Searching for signatures of young hot Jupiters

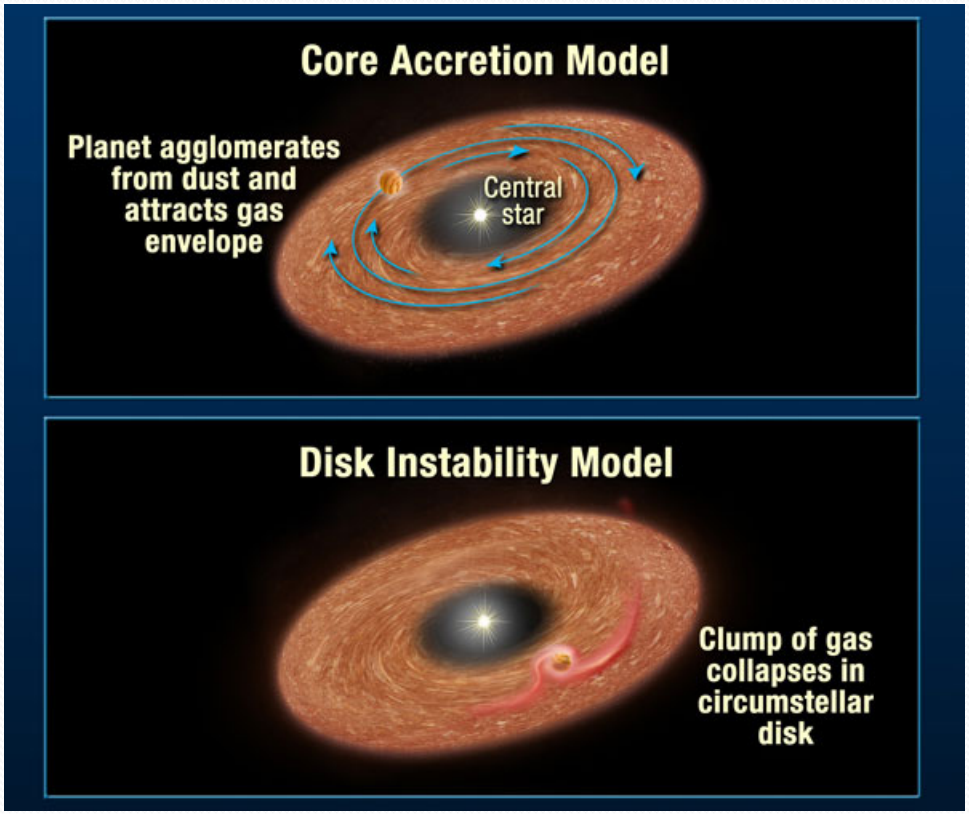
Laura Flagg

Rice University

Theories of Planet Formation

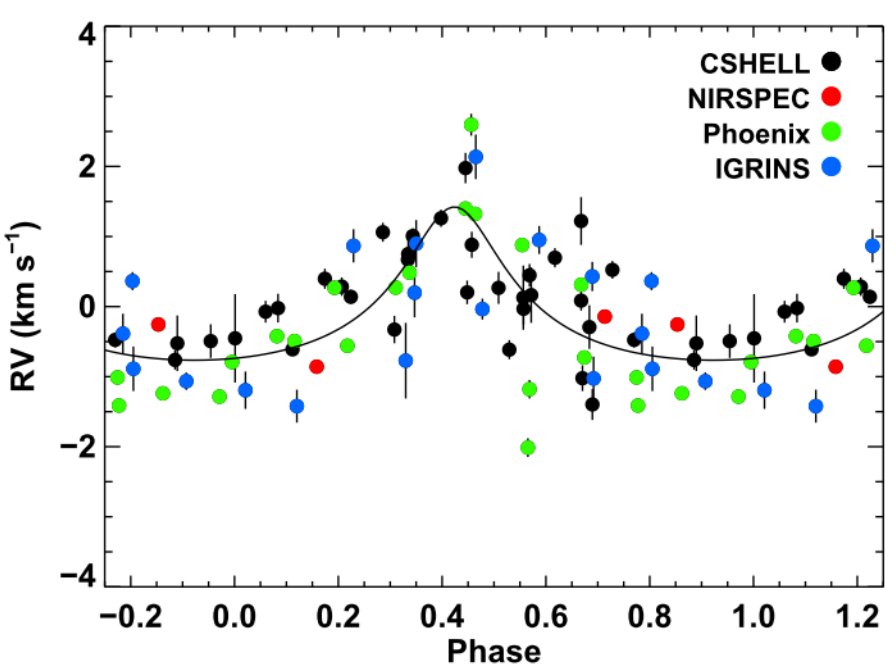
graphic from NASA / ESA / A. Feild

- two dominant theories:
  - core accretion – the "cold start" model
  - gravitational instability – the "hot start" model
- both theories have issues are not yet resolved -> new theories proposed
- observations are required to constrain theories
- young planets only recently discovered



Theories of Planet Formation

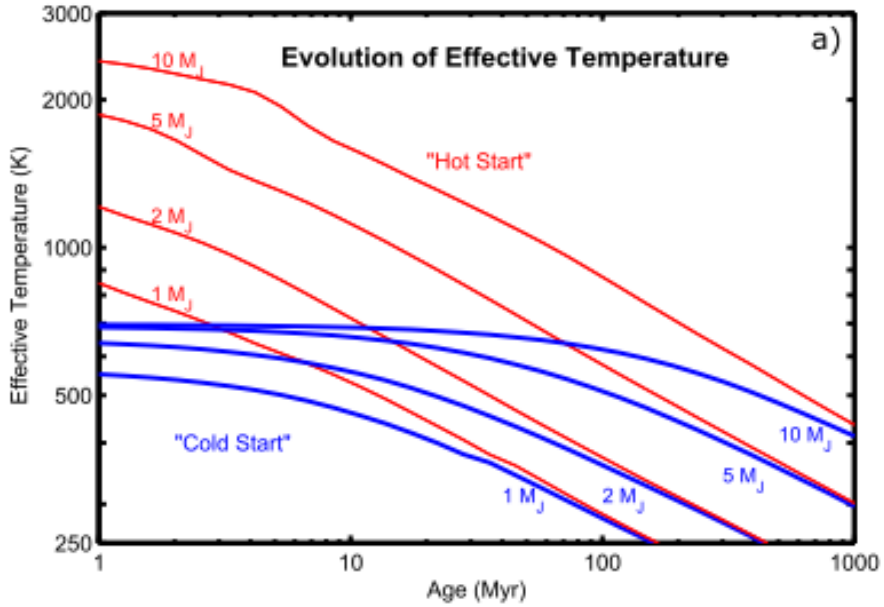
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Johns-Krull et al. 2016

