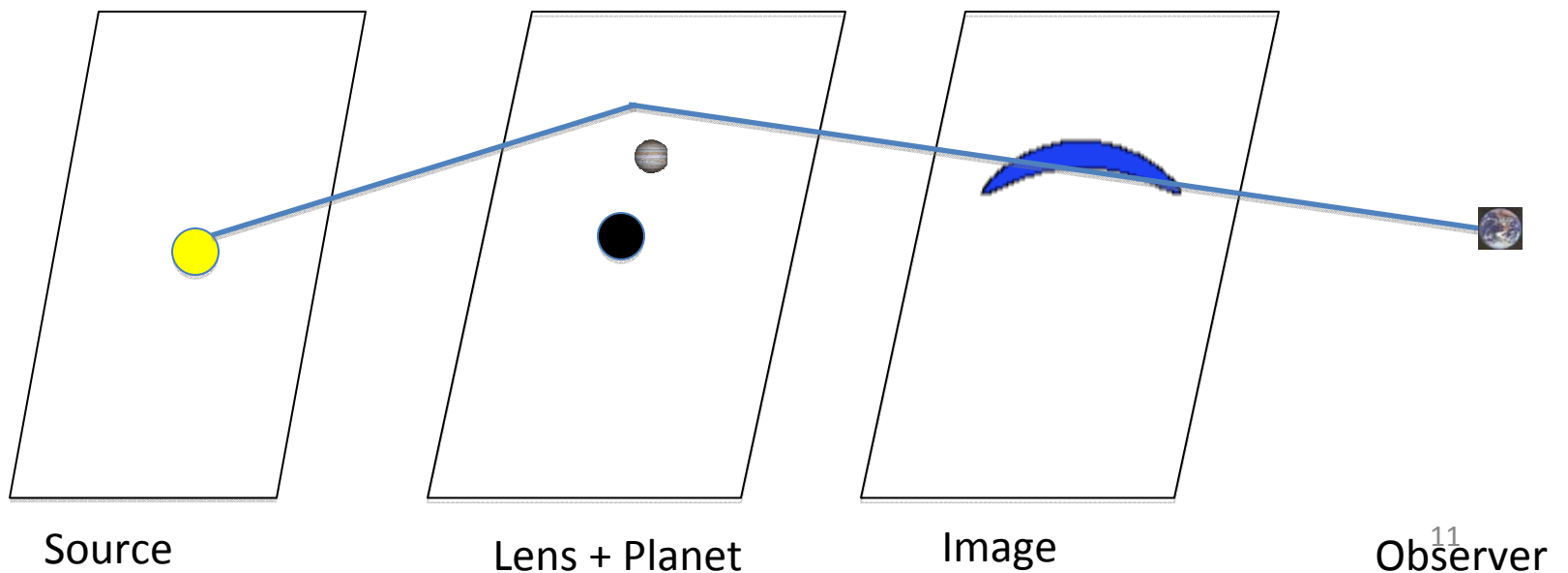


OGLE-2005-BLG-169

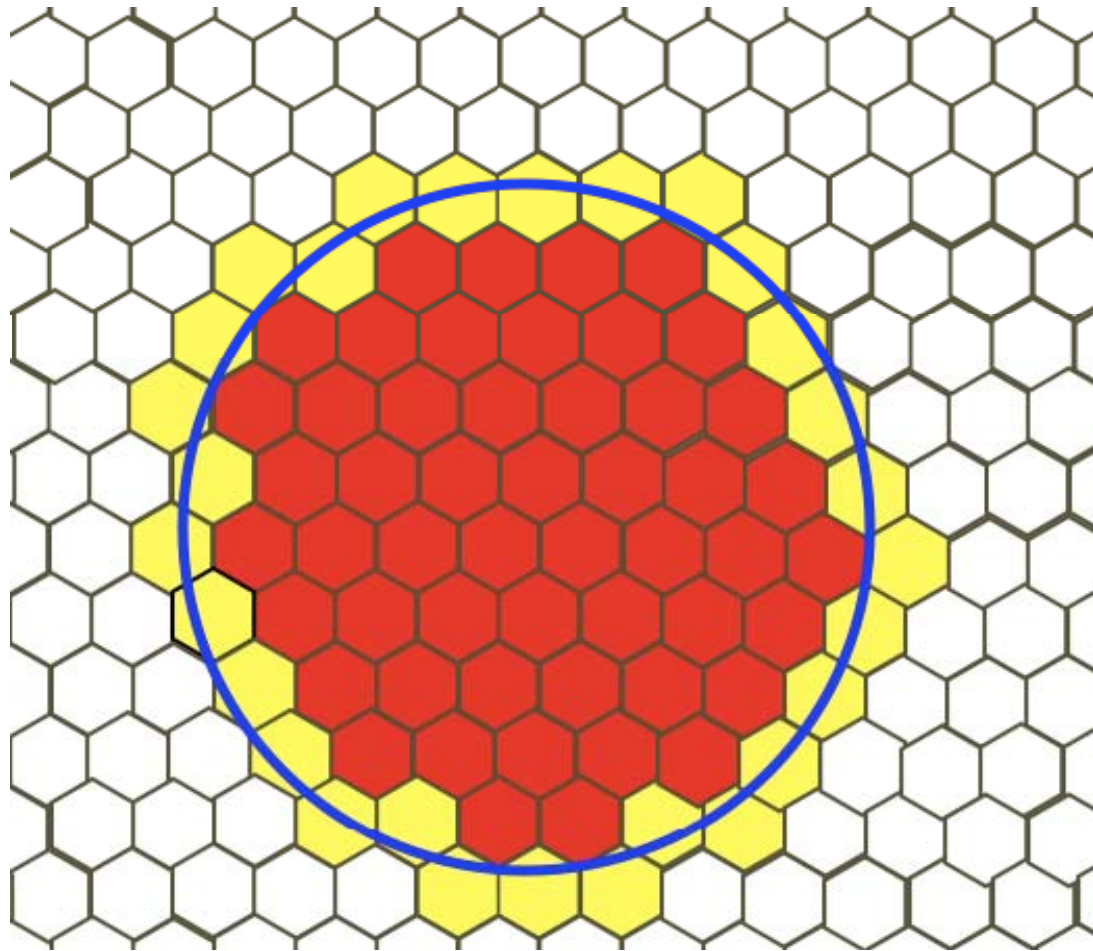


Ray-Tracing

- For a uniform source, Magnification = Area of the Images / Area of the Source
- Shoot many millions of rays from image plane to source plane to create magnification maps for each (d, q)



A hybrid of ray and pixel maps

