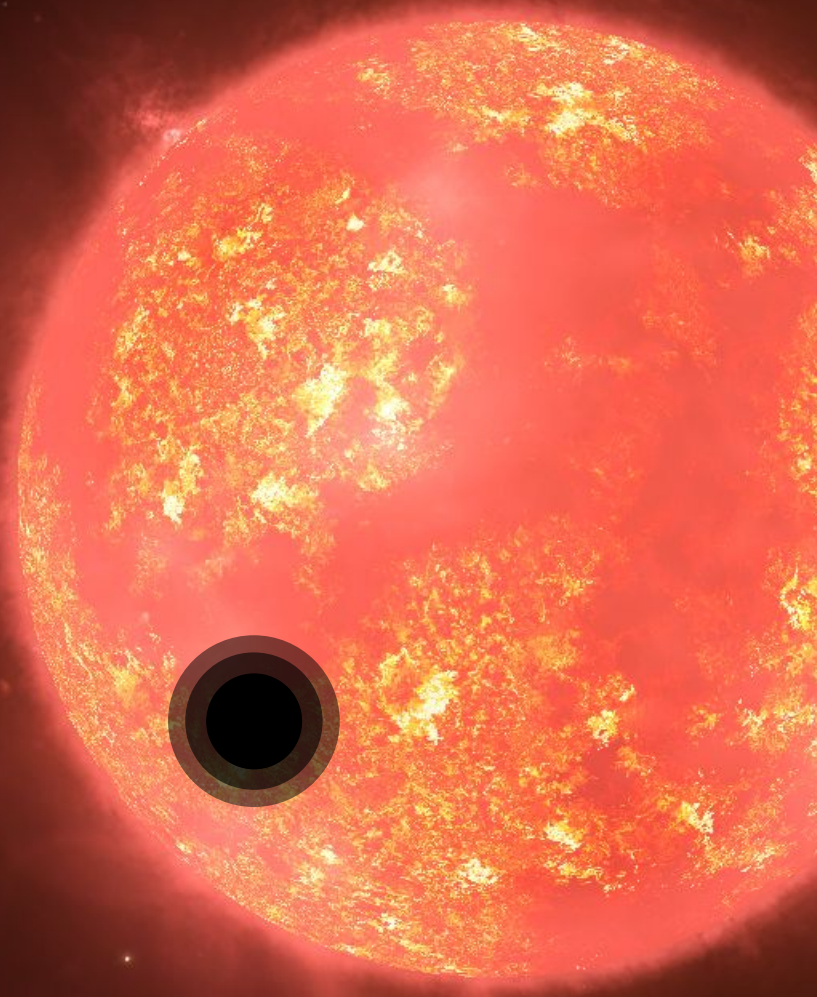
KU ExoLab

Fun With Transmission Spectroscopy

Yoni Brande

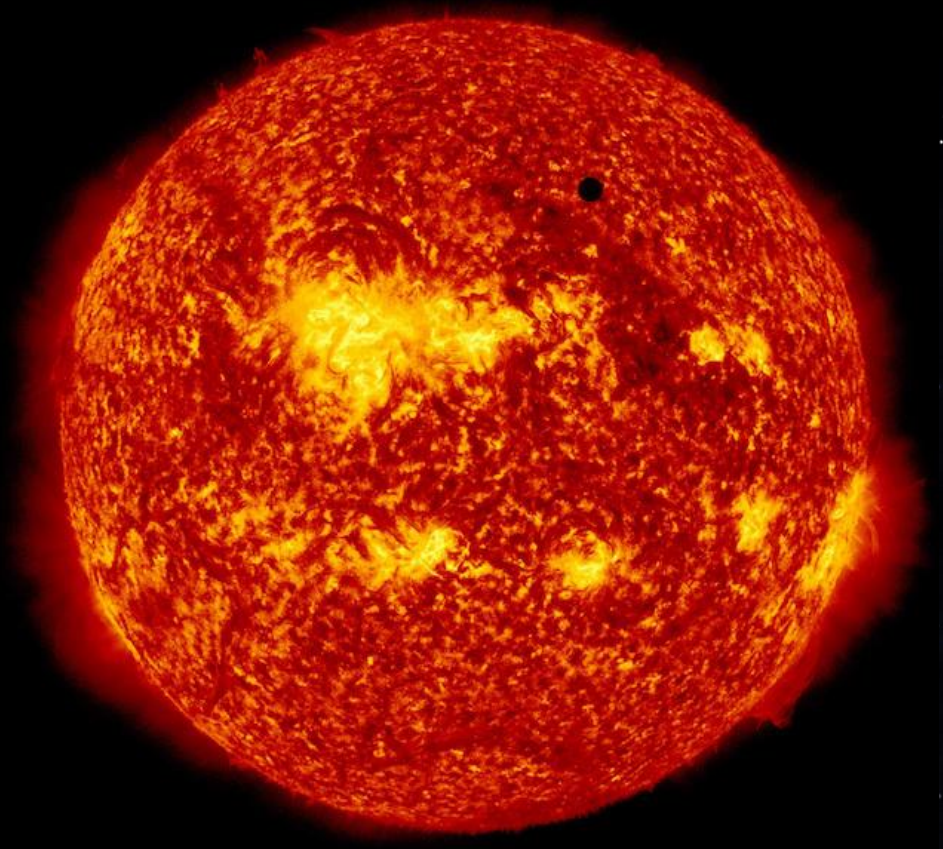
jbrande@ku.edu

