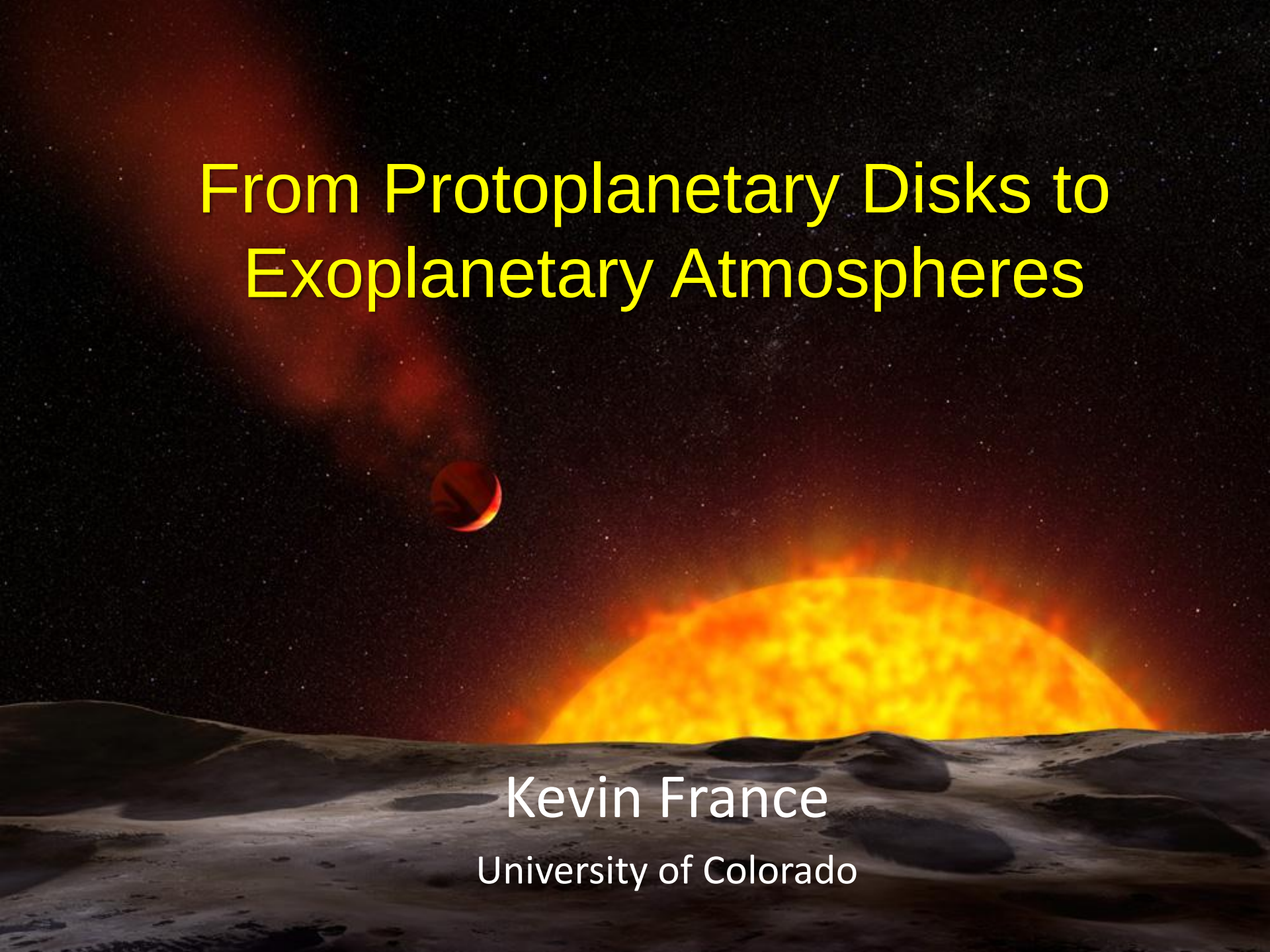


From Protoplanetary Disks to Exoplanetary Atmospheres

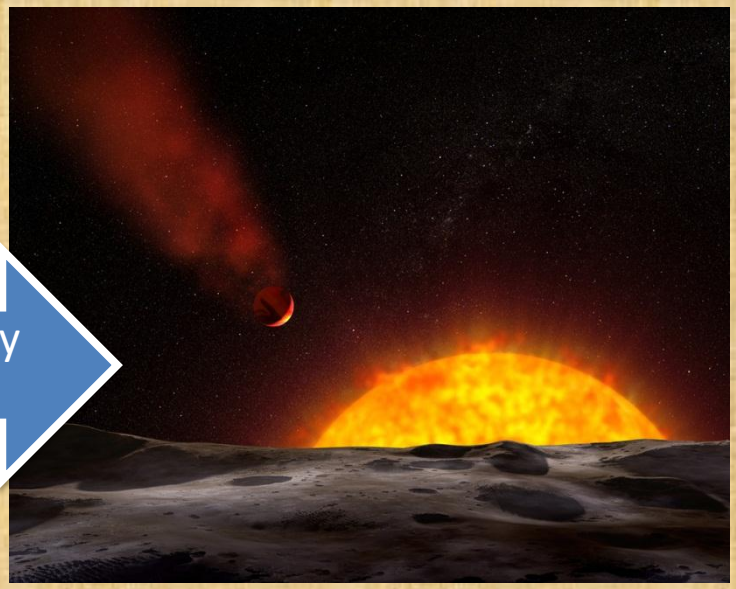
Kevin France

University of Colorado

FROM PROTOPLANETARY DISKS TO EXOPLANET ATMOSPHERES:

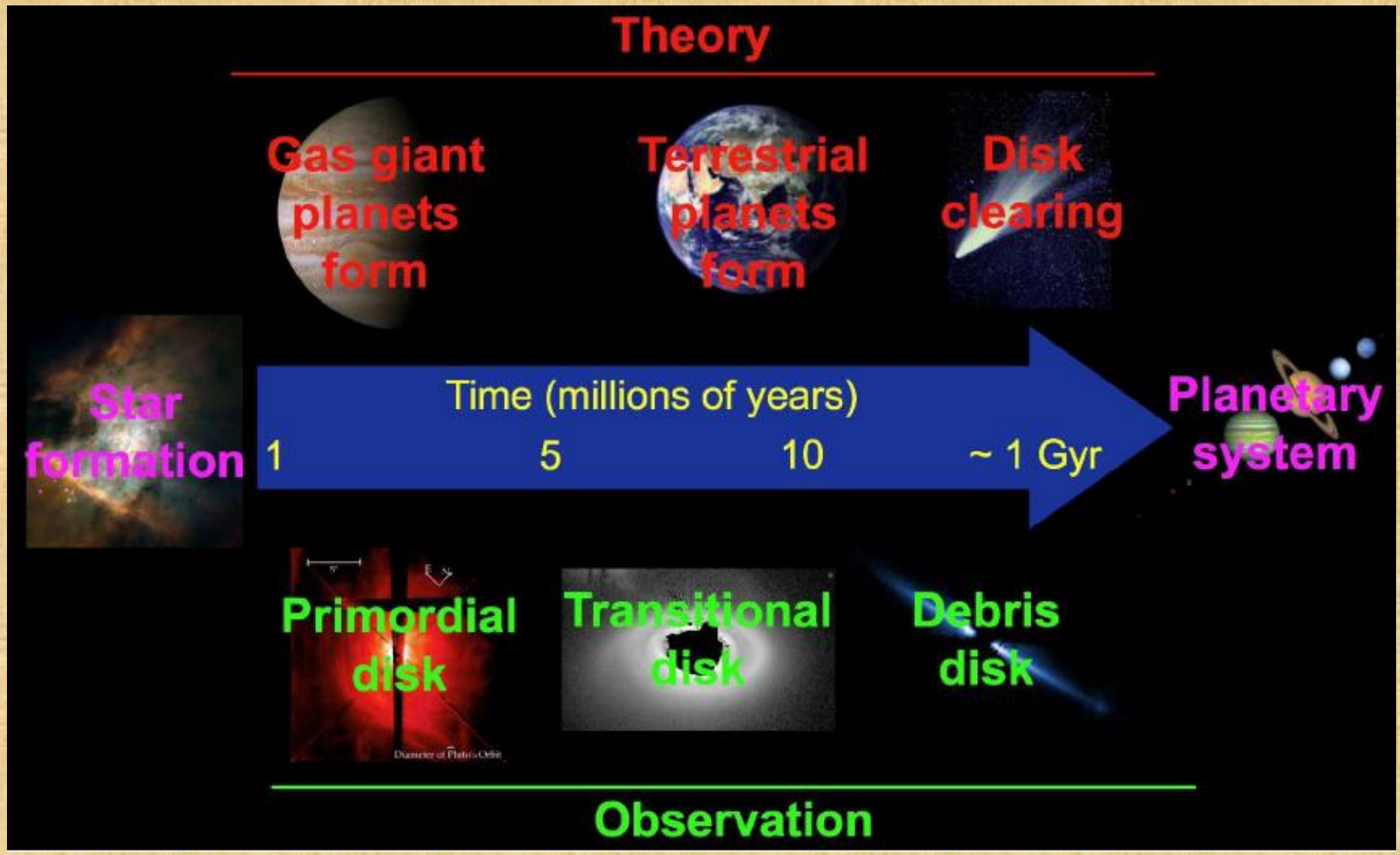
TELLING THE STORY OF EXOPLANET EVOLUTION WITH UV SPECTROSCOPY

Disks → Planetary Systems

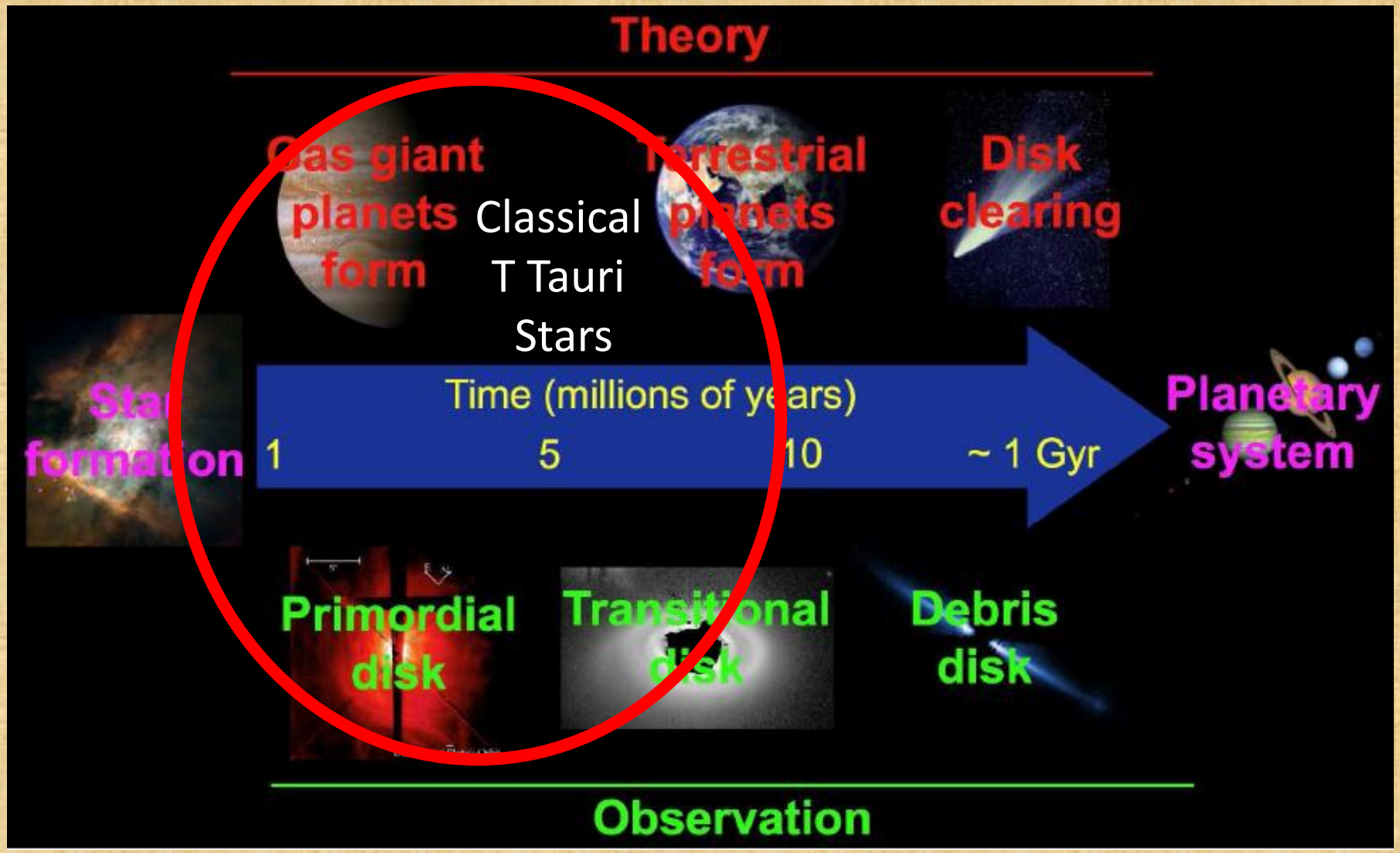


Kevin France

University of Colorado

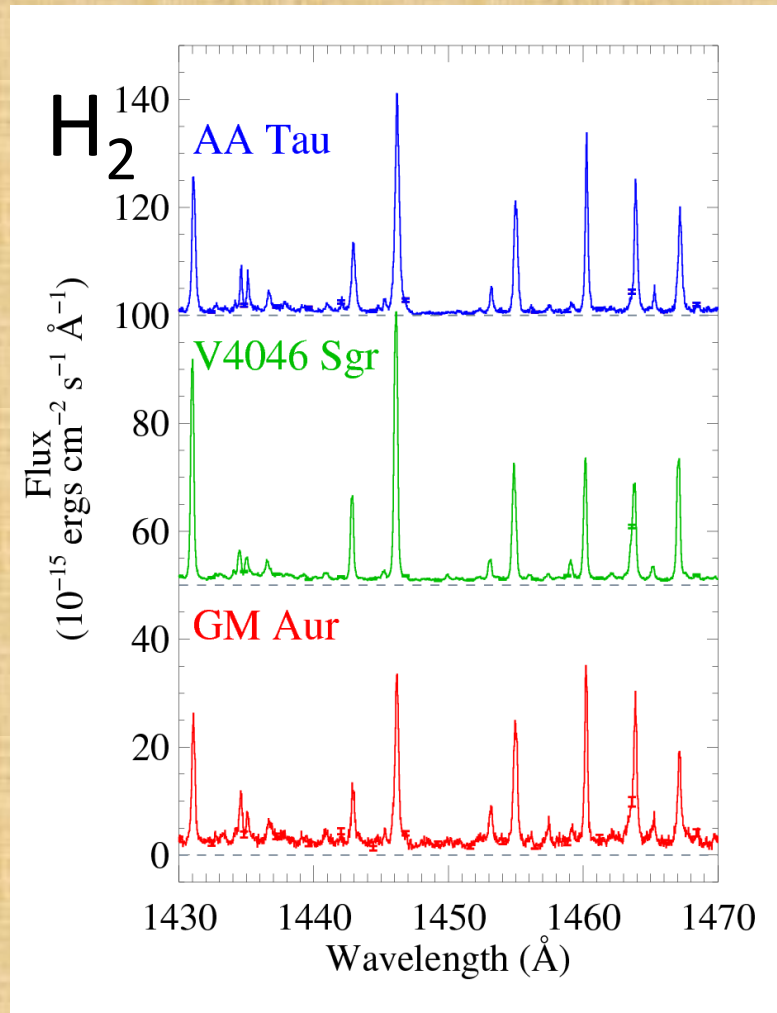


A. Roberge et al. 2009 – Astro2010 White Paper



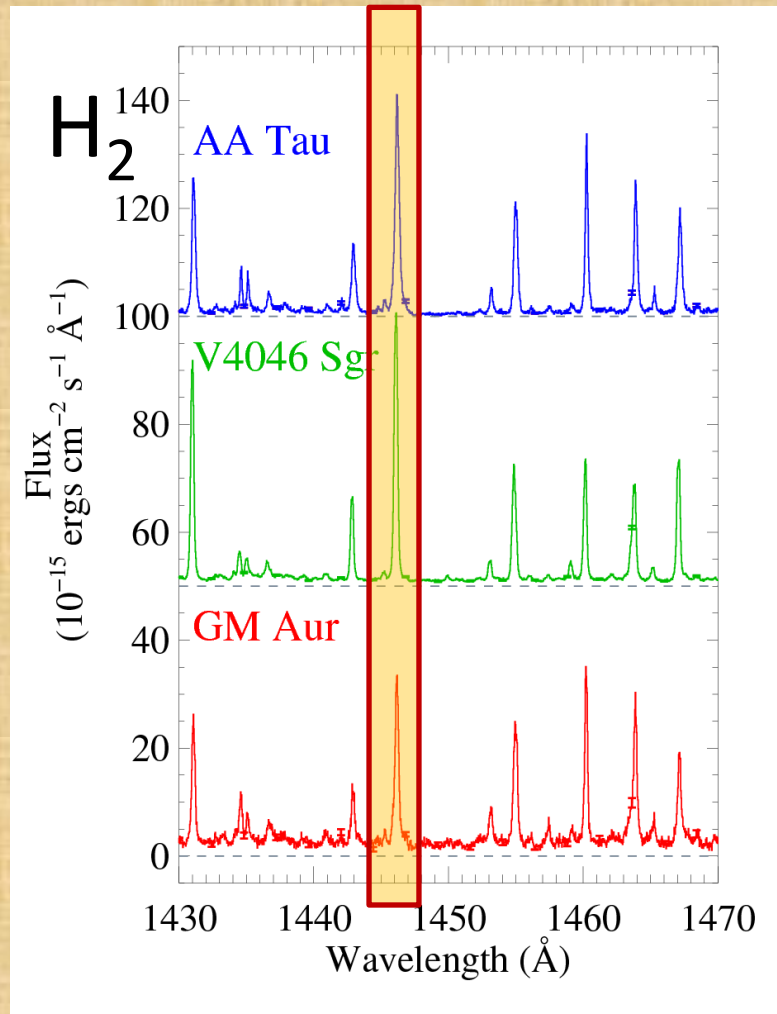
A. Roberge et al. 2009 – Astro2010 White Paper

