Orbital Eccentricity of Young Exoplanets

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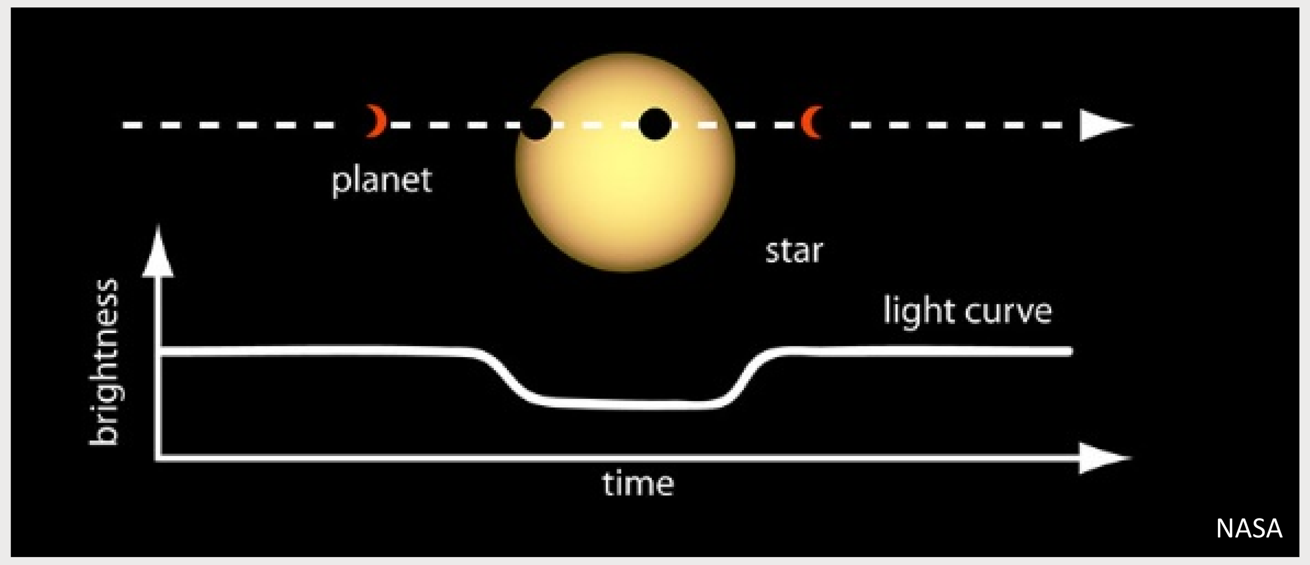
Motivation: Studying Young Planets

- Comparison with other planetary systems is a great method to learn about how unique or common our own solar system is
- Studying the orbital eccentricity of young exoplanets gives insight on the environment and orbits that planets are formed in
  - Highly eccentric, chaotic orbits vs circular orbits that we see in our solar system today