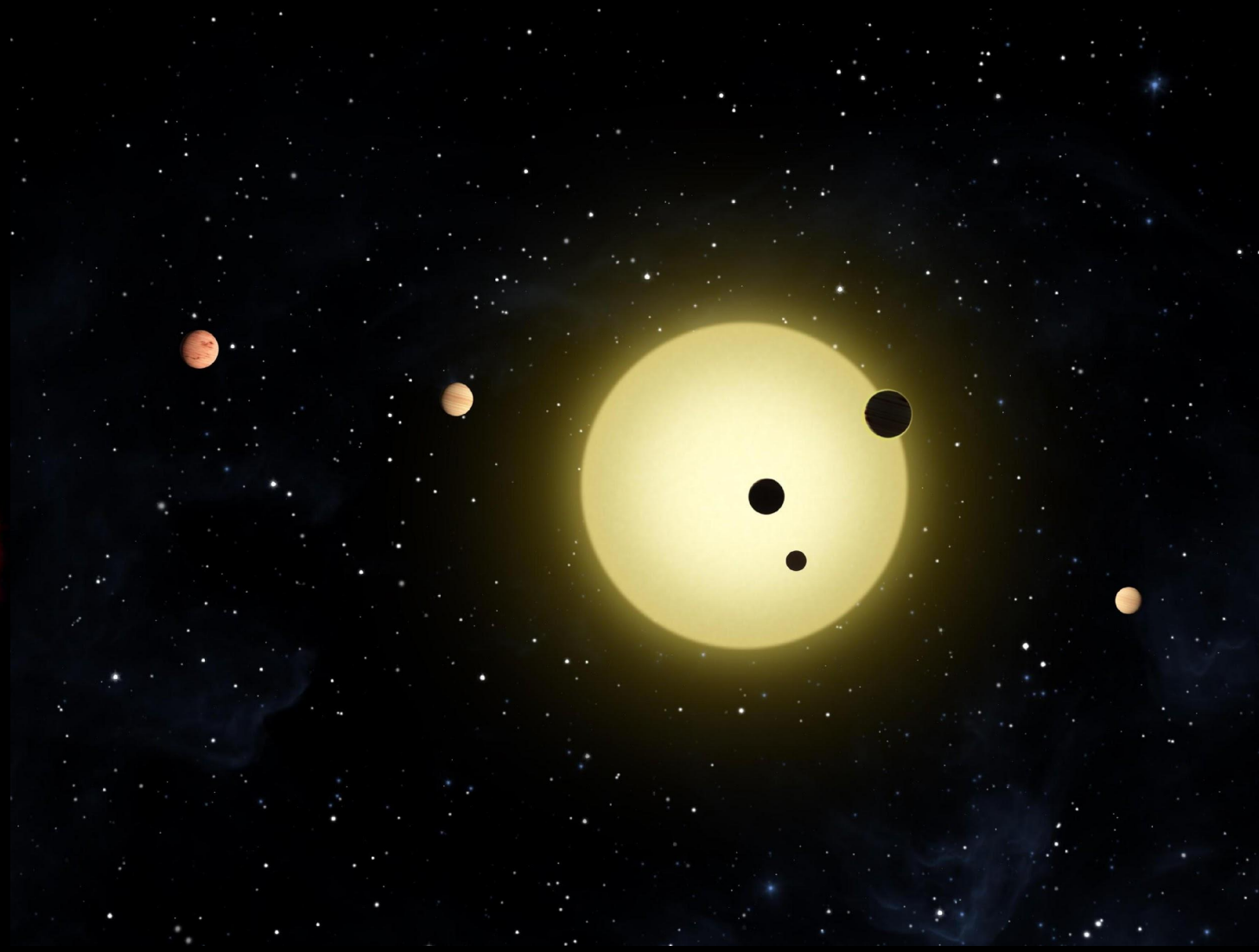
@YoniAstro



Elite Dangerous, Frontier Developments

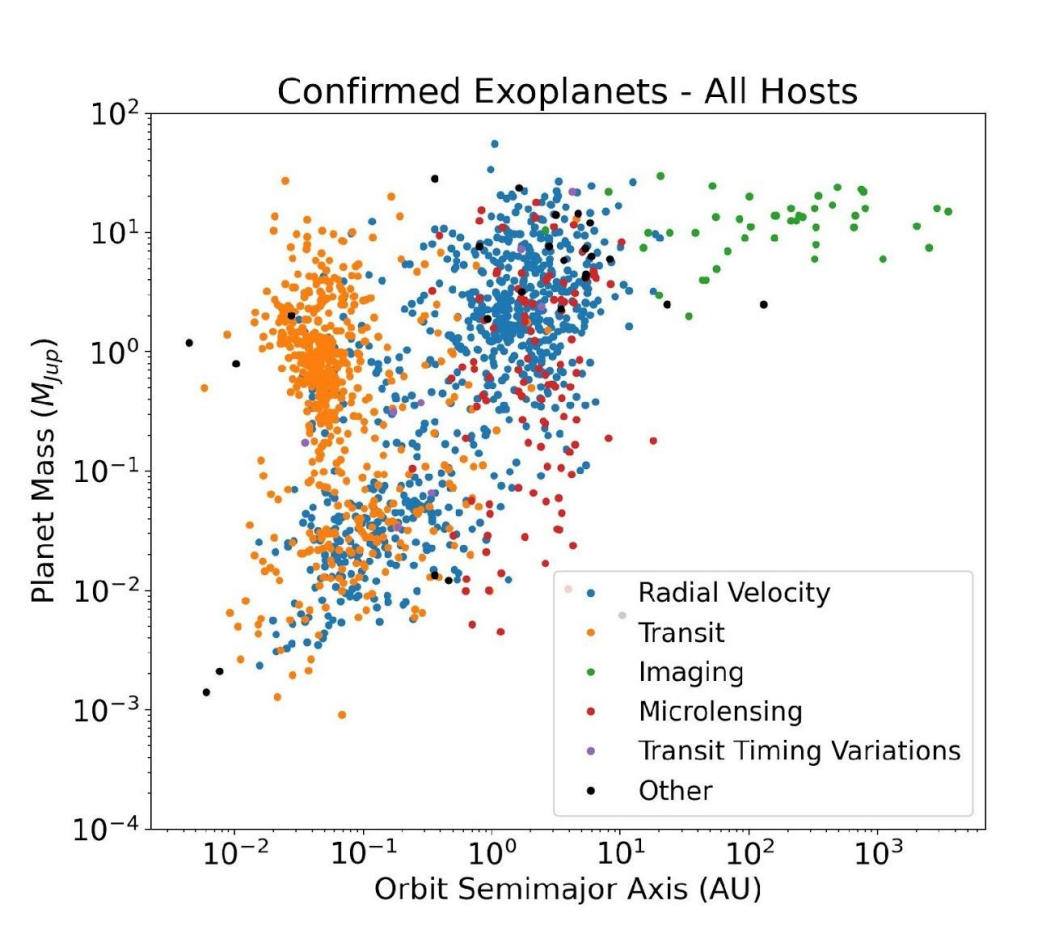
What is an Exoplanet?





