L⊙CSST

Modeling Long-Term Variability in Compact Object-Stellar Binary Systems For Mass Determination

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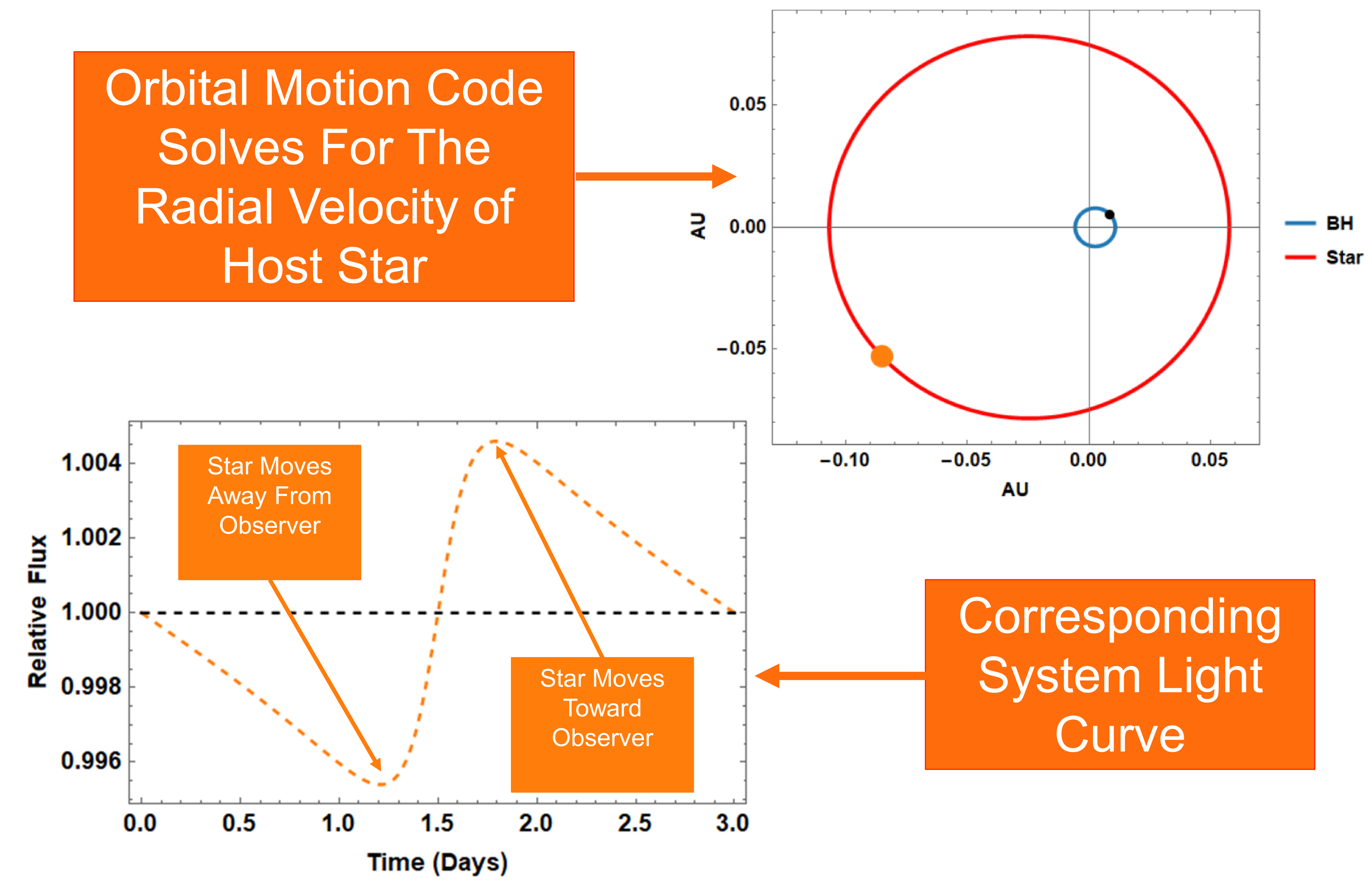
Introduction:

- Non-Interacting Binary Systems containing a star and compact object can exhibit various effects in their light curves
  - **Ellipsoidal Variations** due to extreme tidal forces
  - **Doppler Boosting** caused by high orbital velocities
  - **Gravitational Lensing** of the host star by the compact object
- Our model combines these effects to produce synthetic light curves
- This model can estimate binary parameters such as mass, inclination, eccentricity and stellar radius by fitting it to real world light curves

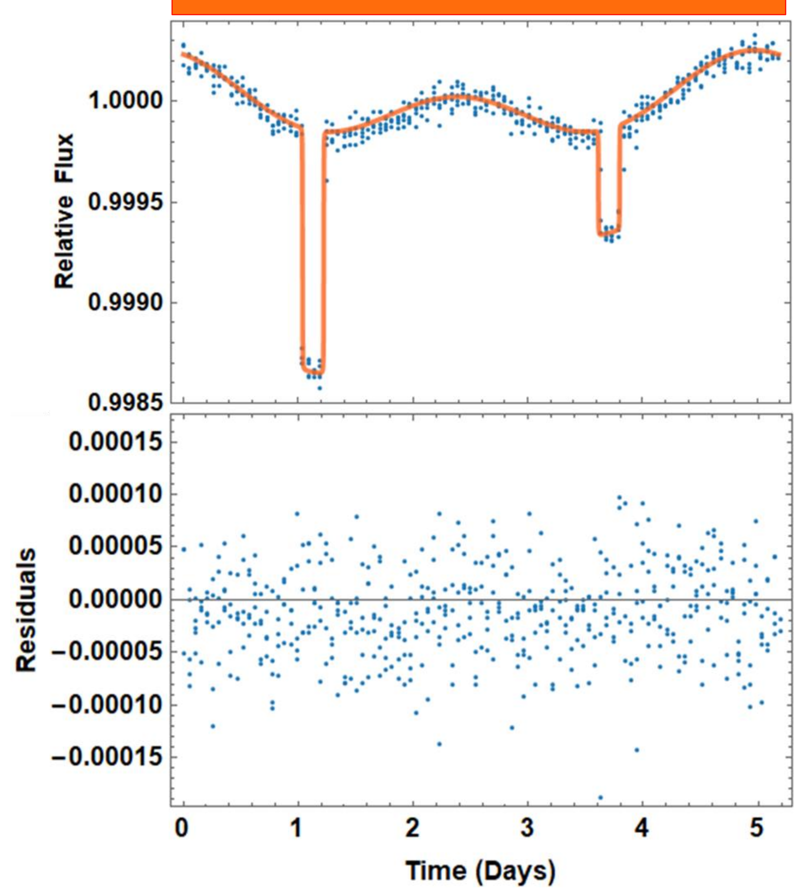
Doppler Boosting:



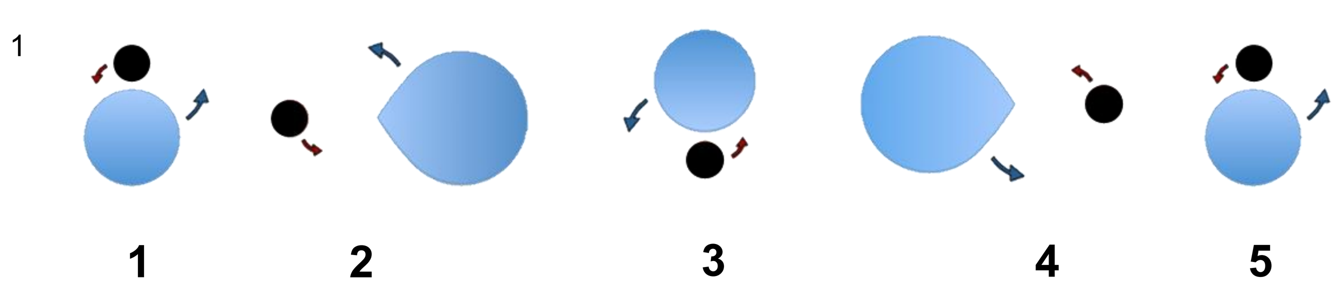
An Eclipsing System:

- KIC 6889235 is a binary containing an A-Type star and a White Dwarf companion
- Using parameters estimated for the system by recent studies[4], we have fitted our model **(plus eclipses)** to the data from the Kepler Space Telescope

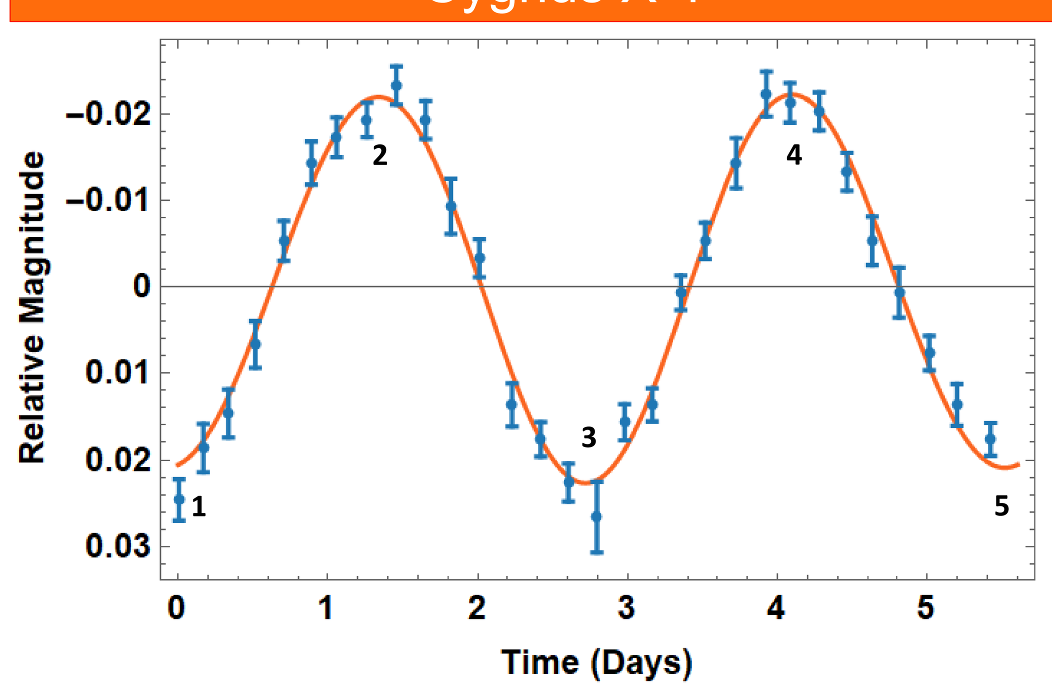
Model Fit to KIC 6889235



Ellipsoidal Variations:



