**Clever name suggestions appreciated!*

Optical/Near-Infrared multi-Resolution Spectrograph*

Courtney Dressing
Caltech
on behalf of the ONIRS Instrument Team

November 9, 2016 LUVOIR STDT F2F3 New Haven, CT

O/NIRS Science Team

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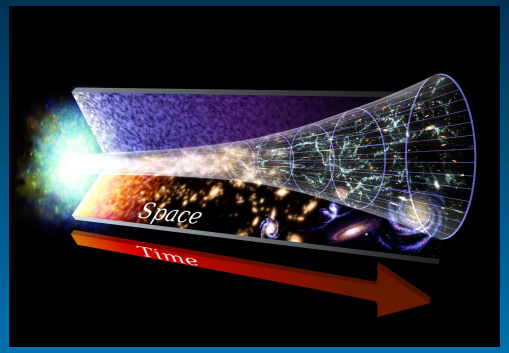
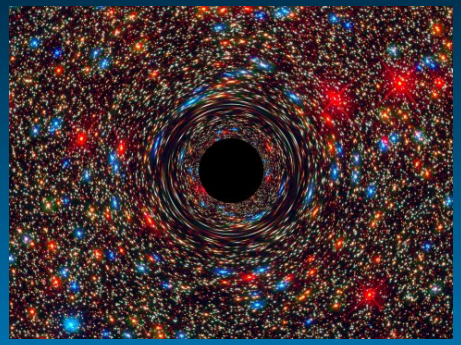
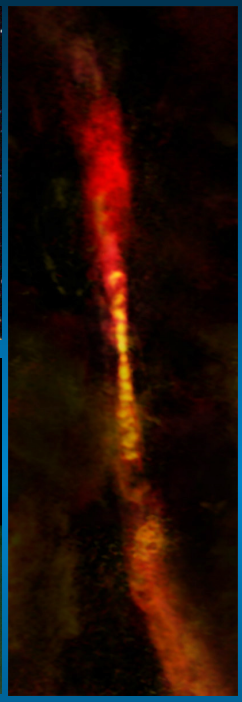
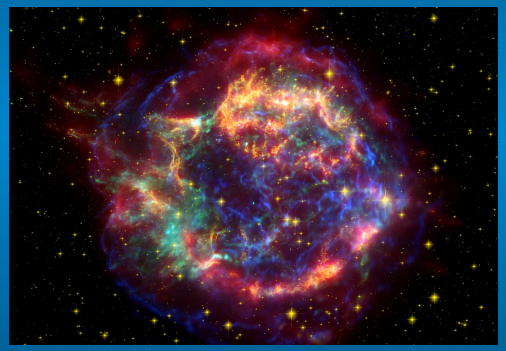
YOU? (especially Cosmic Origins + Solar System people)

