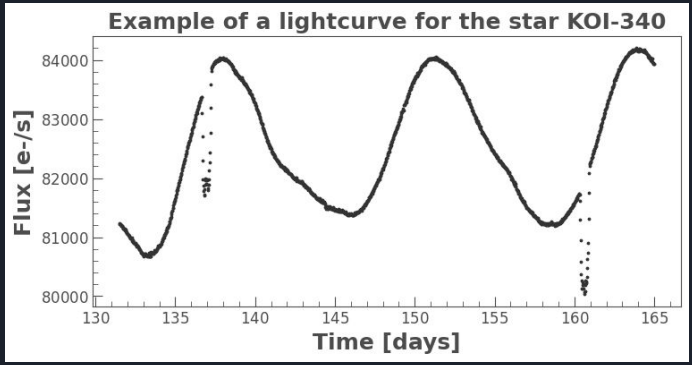
Modeling starspots

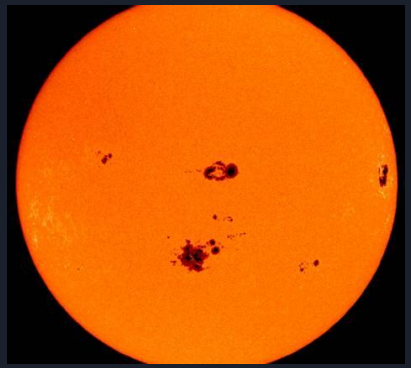
with Dr. John Wisniewski

Presentation by Simon Lowry

Can we look at a lightcurve of KOI-340 with a transiting companion to model the spots on the star’s surface?

Key words: Lightcurve, Starspots



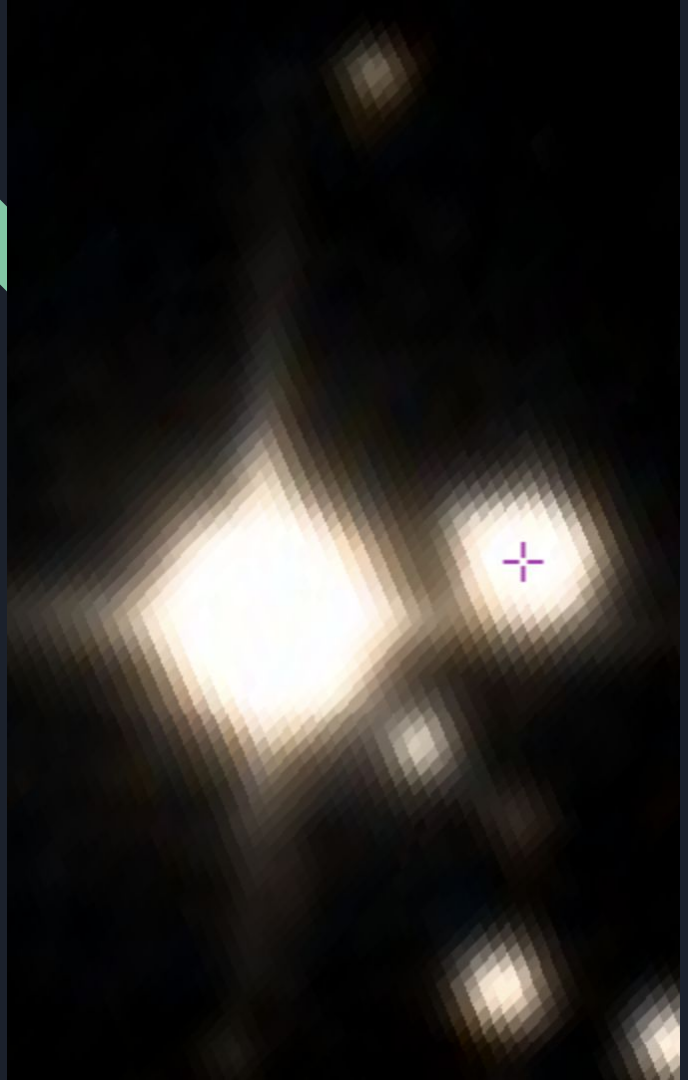


Who cares?