Our Model Fitted to Optical Data[2] From Cygnus X-1

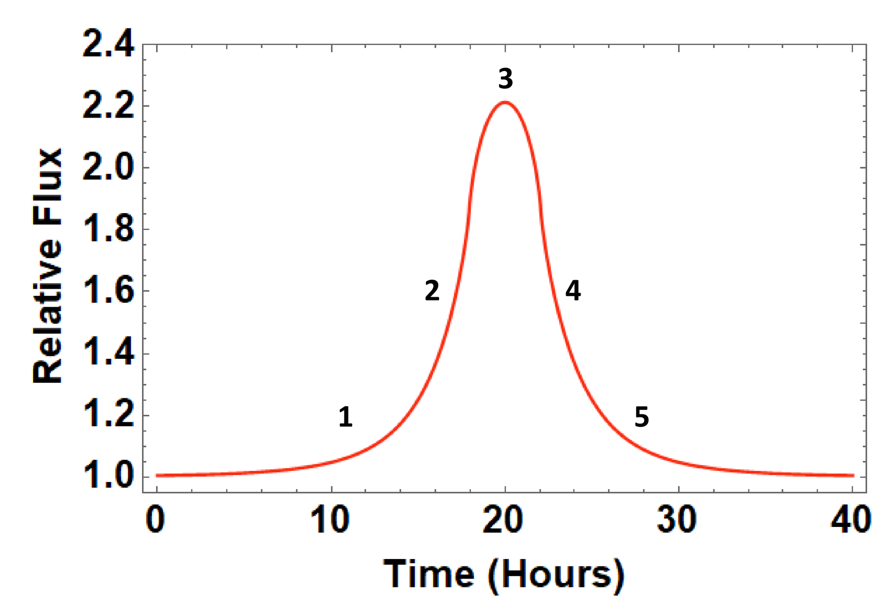


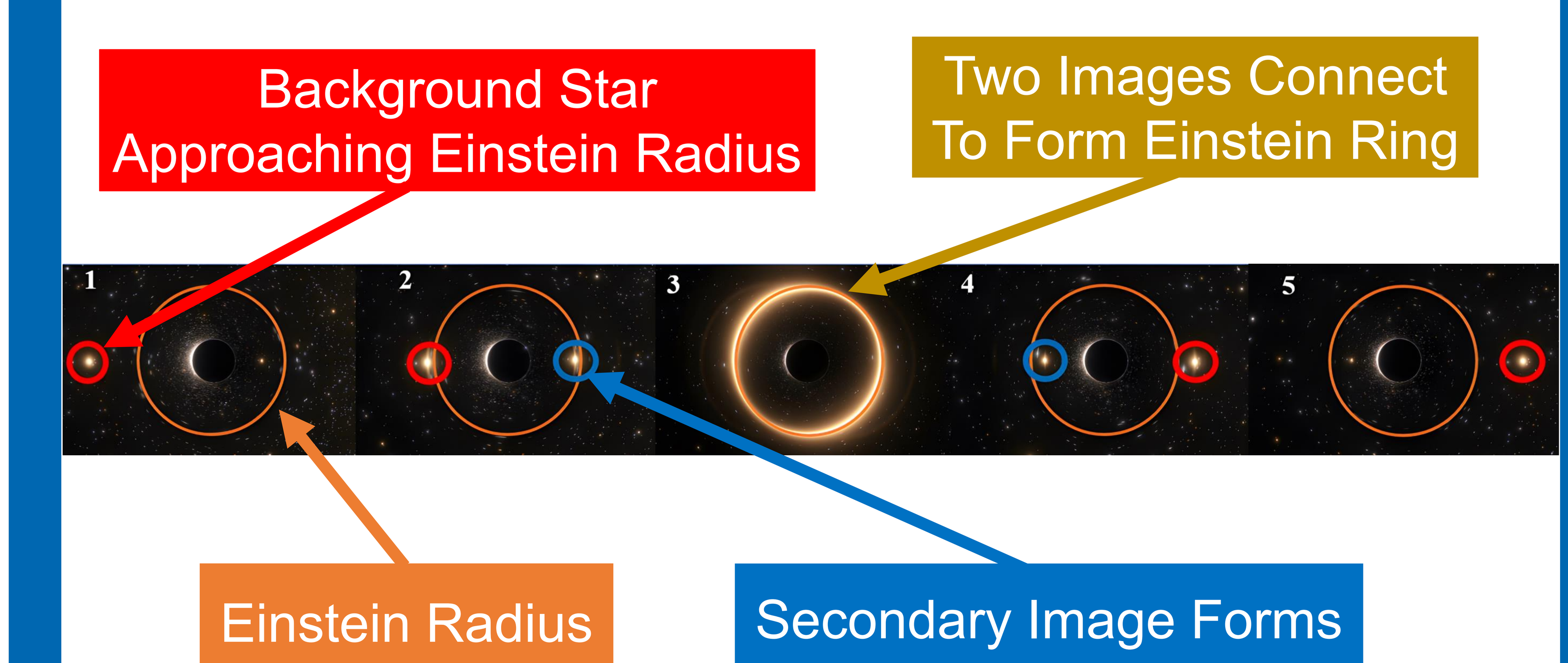
PARAMETERS	BEST FIT
Black Hole Mass ($M_\odot$)	22.95 ± 0.26
Companion Star Mass ($M_\odot$)	35.30 ± 0.50
Stellar Radius ($R_\odot$)	25.03 ± 0.70
Eccentricity	0.022 ± 0.004
Orbital Inclination (deg)	27.78 ± 1.23
α	0.86 ± 0.21
True Anomaly (deg)	58.70 ± 0.04
R^2	0.982
Reduced χ^2	1.060