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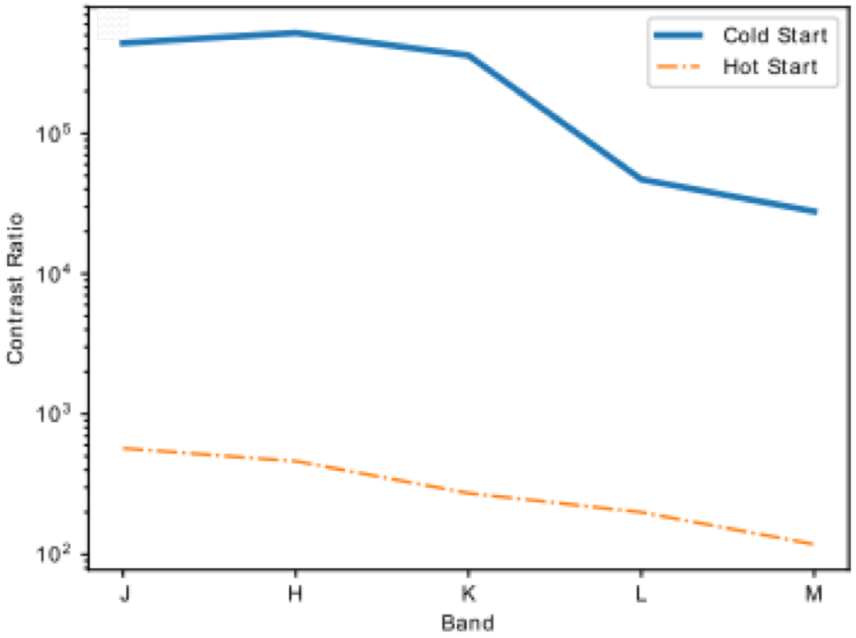
- planet's initial effective temperature determined by the amount of entropy at its formation
- planet's effective temperature at young ages is an indication of how it formed
- we can measure or put limits on a contrast ratio which gives us the magnitude of the planet



source: Spiegel & Burrows 2012

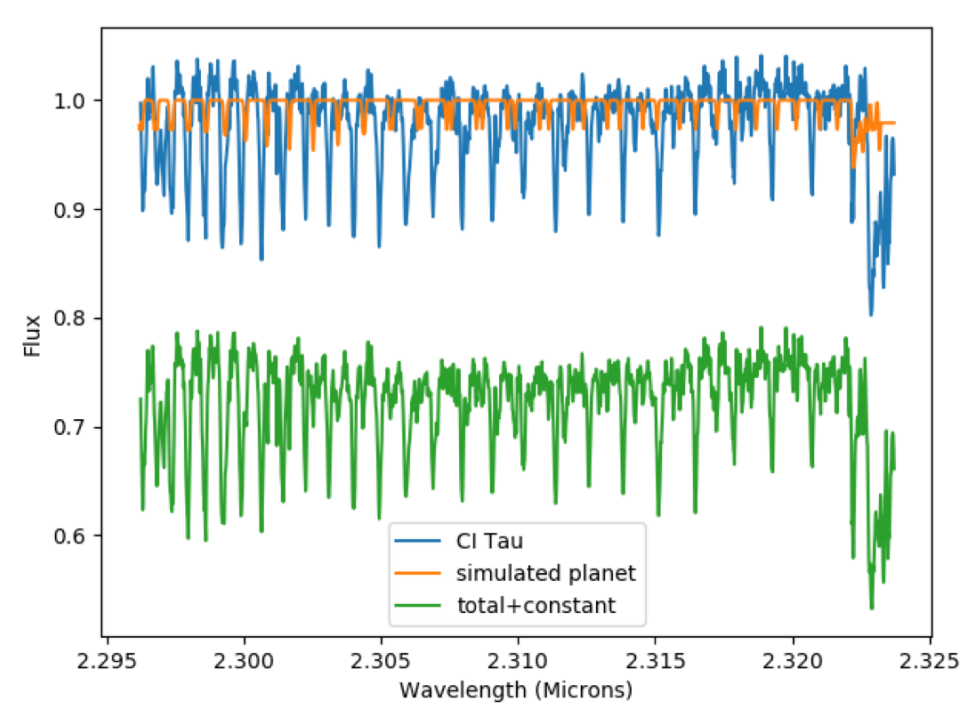
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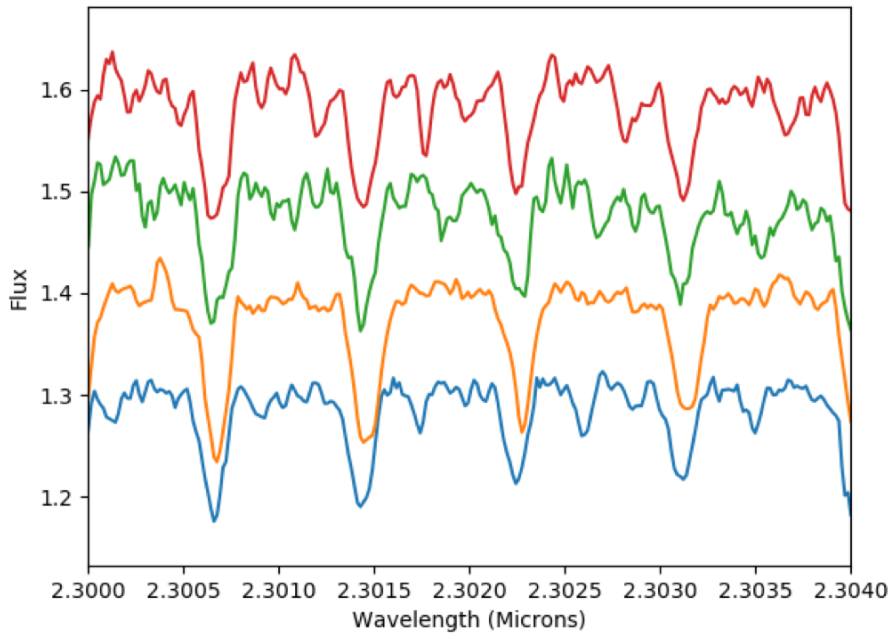
Detecting the planet's signal

