Gravitational Microlensing

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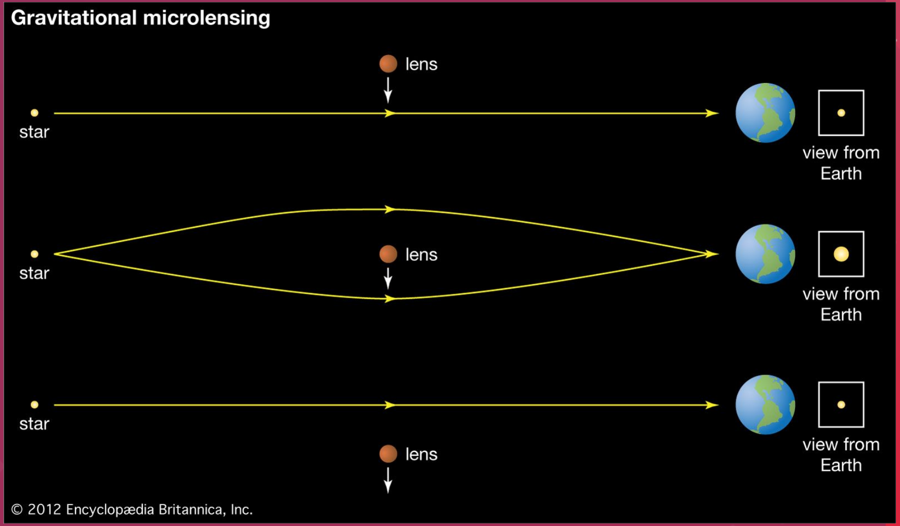
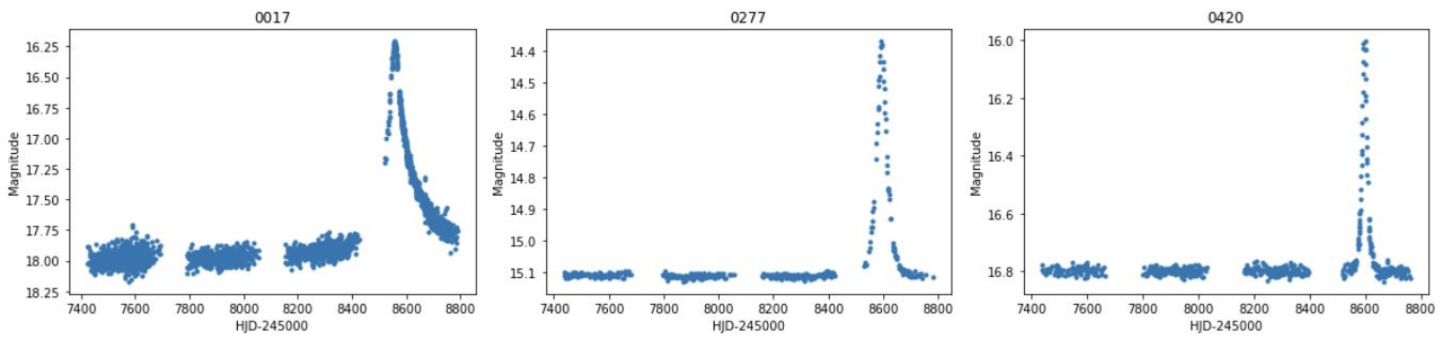
Background

- Gravitational microlensing
  - The focusing of light as mass moves past star
- Took data from Optical Gravitational Lensing Experiment (OGLE)
  - Polish based
  - Long running observations of trying to find microlensing events
- Our Goal:
  - Fit and analyze Paczynski Light Curve Model to OGLE's data



Data

- Collected from OGLE-IV project
  - Database of microlensing events from 2019
  - One of the largest sky variability surveys
- X-axis measures time, the Y-axis measures the magnitude, and the data points themselves represent a measure of brightness as a function of time
- Picked three microlensing events



