Jet Propulsion Laboratory
California Institute of Technology

Coronagraph Science Studies by the WFIRST Preparatory Science Teams

Wesley A. Traub, Jet Propulsion Laboratory, California Institute of Technology

Geoff Bryden, JPL

Christine Chen, STScI

Nikole Lewis, MIT

Dmitry Savransky, Cornell Univ.

Margaret Turnbull, GSI, SETI

Community Astrophysics with WFIRST
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WFIRST Preparatory Science (WPS): Coronagraph Instrument (CGI)

- Several-year studies of CGI-related science by these PIs and their groups:

- Geoff Bryden: RV orbits
- Christine Chen: debris disk images
- Nikole Lewis: model atmospheres
- Dmitry Savransky: science yield via DRMs
- Maggie Turnbull: exoplanet colors

Basic CGI-related questions that need answers

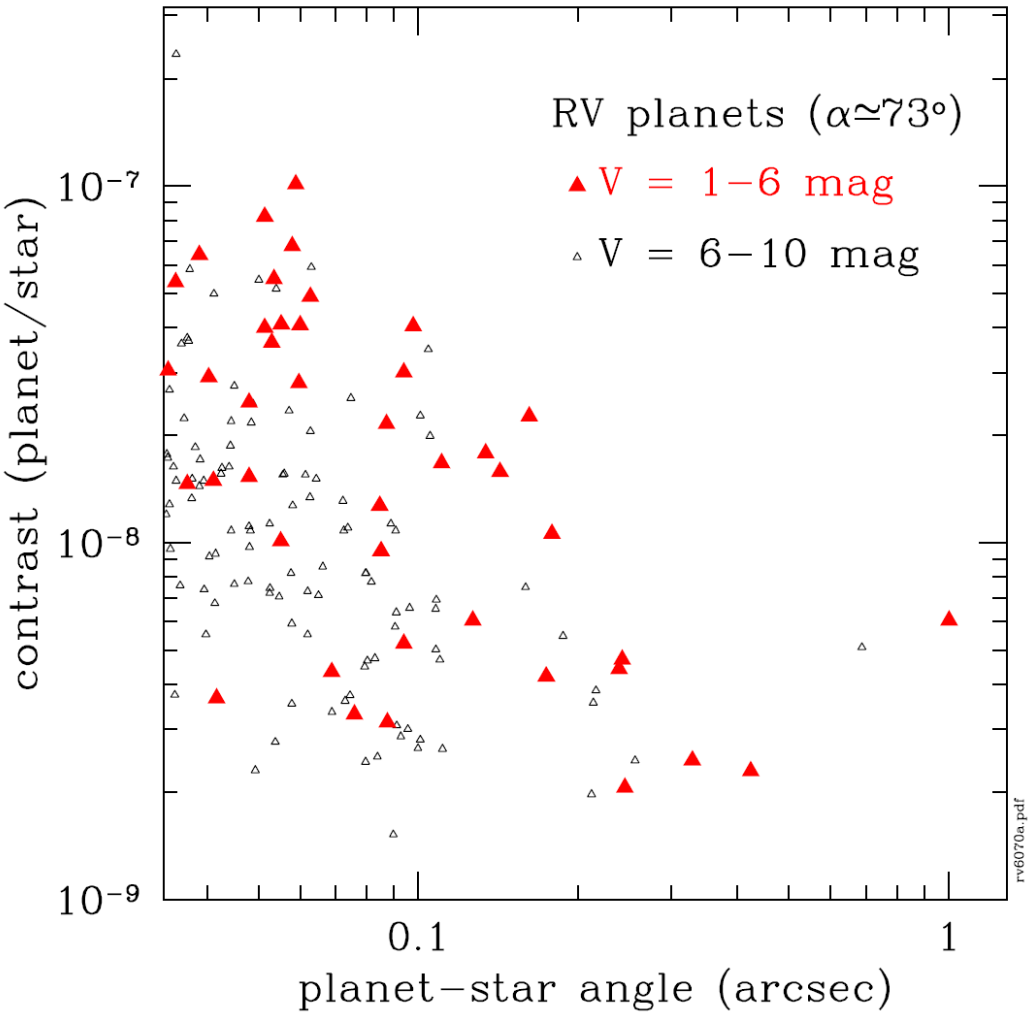
- When & where should we look to find RV planets?
  - *What do the images tell us about orbital parameters?*
- How bright are RV planets in broad spectral bands?
  - *How do we interpret colors in terms of atmospheric properties?*
- What are the expected spectra of RV planets?
  - *How do we extract abundances and cloud properties from noisy spectra?*
- What background confusion is expected?
  - *How can we separate planet light from background objects?*
- What will disk images look like at CGI sensitivity & resolution?
  - *How do we interpret disk properties and the disk-planet relationships from images?*
- What is the expected yield from an optimal use of 1 year of CGI observing time?