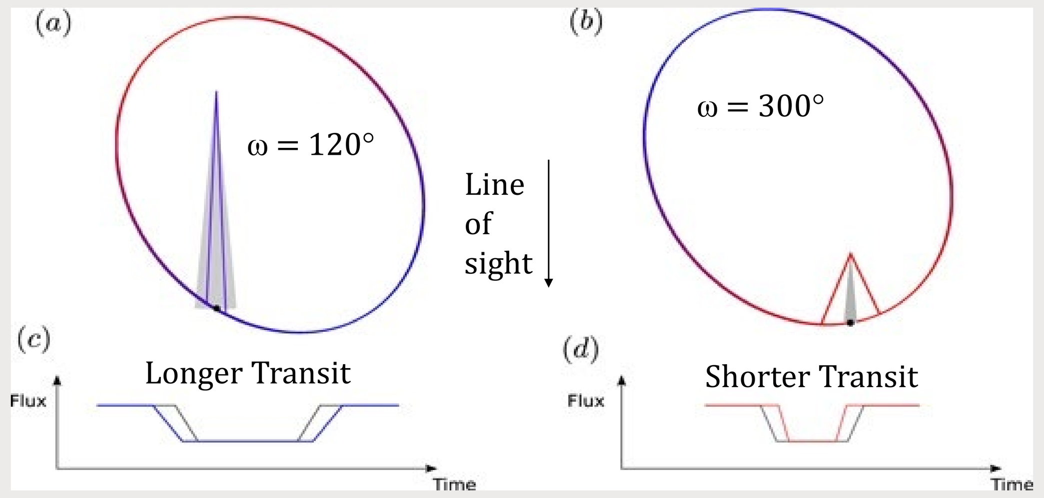
Detecting Exoplanets: Transits

- When an exoplanet passes in front of its host star in our line of sight, it blocks a fraction of the star's light
  - Transits occur at regular intervals that reflect the planet's orbital period

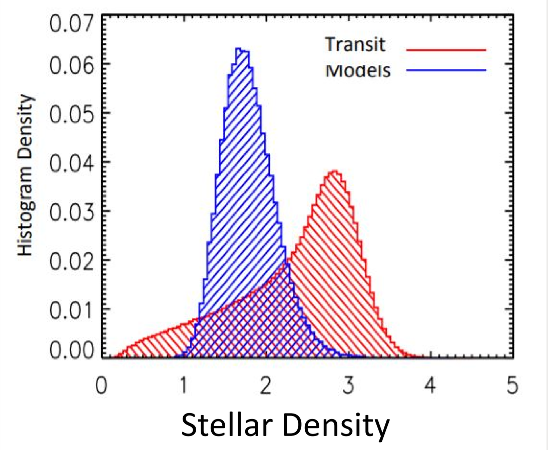


Determining Planet Eccentricity

- Eccentric orbits effect the shape of transits
  - Transits may last longer or shorter depending on the *angle of periastron (ω)* (1)

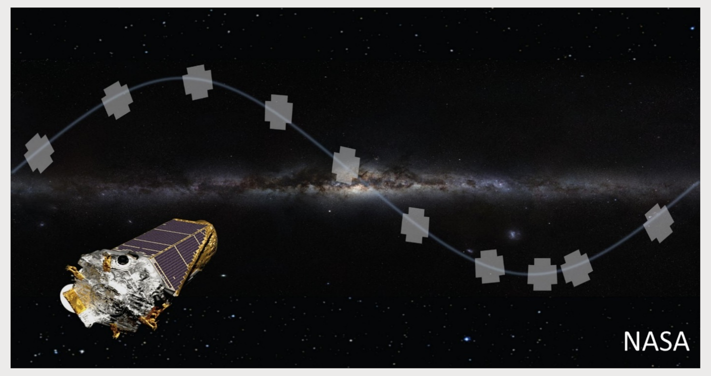


- It is also possible to derive the host star's density solely from the planet transit (2)
  - This derivation assumes a circular orbit
  - If the orbit is actually eccentric, this stellar density will differ from the density calculated from stellar models



K2 Observations and Sample

- NASA's *K2* mission observed regions of the sky continuously for ~80 days with the goal of detecting exoplanets transiting their host star
  - Included observing several young star clusters (< 1 Gyr) such as Hyades, Praesepe, Pleiades, and Taurus
- We focus on 15 young transiting exoplanets for this sample (4)



The K2 telescope and observation regions highlighted

Preparing *K2* Light Curves For Analysis

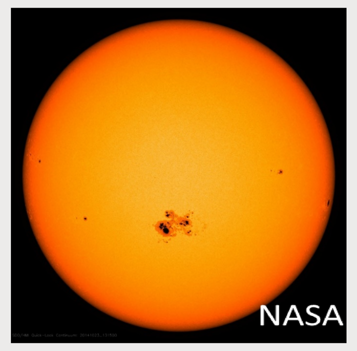
- Data from the *K2* telescope, known as light curves, may contain transits, but some steps are required before information about the exoplanets can be extracted