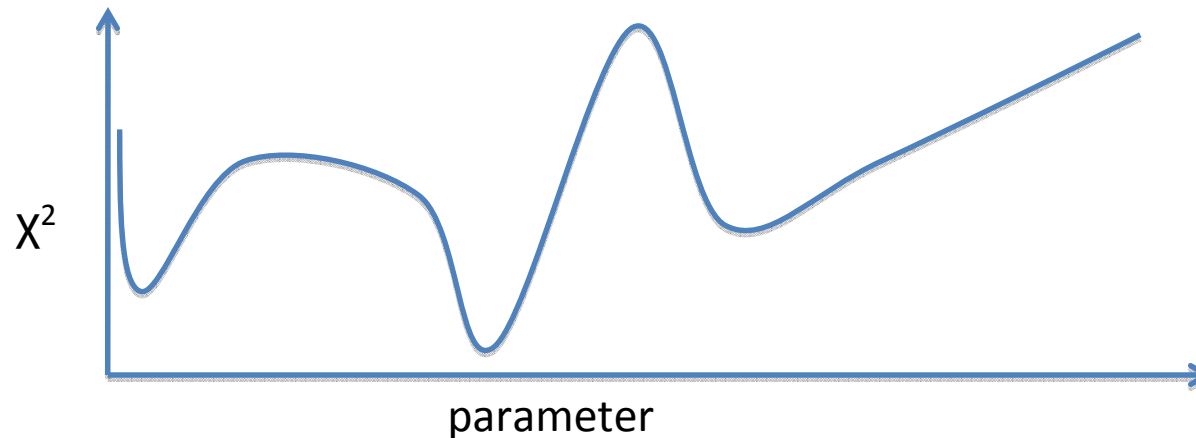


Goodness of a fit

- χ^2 measures the goodness of fit:

$$\chi^2 = \sum_i \left(\frac{f_{obs,i} - f_{model}}{error_i} \right)^2; f_{model} = f_{source} \times A + f_{blend}$$

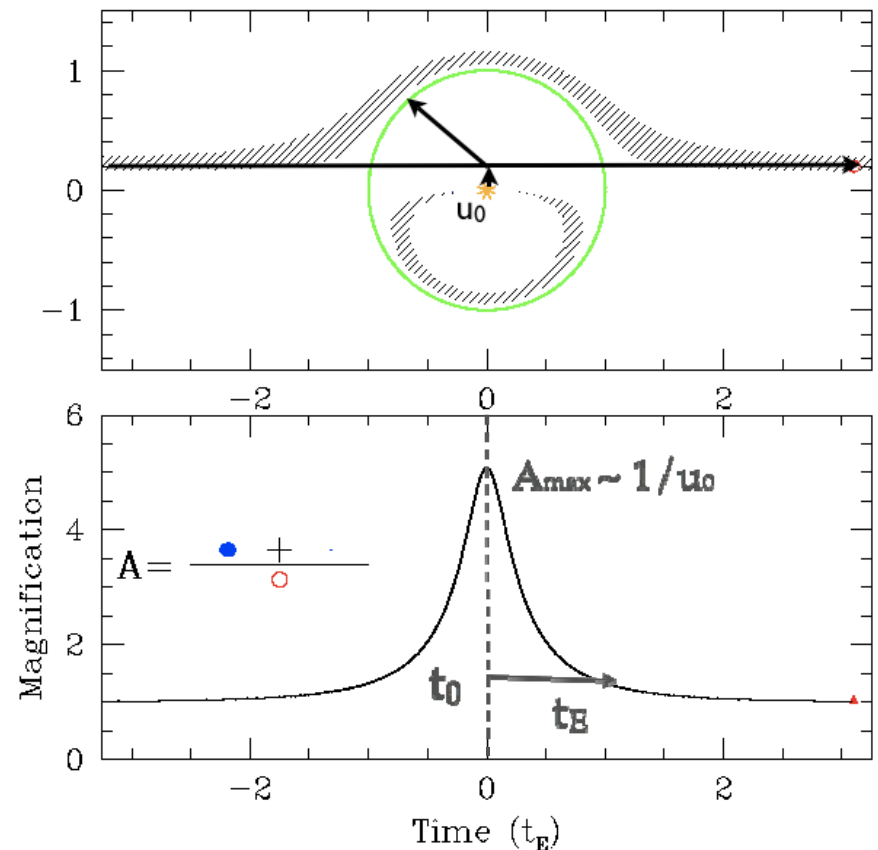
- Search for the solution with the minimum χ^2 in the multi-dimensional complex “parameter space”