- median subtract from each spectrum leaving just the planet's signal and a lot of noise
- adjust the spectra for differences in RV due to the planet's orbit
- add the spectra together
- cross correlate with a template
- this procedure has been used to detect CO around main sequence stars



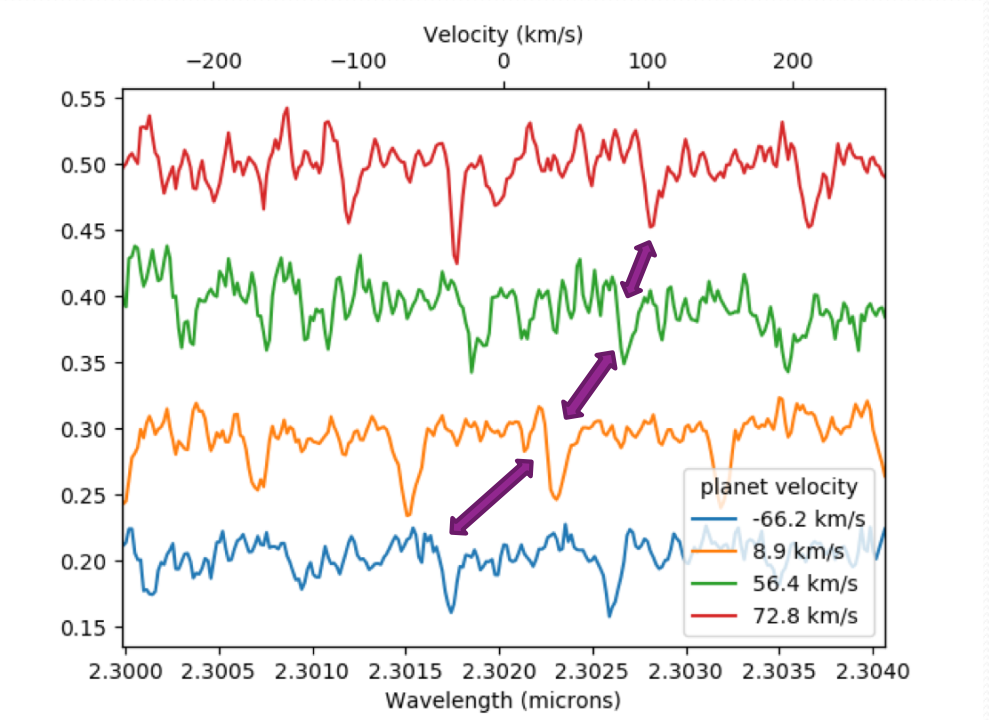
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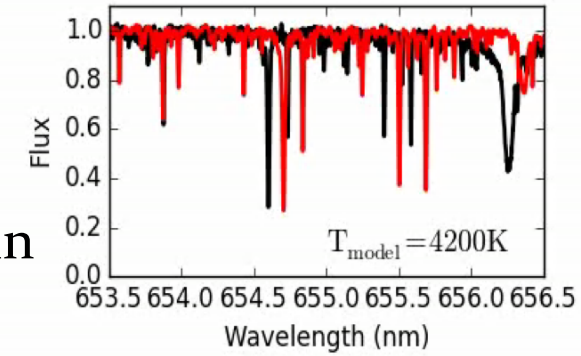
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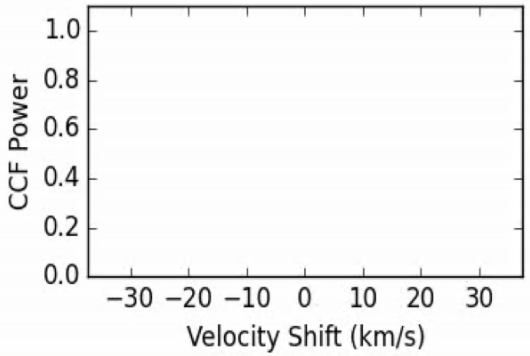
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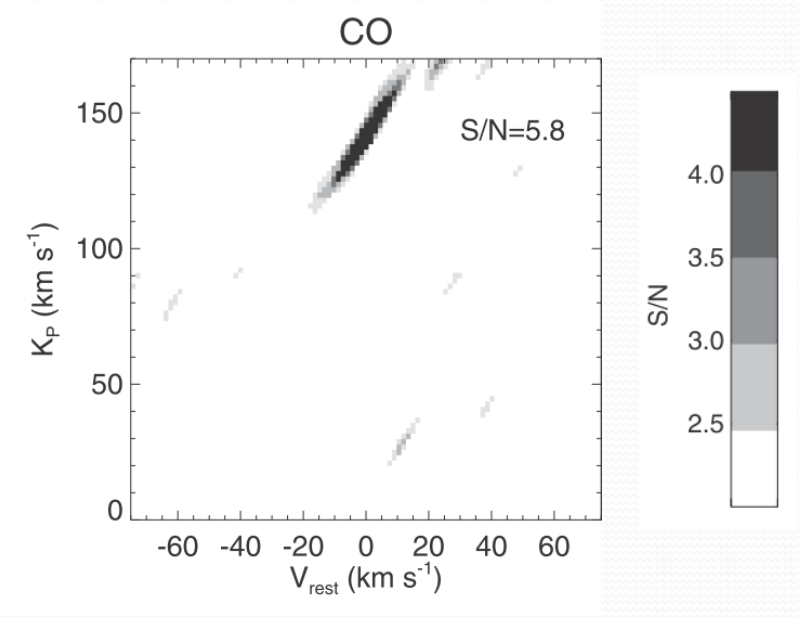


