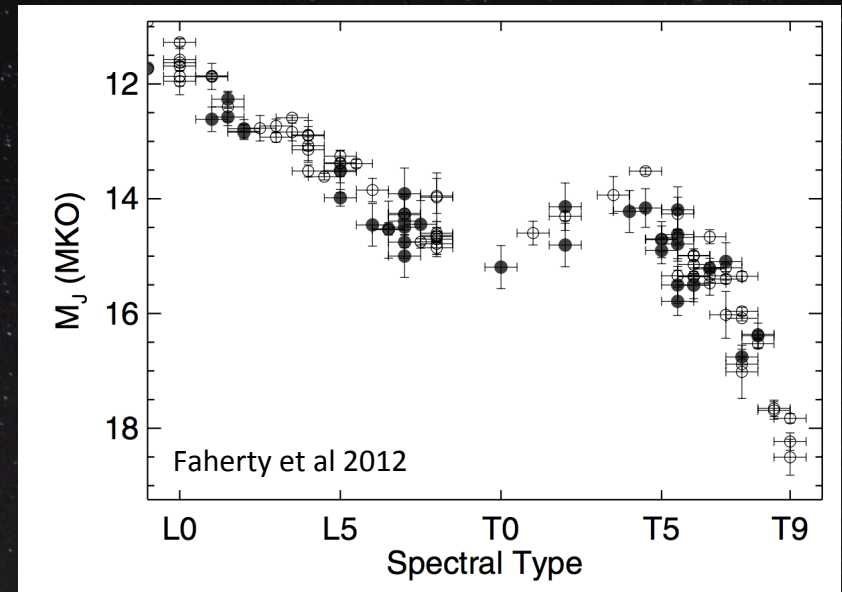
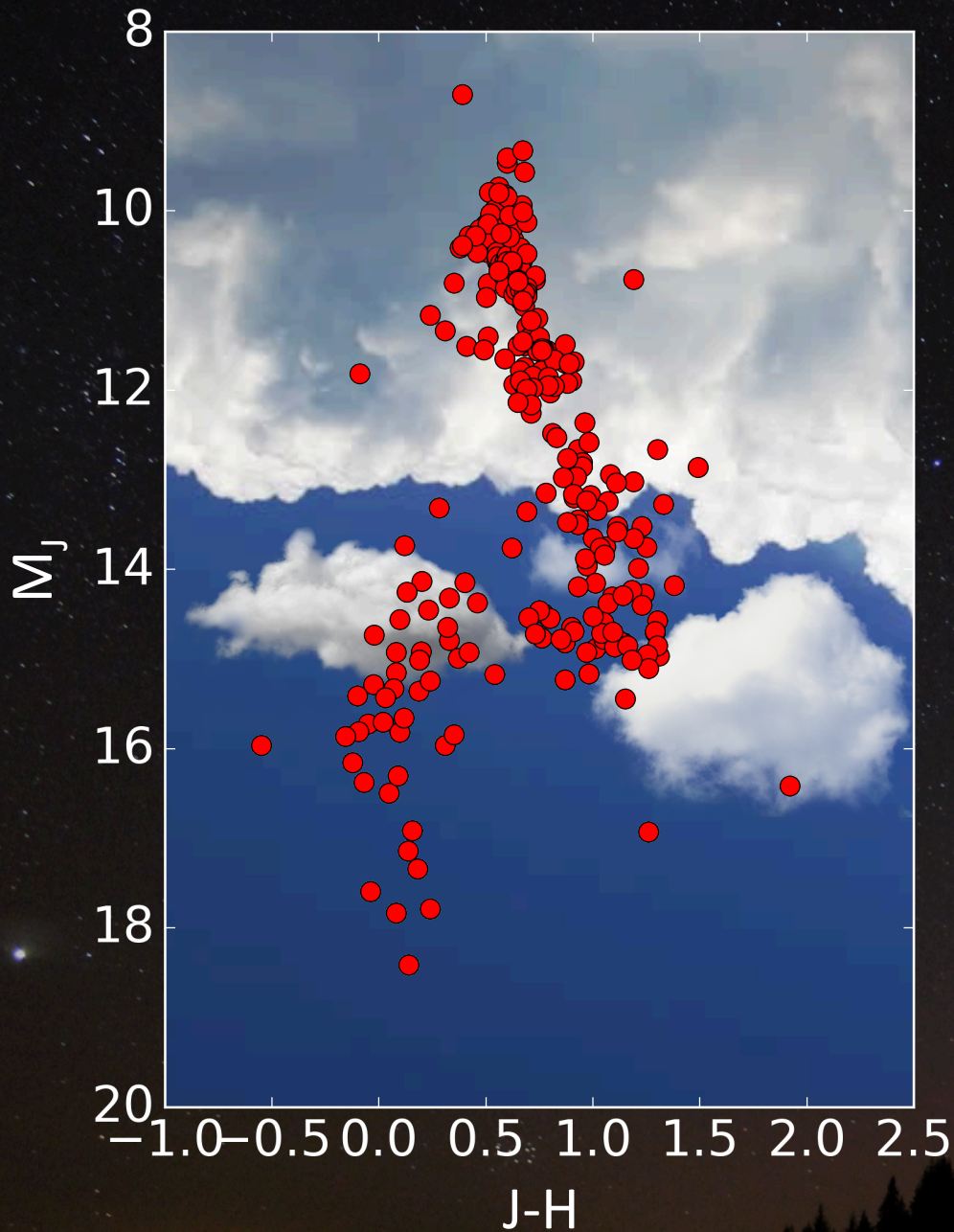