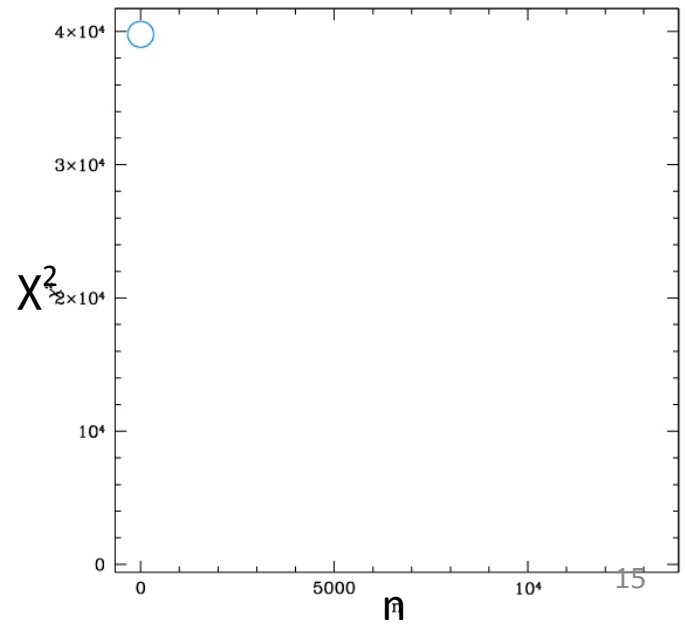
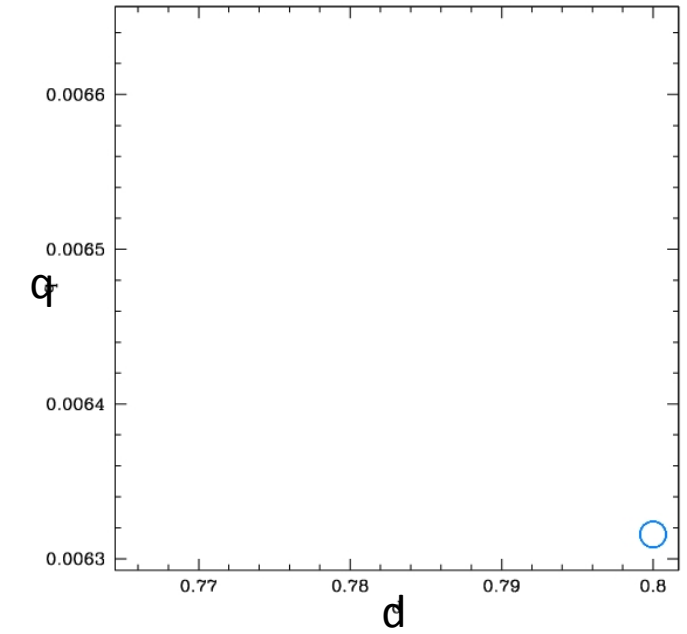
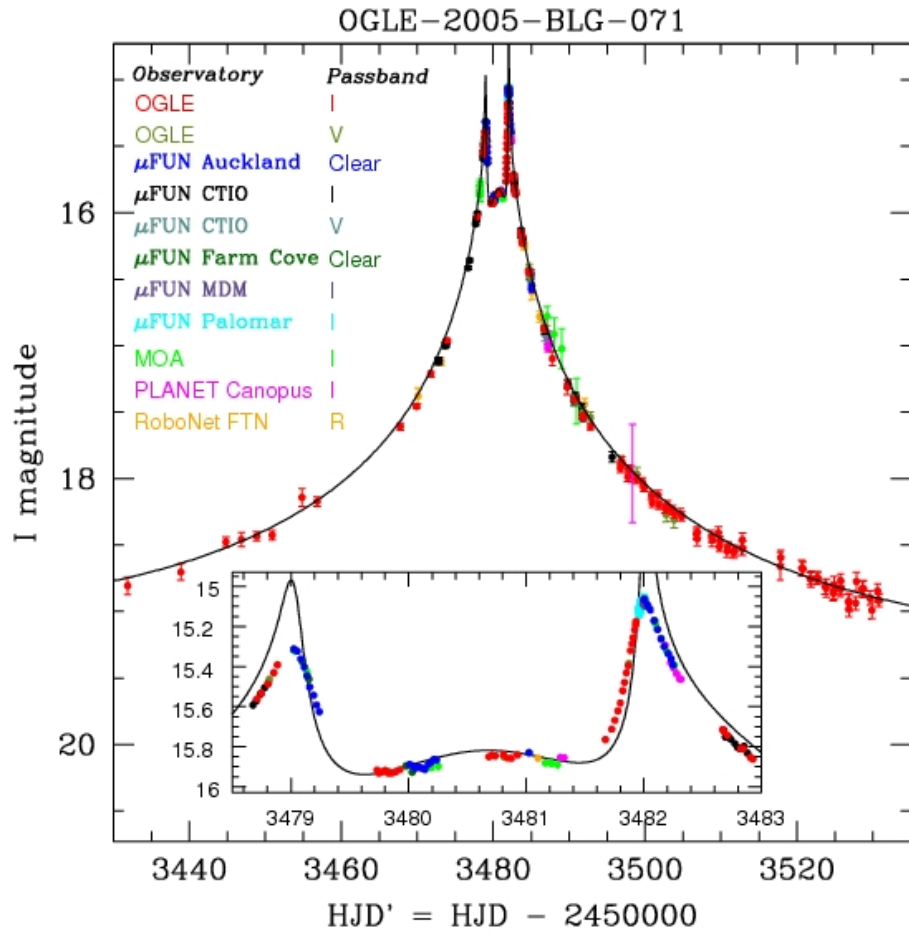
Search for Solution

Not All Parameters Are Created Equal.