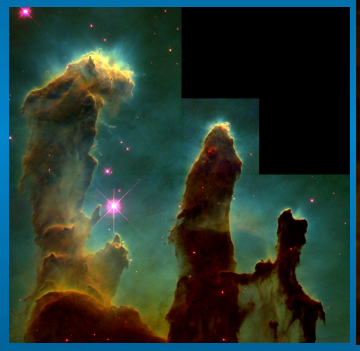
O/NIRS Cosmic Origins Science

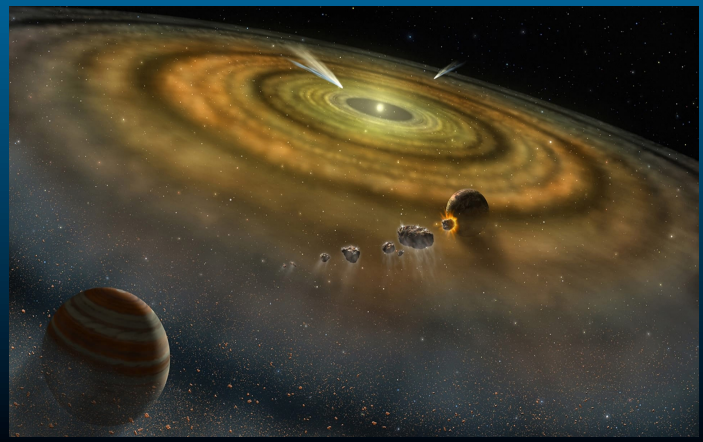




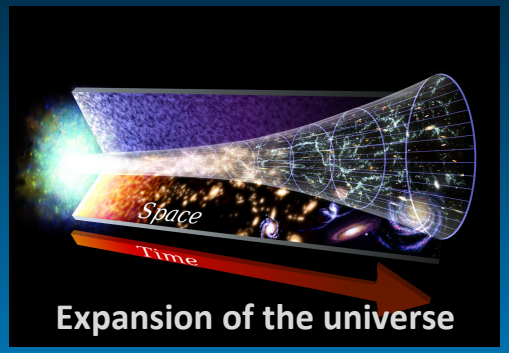








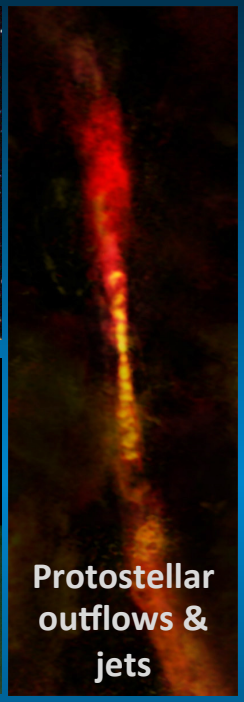
O/NIRS Cosmic Origins Science



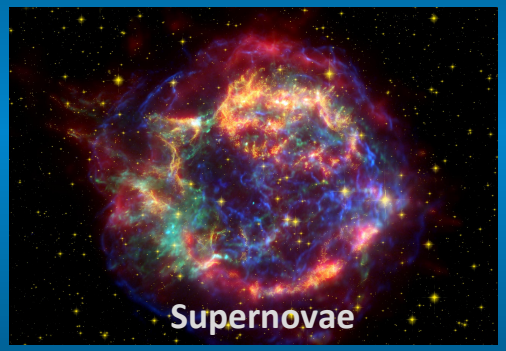
