Determining Planet Eccentricity

- Eccentric orbits affect the shape of transits
  - Transits may last longer or shorter depending on the angle of periastron ($\omega$) (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

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

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)

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

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

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

References


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

- 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

 Orbital Eccentricity of Young Exoplanets

Dylan Owens and Andrew Mann
University of North Carolina - Chapel Hill, Department of Physics and Astronomy, Chapel Hill, NC
Email: dylowens6@gmail.com

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

- 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

 Orbital Eccentricity of Young Exoplanets

Dylan Owens and Andrew Mann
University of North Carolina - Chapel Hill, Department of Physics and Astronomy, Chapel Hill, NC
Email: dylowens6@gmail.com