Molecules in Protoplanetary Disks: Ultraviolet Emission from the Inner Disk

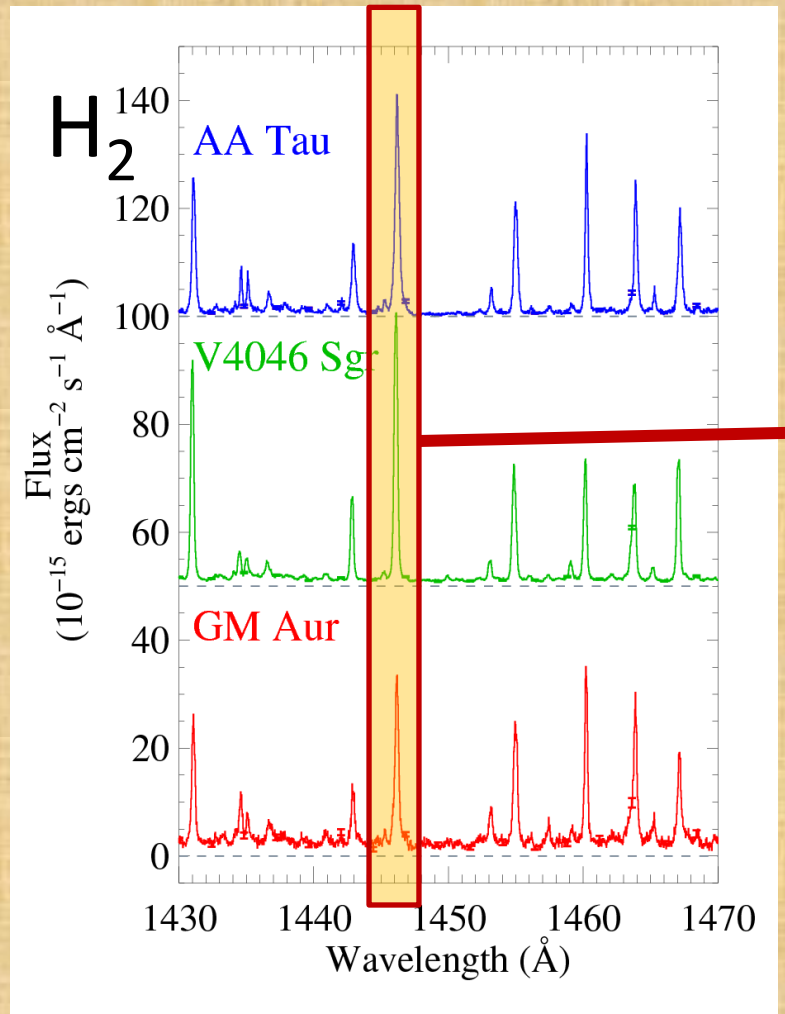


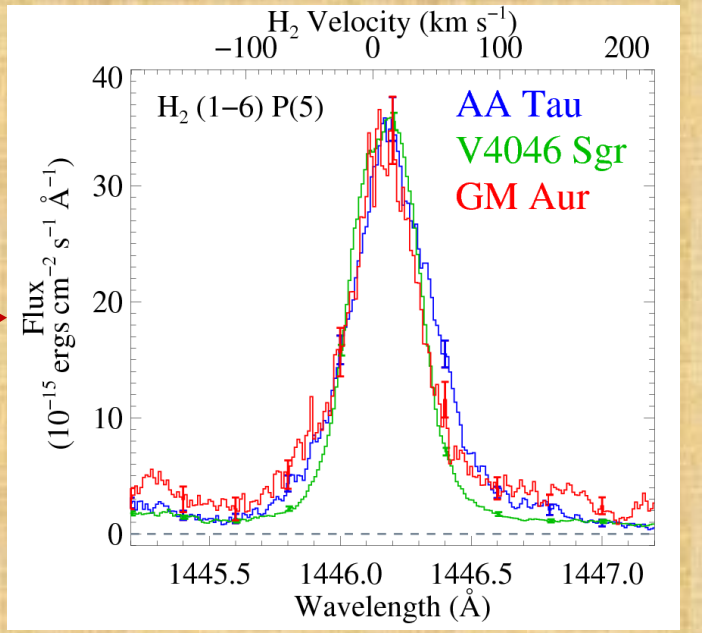
- H_2 makes up 99% of the gas mass in protoplanetary disks
- Very hard from the ground, may only be done with JWST

Molecules in Protoplanetary Disks: Ultraviolet Emission from the Inner Disk



Molecules in Protoplanetary Disks: Ultraviolet Emission from the Inner Disk

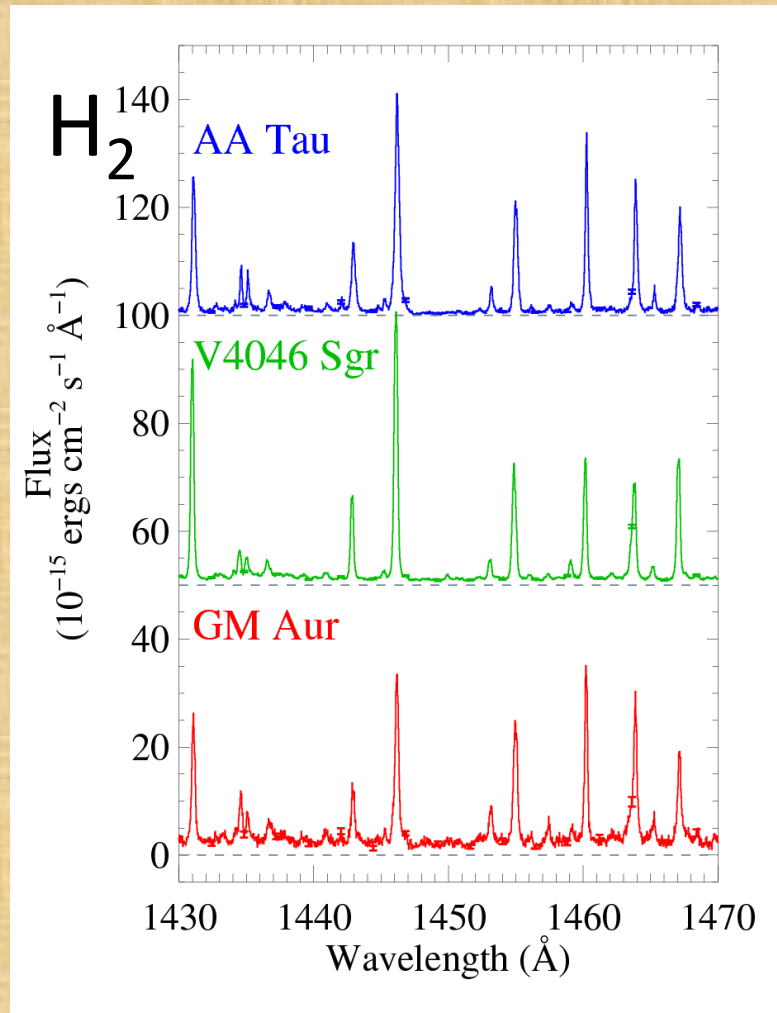




- Rotation curves for gas at planet-forming radii (a < 2-4 AU)

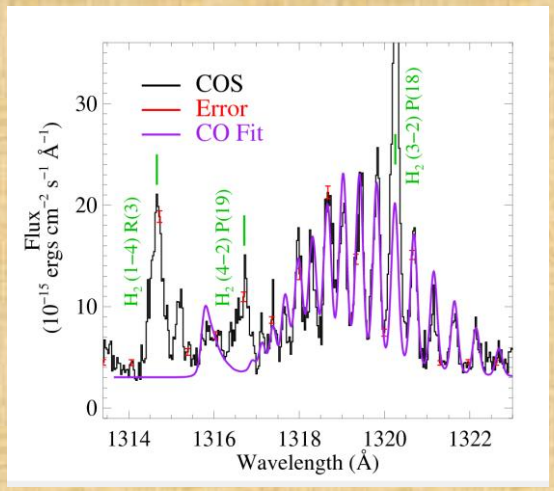
France et al. (2011a)

Molecules in Protoplanetary Disks: Ultraviolet Emission from the Inner Disk



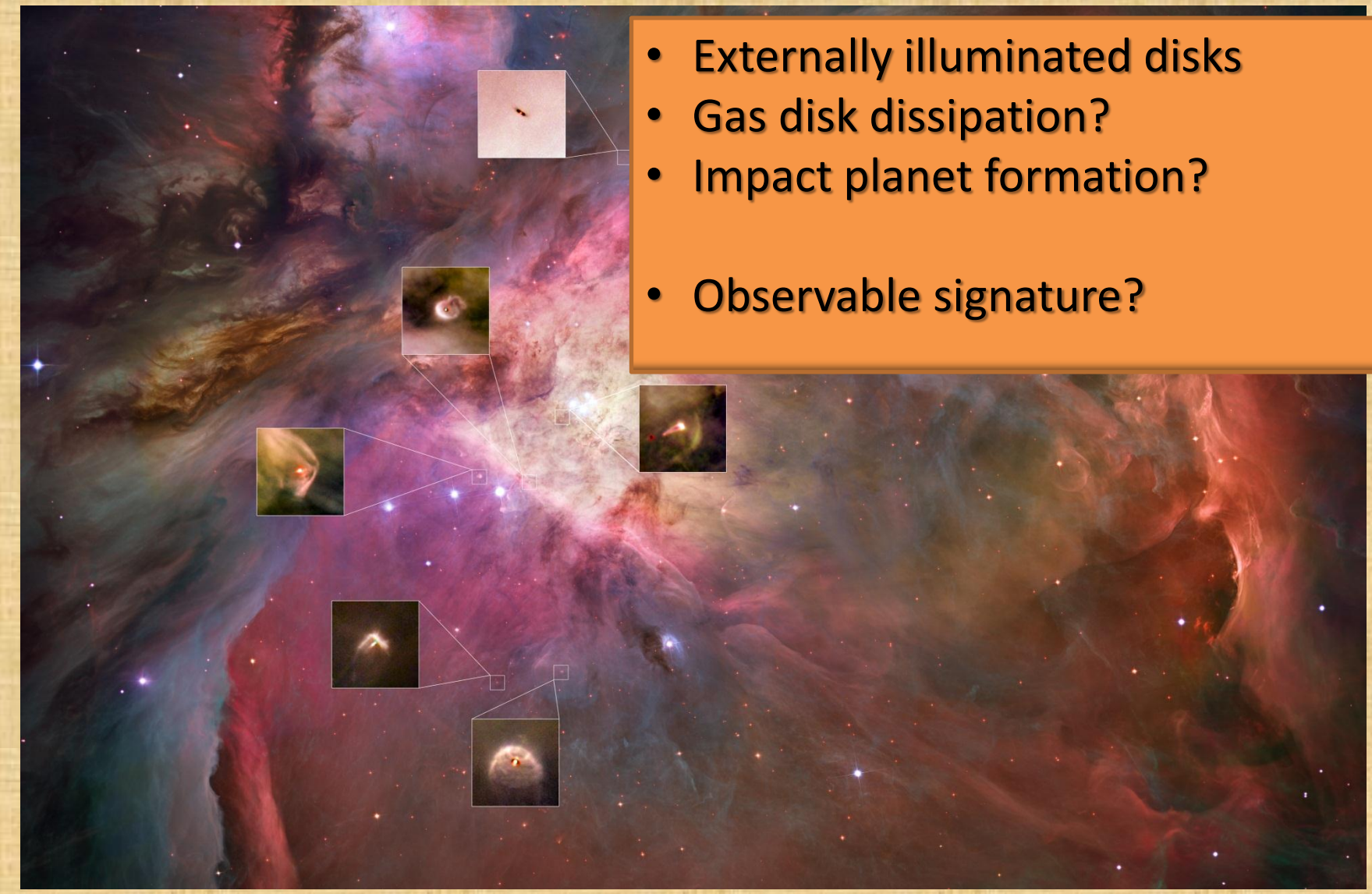
- H_2 makes up 99% of the gas mass in protoplanetary disks
- Very hard from the ground, may only be done with JWST

- CO, 2nd most abundant molecule:
  - Chemistry
  - Disk Structure



France et al. (2011a)

France et al. (2011b)