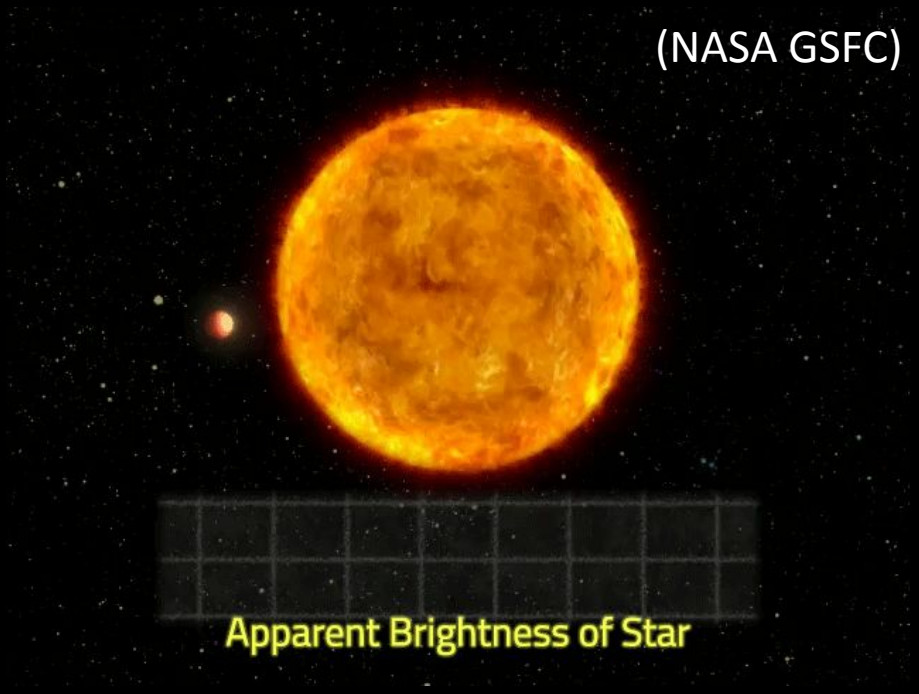
Science Motivation

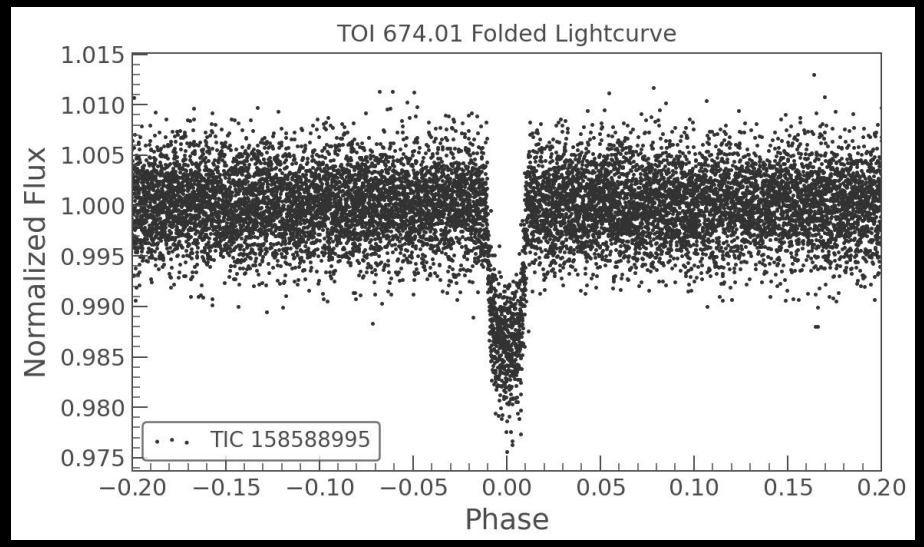
- How do planets form?
- Do different stars form different planets?
- How can we explain systems that don't fit our current understanding?
- All of these -> what are planets made of?
- Can't answer without data!



