Searching for signatures of young hot Jupiters

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Theories of Planet Formation

- 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
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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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0.8 M\textsubscript{S} star with a 10 M\textsubscript{J} planet at 2 Myr
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
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Video by Kevin Gullikson
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HD 179949 b CO at a contrast ratio of ~5700

Brogi et al. 2014
Simulated Detections

Contrast Ratio of 100

Contrast Ratio of 250

Normalized Cross Correlation Function

Velocity (km/s)
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!
No detections... yet

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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 0.8 $M_\odot$ star with a 10 $M_\text{J}$ planet at 2 Myr
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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 $R \sim 75000$

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
extra slides...
Contrast Ratios

For a $0.8 \, M_\odot$ 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

source: Spiegel & Burrows 2012
Detecting the planet’s signal

- median subtract from each spectrum leaving just the planet’s signal and a lot of noise
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Observations

- high resolution ($R \sim 40000$) 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