Expansion of the universe

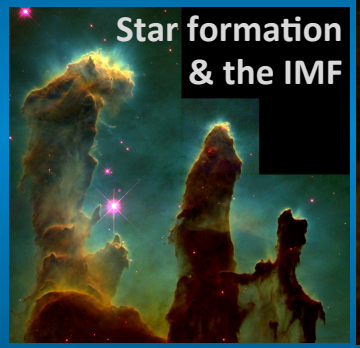

Dynamical Masses of Black Holes

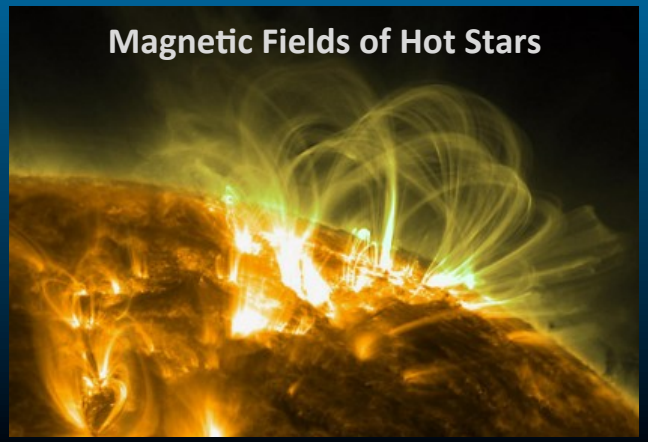

Chemical evolution of high-redshift galaxies


Protostellar outflows & jets


First Quasars & Circumgalactic Medium


Supernovae

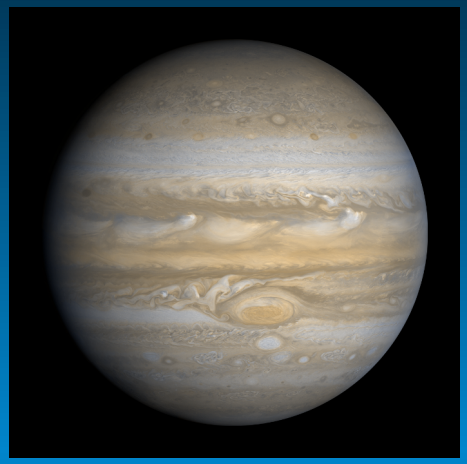