Transits

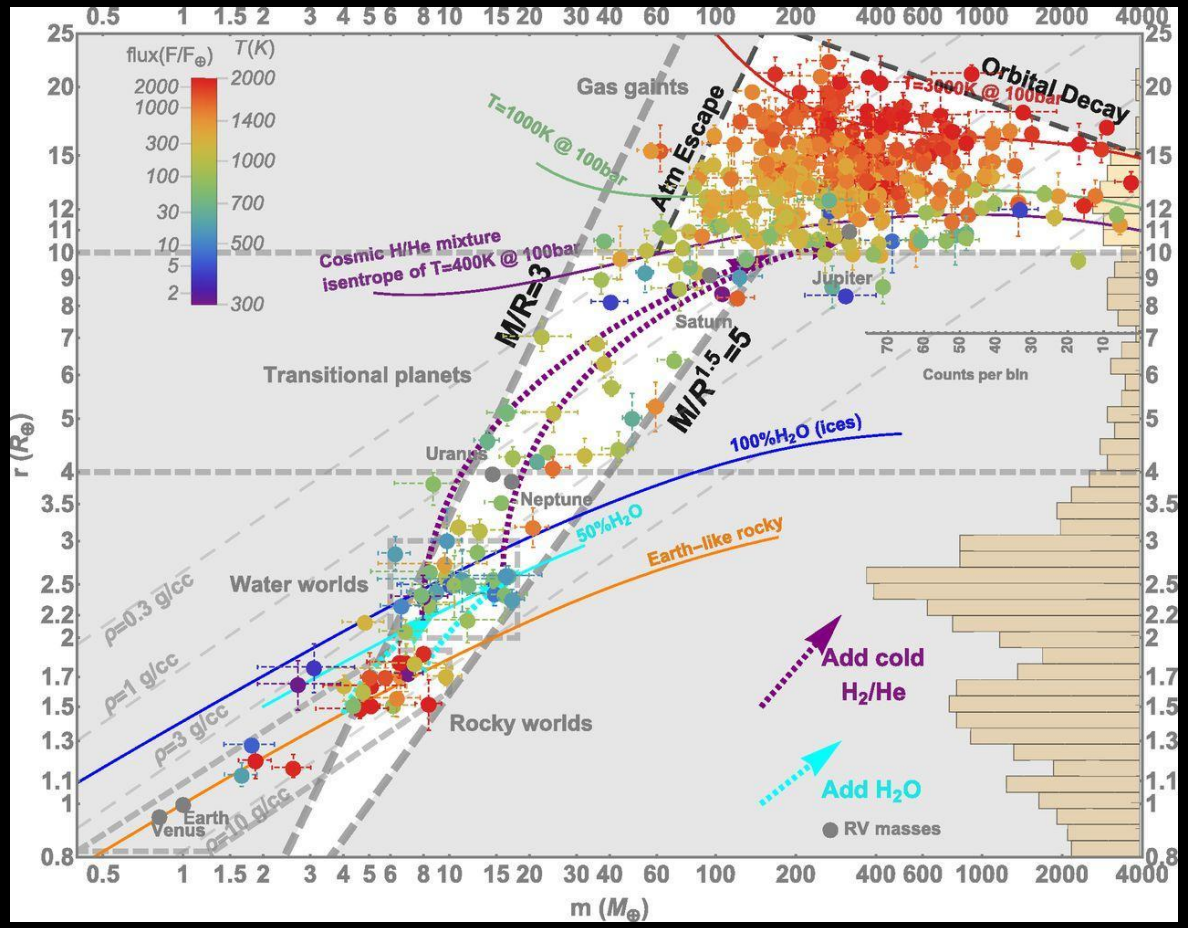
- Indirect detection, measure the brightness of a host star and look for variations
- Short, periodic signals can indicate exoplanets
- Need to rule out false positives
- Often combined with other methods
- Precision photometry can find very small planets
- Requires very specific orbital orientations





Planet Characterization

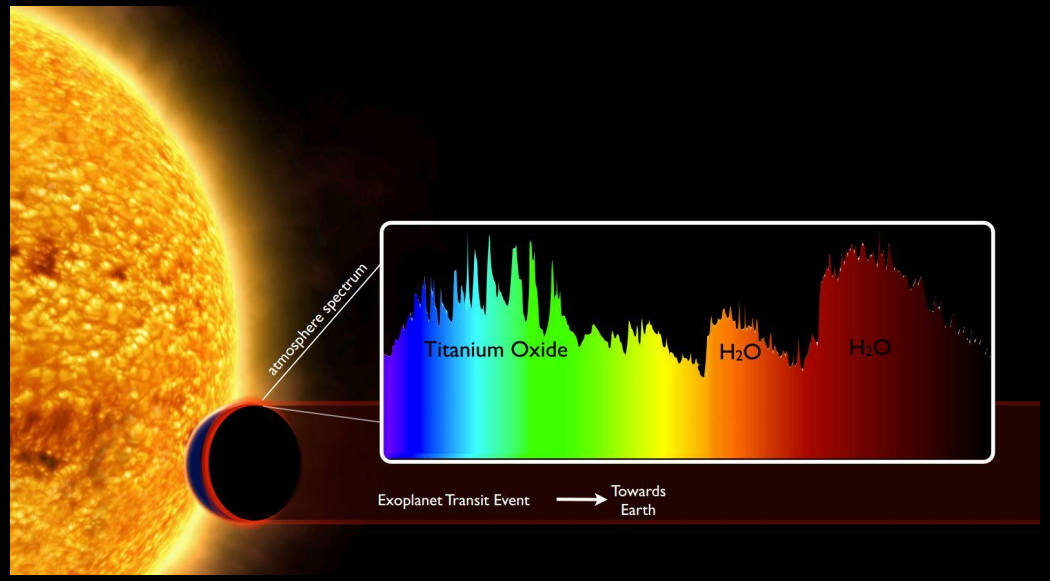
- We can combine methods like Transits/RVs to understand more about a planet
- Radius + Mass -> density -> bulk composition
- Useful for interpreting other observations like transit spectroscopy

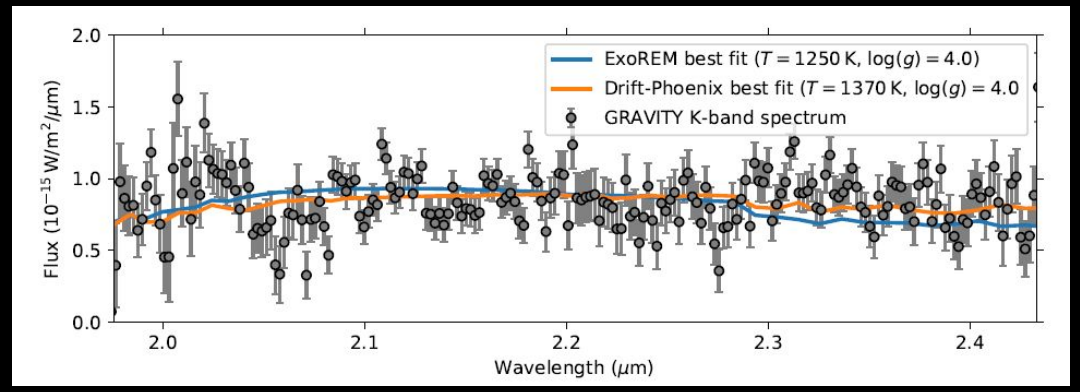


Planet Characterization

- Transit spectroscopy shows absorbing species in atmosphere
- Often hard to interpret without good stellar spectra, planet atmosphere models
- Spectroscopy also possible from direct imaging, but needs specific targets