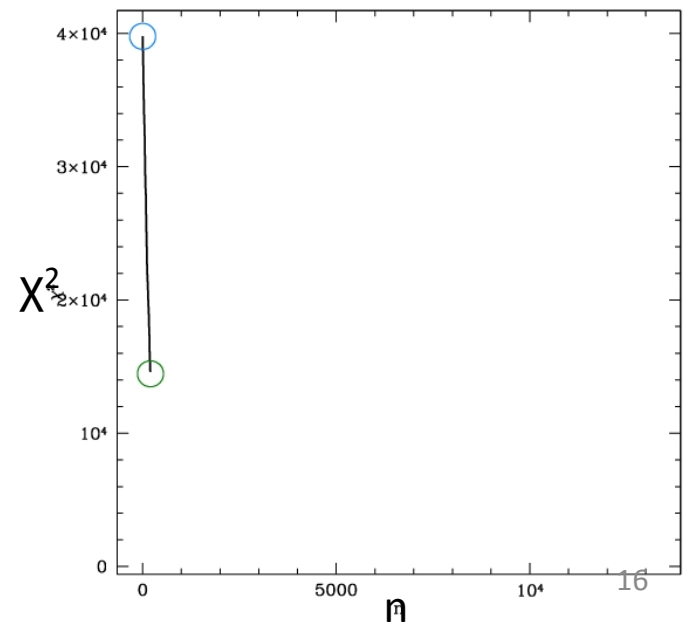
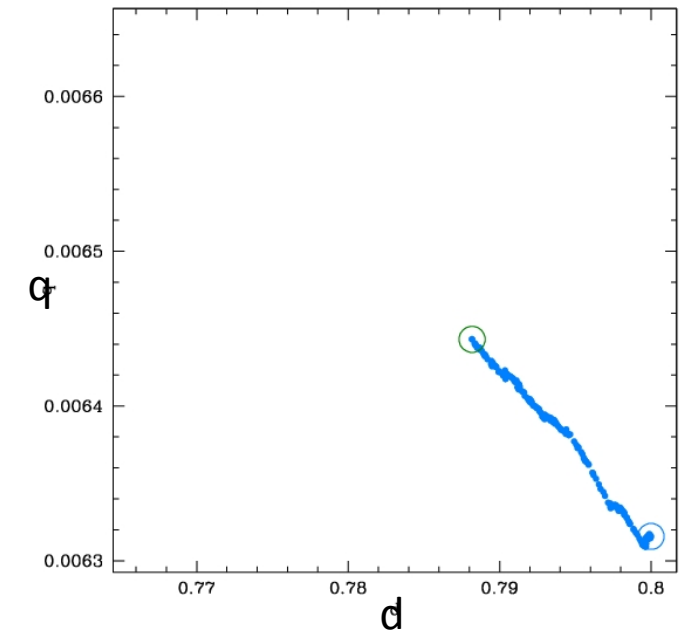
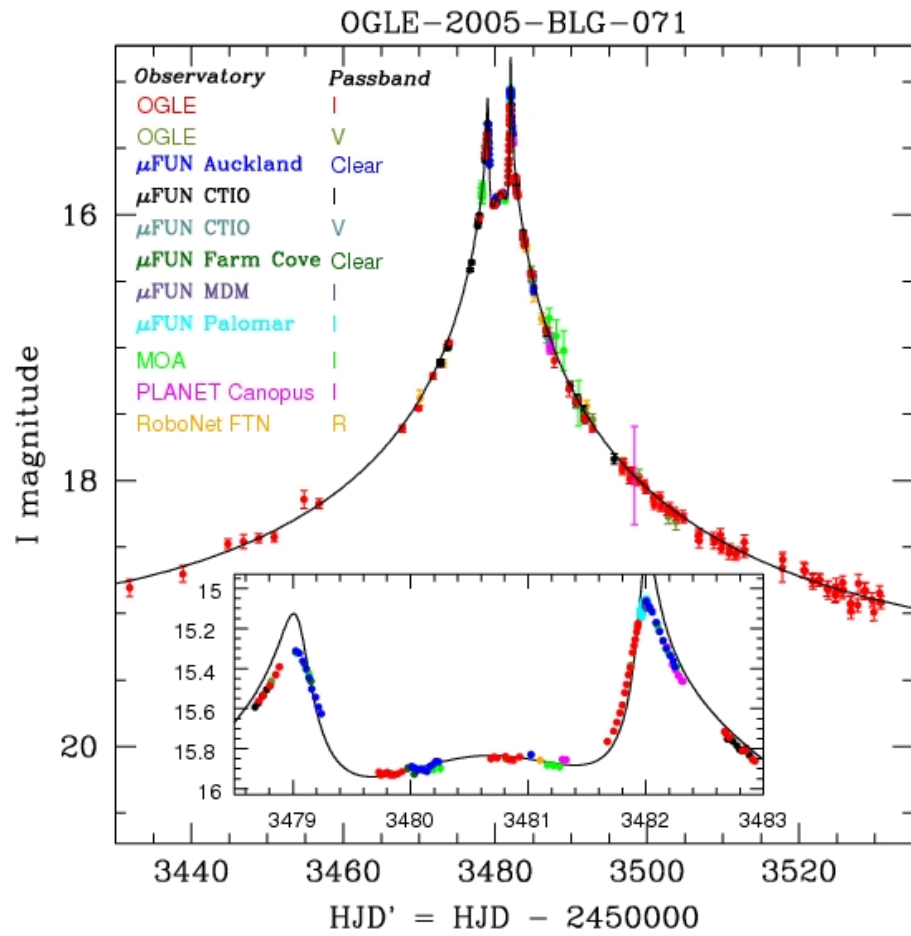
- Initial Brute-force Search
 - Fix (d , q , α) on a grid
 - Minimize (t_0 , u_0 , t_E , ρ) [$+ f_{s,i}$, $f_{b,i}$]
 - Adaptive step size Markov chain Monte Carlo (MCMC)
- Refine Solutions
 - Identify X^2 valleys on the grid
 - Varying all parameters + high-order effects with MCMC