Star formation & the IMF

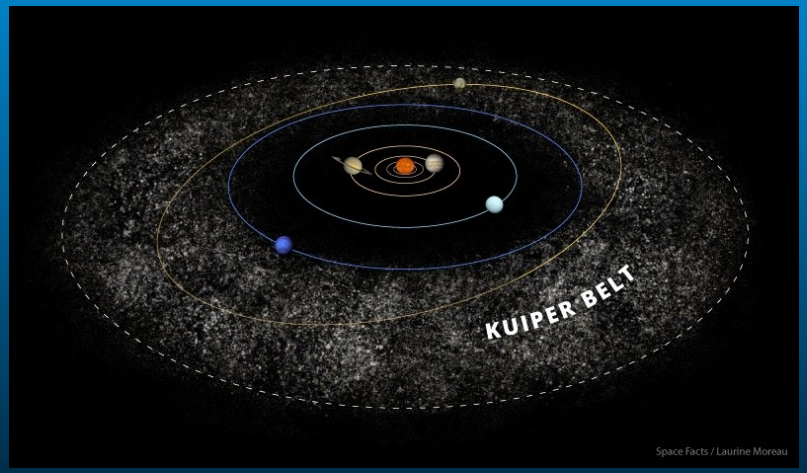

Magnetic Fields of Hot Stars

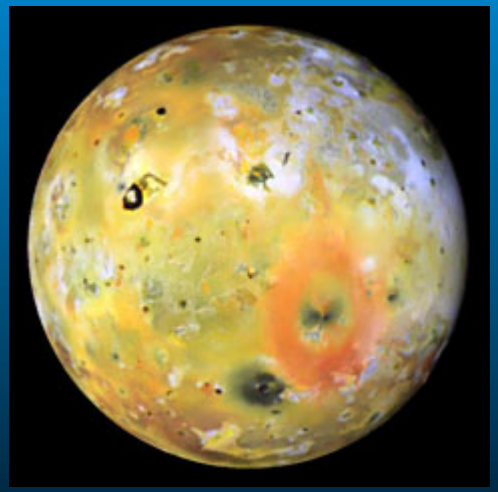

White Dwarfs


Protoplanetary Disks

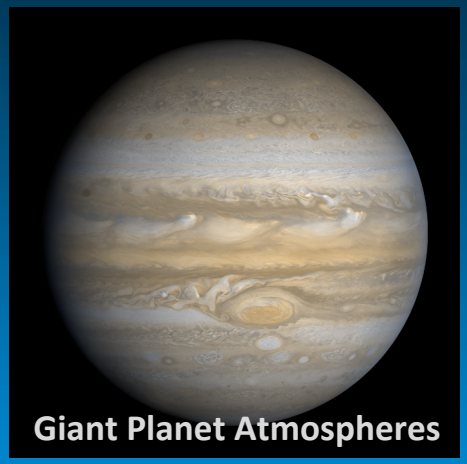
O/NIRS Solar System Science

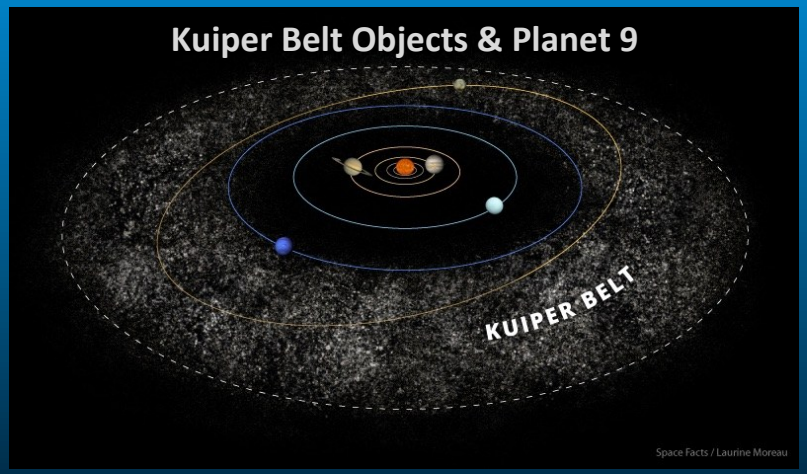