Video by Kevin Gullikson

Detecting the planet's signal

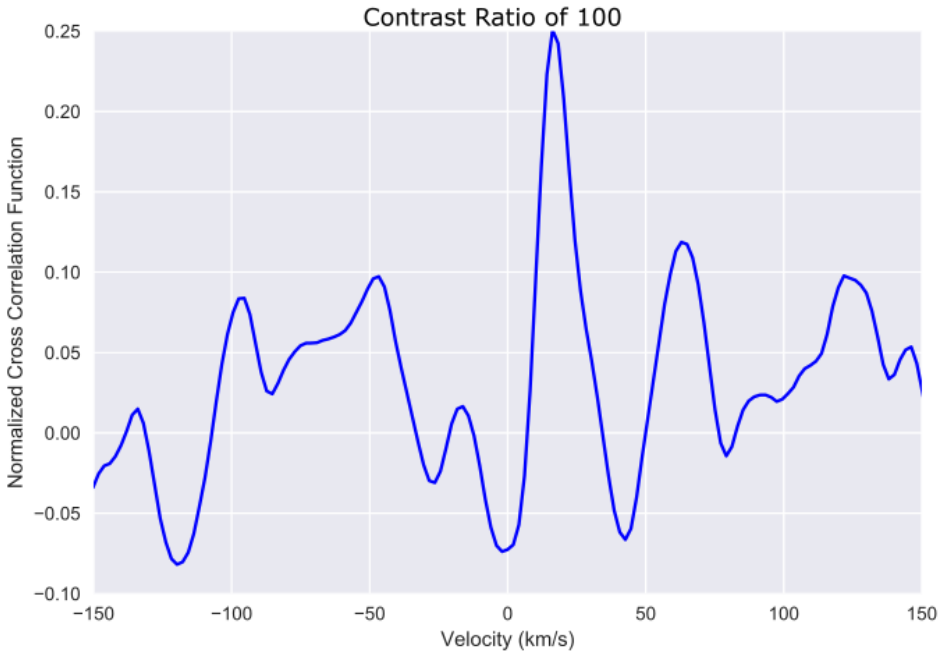
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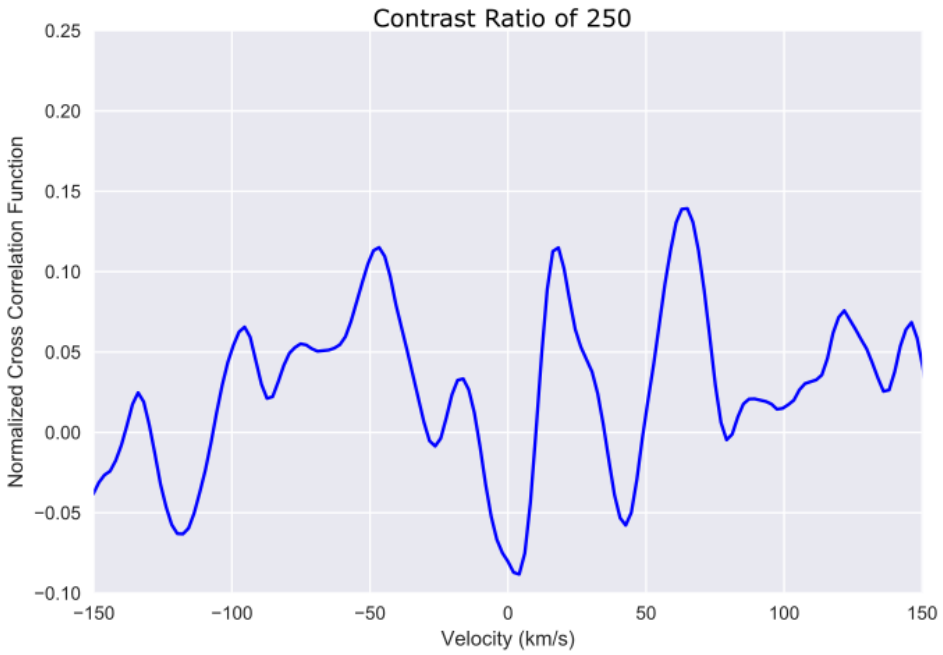
HD 179949 b CO at a contrast ratio of ~5700