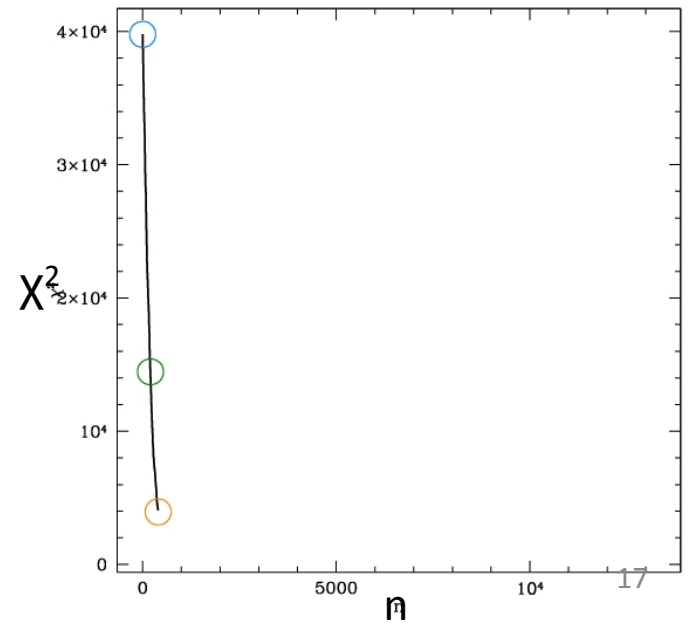
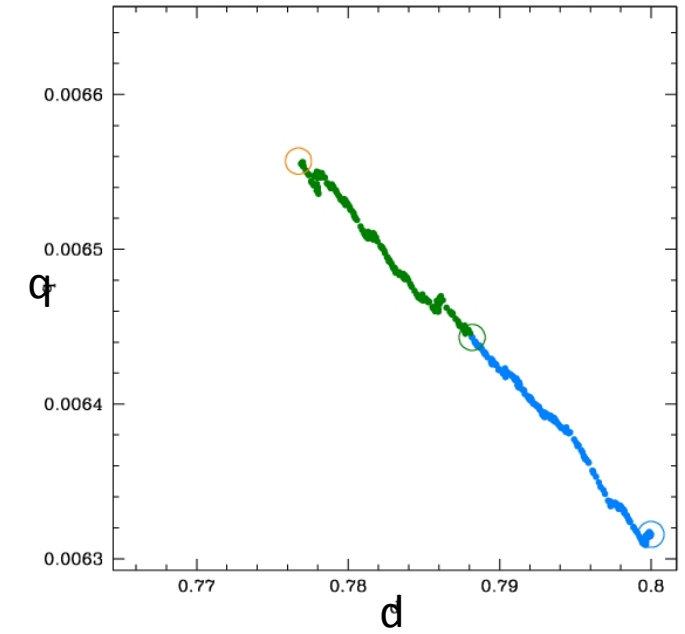
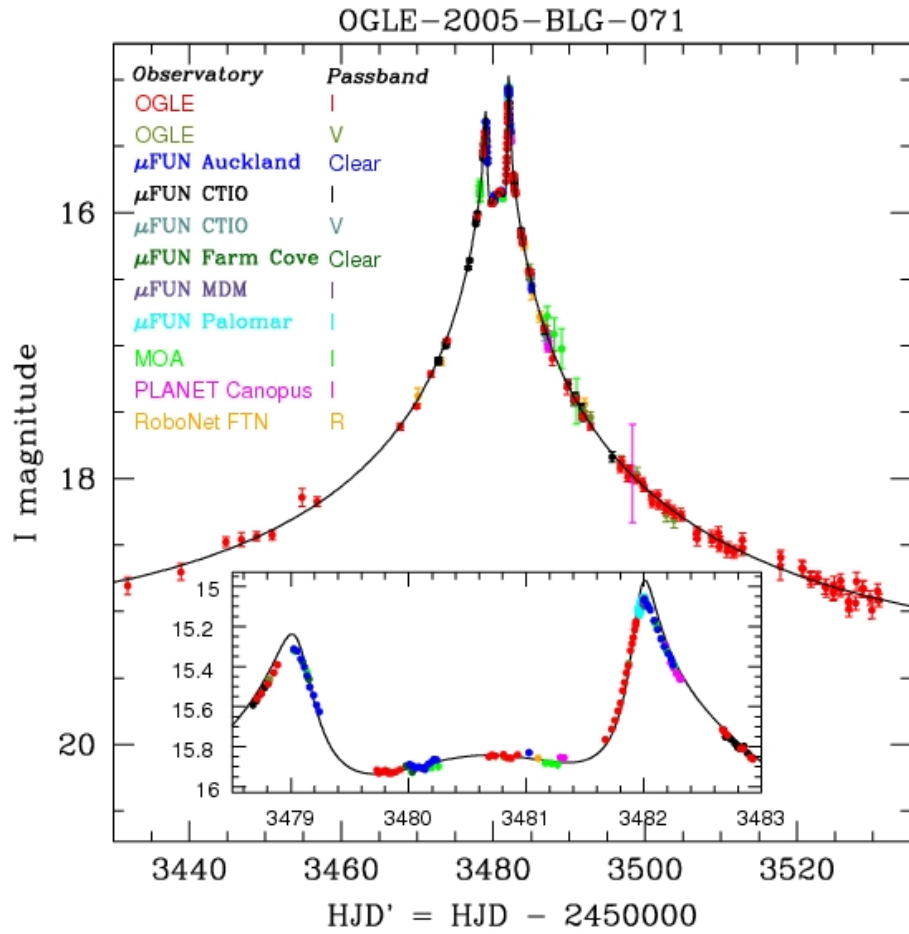
MCMC