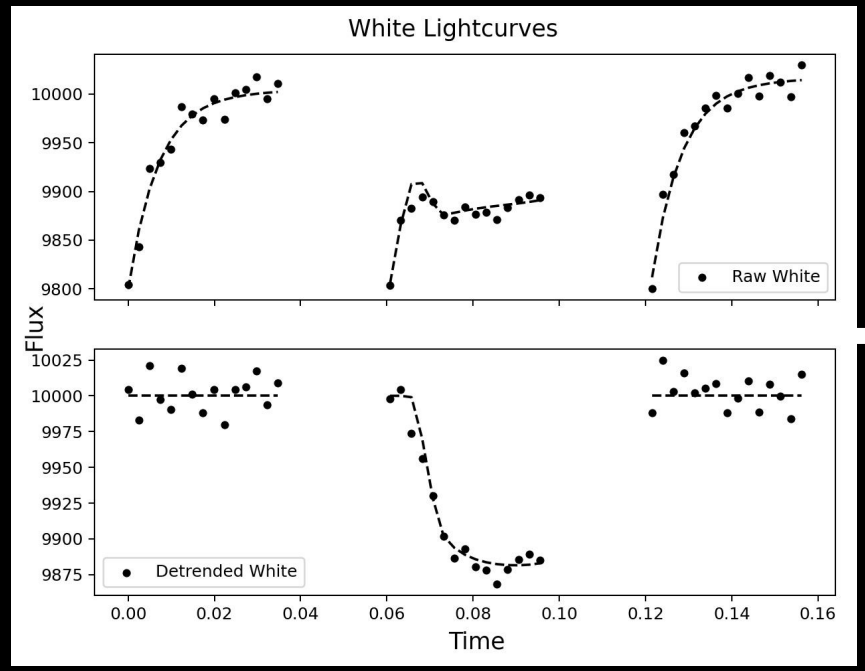
(ESA, Plato Mission)

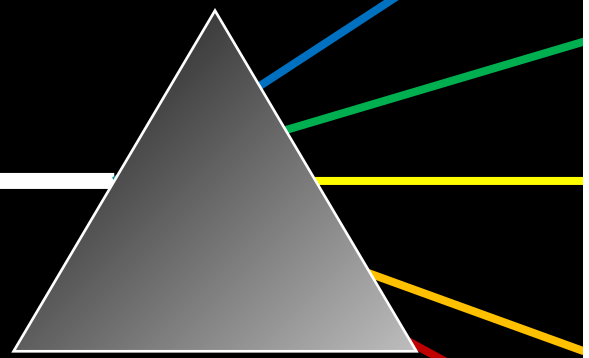


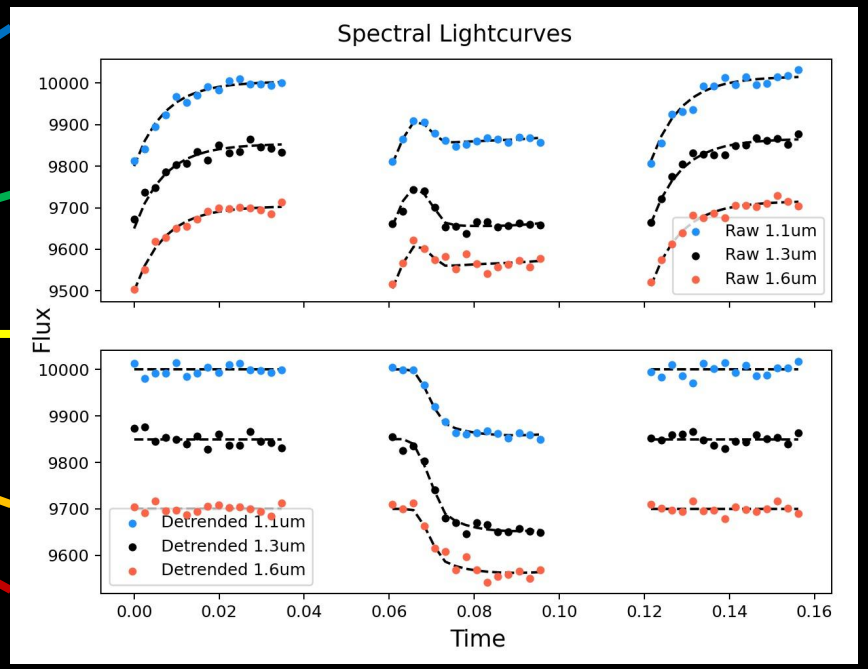


Nowak et al. 2020

What am I doing, anyway?