Evidence for cloud clearing at L/T trans.

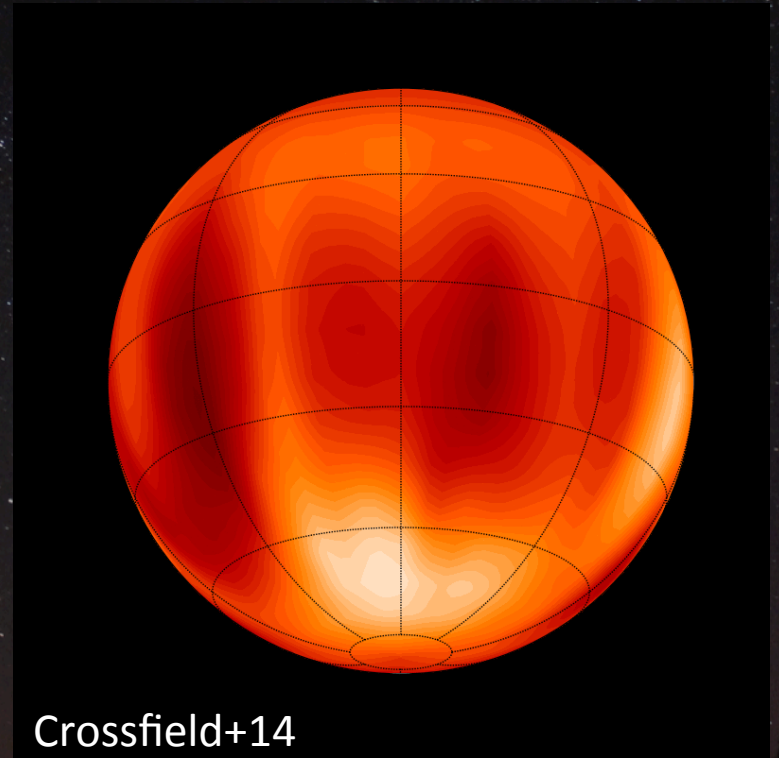
- Enhanced photometric variability
- J-band brightening at constant  $T_{\text{eff}}$