Brogi et al. 2014

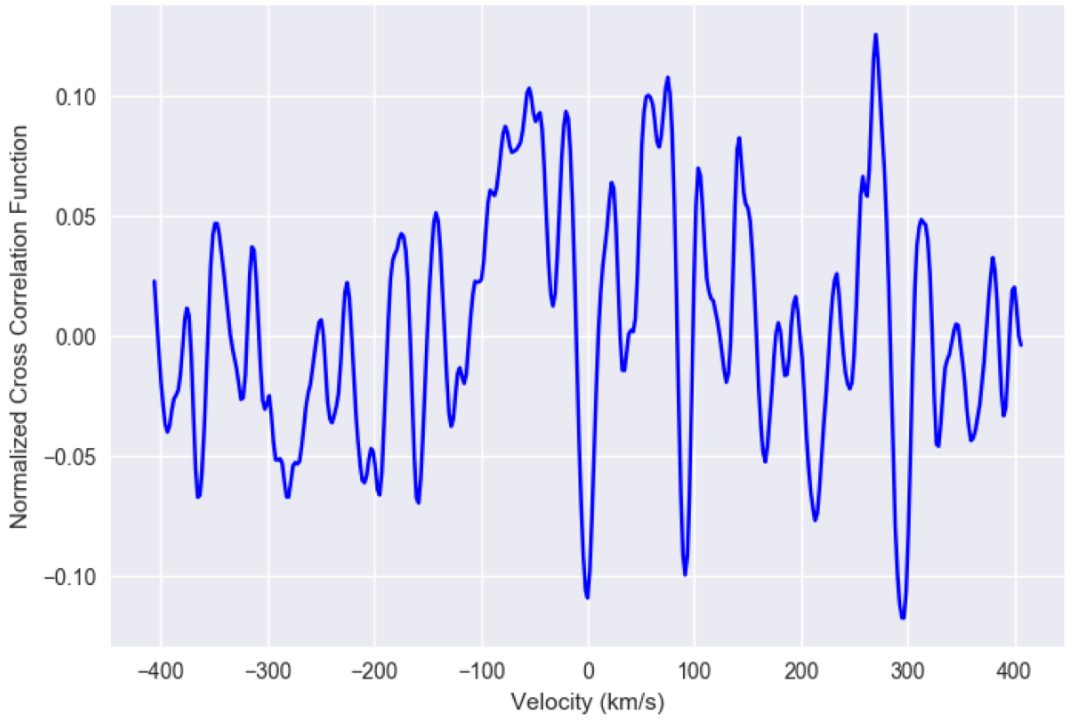
Simulated Detections





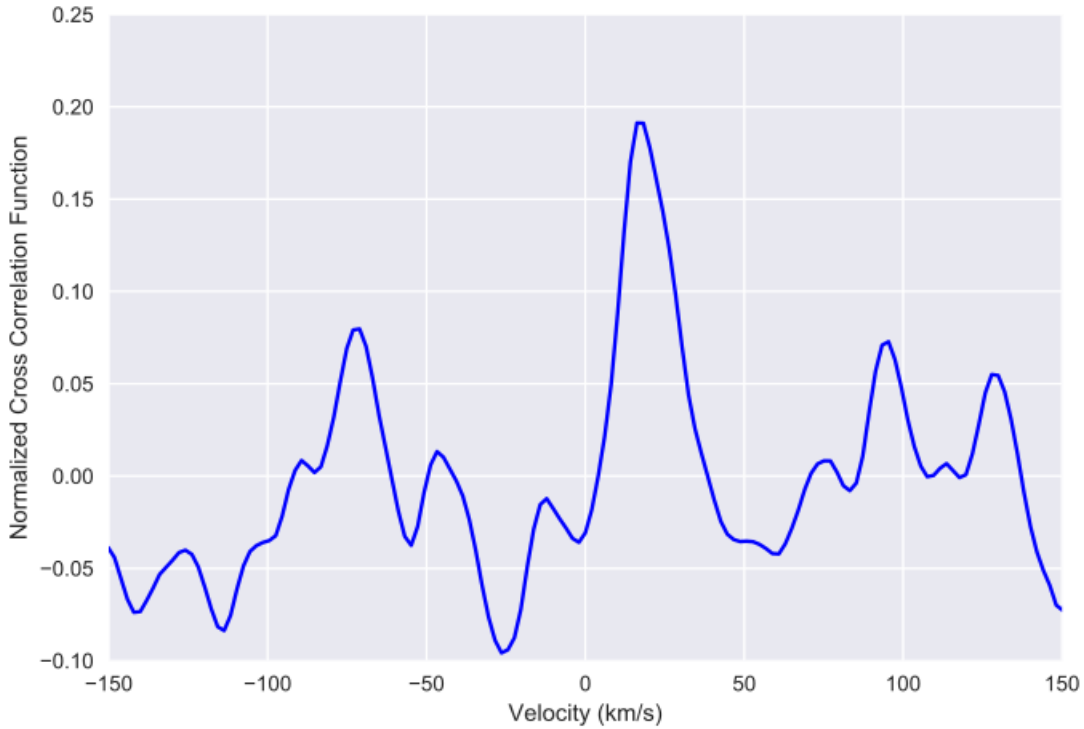
No detections... yet

- for a contrast ratio of 500, only 4 spectra of a signal-to-noise of 400 are needed for a detection
- we have those spectra
- results soon!