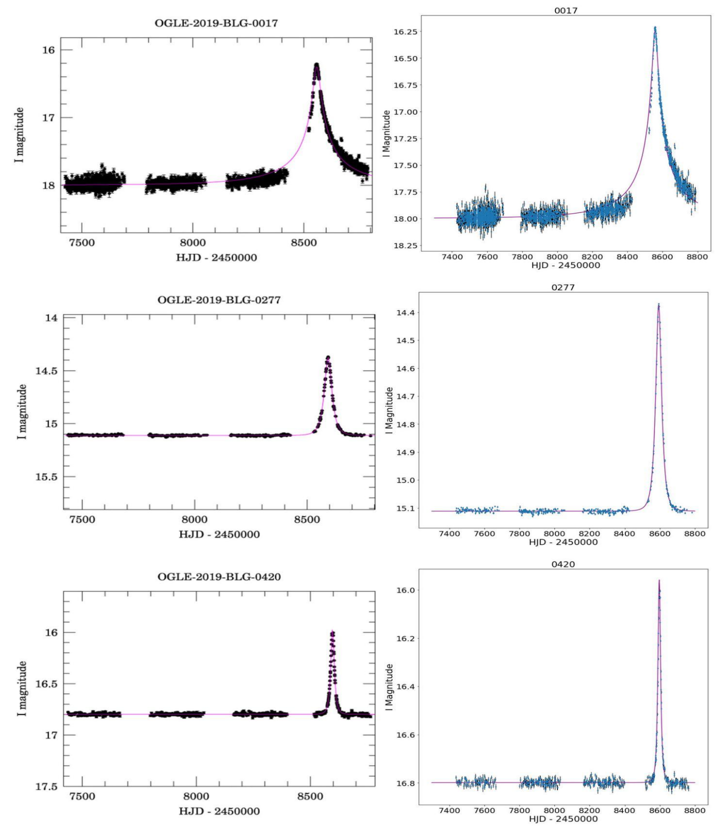
Methods

- Paczynski microlensing model
- $$u(t) = \sqrt{u_{min}^2 + \left(\frac{t - t_0}{t_E}\right)^2}$$
- Non-blended model $$A(t) = \frac{u^2+2}{u\sqrt{u^2+4}}$$ Blended model $$A(t) = f_{bl}\left(\frac{u^2+2}{u\sqrt{u^2+4}} - 1\right) + 1$$
- $$m_{mod}(t) = m_{bl} - 2.5\log_{10}(A(t))$$
- Found parameters by optimizing a chi^2 function for both models
- Used Markov Chain Monte Carlo (MCMC) simulation to analyze error in parameters

- u(t): angular separation of source and lens
- u_min: minimum separation
- A(t): Magnification of light from lensing
- m_bl: intensity of light with A = 1
- f_bl: fraction of incoming light that is from the source
- m_mod(t): intensity of light predicted by our model

Results

- Both model's lined up well with the data
- We were able to mimic OGLE's results
    - With aesthetic differences
- Blended vs Unblended parameter fitting

