Re-analysis of OB110462 as a Possible Binary Microlensing Event

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Background

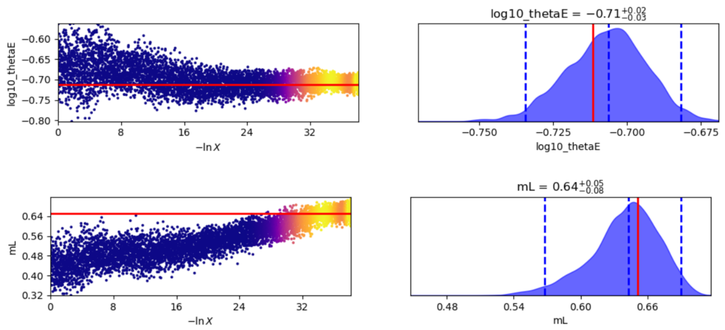
- **Microlensing**: Light from background sources is bent and amplified by objects in front of it.
- In June 2011, a microlensing event named OGLE-2011-BLG-0462, shortened to **OB110462**, was observed by microlensing surveys OGLE.
- Many black holes are thought to be in **binary systems** [3]. OB110462 was believed to be the first **isolated black hole** detected using gravitational microlensing.
- This project utilized the Bayesian Analysis of Gravitational Lensing Events (**BAGLE**) package to determine if OB110462's system fits a Binary Source Point Lens (**BSPL**) or a Point Source Binary Lens (**PSBL**) model.

Fitting Routine

- **Data Collection**: Gather photometric and astrometric data of OB110462 from previous studies.
- **Model Fitting and Execution**: Use **BAGLE** to simultaneously fit the data via Bayesian inference and MCMC sampling.
- **Parameter Estimation**: Set initial input of physical parameters (priors) and statistical analysis they are estimated, taken from the main reference paper [1]. This includes lens mass, Einstein radius, and Einstein period.
- **Result Visualization**: Generate light curves, residuals, trace plots to assess parameter precision.

Trace Plots

- Trace plots show the convergence of a single parameter over time.



Light Curves

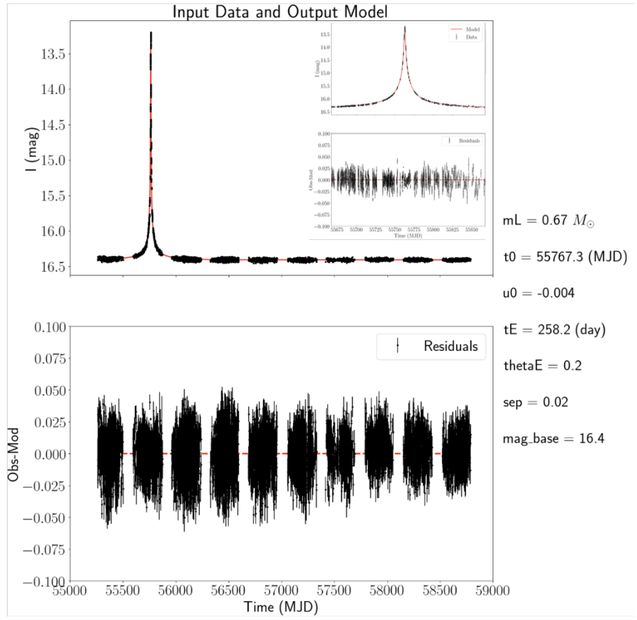


Figure 1. (Top) I-OGLE BSPL Fit with a zoomed-in version around the Einstein crossing time t_E. (Bottom) Residuals for the best-fit BSPL light curve.

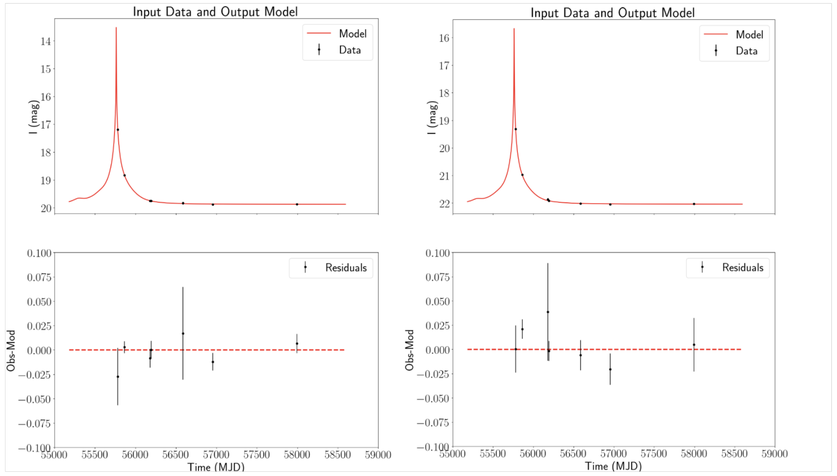


Figure 2. (Top Left) HST F814W BSPL Fit. (Bottom Left) Residuals for the best-fit BSPL light curve. (Top Right) HST F606W BSPL Fit. (Bottom Right) Residuals for the best-fit BSPL light curve.

Discussion

Filter	Reduced Chi- Squared ($\tilde{\chi}^2$)
I-OGLE	3.463
HST F814W	0.611
HST F606W	0.952

Table 1. $\tilde{\chi}^2$ values for I-OGLE, HST F814W, and HST F606W with equal weighting applied to photometric and astrometric considerations.

Light Curve Analysis:

- Photometric residuals for I-OGLE show a relatively uniform distribution, however, the $\tilde{\chi}^2 = 3.463$ is higher than expected. This might be due to the astrometric data affecting the photometric fit.
- Photometric residuals for both HST F814W and HST F606W also show uniform distributions. $\tilde{\chi}^2$ of 0.611 and 0.952 are closer to one.

Trace Plot Analysis:

- Trace plots that converge to a clear and definite single value signify that that parameter has been well fitted.
- Graphs to the right of the trace plots shown display marginalized posteriors of left graphs with errors.

Future Work

- We would like to fit the data to a PSBL model, as we were unable to get any plots for this.
- We would also like to increase the **weight** of the astrometric data since both photometric and astrometric data need to be fit well.
- Our fit is currently dominated by photometry, but increasing astrometric weight might reduce degeneracies.

References

[1] C. Y. Lam and J. R. Lu, "A reanalysis of the isolated black hole candidate ogle-2011-blg-0462/moa-2011-blg-191," *The Astrophysical Journal*, vol. 955, no. 2, p. 116, 2023.

[2] Moving Universe Lab, "Moving universe lab website." `https://movinguniverse.example.com`, 2022.
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[3] N. S. Abrams, J. R. Lu, C. Y. Lam, M. S. Medford, M. W. Hosek, and S. Rose, "Assessing the impact of binary systems on microlensing using spisea and popsycle population simulations," *The Astrophysical Journal*, vol. 980, p. 103, feb 2025.

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