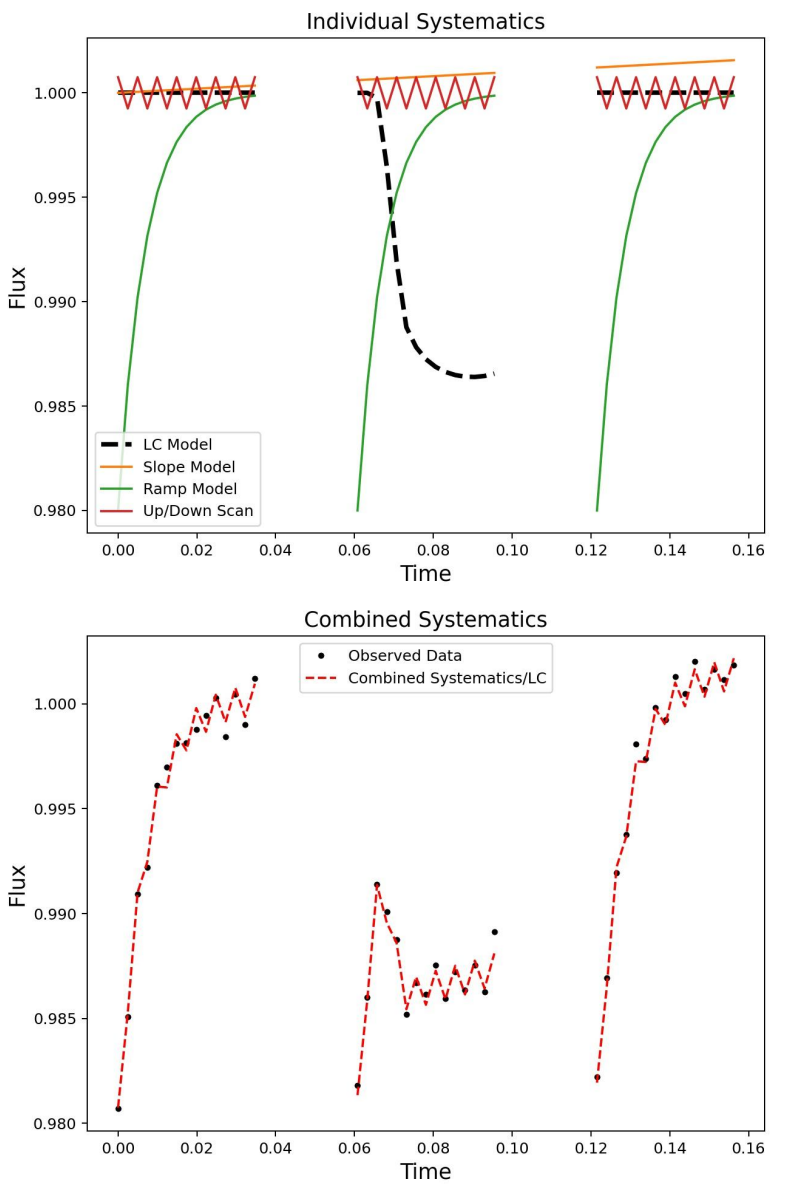






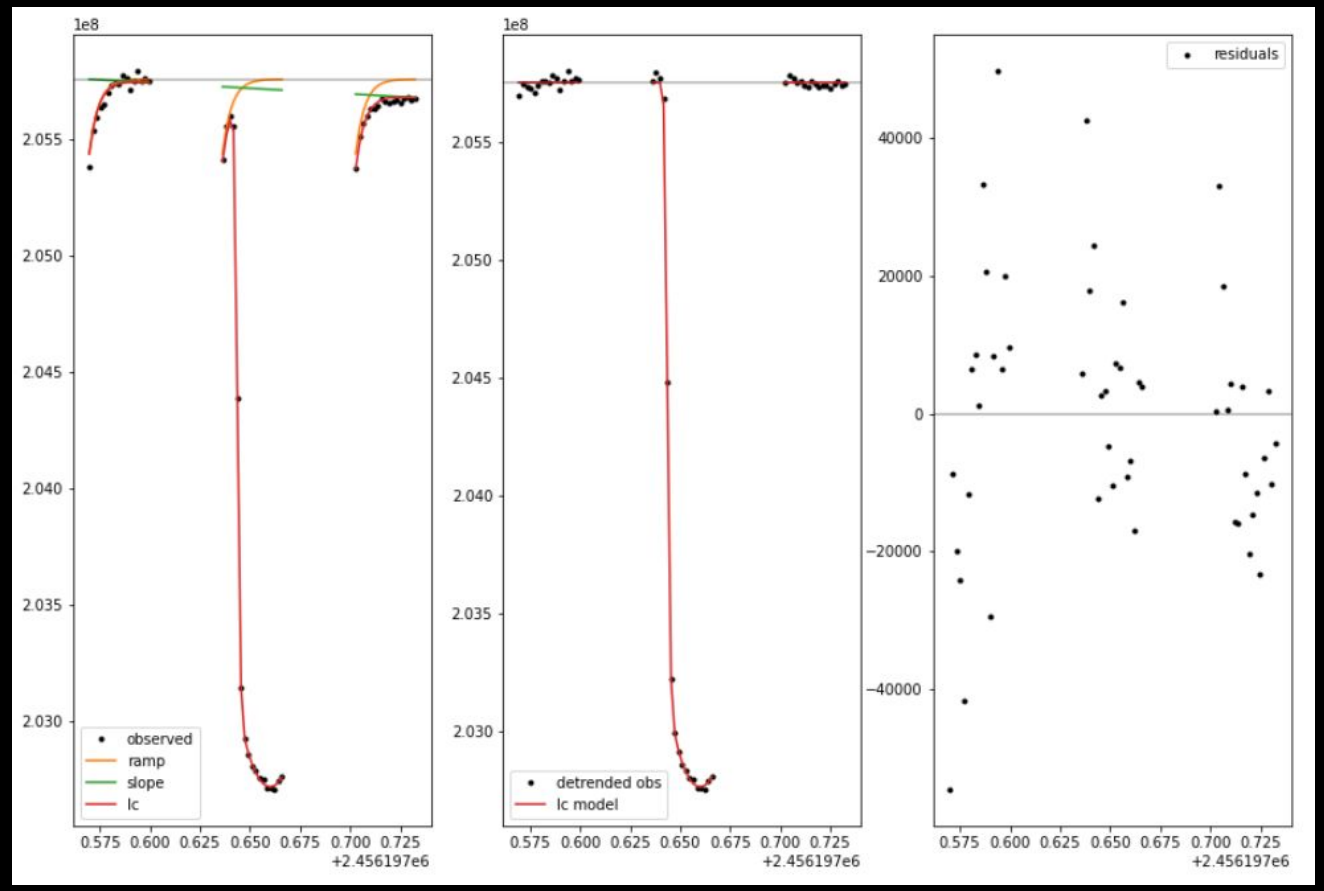
What am I doing, anyway?