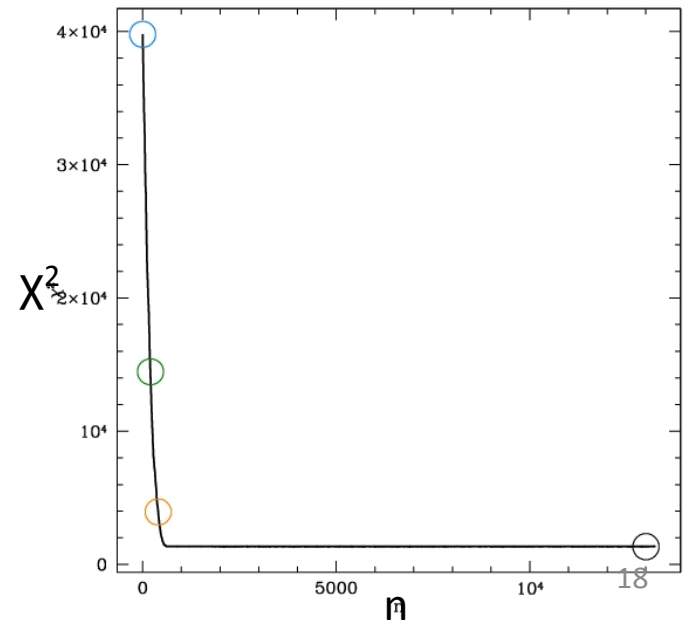
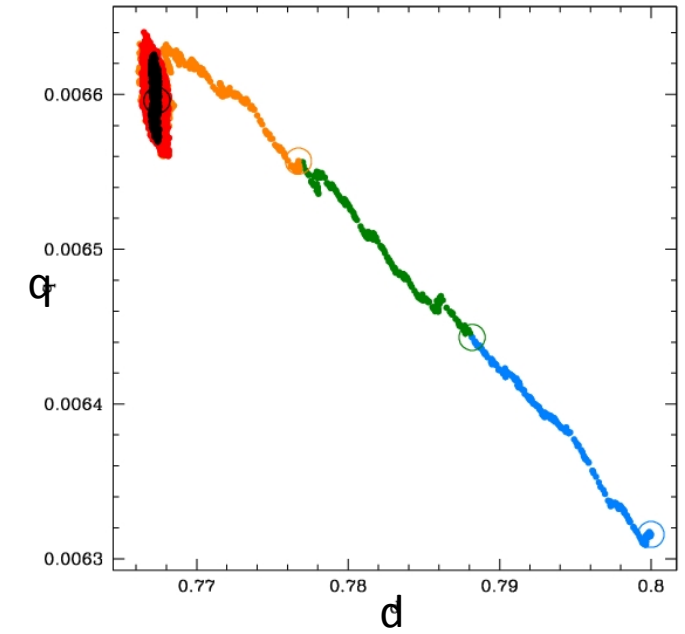
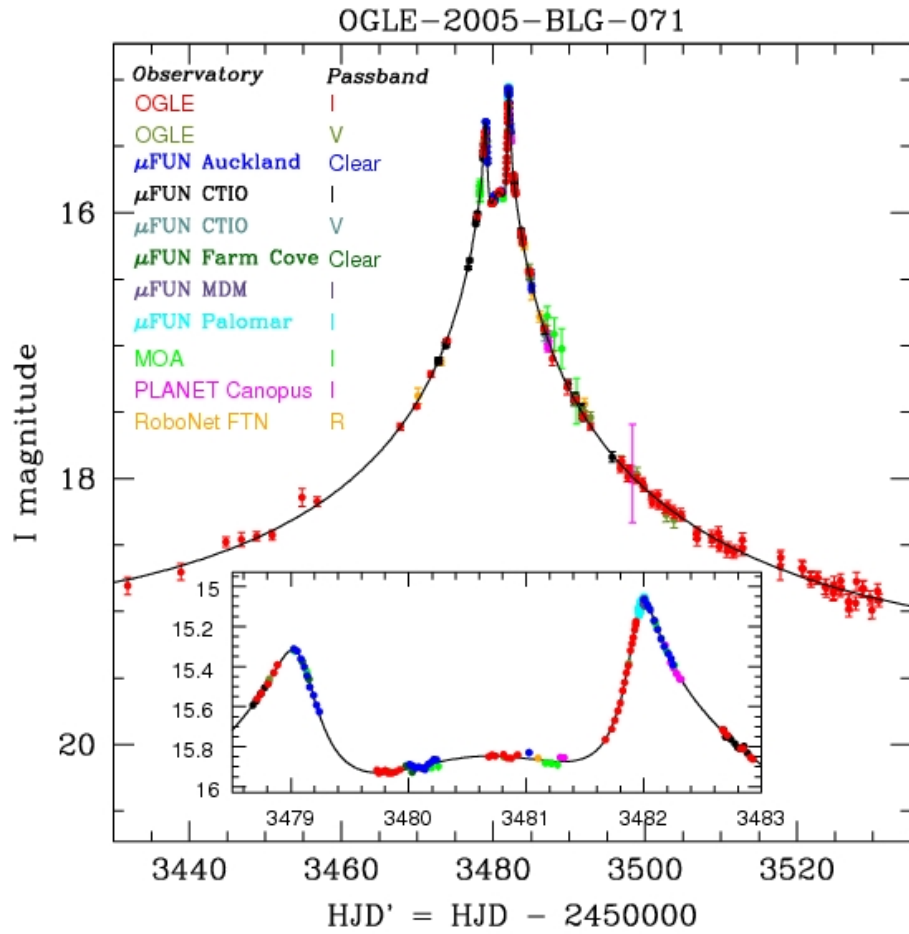
MCMC