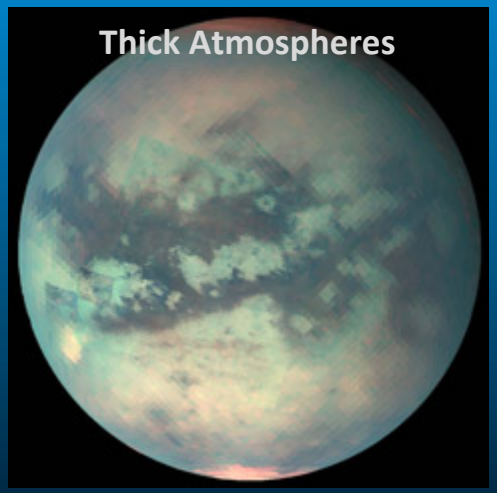


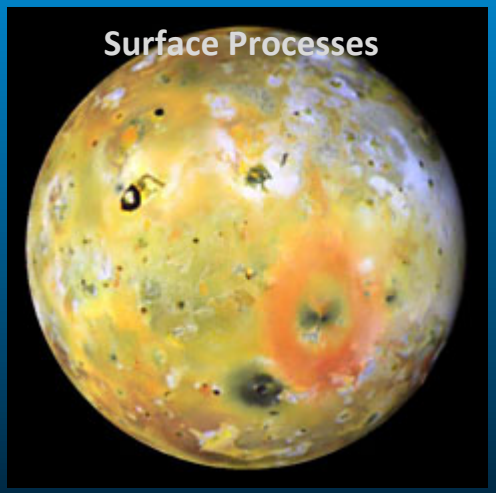


O/NIRS Solar System Science

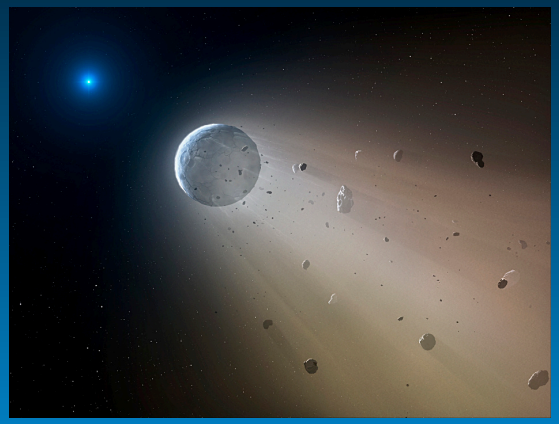


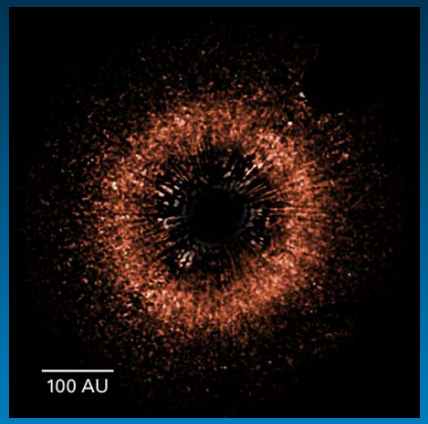


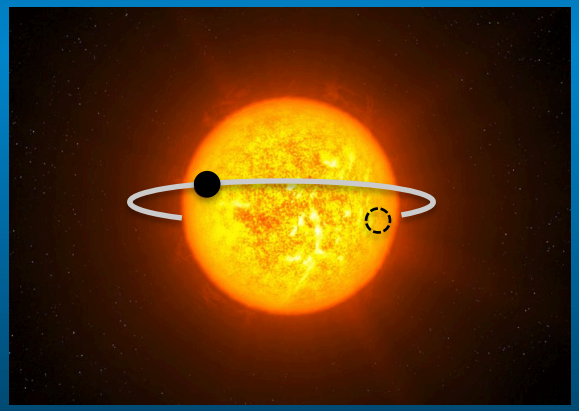


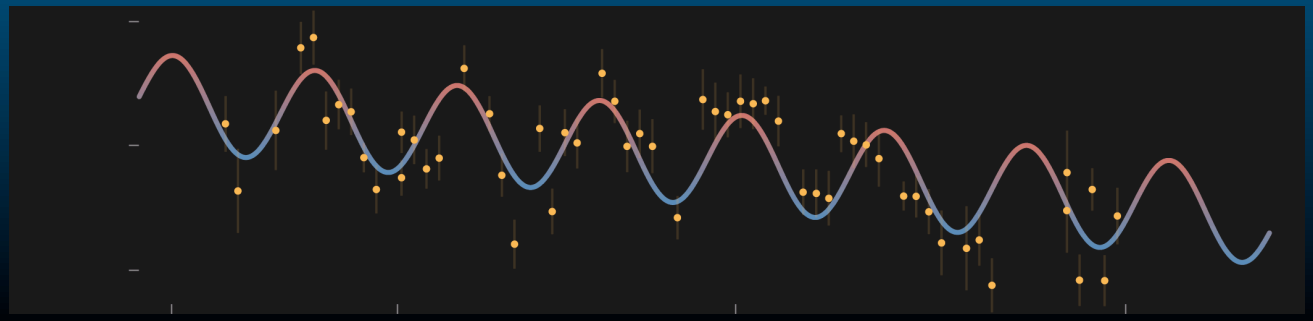


