Analyzing the Microlensing Event of OGLE-2005-BLG-390

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Astron 98 Final Project:

1. Introduction

For this project, I propose to look at a microlensing event and analyze the light curve from the source in hopes of detecting a planetary deviation which would signal the presence of an exoplanet. If the light curves are measured frequently for a few hours, gravitational microlensing events can reveal extrasolar planets orbiting the foreground lens stars.This project involves data analysis, fitting data with error, and providing explanations for the model. Additionally, I aim to use the microlensing fit to determine the planet–star mass ratio.

2. Chosen Event and Data Source

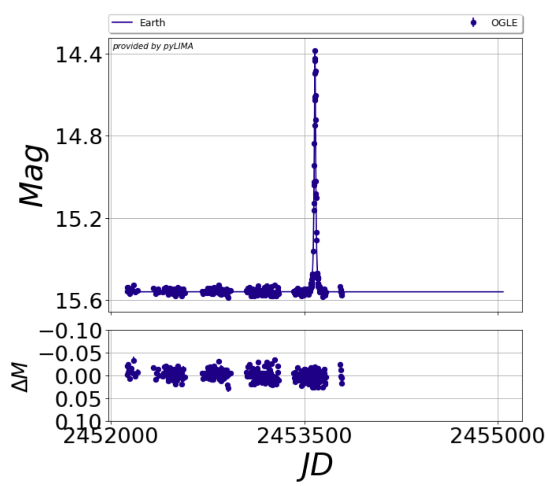
The event I chose for this project is OGLE-2005-BLG-390 (RA = 17:54:19.19, DEC = -30:22:38.3) which has a planet of about 5.5 $M_\oplus$. Microlensing is most effective in finding planets in Earth-to-Jupiter-like orbits (with semi-major axes 1–5 AU), which is why I believe that this planet is a great candidate. The telescope data comes directly from OGLE's public database (https://ogle.astrouw.edu.pl/ogle3/ews/2005/ews.html).
In order to create a light curve, I downloaded csv files from each archive containing information on the source star's magnitude and time, with error. Combining both sources, I had a total of 373 data points.

3. Data Modeling

For this project, I wanted to take advantage of NASA's open source package for microlensing modeling pyLIMA, which is designed to fit real data. pyLIMA facilitates making light curves, modeling the data, and calculating parameters.

First, I used pyLIMA do conduct a standard Levenberg-Marquardt fit, which use the light curve data to find the following parameters:

t_0 (days) = time of the minimum impact parameter
u_0 (angular Einstein ring radius) = minimum impact parameter
t_E (days) = the angular Einstein ring crossing time



After performing the fit, the derived parameters were:
t_0 (days) = 2453582.7513251393

u_0 (angular Einstein ring radius) = 0.3346990461223354
t_E (days) = 11.645304885118838

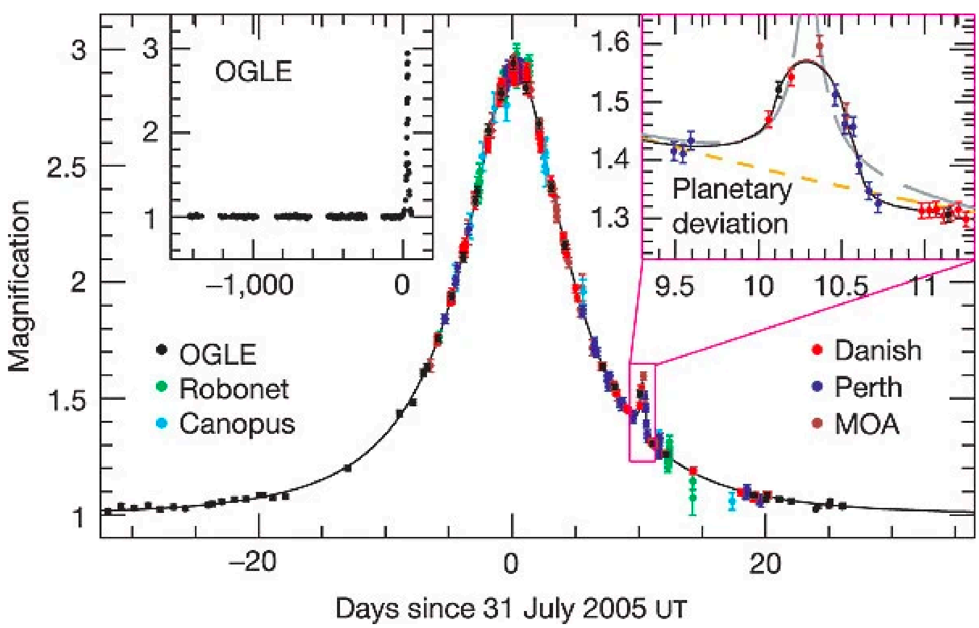
Again using pyLIMA, I fitted the data using another model: [Differential Evolution]() from Storn & Pricedo. Similarly to the LM fit, this model takes in the magnitude vs. time telescope data and returns the same t0, u0, and tE values:
t_0 (days) = 2453582.7530664606
u_0 (angular Einstein ring radius) = 0.3340572770587245
t_E (days) = 11.661736456510795

Using a standard agreement test ($|A - B| \leq 2\sqrt{a^2 + b^2}$), it is clear that all the values are consistent between both models.