Removing *K2 Telescope* Systematics

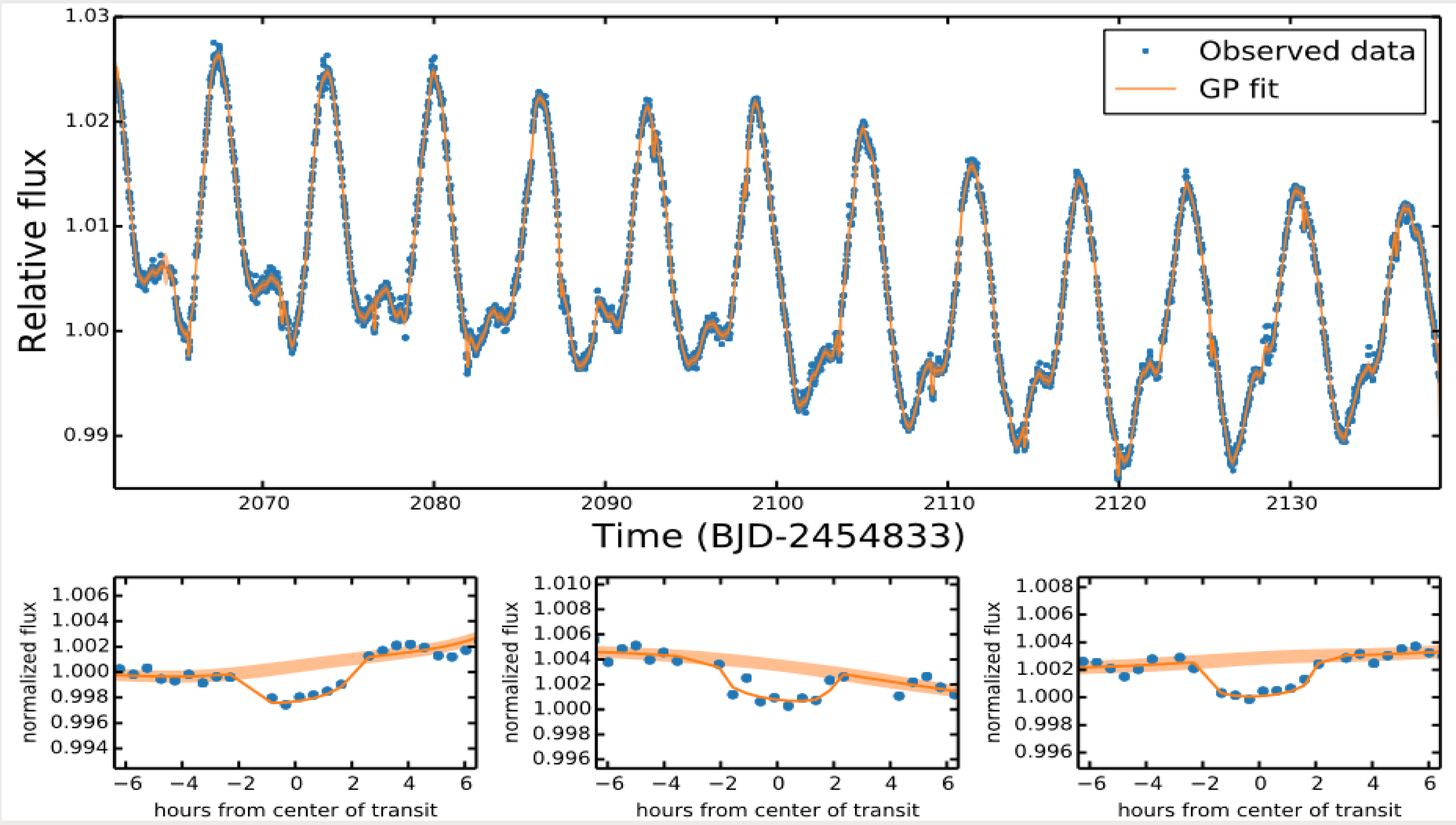
- A pipeline called *K2SFF* was used to correct for systematic telescope drift (3)

Fitting Stellar Rotational Variability

- The flux from a rotating star varies periodically due to star spots unevenly covering its surface
  - This creates a stellar rotation signal that can be over an order of magnitude greater than the transit signal in young stars