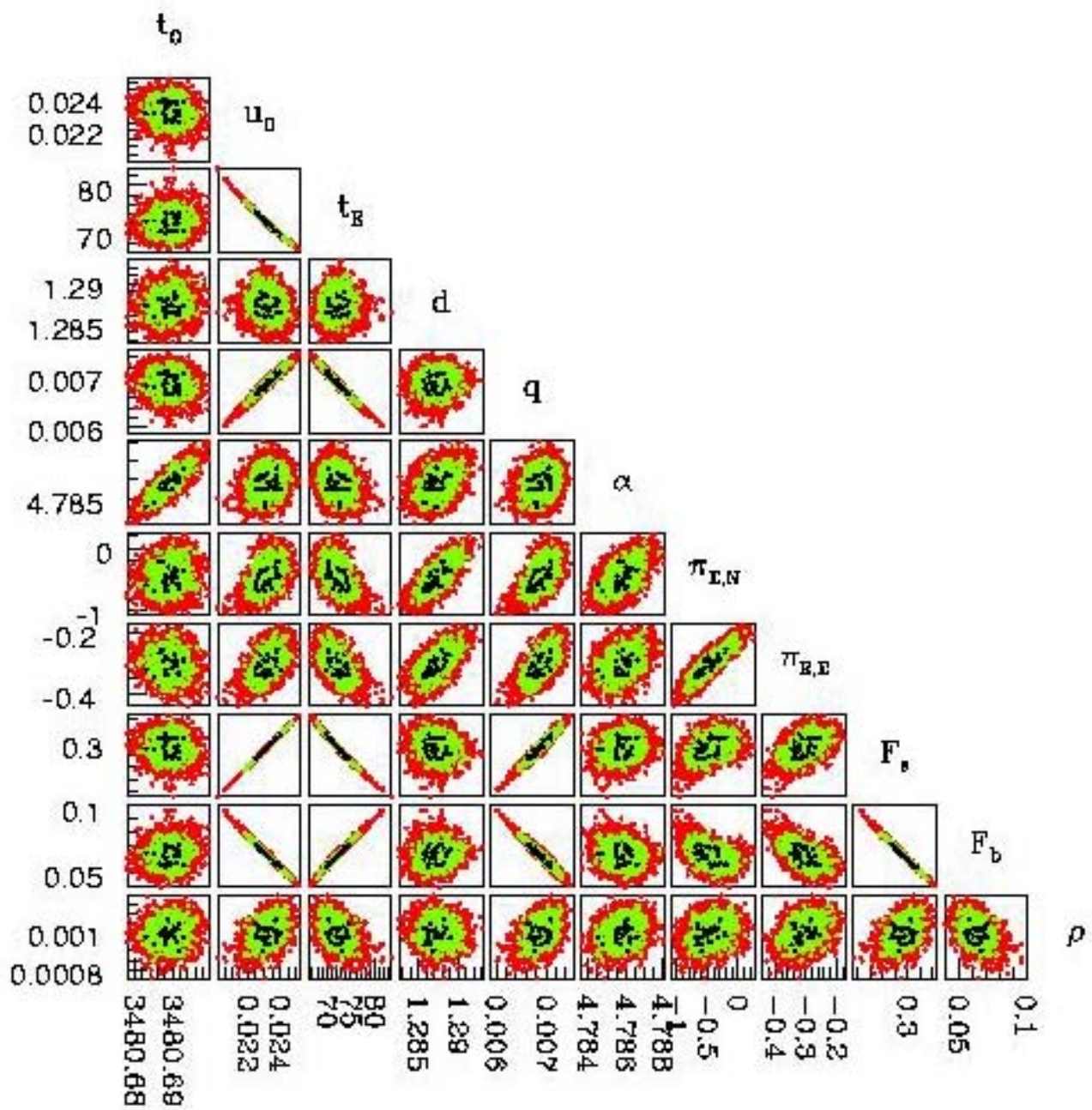


MCMC



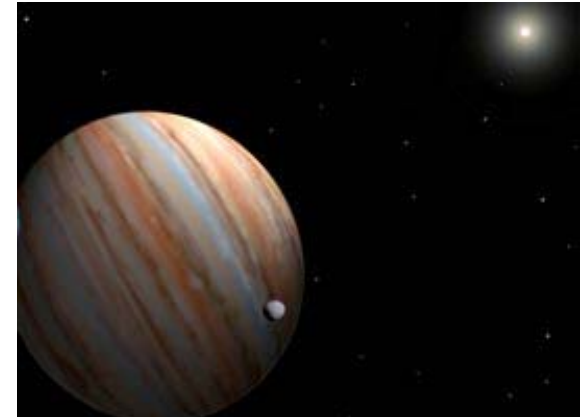
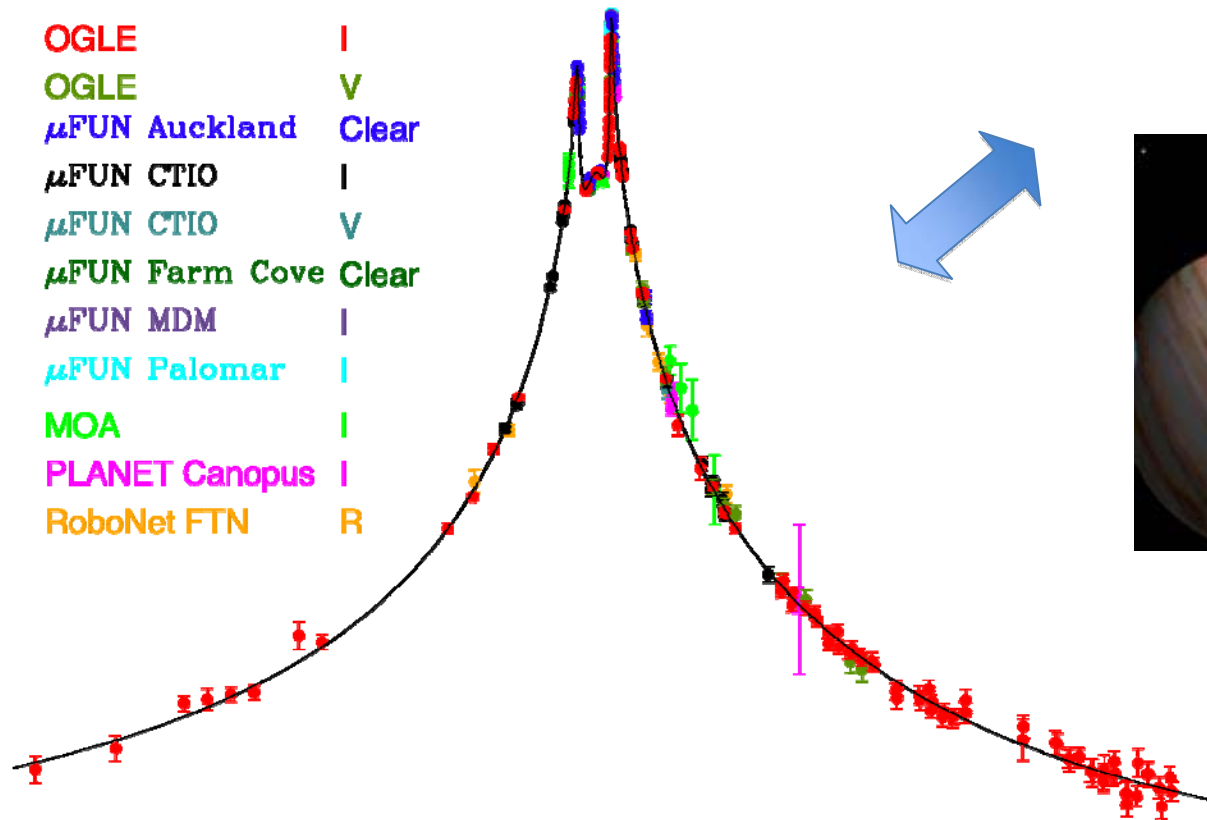
MCMC





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3.8 Jupiter Mass
3.6 AU



Model	t_0	u_0	t_E	b	q	α	ρ	$\pi_{E,N}$	$\pi_{E,E}$	ω	b/b	I_s	I_b	V_s	V_b
χ^2	(HJD')		(day)		$\times 10^3$	(deg)	$\times 10^4$			(yr^{-1})	(yr^{-1})	(mag)	(mag)	(mag)	(mag)
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Extracting Physical Parameters

- Higher-order effect in the light curve:
 - Finite Source: Measure the Angular Einstein Radii
 - Parallax: Measure Projected Einstein Radii
 - Finite Source + Parallax => Mass + Distance
(Andy's talk tomorrow)
- “See” the lens:
 - High-res, high-precision imaging from HST/VLT
(My talk tomorrow)