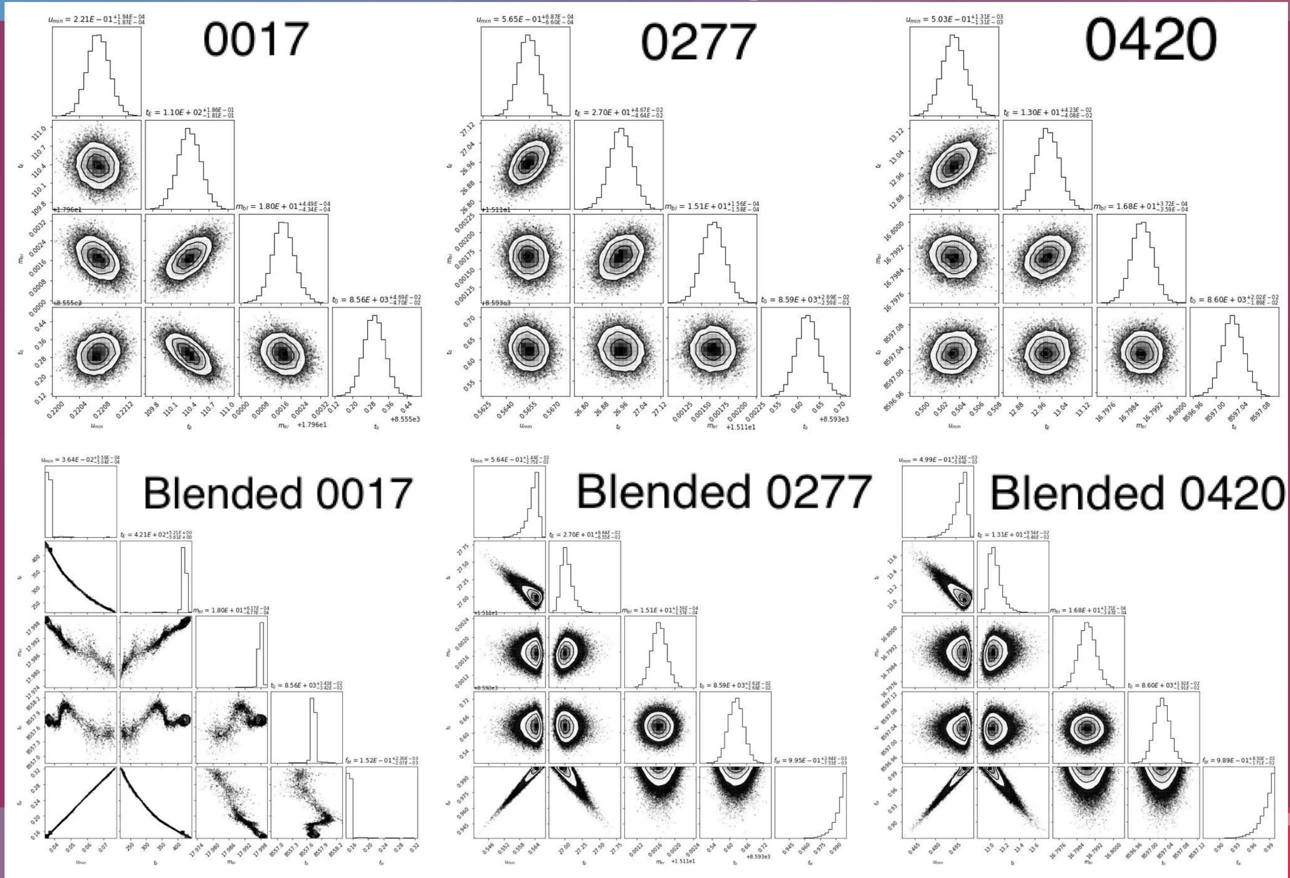


Results

Parameters↓ Event→	0017	0277	0420	OGLE 0017	OGLE 0277	OGLE 0420
u_{min}	0.221	0.565	0.504	0.36	0.565	0.503
t_E [days]	110.381	26.958	12.989	421.250	26.595	12.989
t_0 [HJD - 2450000]	8555.296	8593.624	8597.027	85557.734	8593.624	8597.030
m_{bl}	17.962	15.112	16.795	17.998	15.112	16.799

Parameters[Blended]↓ Event→	0017	0277	0420	OGLE 0017	OGLE 0277	OGLE 0420
u_{min}	0.036	0.565	0.503	0.036	0.565	0.503
t_E [days]	421.242	26.959	12.989	421.250	26.595	12.989
t_0 [HJD - 2450000]	8557.734	8593.624	8597.030	85557.734	8593.624	8597.030
m_{bl}	17.998	15.112	16.799	17.998	15.112	16.799
f_{bl}	0.152	1.0	1.0	0.152	1.0	1.0

Error Analysis



Conclusion

- Limitations:
  - Cannot determine mass of lens
    - Need distances (us to lens, us to source, and lens to source)

$$M = \frac{c^2}{4G} \frac{D_l D_s}{D_{ls}} |\theta_+ \theta_-|$$

- Limitations → Further research, observation, and experimentation

Questions?