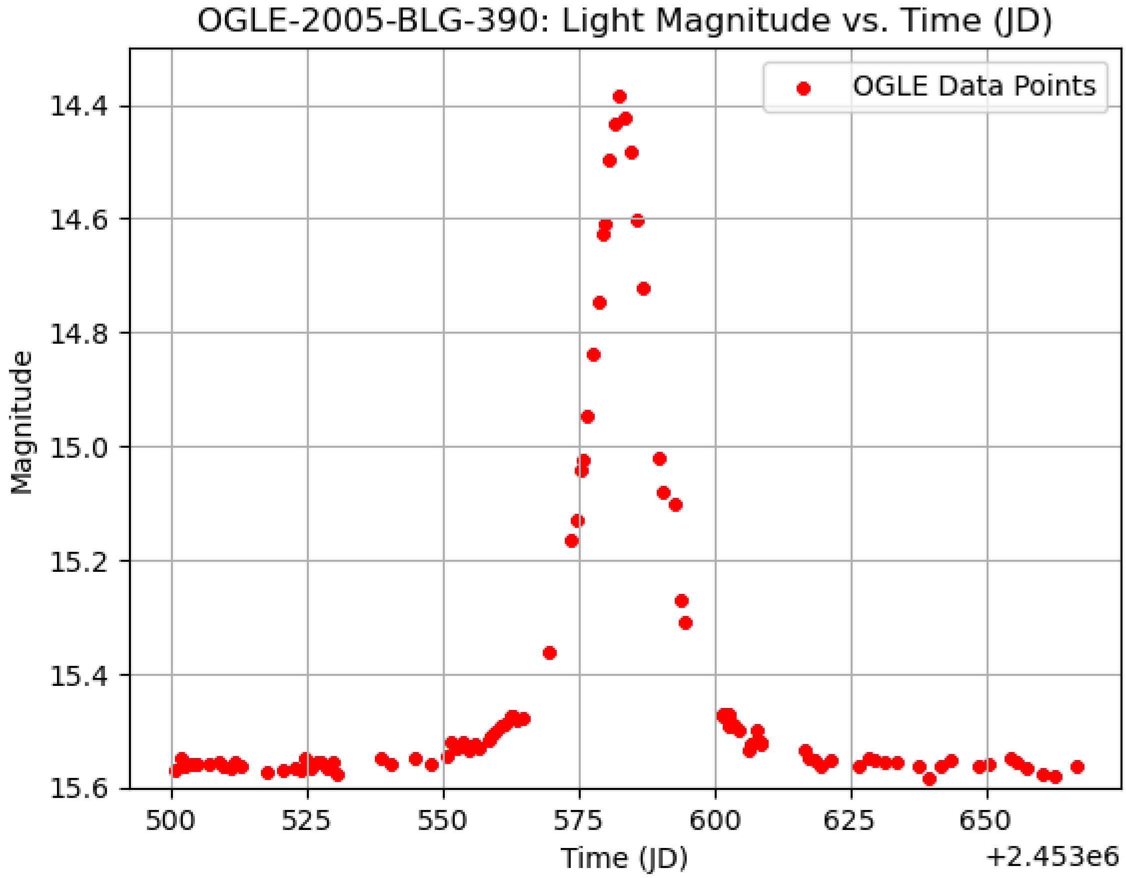
4. Conclusion

The main goal of my project was to detect a planetary deviation, as in the following figure from

Beaulieu, JP., Bennett, D., Fouqué, P. et al. Discovery of a cool planet of 5.5 Earth masses through gravitational microlensing.



Unfortunately, there I did not have a sufficient amount of data points to detect this deviation. While the data from OGLE was relatively accessible, I was unable to find more information about OGLE-2005-BLG-390 from other sources, even after extensive searching. This is made clear in the following figure, which is focused around the angular Einstein ring crossing time:



With more time I would have hoped to find the missing raw data and continue my analysis. Nevertheless, I learned much about microlensing events and the pyLIMA python package, and successfully used pyLIMA to model the light curve of a transient light source, clearly suggesting that OGLE-2005-BLG-390 is a microlensing event.