Gravitational Lensing:

- Lensing increases the surface area of the star, making it appear brighter
- A lensing curve showcasing this effect can be seen on the right
- The Panel below details the different steps during a lensing event[3]

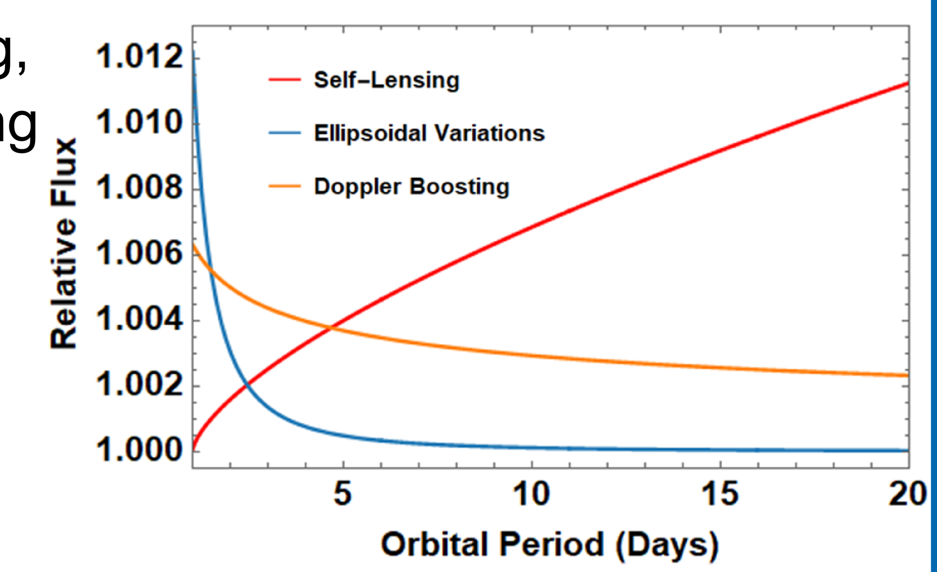
Lensing Curve Where Each Number Corresponds to a Panel Below





Conclusions:

- Whether lensing, Doppler Boosting or ellipsoidal variation is dominant in the light curve is a function of the separation between the binary components, thus, the combination of all three effects allows for a unique mass determination method that greatly expands the parameter space for discovery of compact objects



References:

1. Bell, K. J., Hermes, J. J., & Kuszlewicz, J. S. 2018, arXiv:1809.05623.https://arxiv.org/abs/1809.05623
2. Kemp, J. C., Karitskaya, E. A., Kumsiashvili, M. I., et al. 1987, Soviet Ast., 31, 170
3. Created with SpaceEngine (Romanyuk, 2016)
4. S. Bloemen et al, 2012, MNRAS https://doi.org/10.1111/j.1365-2966.2012.20818.x

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