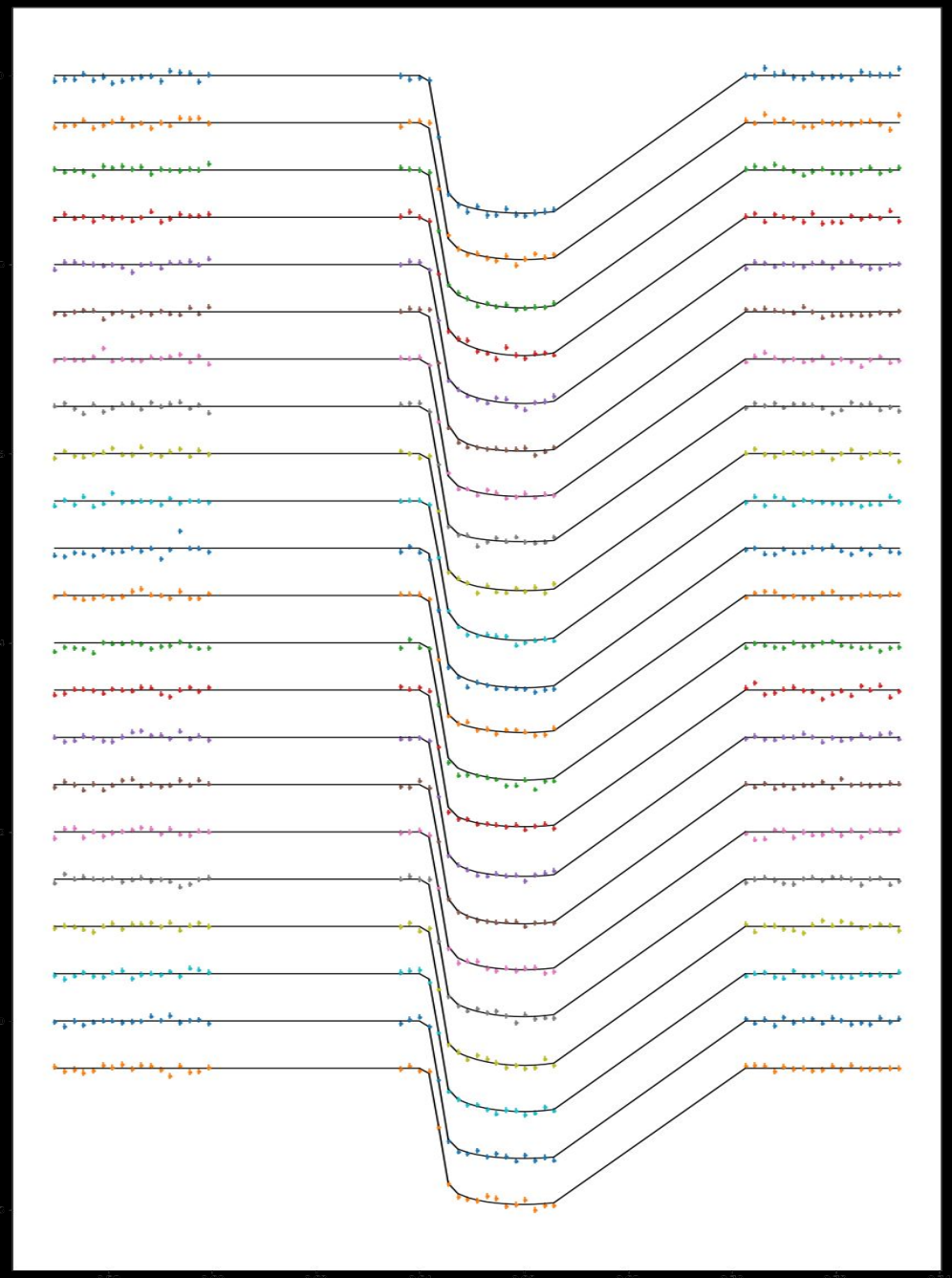
- Lightcurve modeling
  - “true” transit model
  - “true” systematics model
  - Fit components from Kreidberg+ 2014, need to fit for every spectral band
- MCMC sampling over (possibly very) large hierarchical models -> want speedy sampling
- exoplanet – improved sampling performance with Hamiltonian Monte-Carlo, “new” to astrophysics



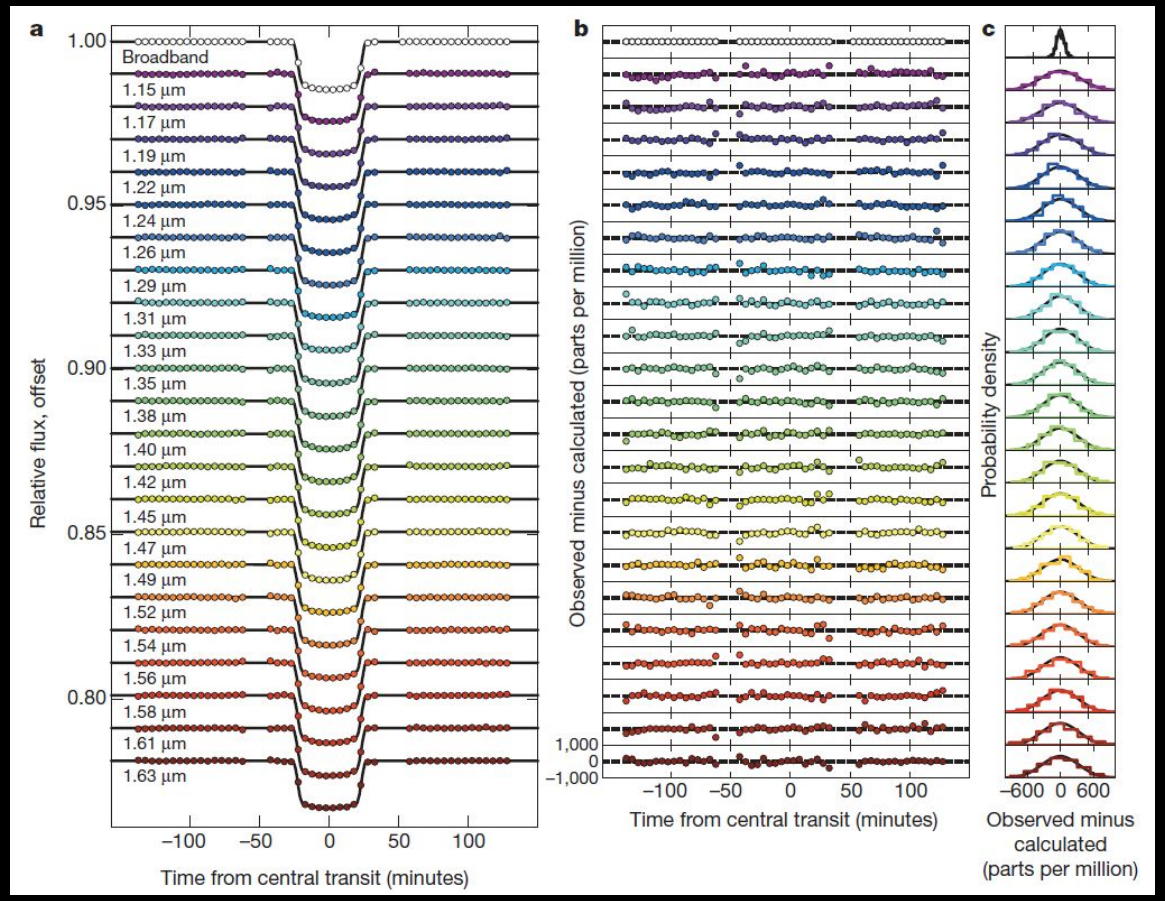
exoplanet (Foreman-Mackey+ 2019)
docs.exoplanet.codes