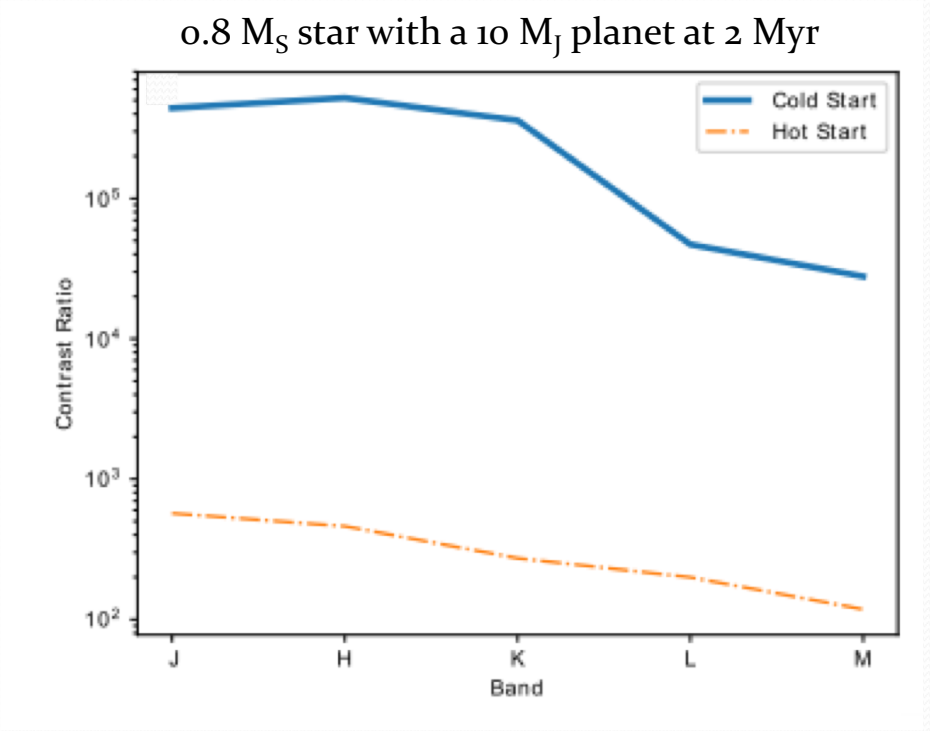
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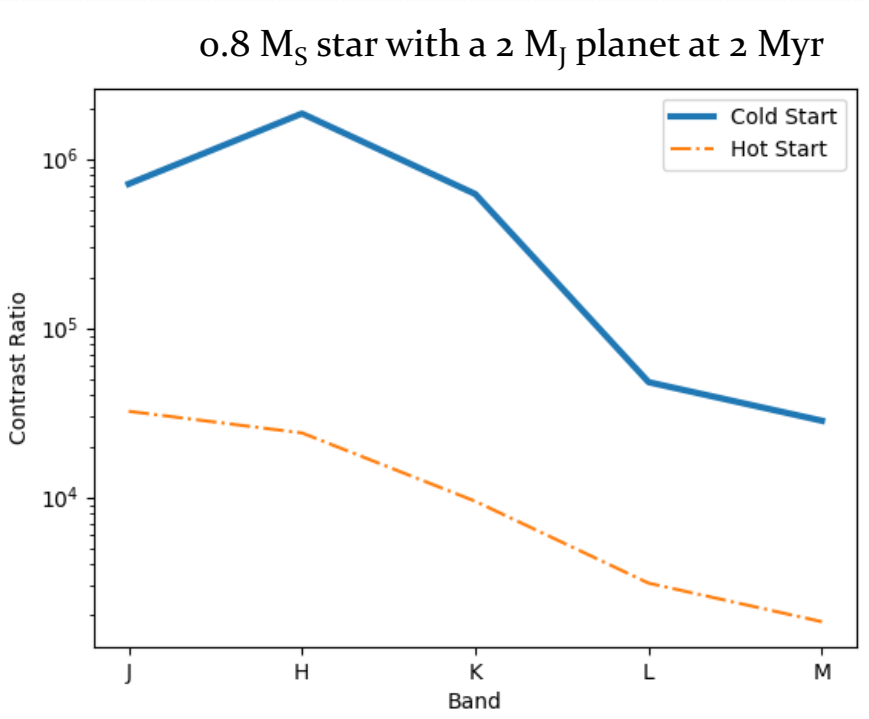
Future Work

- we want to take advantage of the improved contrast ratio at longer wavelengths
- CO is also prominent in the M band
- especially important for lower mass planets like V830 Tau b might be



Future Work

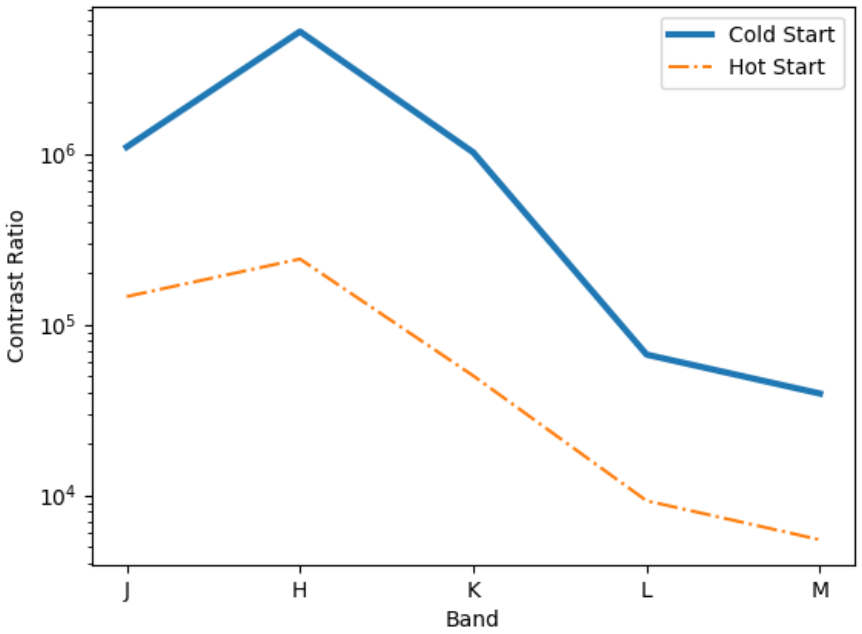
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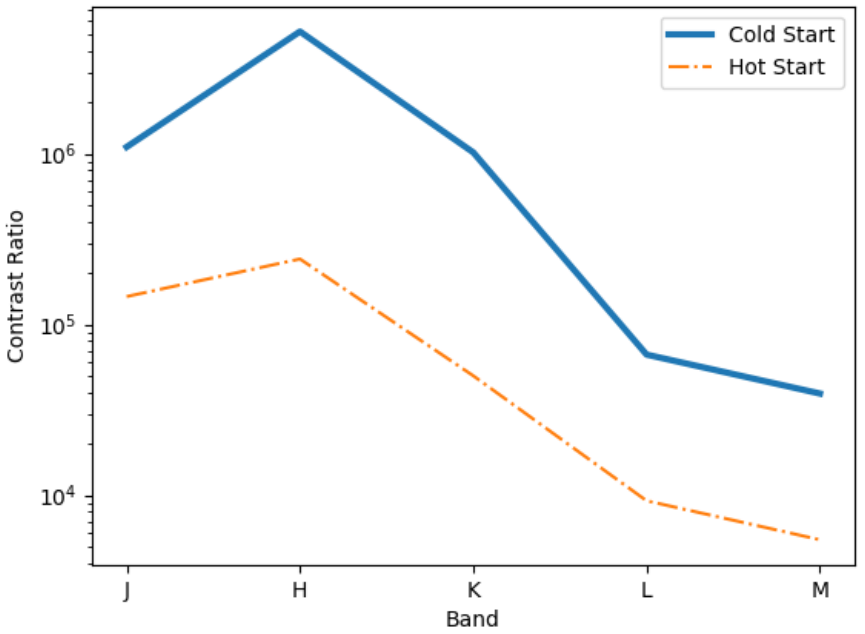
0.8 M_S star with a 1 M_J planet at 2 Myr