Why does it matter if we can model spots on other stars?

- Compare to Solar activity
- Stellar magnetic fields
- Differential rotation of stellar surface
- Investigate different magnetic activity in different stellar types

Information taken from Morris et al. 2017 & Berdyugina's "A Key to the Stellar Dynamo" (2005)



Meet KOI-340, our friendly neighbourhood binary

- ~2,500 lightyears away
- KOI: Kepler Object of Interest
  - Observed by Kepler Spacecraft in 14 Quarters (2009 - 2013)
- KOI-340 is a solar-type primary star with an M-dwarf companion
  - Eclipsing binary
- Orbital period of companion: ~24 days

An introduction to STSP

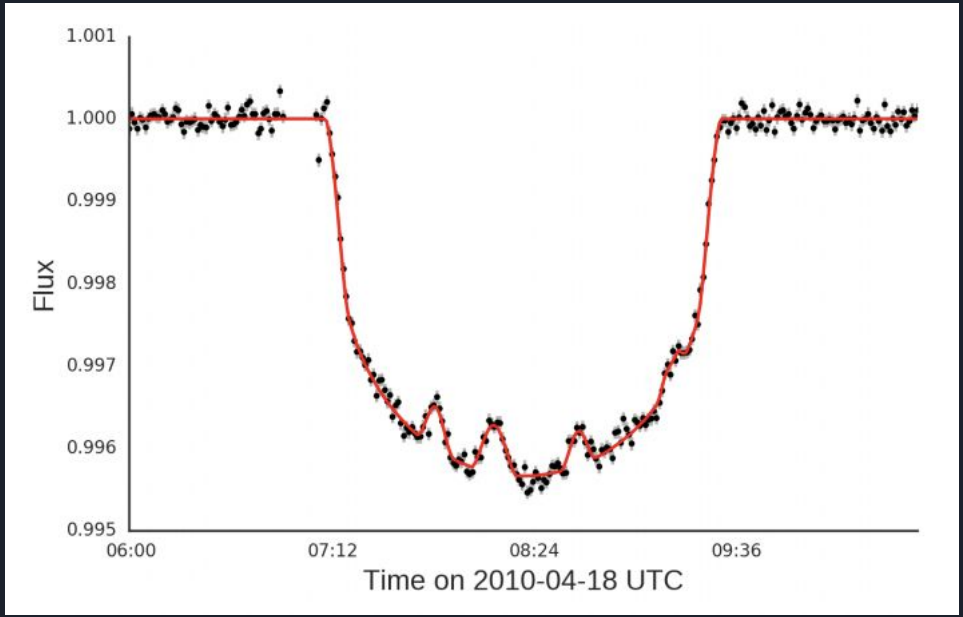
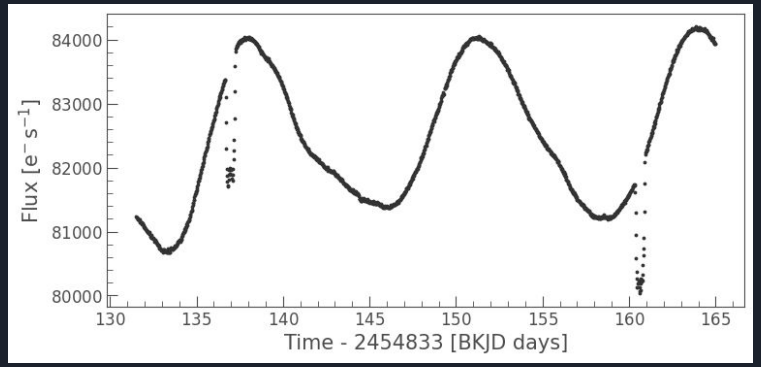