Real Data! GJ 1214 b

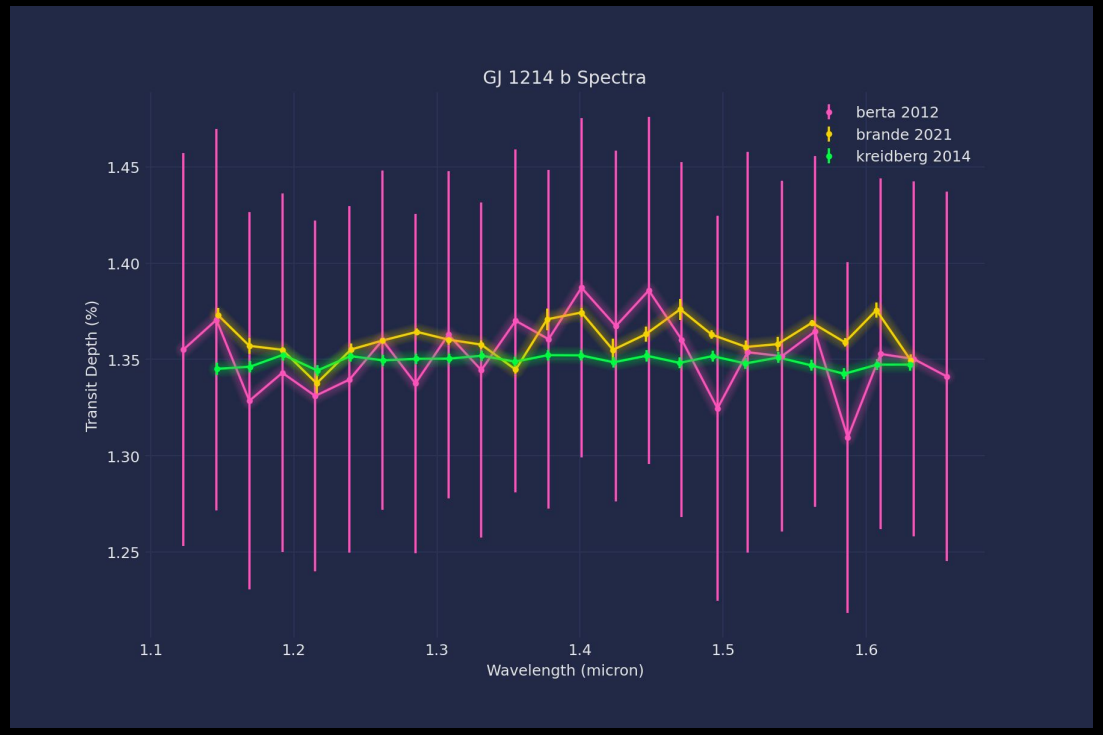




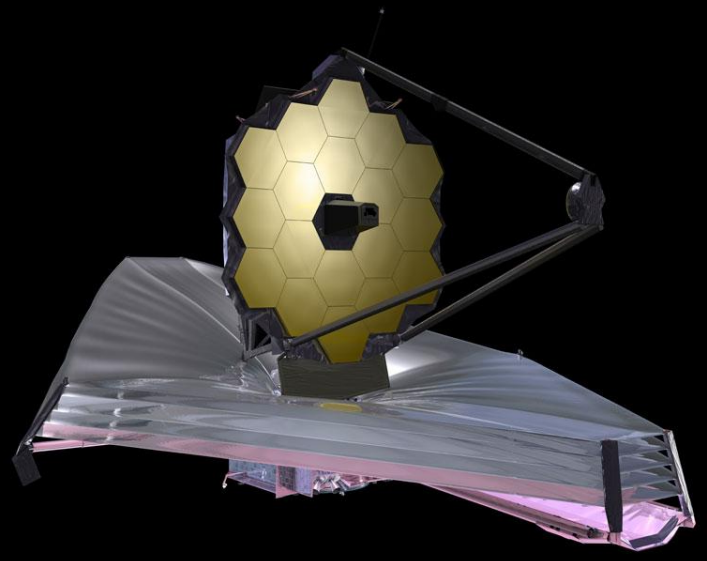
GJ 1214 b – Flat Spectra, Thick Clouds



Kreidberg+ 2014



Next steps



(NASA)

- Continue validating code
- Work on spectral lightcurve extraction
- HST IR spectra of other new exoplanets (TOI 674)
- NASA IRTF infrared spectra next month!
- JWST? Who knows!
- Helium escape, atmospheric erosion? -> tracing EUV flux from host star
- General interest – H2O in temperate planet atmospheres -> “habitable” zone
- Find good spectral retrieval codes to interpret results