  In what order should targets be observed, & for how long?

Known RV planet orbits

Contrast vs angular separation for known RV planets, assuming:

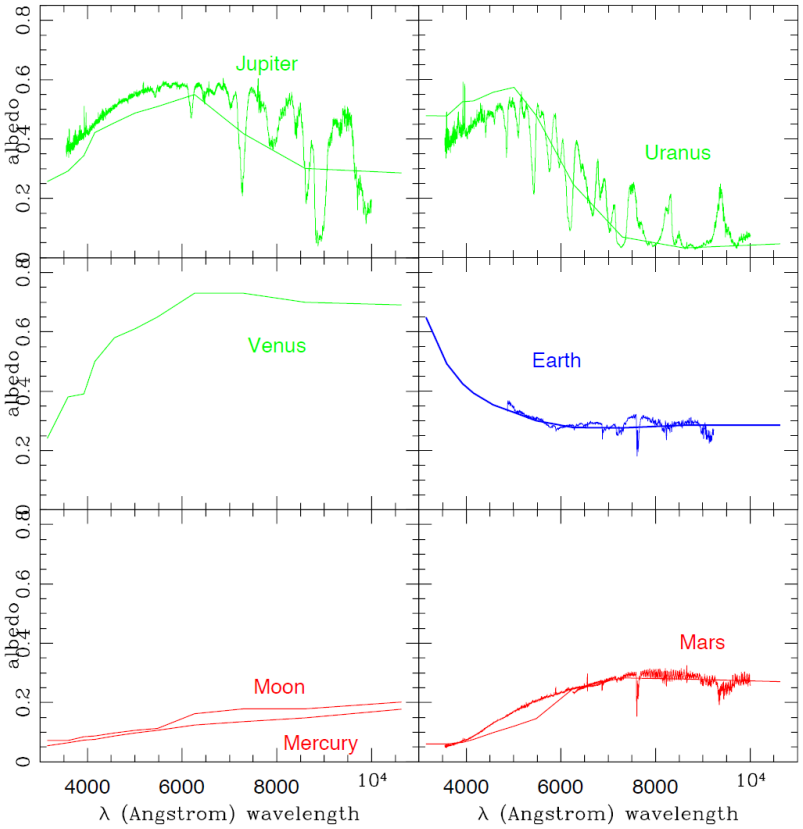
- e = 0
- i = 60 deg
- orbital anomaly = 70 deg
- albedo = 0.50
- Lambert phase fn.



G. Bryden et al. will provide best observing times

Figure: expected contrast of known RV planets, from Traub et al, accepted by JATIS (2016).