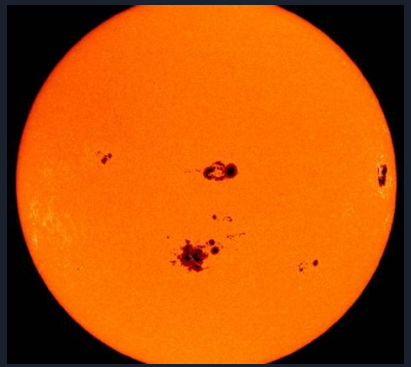
Figure taken from Hebb 2020 (draft)

- Inputs:
  - Star properties
  - Planet properties
  - Lightcurve file with columns for time and flux
  - Fixed spots from in-transit
- STSP outputs parameters for added spots to match lightcurve (red line on left)

Basically, I want to turn this:



into this:

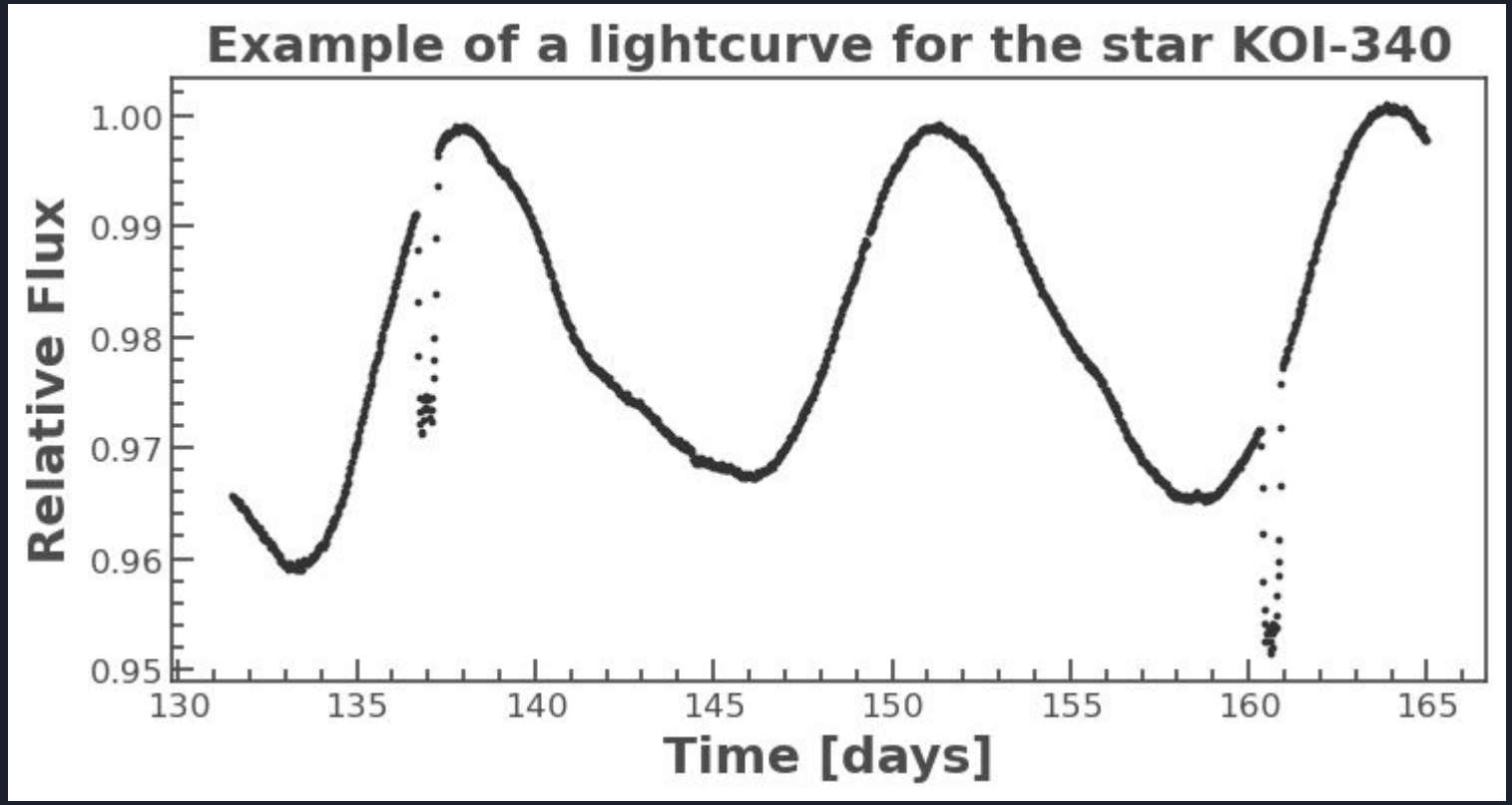


to help increase our understanding of other stars and exoplanets

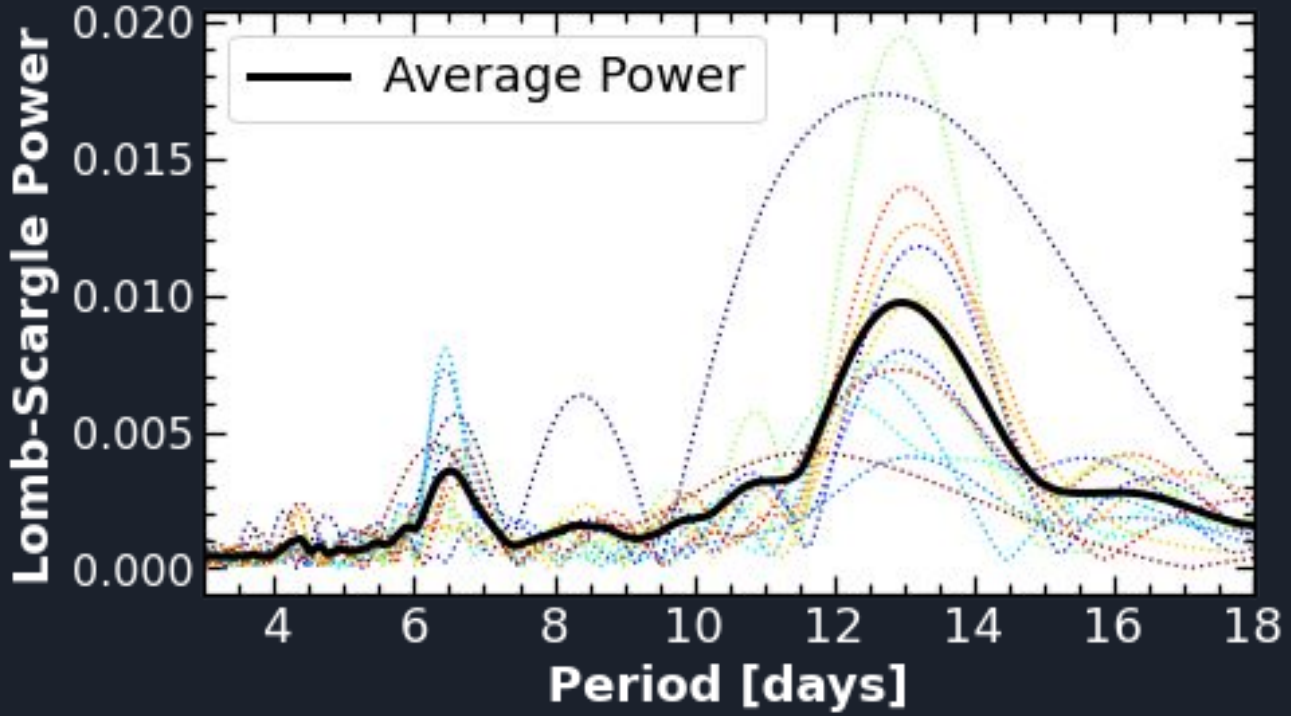
Methodology

What did I do for 8 weeks?