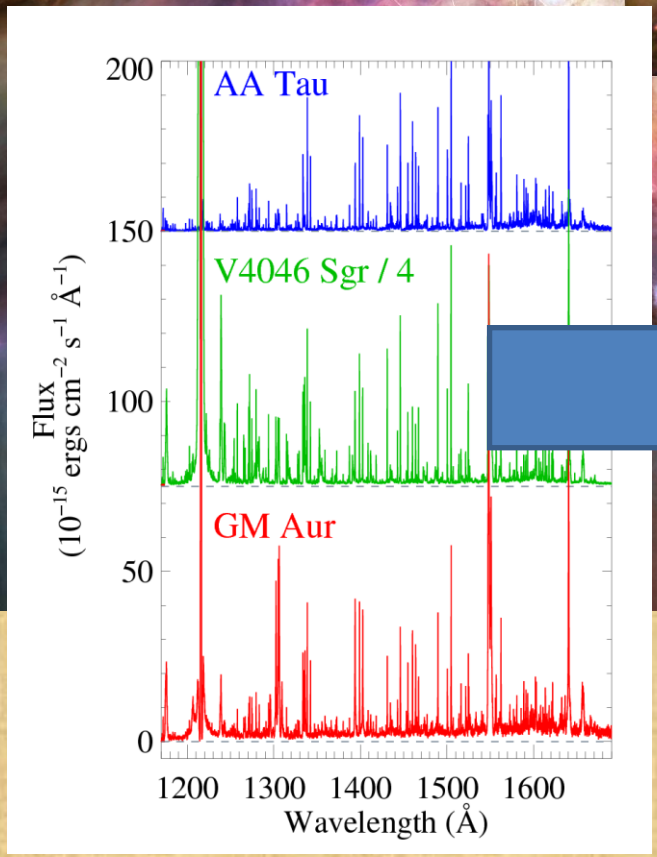


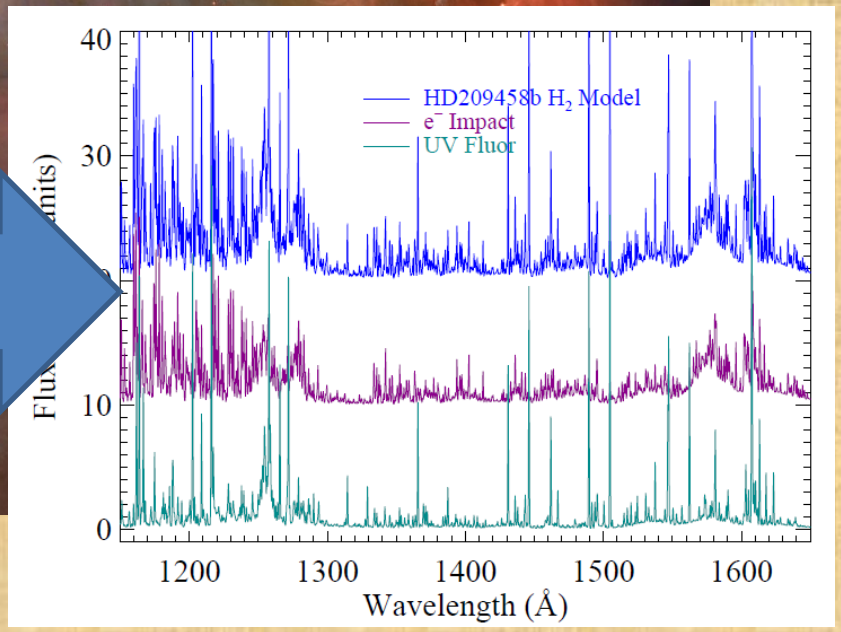
- Externally illuminated disks
- Gas disk dissipation?
- Impact planet formation?

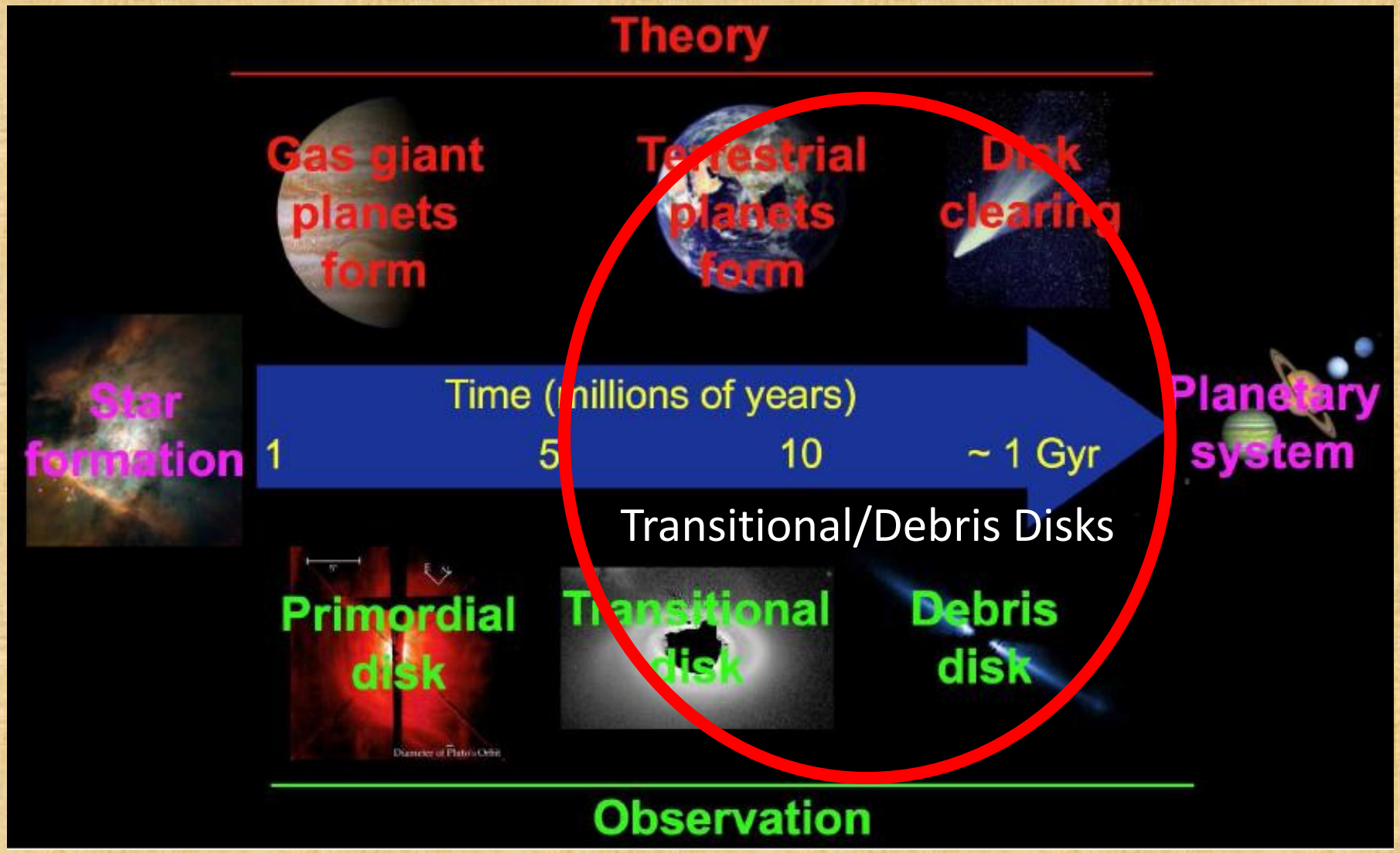
- Observable signature?

- Externally illuminated disks
- Gas disk dissipation?
- Impact planet formation?

- Observable signature?



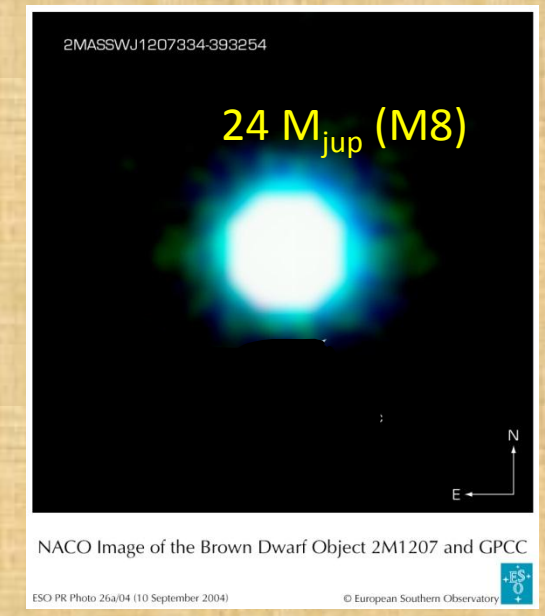


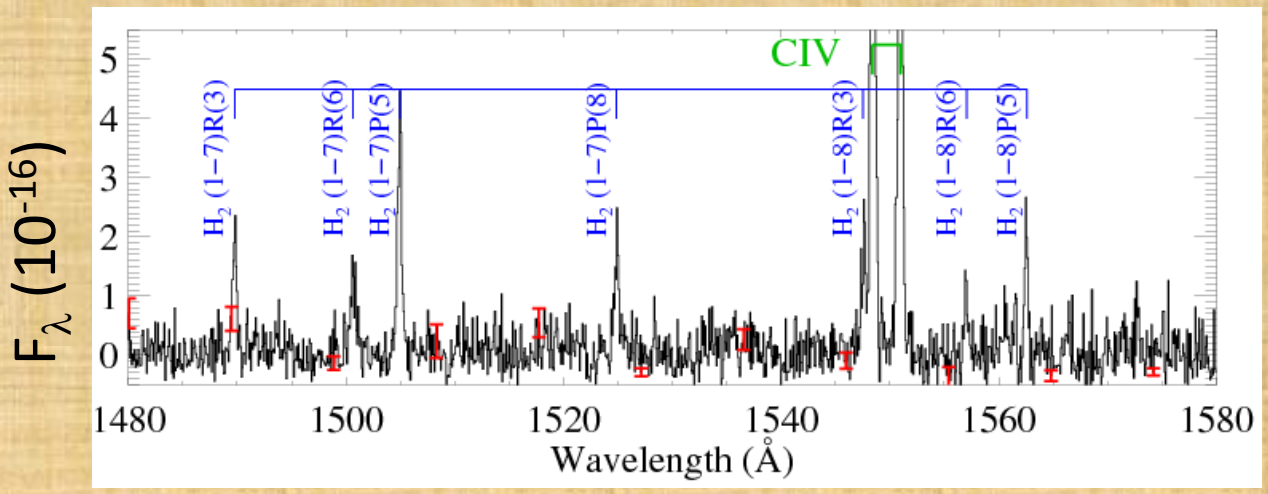


A. Roberge et al. 2009 – Astro2010 White Paper

Building Planets:

Solar-system analogs to Brown Dwarf systems

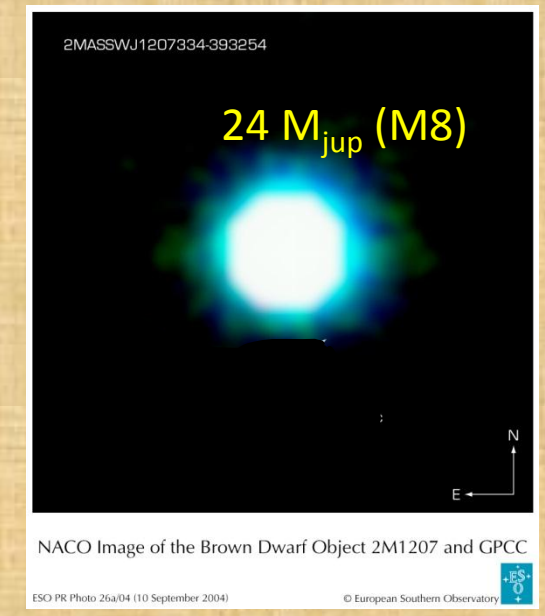




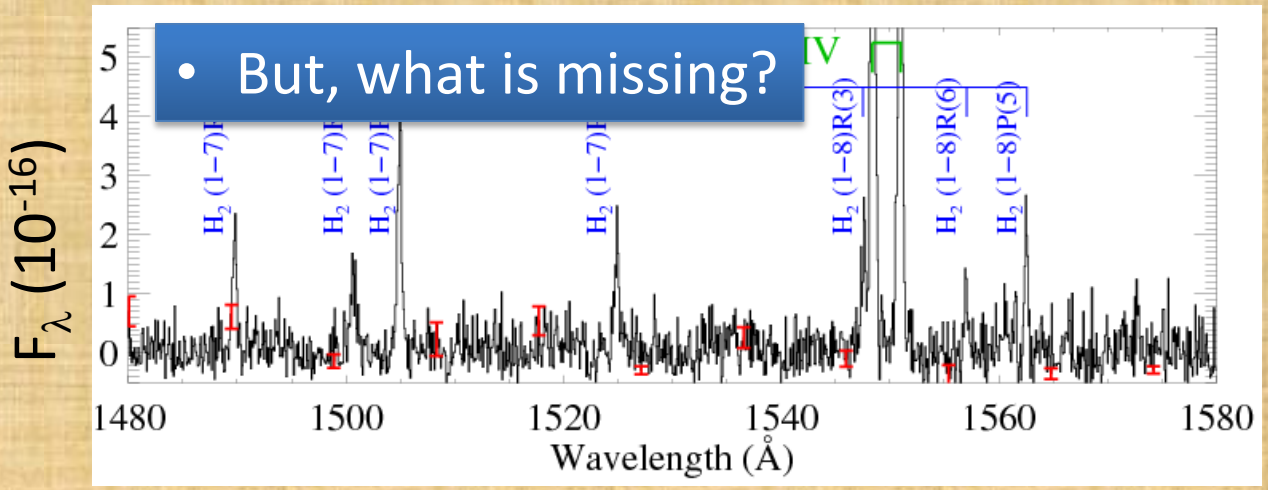
France et al. (2010b)

Building Planets:

Solar-system analogs to Brown Dwarf systems



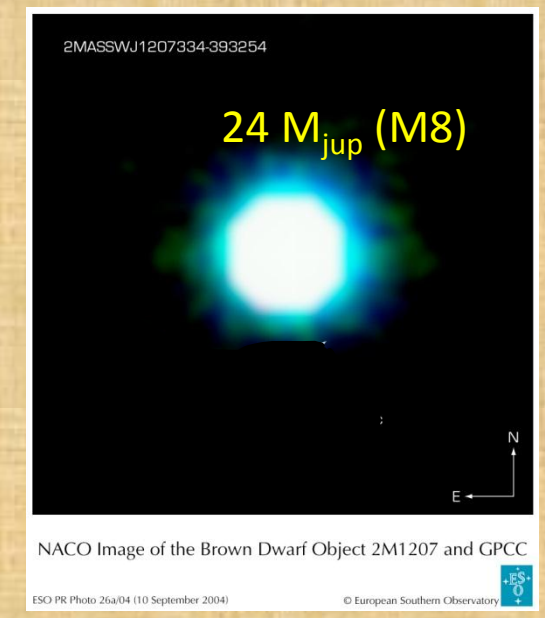
- But, what is missing?



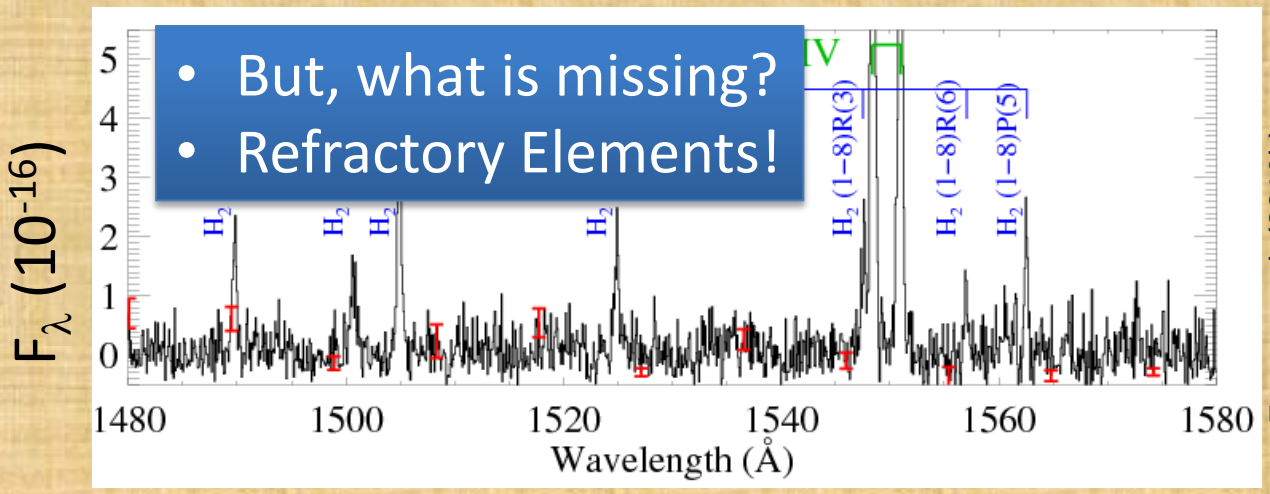
France et al. (2010b)

Building Planets:

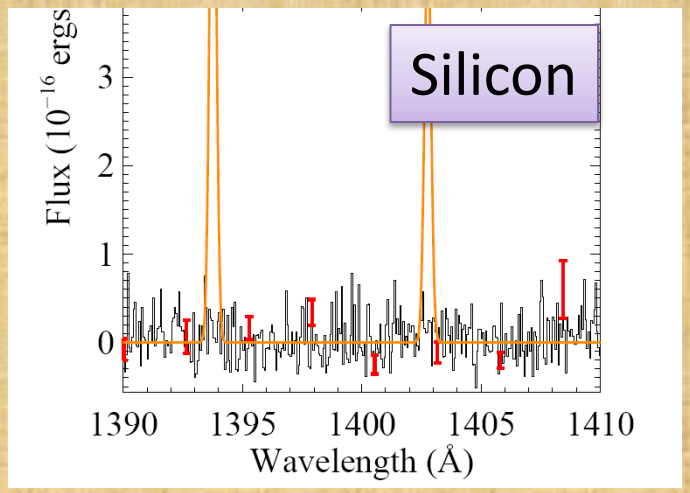
Solar-system analogs to Brown Dwarf systems

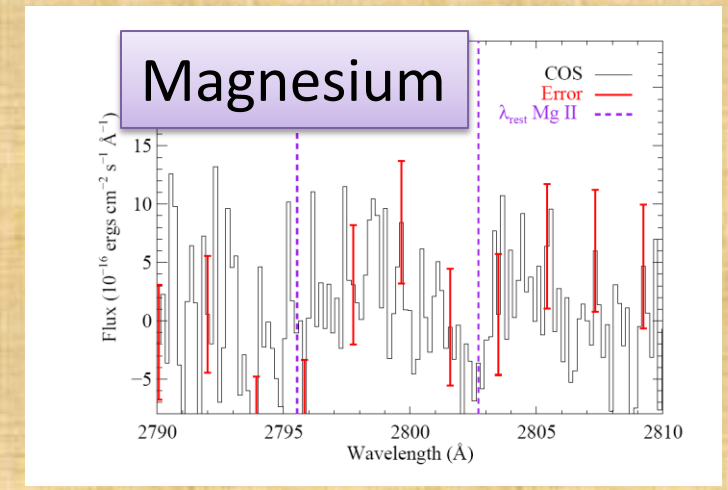


- But, what is missing?
- Refractory Elements!



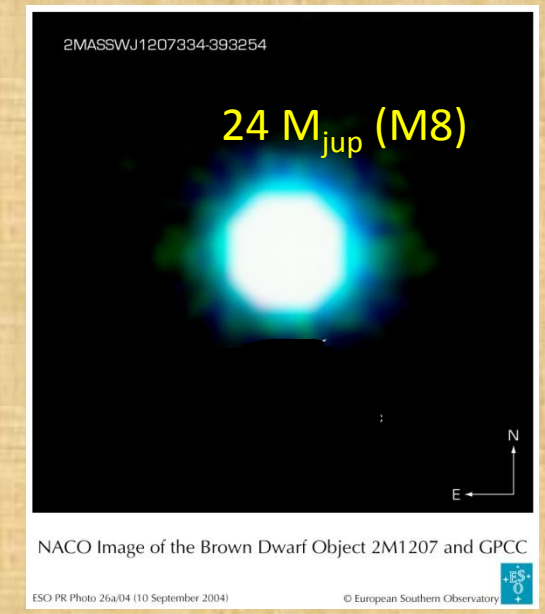
France et al. (2010b)

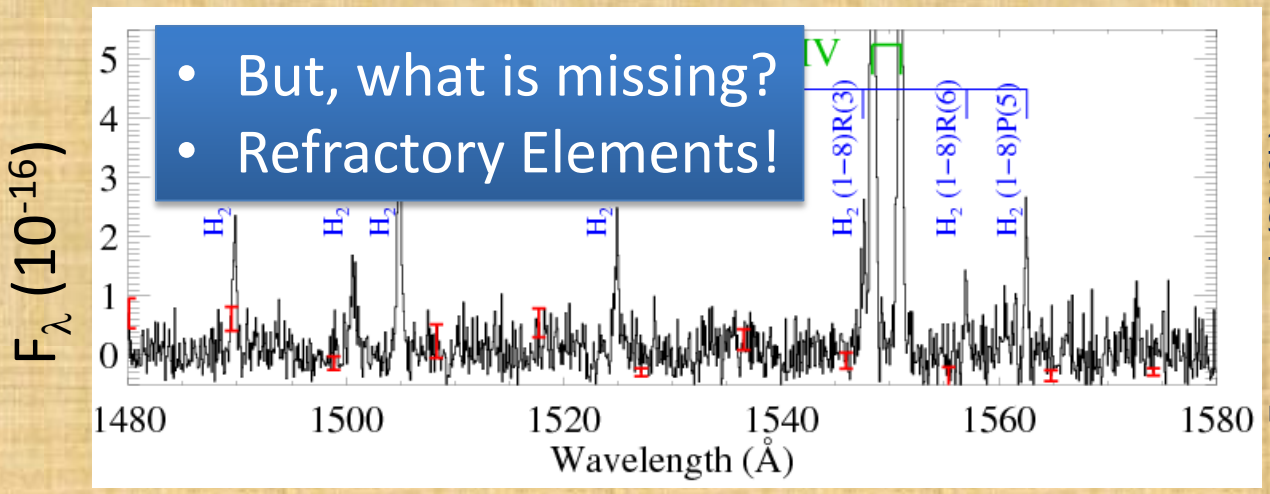




Building Planets:

Solar-system analogs to Brown Dwarf systems

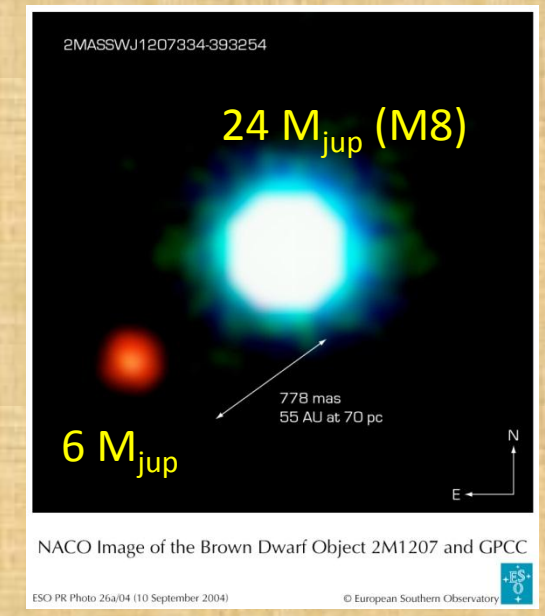


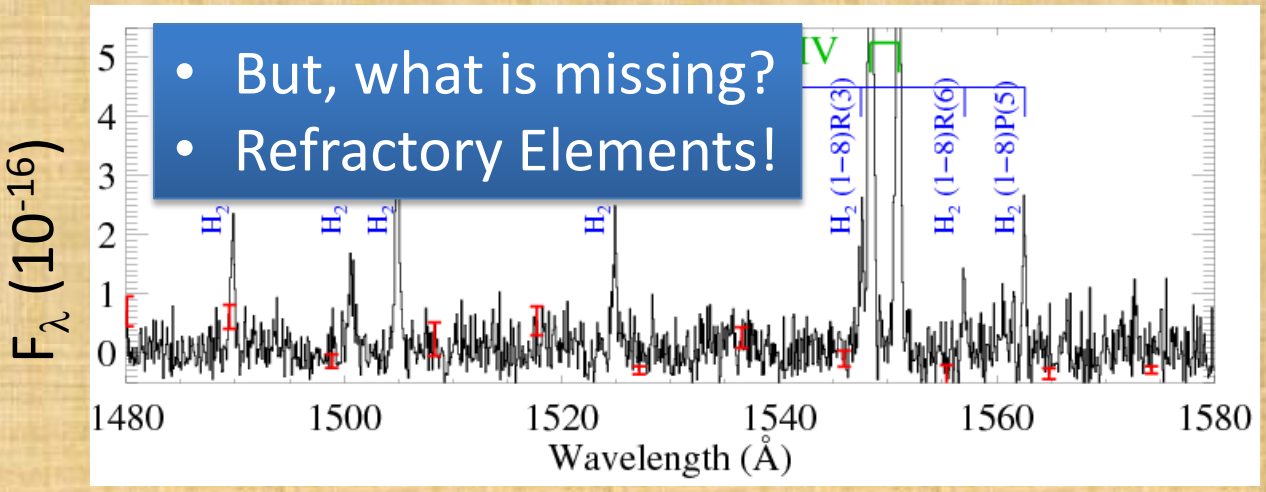


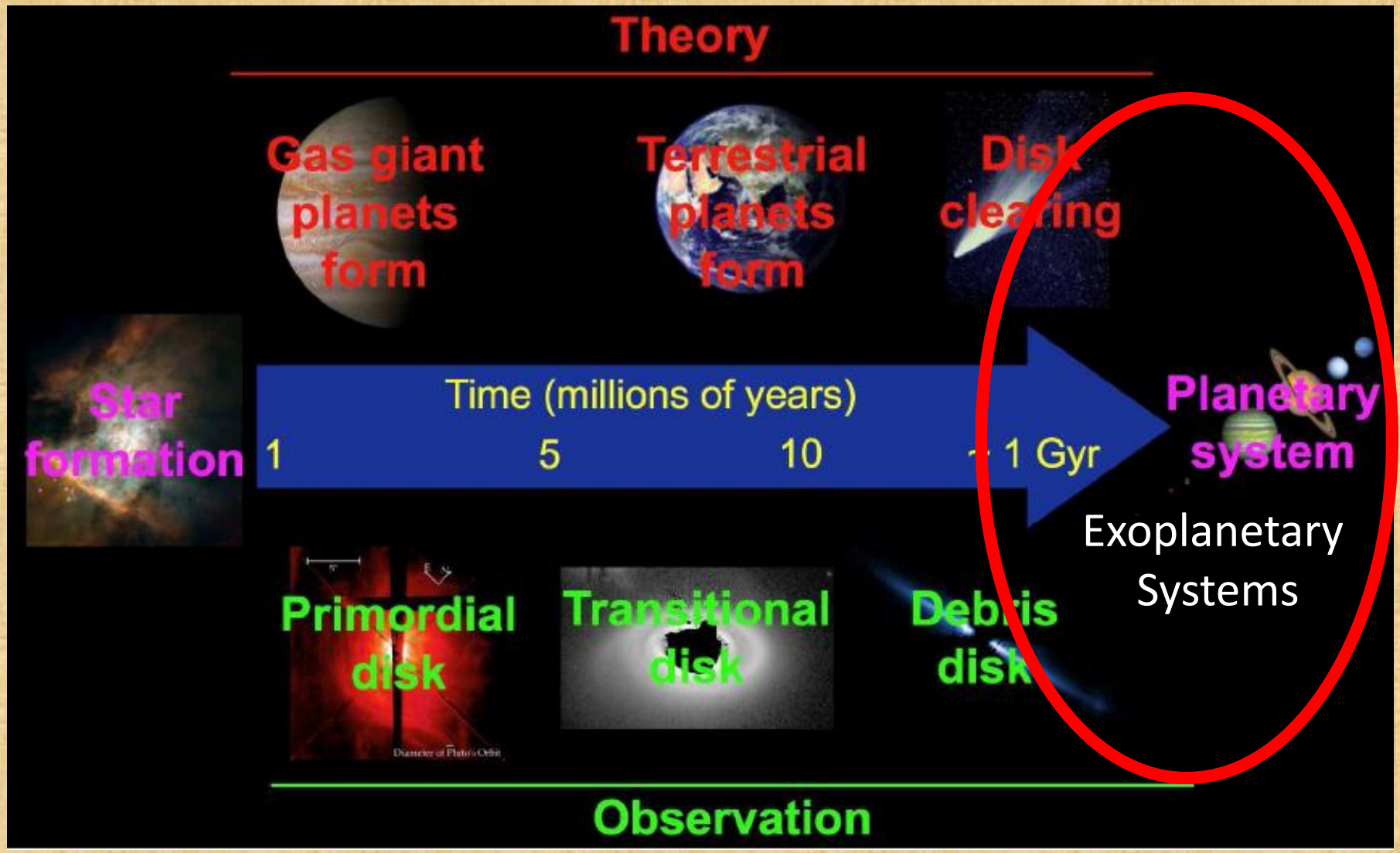
France et al. (2010b)

Building Planets:

Solar-system analogs to Brown Dwarf systems



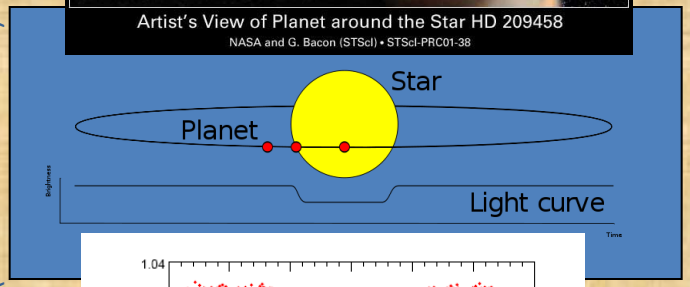




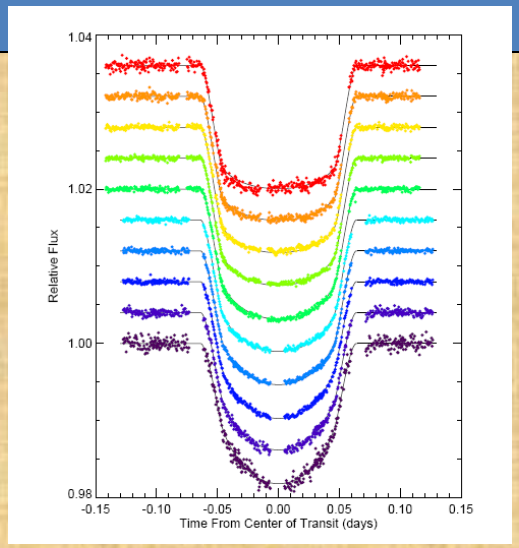
A. Roberge et al. 2009 – Astro2010 White Paper

Exoplanet Atmospheres: Gas Giants

Artist's View of Planet around the Star HD 209458
NASA and G. Bacon (STScI) • STScI-PRC01-38



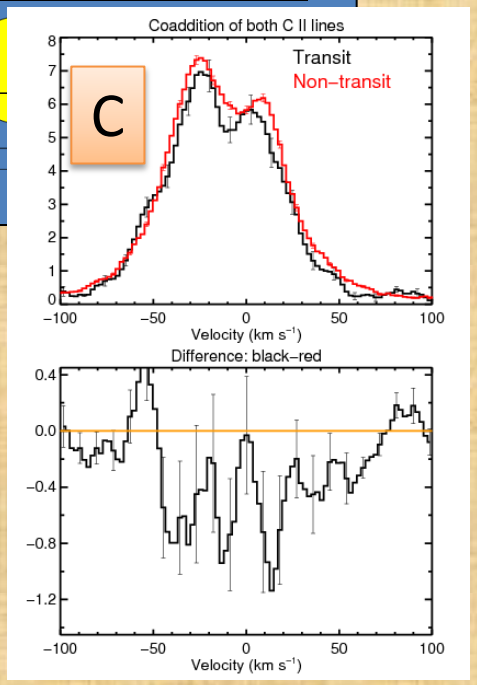
- Transit observations necessary for the characterization of exoplanet atmospheres