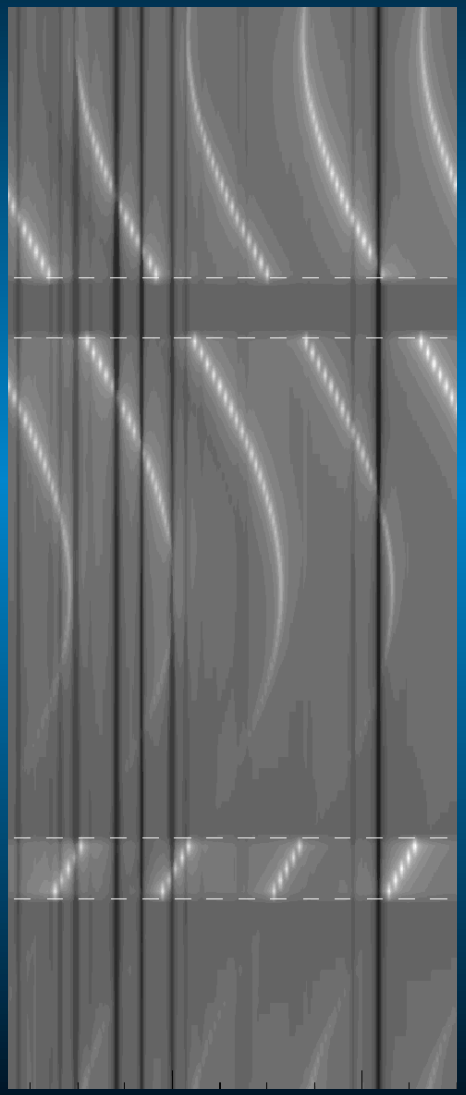
O/NIRS Exoplanet Science











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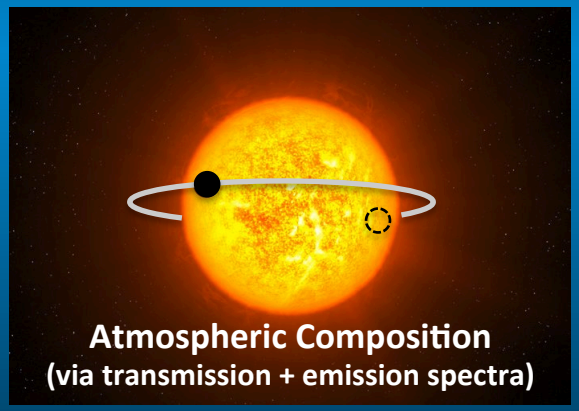
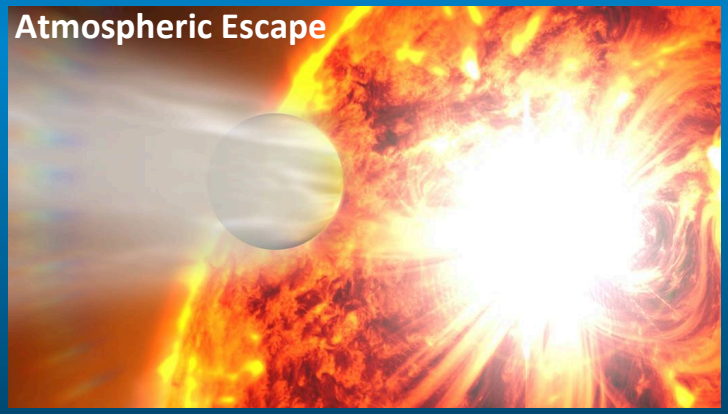
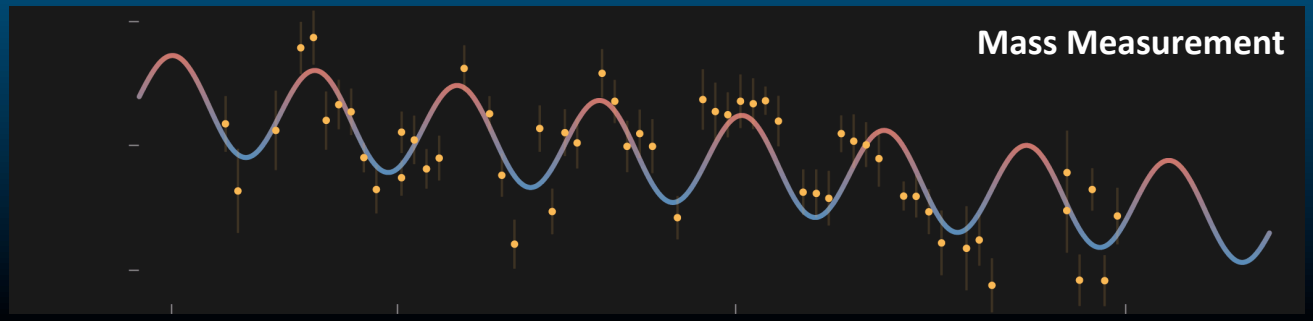
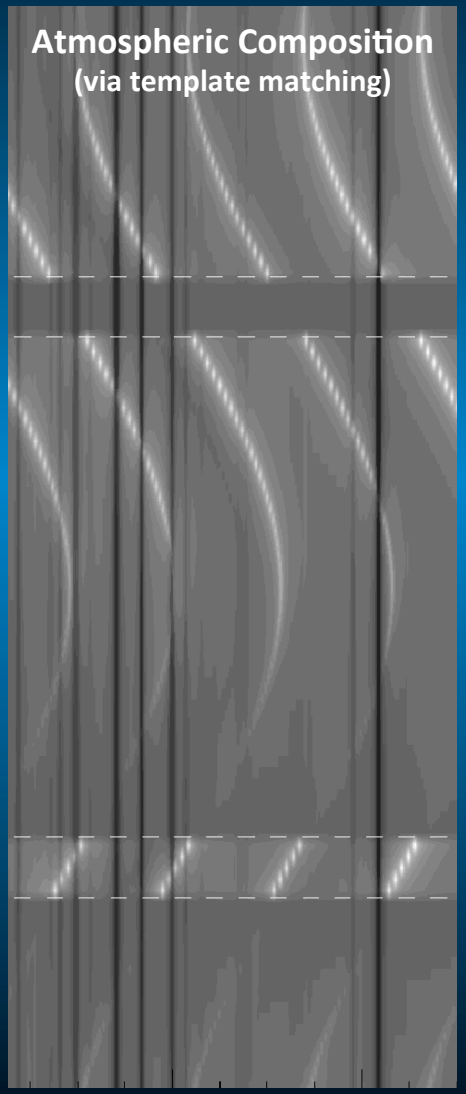