Future Work

- smaller planets will not be detected at shorter wavelengths
- need a high resolution spectrometer that works in the M band
- like ISHELL on IRTF
  - L and M band at R~75000

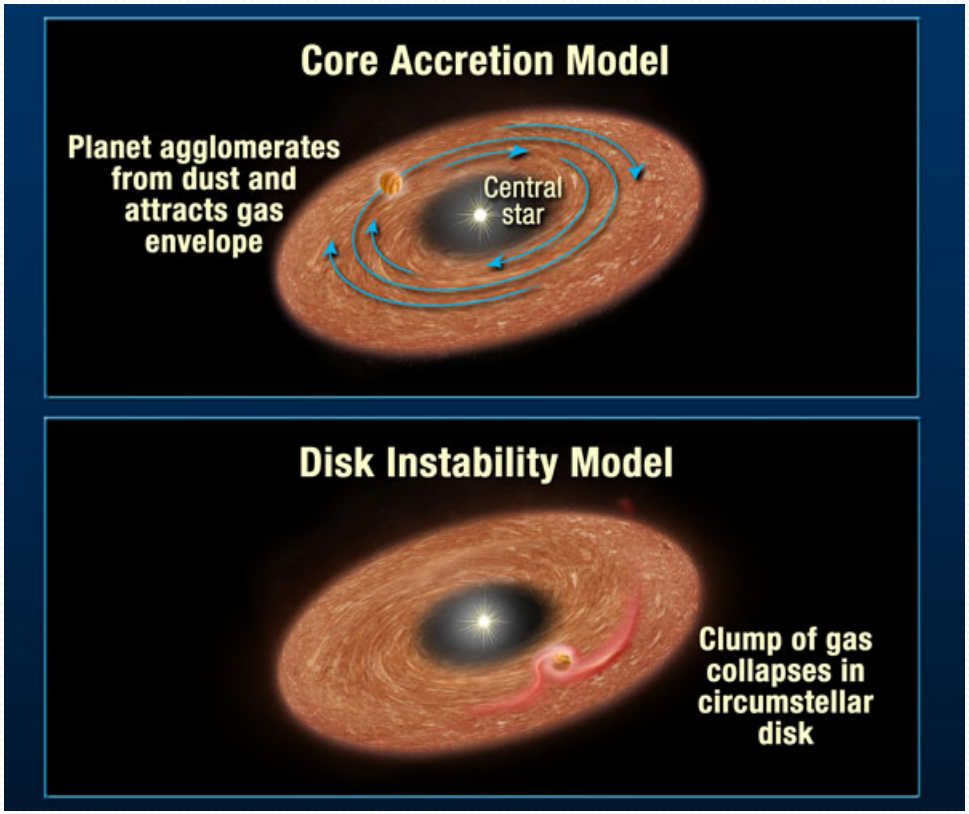
0.8 M_S star with a 1 M_J planet at 2 Myr



Summary

- we need observations of planet formation to distinguish between theories
- putting limits on contrast ratios of planets can do just that
- this can be done more efficiently at longer wavelengths for smaller planets