- Gaussian Process regression was used to model and remove this from each light curve, as shown below in the light curve for K2-33 with three zoomed-in transits

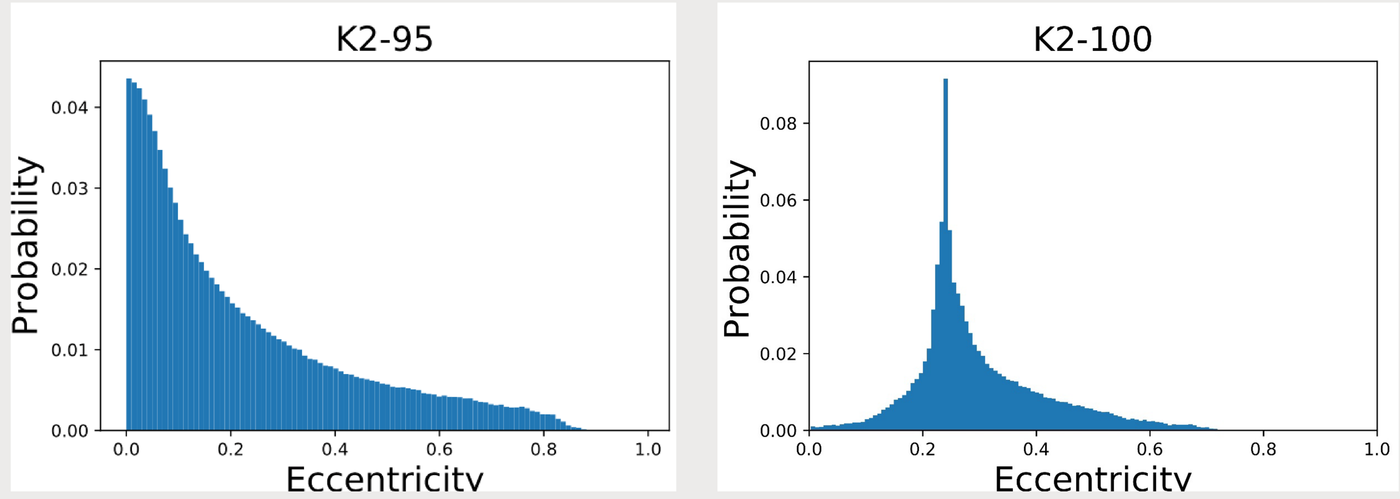


Transit Fitting With MCMC

- Light curves were run through a code called *MISTTBORN* (4), which uses Bayesian statistics and a Monte Carlo Markov Chain (MCMC) to fit transits and the corresponding planet properties

MISTTBORN and MCMC Fit

- MISTTBORN uses the *emcee* Python module (5) to simultaneously fit nine planet parameters, including eccentricity, to best model the observed transit
- MCMC fit produces distributions of probable values for each of the transit parameters, including eccentricity:



Two example eccentricity distributions from *MISTTBORN*, K2-95 (left) is consistent with a circular orbit, while K2-100 (right) likely has a more eccentric orbit

Preliminary Results

- Fits among the sample have been **mostly consistent with circular orbits** so far
  - Planets may actually be formed in circular orbits more often than highly eccentric orbits
  - While the sample systems are young, perhaps they have already settled into circular orbits from more eccentric orbits
- Next steps:
  - Continuing to fit the current sample of *K2* systems
  - Potentially adding *TESS* observed systems

References

(1) Van Eylen, V., & Albrecht, S. 2015, ApJ, 808, 126
(2) Seager, S., & Mallén-Ornelas, G. 2003, ApJ, 585, 1038
(3) Vanderburg, A., & Johnson, J. A. 2014, PASP, 126, 948
(4) Mann, A. W., Gaidos, E., Mace, G. N., et al. 2016a, ApJ, 818, 46
(5) Foreman-Mackey, D., Hogg, D. W., Lang, D., & Goodman, J. 2013, PASP, 125, 306