Identifying Massive Black Holes by Analyzing Microlensing Lightcurves

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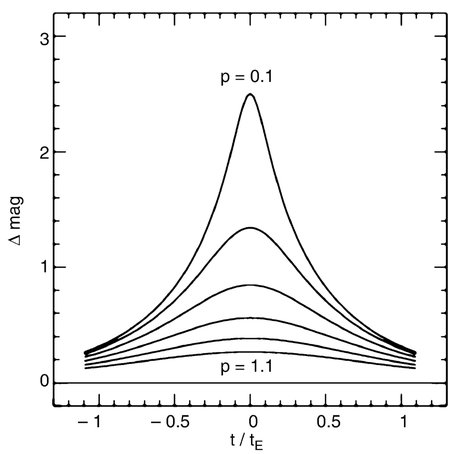
Background

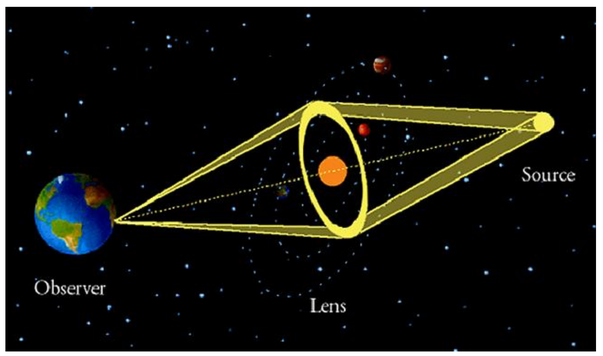
- Gravitational lensing occurs when there is a massive object between a source and observer whose gravitational field distorts the light rays reaching the observer
- Microlensing is a form of gravitational lensing in which there is a very noticeable change in intensity (brightness) over the course of the event.
- Our goal is to utilize the technique of gravitational microlensing to locate massive blackholes ($M \geq 10M\odot$).

Lightcurves

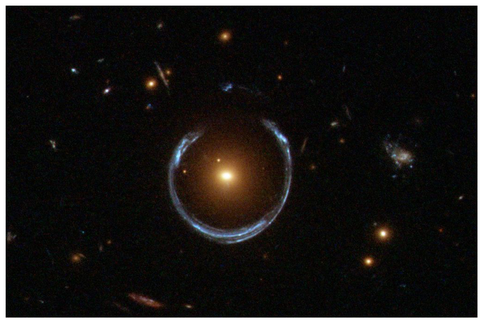
- These are are the "tool of the trade" in regards to visualizing microlensing phenomena.
- Simply a graph of intensity vs time for microlensing "event".
- Yield four important parameters:
  - Characteristic time scale (t_E)
  - Time of max intensity (T_{max})
  - Impact parameter (p)
  - Incident intensity (I_0)
- Events with very long characteristic time scale or whose lightcurve has a large reduced chi square values are much more interesting.



the standard lightcurve



diagram[2] of gravitational lensing event



image[3] of an Einstein ring

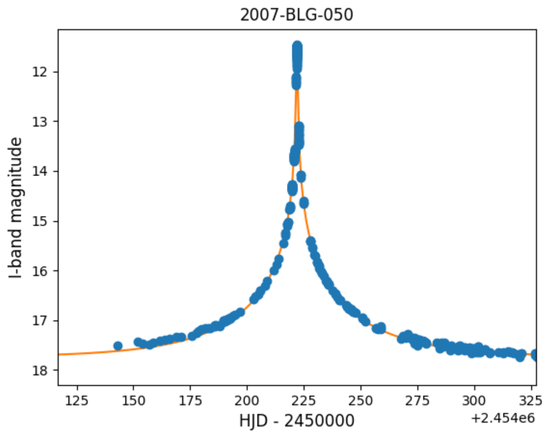
oglelib

- There is an abundance of microlensing data available courtesy of OGLE[1] project.
- Created open-source python library for retrieving and interacting with data stored on OGLE ftp server.

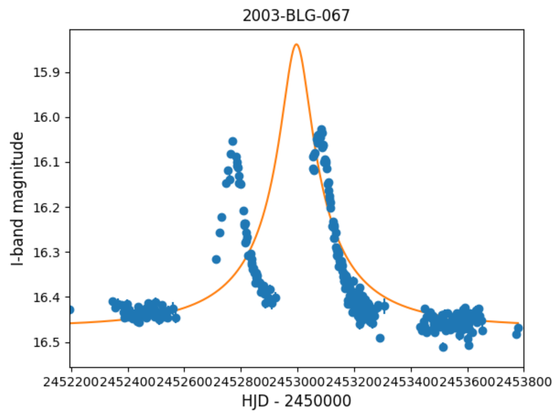
Data Mining

- Utilized oglelib download functionality to create SQL database of more than 19,000 microlensing events.
- Gleaned some important insights:
  - Event with highest reduced chi square value: 2002-blg-80
  - Event with longest t_E value: 2007-blg-35
  - Average incident intensity of objects being lensed $I_{0,avg} \approx 18.45$
  - Average characteristic timescale: $t_{E,avg} \approx 30.768$ days
  - Average reduced chi square: $rcs_{avg} \approx 30.42$

Exciting prospects



event with rcs value of 301.31



event with t_E value of 401.09 days

Future Projects

- There is great potential for the application of machine learning into this kind of research.
- The vast microlensing data archive will be invaluable in training machine learning models to do the hard work of discerning which events are truly "interesting".

PSEG

Acknowledgements: 1) The OGLE project: http://ogle.astrouw.edu.pl/ogle4/ews/ews.html. 2) Brandon Bartell: http://minerva.union.edu/bartellb/Types%20of%20Lensing.html. 3) ESA/Hubble: https://commons.wikimedia.org/wiki/File:Lensshoe_hubble.jpg.