Continuum shapes correlate with planet type

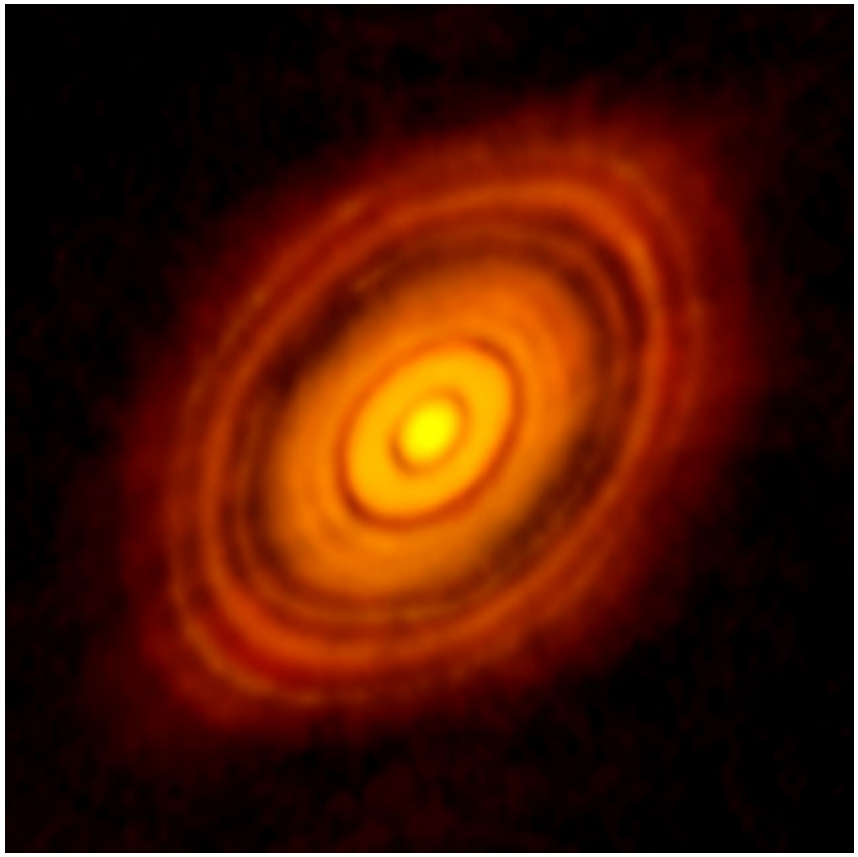


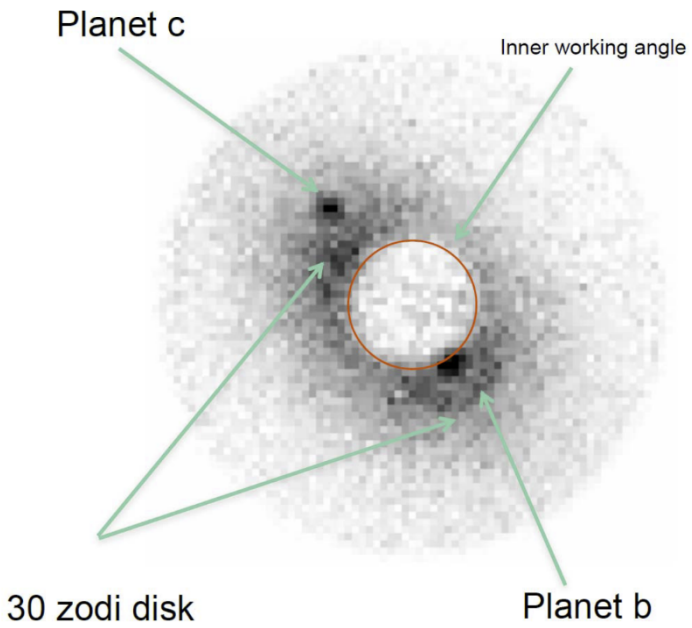
M. Turnbull et al. will provide expected colors and backgrounds

Ref.: Sci. Frontiers in Res. on Extrasolar Planets, Deming & Seager eds, W. Traub, 2003

Ref.: http://imgsrc.hubblesite.org/hu/db/images/hs-2004-07-a-pdf.pdf

Dust disks, relation to planets?