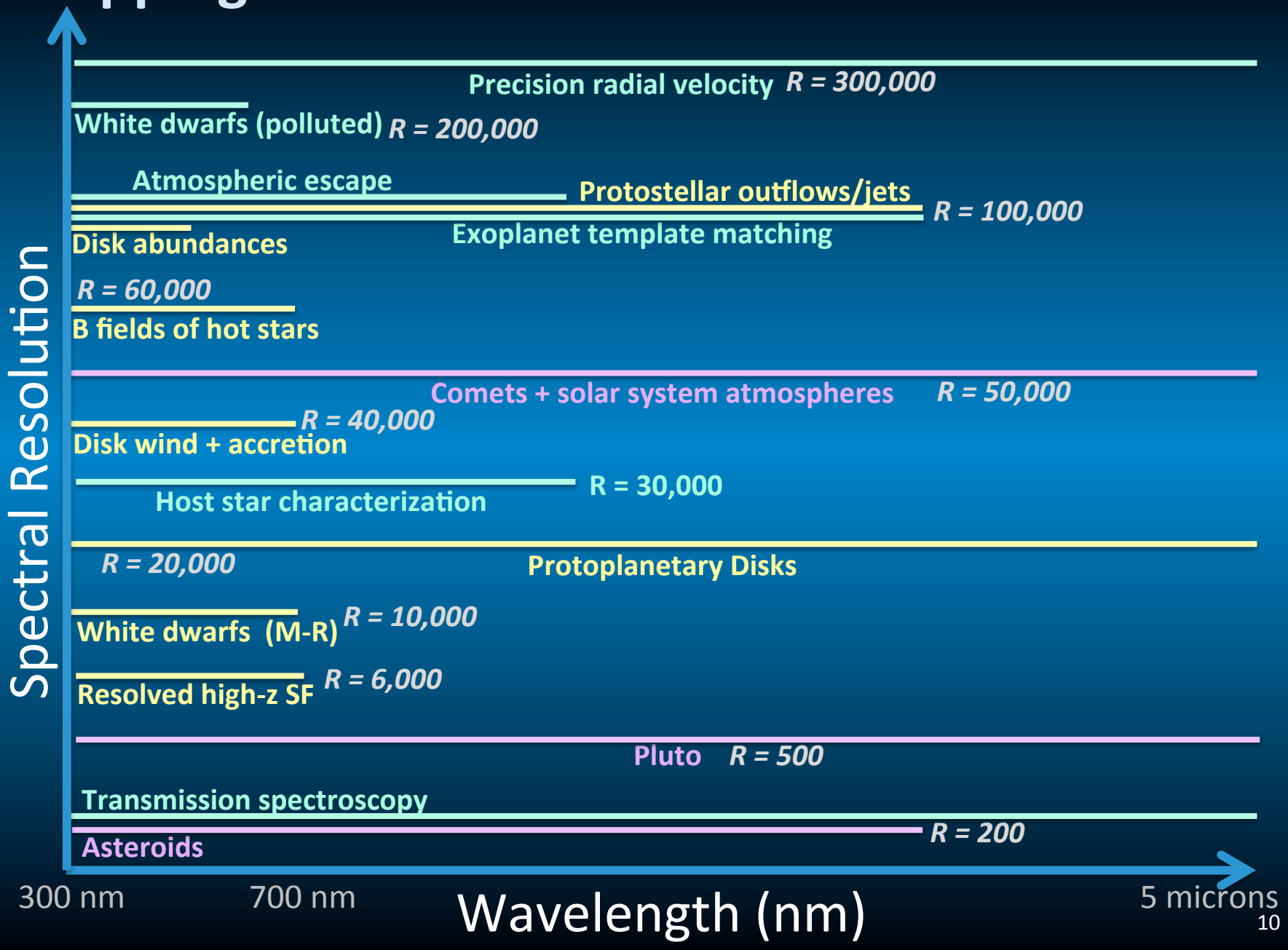




Desired Spectral Resolution Range

- **Low:**
  - Exoplanet transmission spectra (R = 200)
  - Pluto surface characterization (R = 500)
- **Medium:**
  - White dwarf mass/radius relation (R = 10,000)
  - Protoplanetary & debris disks (R = 20,000 – 30,000)
  - Host star characterization (R = 30,000)
- **High:**
  - Expansion of the universe (R = 100,000)
  - Template matching (R = 100,000)
  - Radial velocity mass measurements (R = 300,000)

Mapping Science Cases to Instrument Parameters



Desired Fields of View for Spatially Resolved Observations

- **Small:**
  - 20” (gas in debris disks)
  - 30” (protostellar outflows/jets
- **Medium**
  - 2’ x 2’ (disk wind & mass accretion)
  - 1’ - 2’ (SF & IMF)
- **Large**
  - 2’ – 5’ (comets; but IFU over smaller area = OK)
  - 10’ (high-redshift galaxies)

Desired Spatial Resolution

- **High**
  - 0.008” (solar system atmospheres)
  - 0.01” (disk wind + mass accretion; protostellar outflows/jets)
- **Low – Medium**
  - 0.1” (high-redshift galaxies)
  - 0.7” – 7” (protoplanetary disks)