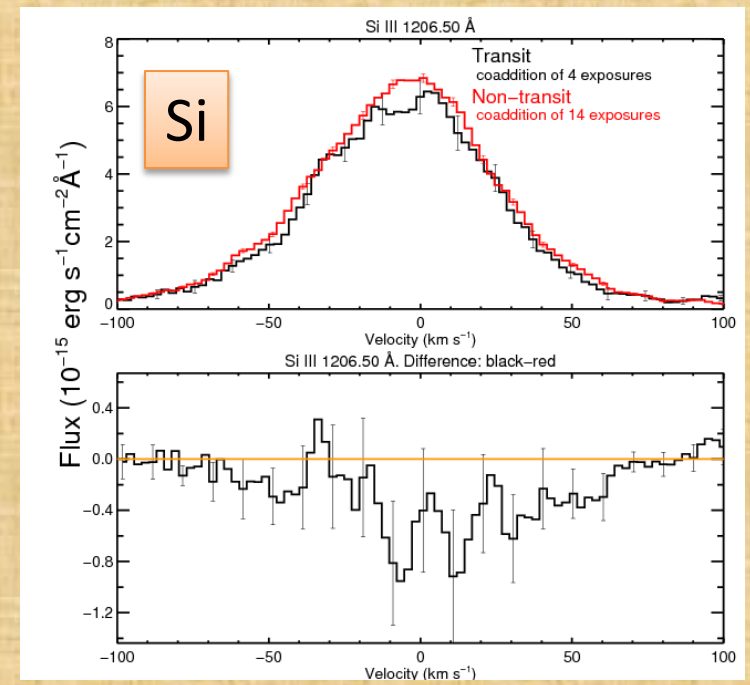


STIS transit of HD209458b (Knutson et al. 2007)

Exoplanet Atmospheres: Gas Giants

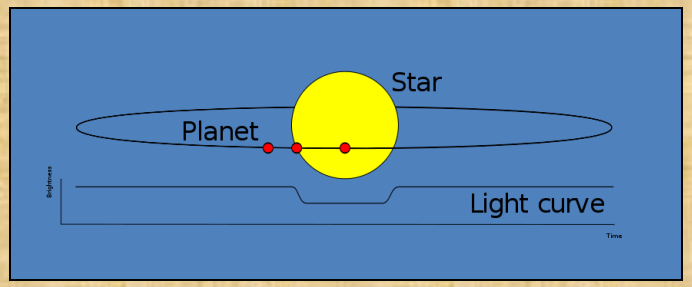
- Transit observations necessary for the characterization of exoplanet atmospheres
- Resonance lines in UV best tracers of atomic gas and mass loss from "hot Jupiters"

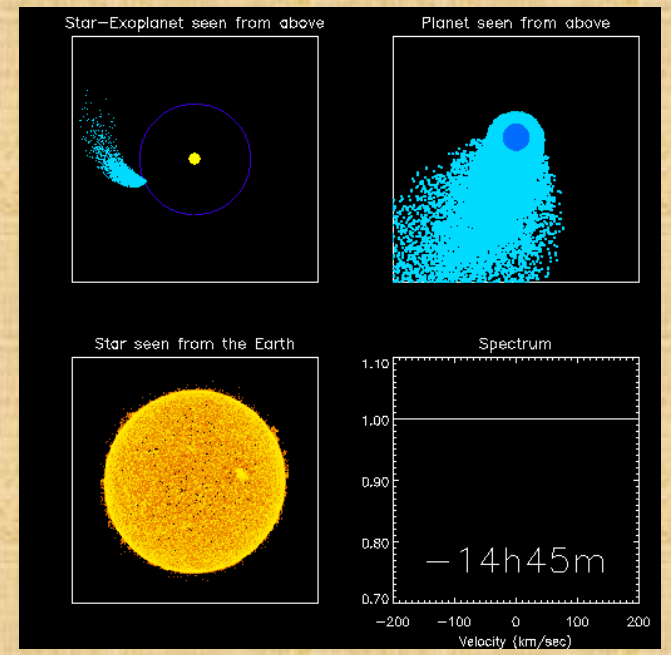


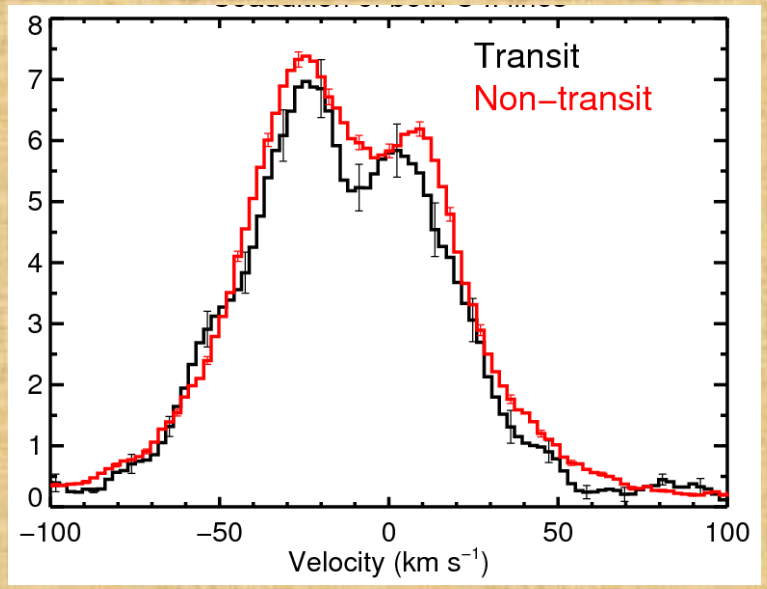


Linsky et al. 2010

Exoplanet Atmospheres: A Comet Tale







- Characterization of H, C, O, Si, Fe
- Do “hot Jupiters” evaporate?

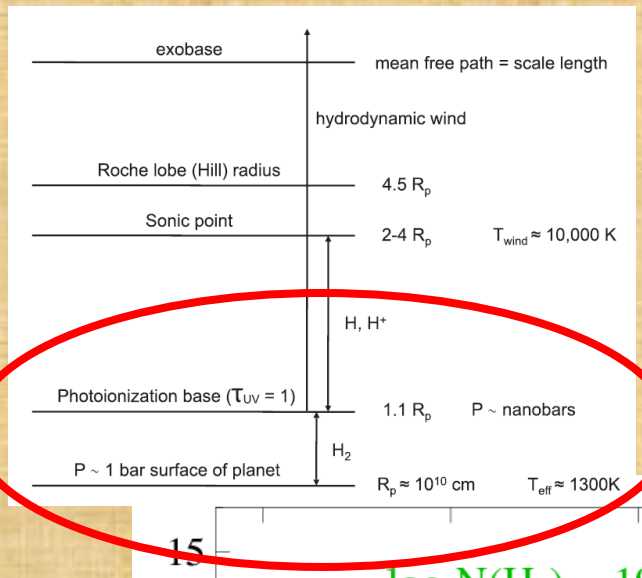
- Migration ↔ Gas Disks

Linsky et al. 2010

Jean-Michel Desert & Alain Lecavelier des Etangs, IAP

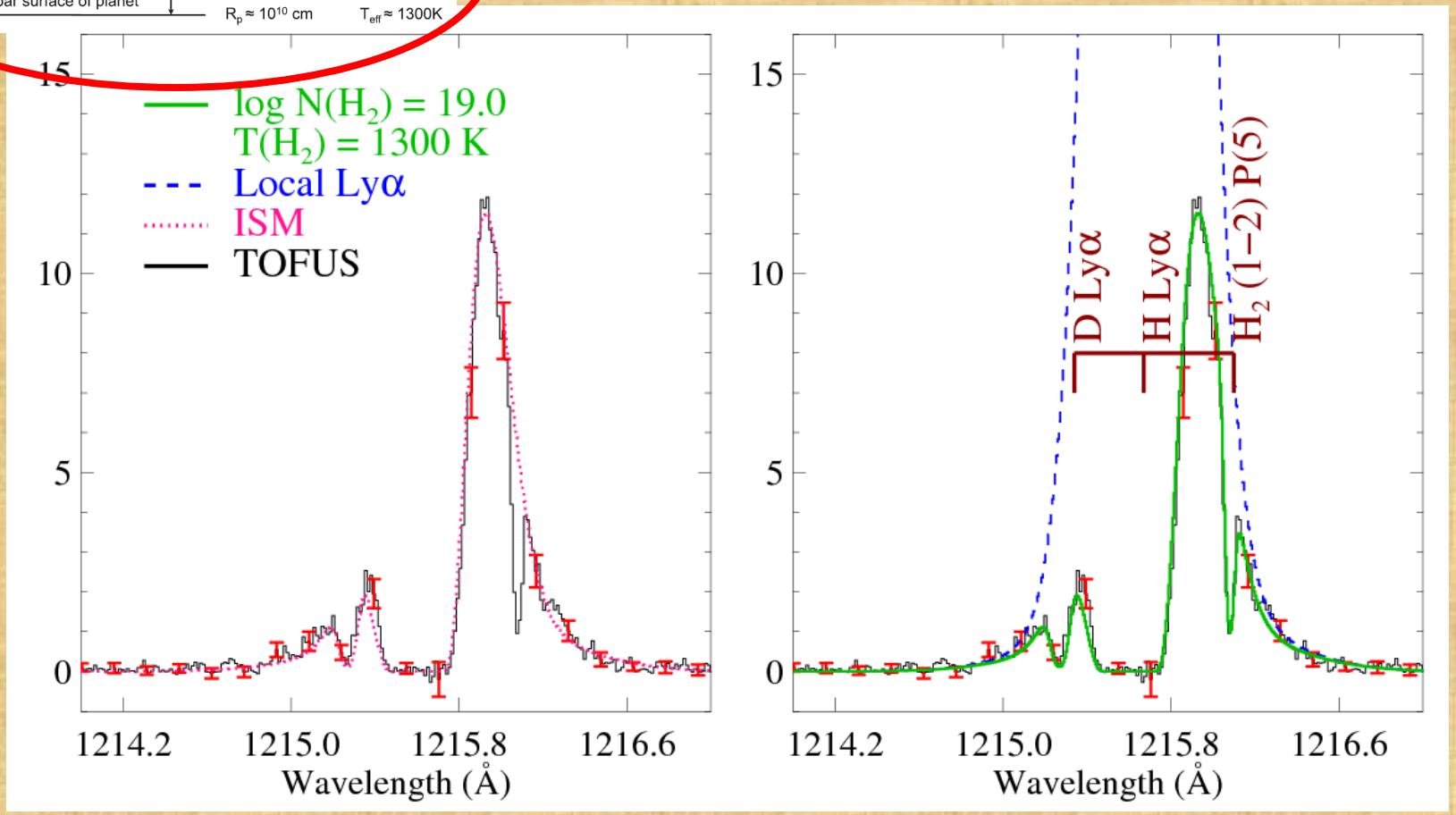
UV Spectroscopy on Late Night with Jimmy Fallon