graphic from NASA / ESA / A. Feild

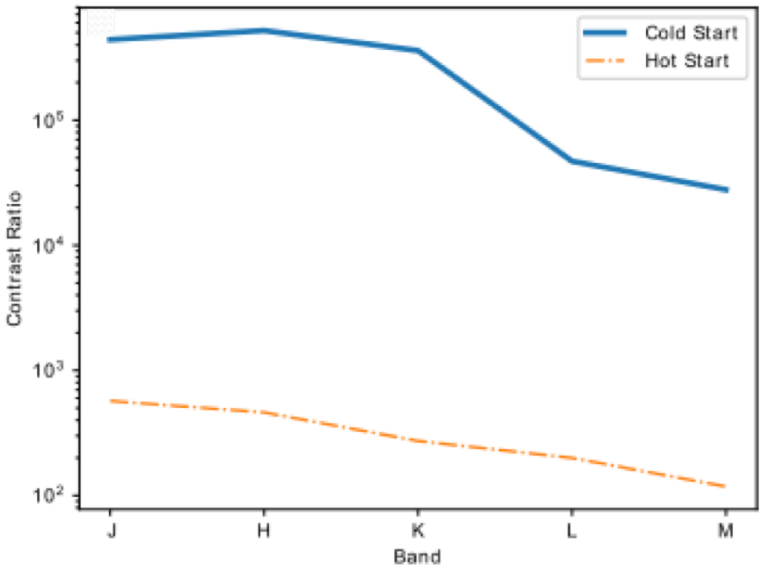


extra slides…

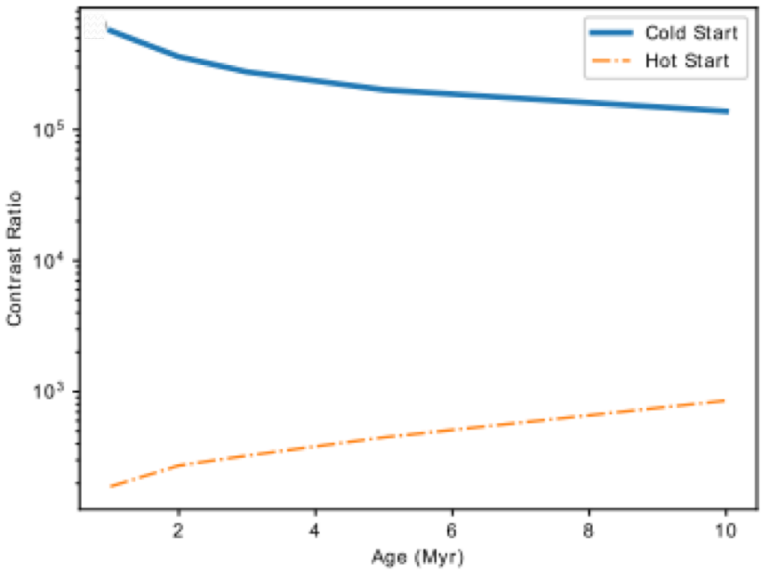
Contrast Ratios

For a 0.8 M_S star with a 10 M_J planet:

at 2 Myr

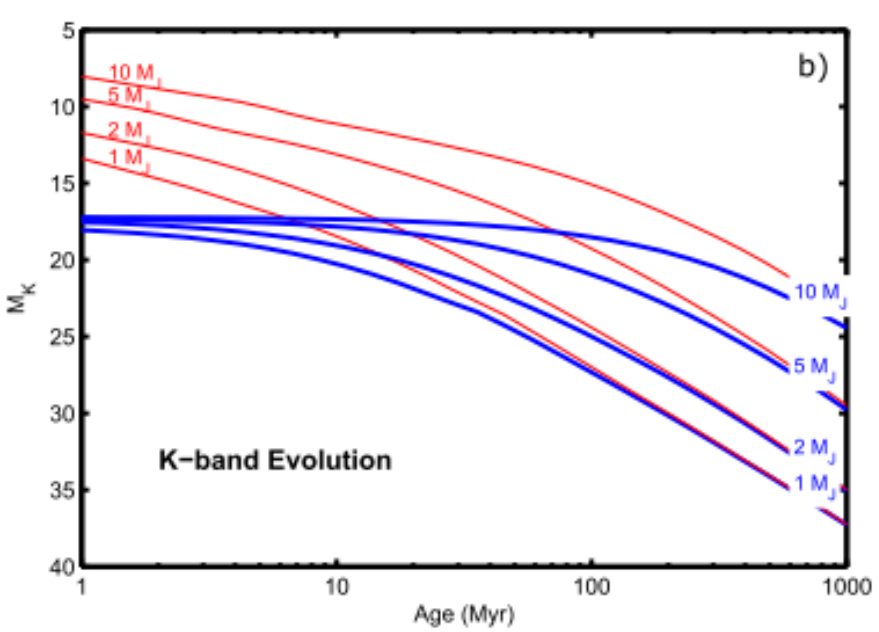


in K band



Theories of Planet Formation

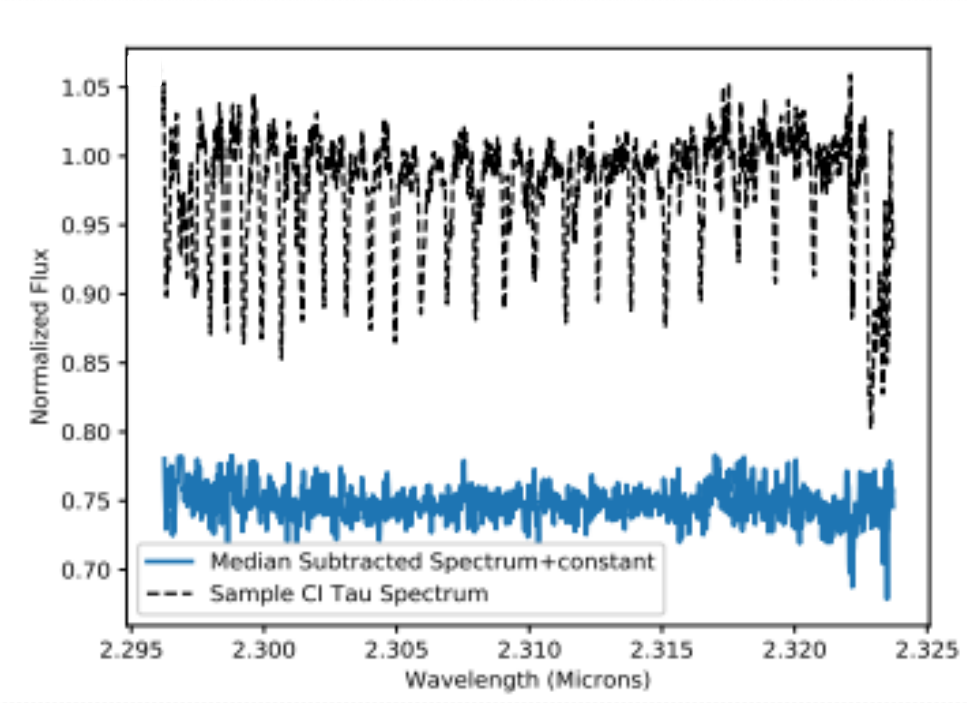
- with current technology, we are not determining effective temperature for hot Jupiters
- we can measure or put limits on a contrast ratio which gives us the magnitude of the planet



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Observations

- high resolution (R~40000) spectra using IGRINS
- taken with ABBA format
- each spectrum:
  - telluric lines removed
  - corrected for veiling
- left with just the star and the unseen planet

Motivation

- many theories of planet formation
- few observations to constrain those theories
- only recently have planets have been detected around T-Tauri stars
  - so now those observations can be done
- necessary to progress planet formation theories