From Protoplanetary Disks to Exoplanetary Atmospheres

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FROM PROTOPLANETARY DISKS TO EXOPLANET ATMOSPHERES:

TELLING THE STORY OF EXOPLANET EVOLUTION WITH UV SPECTROSCOPY

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Classical T Tauri Stars
Molecules in Protoplanetary Disks: Ultraviolet Emission from the Inner Disk

- $\text{H}_2$ 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

\(\text{H}_2\)
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

- $\text{H}_2$ makes up 99% of the gas mass in protoplanetary disks
- Very hard from the ground, may only be done with JWST
- CO, 2$^{nd}$ 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?
Transitional/Debris Disks
Building Planets:
Solar-system analogs to Brown Dwarf systems

24 M_{Jup} (M8)

France et al. (2010b)
Building Planets: Solar-system analogs to Brown Dwarf systems

- But, what is missing?

24 M\textsubscript{jup} (M8)
Building Planets:
Solar-system analogs to Brown Dwarf systems

• But, what is missing?
• Refractory Elements!

France et al. (2010b)

24 M\textsubscript{jup} (M8)

NACO Image of the Brown Dwarf Object 2M1207 and GPCC

\begin{align*}
F_{\lambda} (10^{-16}) & \\
\text{Wavelength (Å)} & \\
1480 & 1500 & 1520 & 1540 & 1560 & 1580
\end{align*}

Silicon

Magnesium

\begin{align*}
\text{Flux (10^{-16} ergs)} & \\
\text{Wavelength (Å)} & \\
1390 & 1395 & 1400 & 1405 & 1410
\end{align*}

\begin{align*}
\text{Flux (10^{-16} ergs cm^{-2} s^{-1} Å^{-1})} & \\
\text{Wavelength (Å)} & \\
2790 & 2795 & 2800 & 2805 & 2810
\end{align*}
Building Planets: Solar-system analogs to Brown Dwarf systems

- But, what is missing?
- Refractory Elements!

Si, Mg-rich Planetismals

H₂ Gas Disk

France et al. (2010b)
Building Planets: Solar-system analogs to Brown Dwarf systems

- But, what is missing?
- Refractory Elements!

Si, Mg-rich Planetismals

H₂ Gas Disk
Exoplanet Atmospheres: Gas Giants

• Transit observations necessary for the characterization of exoplanet atmospheres
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
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

Borucki et al. (2011)
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

Borucki et al. (2011)
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- Factor of $\sim 10$ sensitivity
  - w/ Flux Dynamic Range
  - w/ Lower Background Equiv Flux
- $R \geq 50,000$, $1000 \leq \lambda \leq 1750\text{Å}$
- 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

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