Linsky et al. 2010



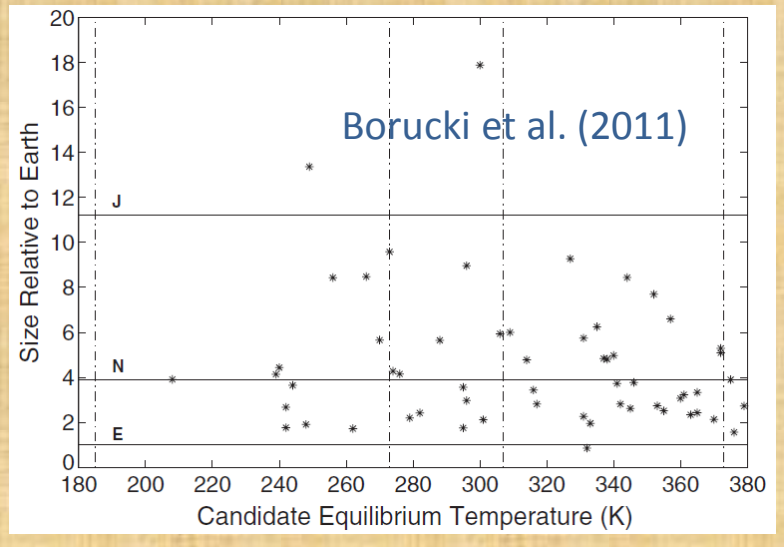
Atmospheres: Gas Giants

- With enough sensitivity and spectral resolution, we could perform transmission spectroscopy of the planetary "surface"



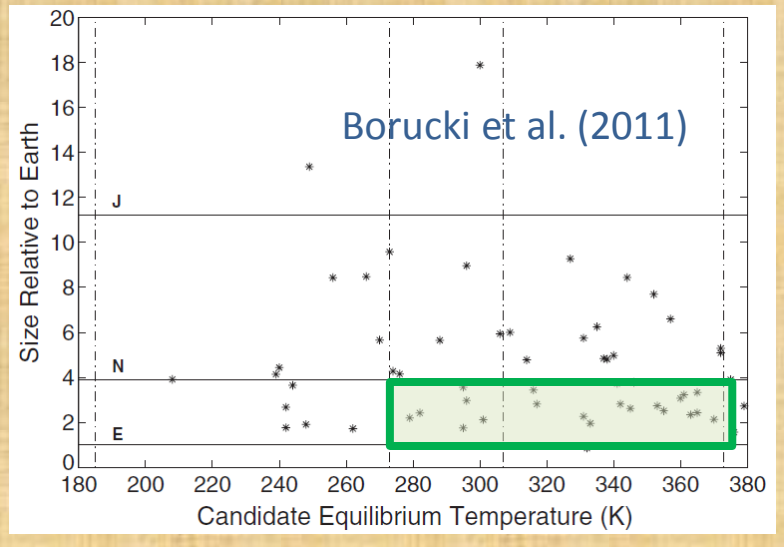
Exoplanet Atmospheres: Exo-Earths

- Many habitable planet candidates will exist by mid-decade



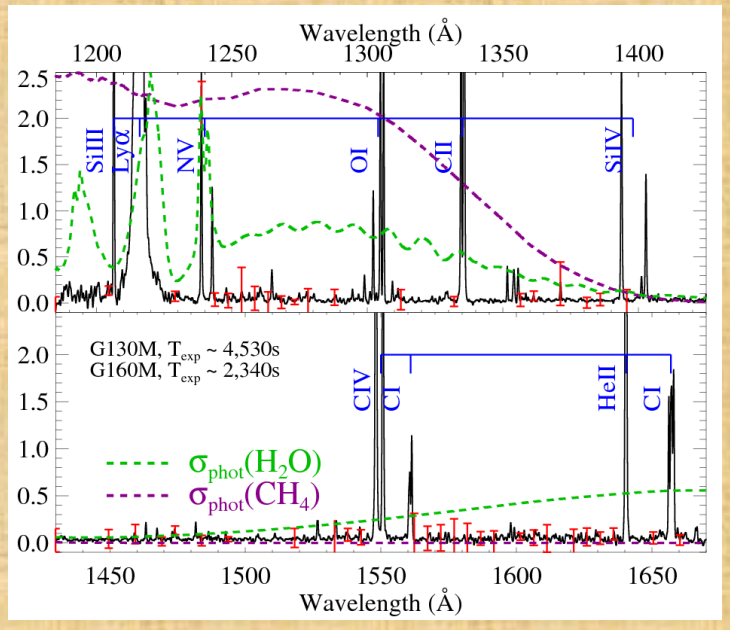
Exoplanet Atmospheres: Exo-Earths

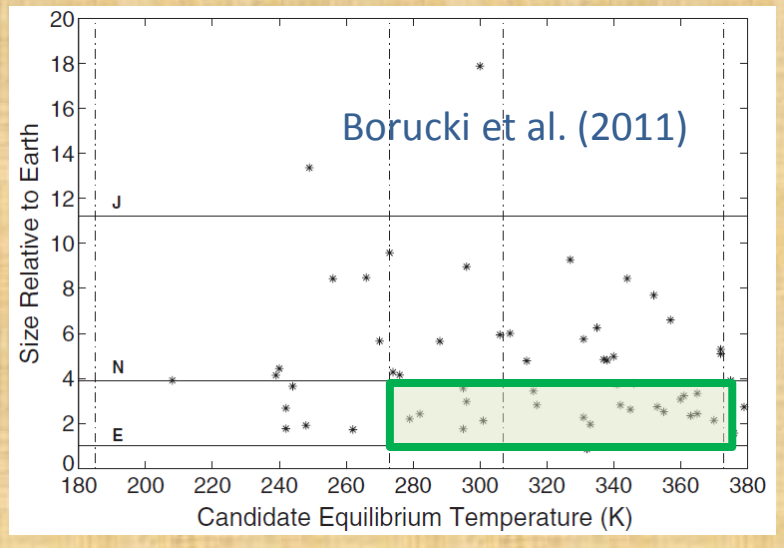
- Many habitable planet candidates will exist by mid-decade



Exoplanet Atmospheres: Exo-Earths

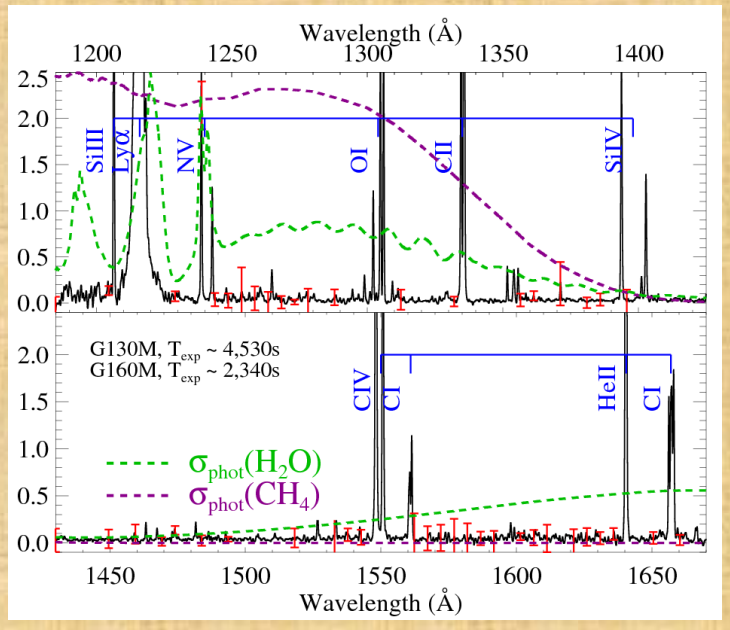
- Many habitable planet candidates will exist by mid-decade
- The UV radiation fields of their host stars control the thermal and photochemical structure of their atmospheres

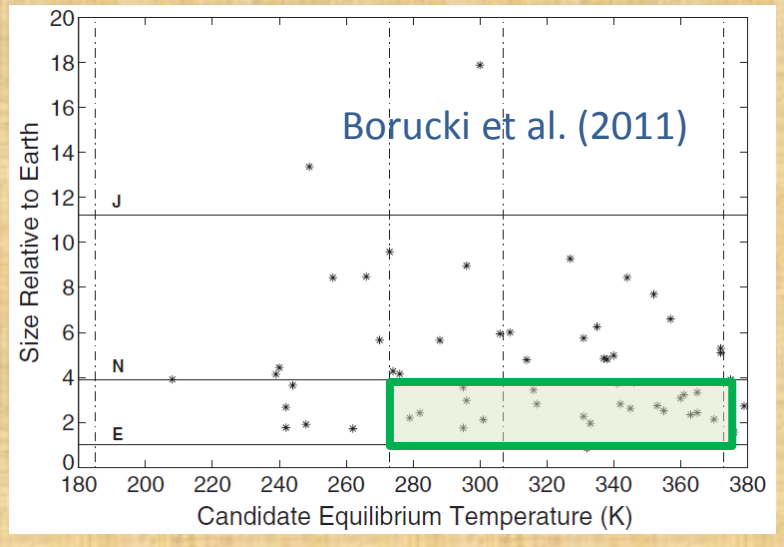




Exoplanet Atmospheres: Exo-Earths

- Many habitable planet candidates will exist by mid-decade
- The UV radiation fields of their host stars control the thermal and photochemical structure of their atmospheres
- But we know relatively little about chromospheric/coronal structure of average low-mass (M and late K) stars





From Protoplanetary Disks to Exoplanetary Atmospheres

- Factor of ~10 sensitivity

w/ Flux Dynamic Range

w/ Lower Background Equiv Flux

- $R \geq 50{,}000$, $1000 \leq \lambda \leq 1750$Å
- Wavelength solutions stable to $< \frac{1}{2}$ resolution element
- Photon-counting detector

From Protoplanetary Disks to Exoplanetary Atmospheres

- Protoplanetary gas disks
- Formation of planetismals
- Transit spectroscopy of Jovian atmospheres
- Incident UV fields for exo-Earths

Kevin France

University of Colorado