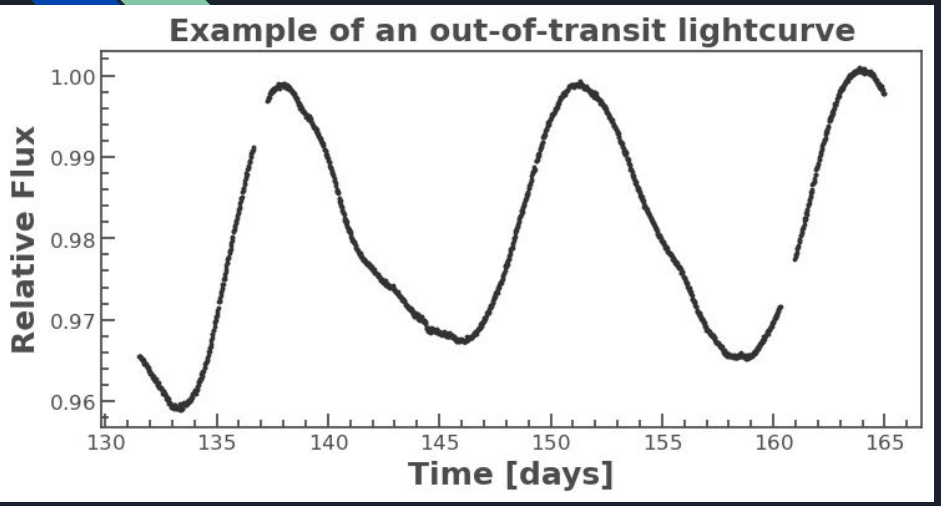
Download and normalise lightcurves

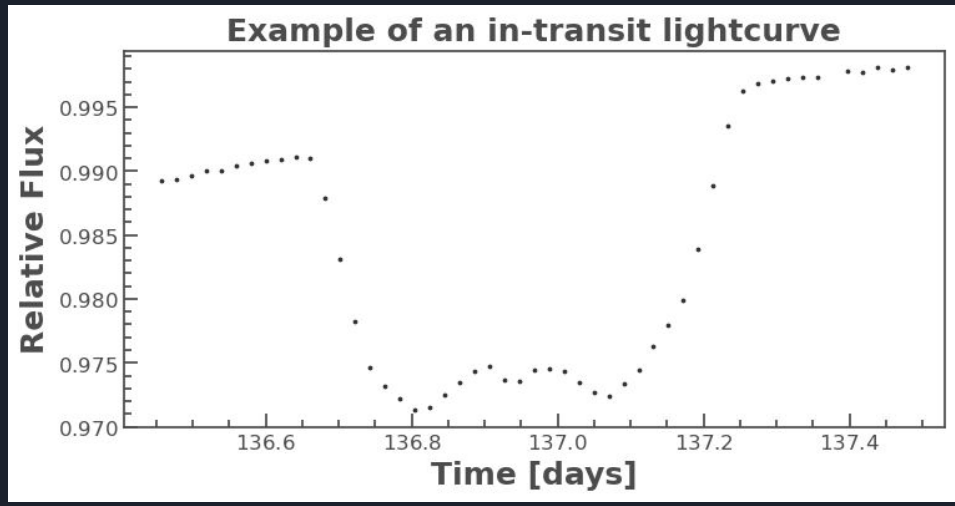


12.96 **days** Rotational Period of KOI-340



Filter lightcurves into *out-of-transit* and *in-transit*





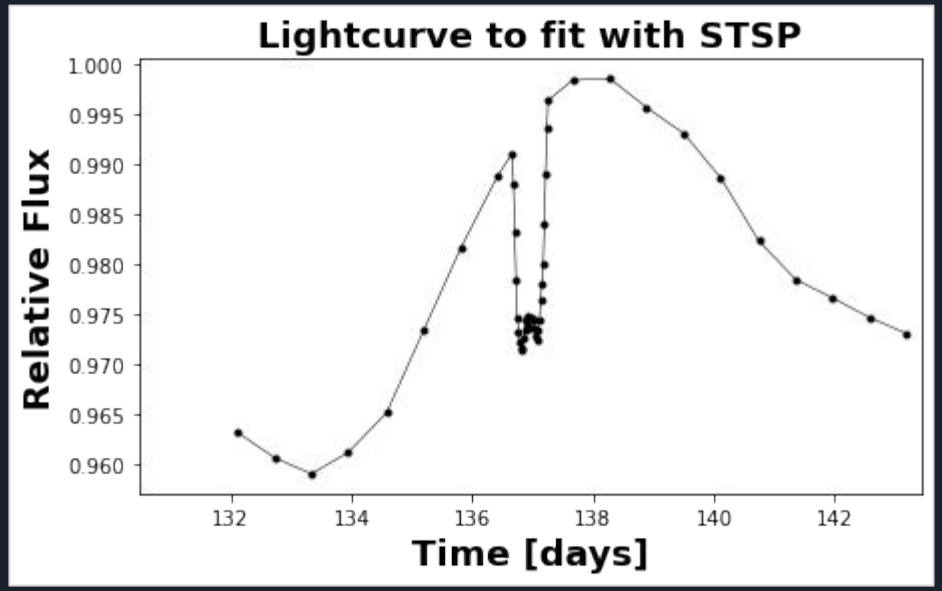
- Many more out-of-transit data points
- Influences chi-squared value of STSP's model
- Cannot ignore the in-transit data points
- Need to reduce out-of-transit data

Spot modeling

The interesting stuff