Special Considerations

- **Coupled to coronagraph:**
  - Exoplanet atmospheres via template matching
  - Black hole mass measurements (contrast required?)
- **Coupled to polarimeter:**
  - Magnetic fields of hot stars
- **Exquisite wavelength calibration + stability:**
  - High-precision radial velocity
  - Expansion of the universe

Special Considerations

- **Coupled to coronagraph:** ← Testing in "small" architecture
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Testing in "small" architecture

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Testing in "small" architecture

Peter Plavchan's Probe Study

Initial Instrument Parameters

- **Wavelength range:**
  - Blue limit: 300 nm (at least as blue as LUMOS cutoff)
  - Red limit: 5 microns (as red as possible)
  - Simultaneous coverage of broad bandpass
- **Spectral Resolution:**
  - Low: R = 100 – 500
  - Medium: R = 5,000 – 50,000
  - High: R = 100,000 – 300,000
- **Spatial Resolution:** 0.01”
- **Field of view:** 2’ x 2’ ???
- IFU + fixed slits

Questions for the LUVOIR STDT

- Are there other science cases requiring lower or higher resolution?
- How wide of a field of view do you need?
- What would you like to do with O/NIRS that you cannot do with other instruments?

O/NIRS Current Accomplishments

- Established science case for template matching (Thanks to Matteo Brogi, Jayne Birkby, & Ji Wang!)
- Merged multiple science cases into a coherent "wish list" of instrument parameters
- Consulted community precision radial velocity experts for perspectives on instrument design

O/NIRS Ongoing Work

- **Recruiting** more **COR & Solar System** members
- **Reviewing designs** for other near-infrared spectrographs & assessing lessons learned
- **Running simulations** to determine impact of design choices on instrument performance
  - Geronimo Villanueva's online instrument simulator
  - Chas Beichman's precision radial velocity code
- **Brainstorming** better instrument **names**

Summary: multi-resolution Optical/Near InfraRed Spectrograph

- Flexible instrument enabling a wide range of LUVOIR science (COR, EXO, & Solar System)
  - **Broad wavelength** coverage: 300 nm – 5 microns
  - **Variable resolution**: R = 100 – 300,000
  - **IFU** and **slit spectroscopy** capabilities
- Technology Needs
  - Large IFU with broad wavelength coverage (fiber bundles?)
  - High-efficiency, low read-noise detectors
  - Space-based laser comb (for high-precision radial velocity)

ADDITIONAL SLIDES

Requirements for Template Matching
(from science case written by Brogi & Birkby)

HDS+HDI requirement table

Observation Requirement	Major Progress	Substantial Progress	Incremental Progress
Wavelengths	0.3-2.4 μm	0.3-2.0 μm	0.7-1.5 μm
Spatial resolution	lambda/D	2lambda/D	3lambda/D
Spectral resolution	R=100,000+	R=50,000	R=50,000
Field-of-view	Enough for HZ of alpha Cen and Jupiter analog at 10 pc	Enough for HZ of alpha Cen	Enough for HZ of closest early K-dwarfs / late G-dwarfs
Contrast	1e-7 HCI 1e-6 HDS	1e-6 HCI 1e-5 HDS	1e-5 HCI 1e-5 HDS
Telescope aperture	16m	12m	8m
HCI-HDS coupling	Full IFU	Configurable IFU	Fiber on planet
Exposure time	N/A	N/A	N/A

Science Goals: Cosmic Origins

- Expansion of the universe
- Black Holes (dynamical masses)
- High-redshift galaxies (chemical evolution)
- First Quasars (inflows/outflows between galaxies & circumgalactic medium)
- Supernovae (progenitors, formation sites, very early/late observations)
- Star formation & the initial mass function
- Magnetic fields of hot stars
- White dwarfs (mass/radius relation)
- Protoplanetary disks (abundances, winds, & mass accretion)
- Protostellar outflows/jets

Science Goals: Solar System

- Geology & Surface Processes
- Comets
- Thick Solar System Atmospheres
- Asteroids

Science Goals: Exoplanets

- Host star characterization
- Polluted white dwarfs
- Debris disks (map gas & determine composition)
- Exoplanet atmospheric composition (via transmission + emission spectra)
- Exoplanet atmospheric escape (via transmission spectra)
- Exoplanet atmospheric composition (via template matching)
- Exoplanet mass measurements (via precision radial velocity)