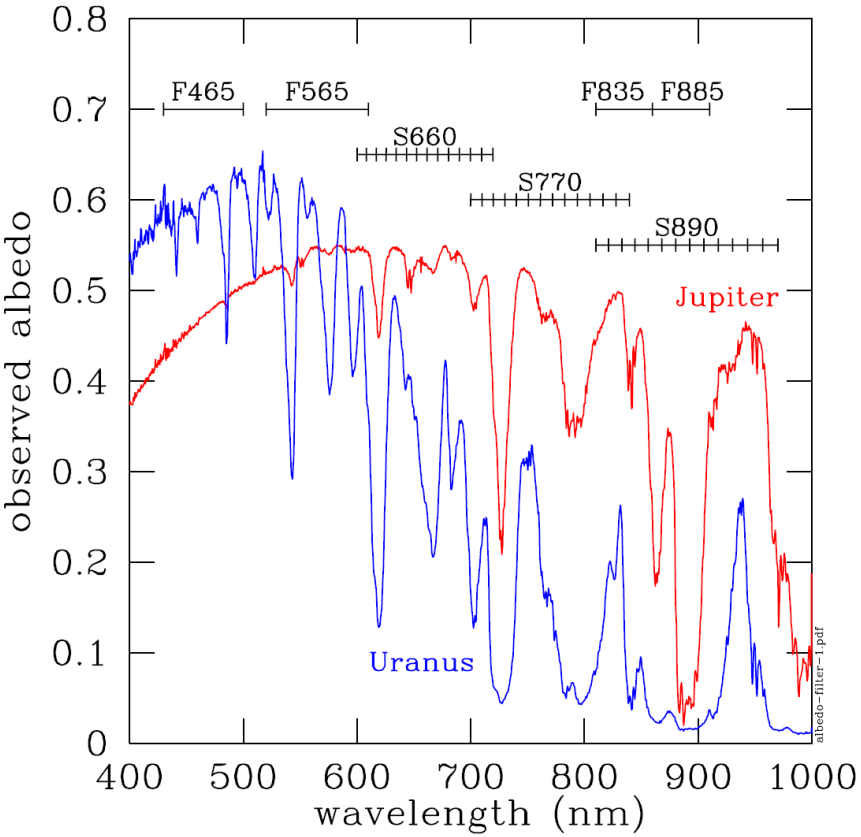


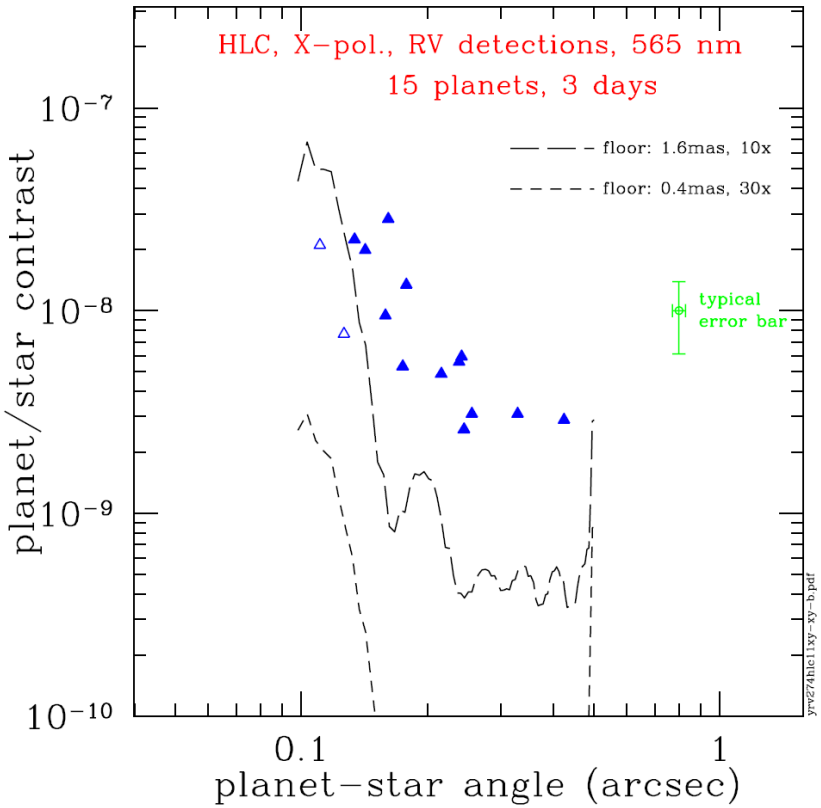
C. Chen et al. will provide expected disk models & interpretations

(left) HL Tau 1.28 mm observation, ALMA (NRAO/ESO/NAOJ); C. Brogan, B. Saxton (NRAO/AUI/NSF)

(right) 47 Uma simulation: WFIRST-AFTA 2015 Report, Fig. 2-35 (T. Greene)

Jupiter/Uranus spectra, & CGI bands





N. Lewis et al. will provide atmospheric models & interpretations

(left) Jupiter & Uranus full-disk visible spectra, by Karkoschka (1998), from Traub et al, accepted by JATIS (2016).

(right) HLC contrast and known RV planet expected contrasts, from Traub et al, JATIS (2016).

WFIRST coronagraph estimated yields

Output channel	Coron. name	Spectral resolution	Polarization	Primary science	Wavelength (nm)	Number of RV planets detectable	Requirement
imager	HLC	R = 10	X & Y pol., seperately	RV exoplanets & disks	blue: 465	18	>12
					green: 565	19	
					red: 835	10	
spectrometer (IFS)	SPC	R = 70	unpolarized	RV exoplanets	near-red: 670	10	>6
					mid-red: 770	8	
					far-red: 890	5	

1. Detections assume a best case of small pointing jitter (0.4 mas) and excellent post-processing speckle reduction factor (30x).

2. We expect that the actual case will be close to the best case, by using (a) feedback to control jitter, (b) advanced processing to reduce speckles, and (c) continued RV observations (WIYN) to discover more RV planets.

3. Most planets can be imaged in much less than 1 day; spectra will often take a few days. The totals are for a month-long campaign for imaging, and another month for spectroscopy.

4. **The baseline coronagraph is expected to exceed its requirements, with margin.**

D. Savransky et al. will provide DRM models & science yields, in collaboration with R. Morgan (JPL) and all of the WPS teams. (See poster by C. Delacroix.)

Table from Traub et al., Spirit of Lyot mtg., Montreal (2015).

Summary

The coronagraph on WFIRST is a community effort, with active inputs from many scientists across the US.

25% of the coronagraph's 1-year allocation on WFIRST is reserved for GO/GI science.

This week's Community Astrophysics meeting is just the start.