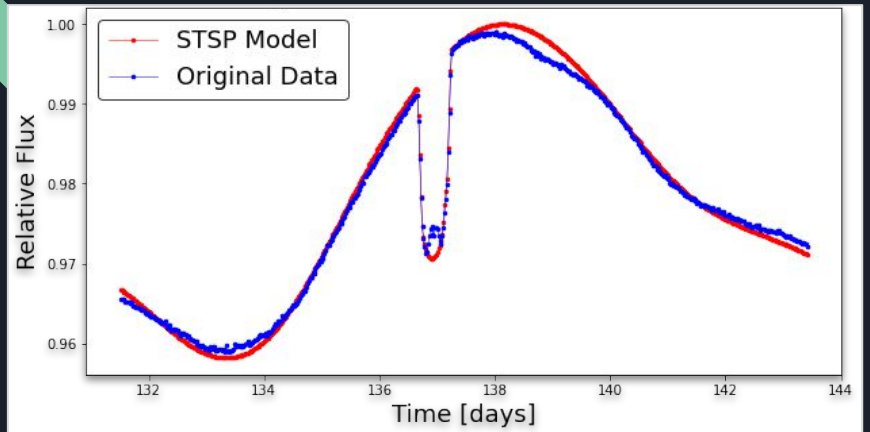
- Given spots that fit the in-transit data, add spots to fit the out-of-transit modulation

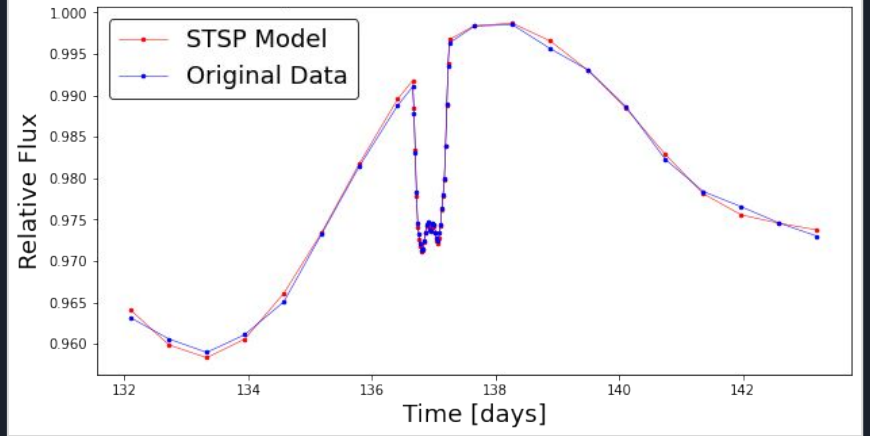
Using STSP, model lightcurves for one phase of rotation, centred around each transit



- One rotational period
- Model spots across all longitudes
- Spots will be modeled one transit at a time (consecutive transits should show persistent spot activity)
- There are 46 transits in the Kepler data

Binning out-of-transit data improves the model:





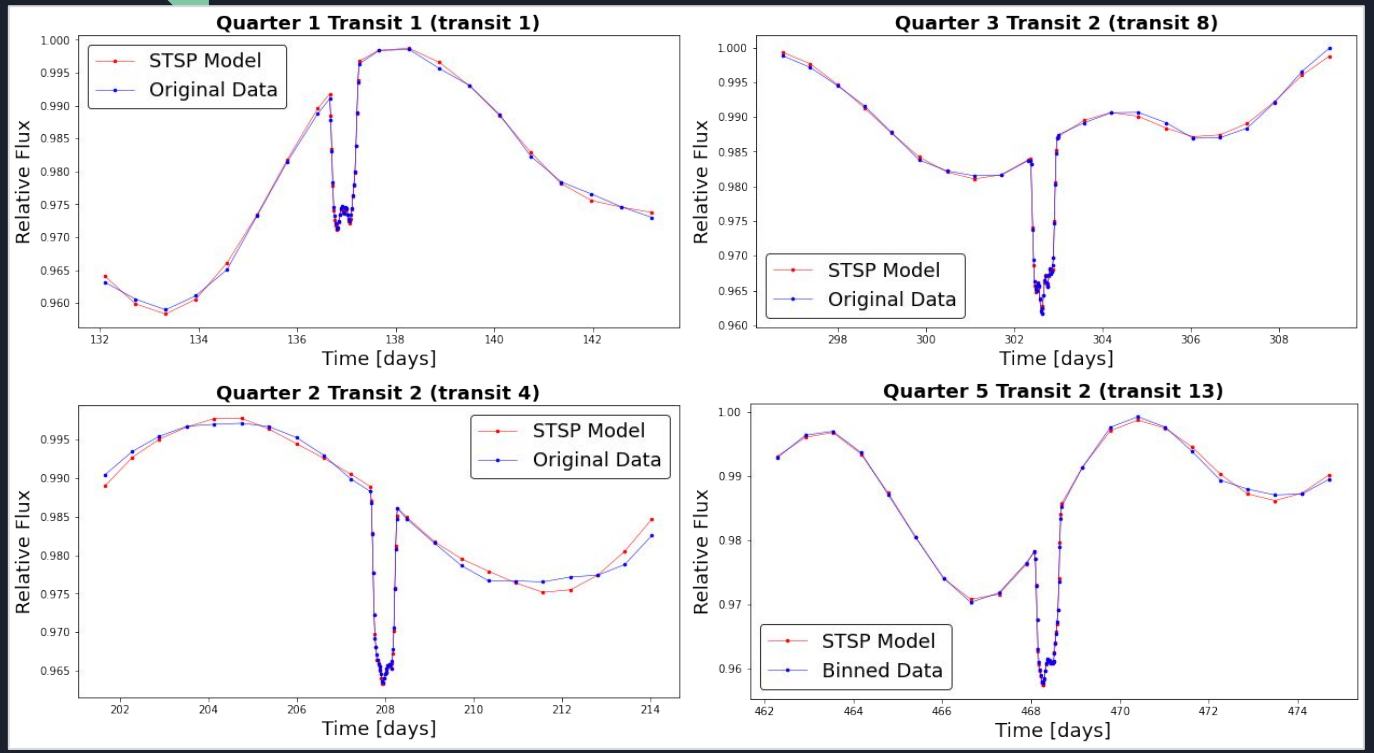
Before binning out-of-transit data points

➔ Notice it ignores the in-transit details

After binning out-of-transit data points

➔ Fits the entire lightcurve quite neatly

Find the minimum number of added spots to get good fits for all 46 transits



- Spot parameters are not unique
- Degenerate solutions
- Minimum number of added spots
- Large out-of-transit modulation = large spot
- Might be many smaller spots

So what do these models look like anyways?

ANDROID: OPEN WITH -> GALLERY | **IPHONE**: DOWNLOAD -> VIEW

Questions?

Thank you!!