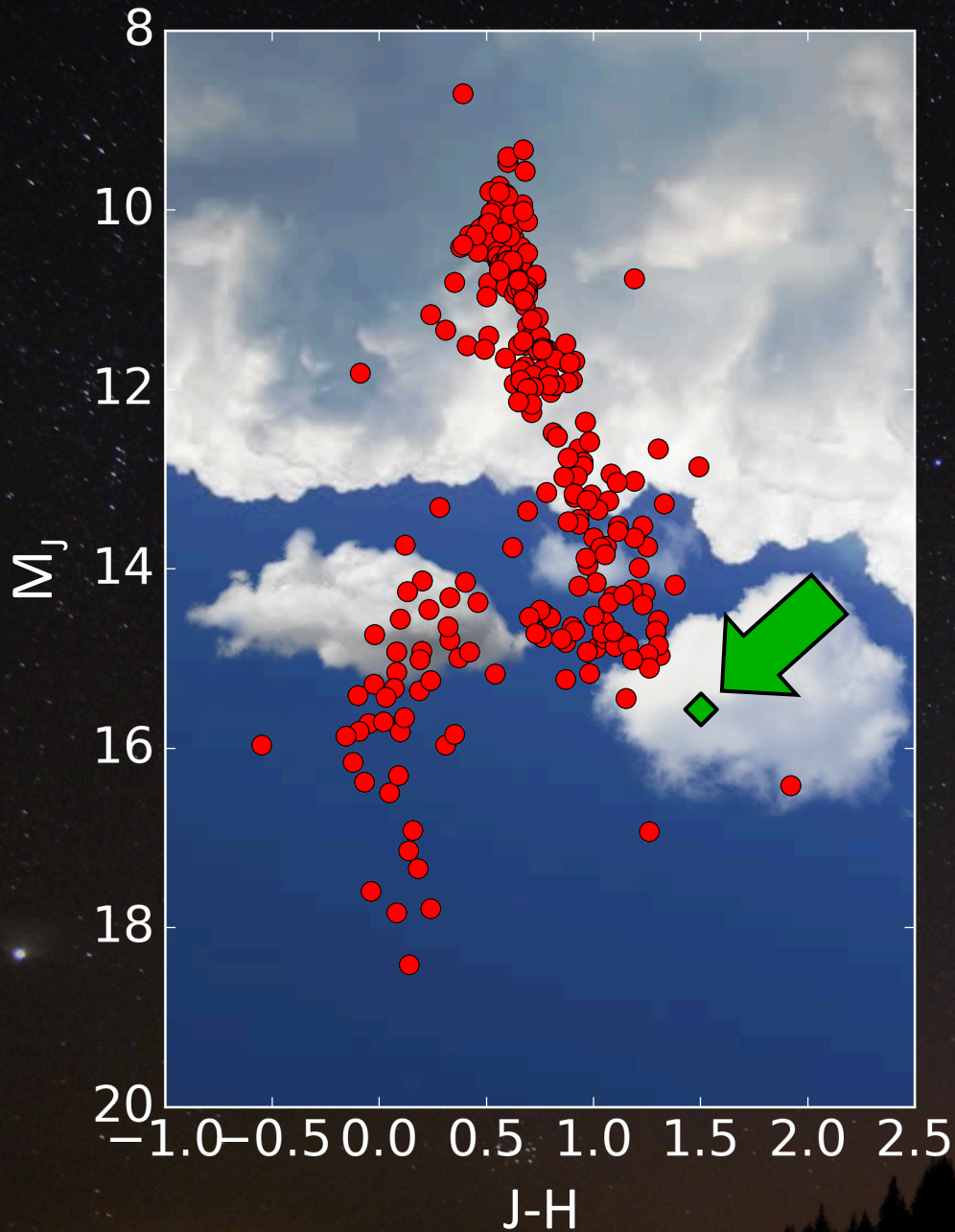




Evidence for cloud clearing at L/T trans.

- Enhanced photometric variability
- J-band brightening at constant  $T_{\text{eff}}$
- Doppler imaging



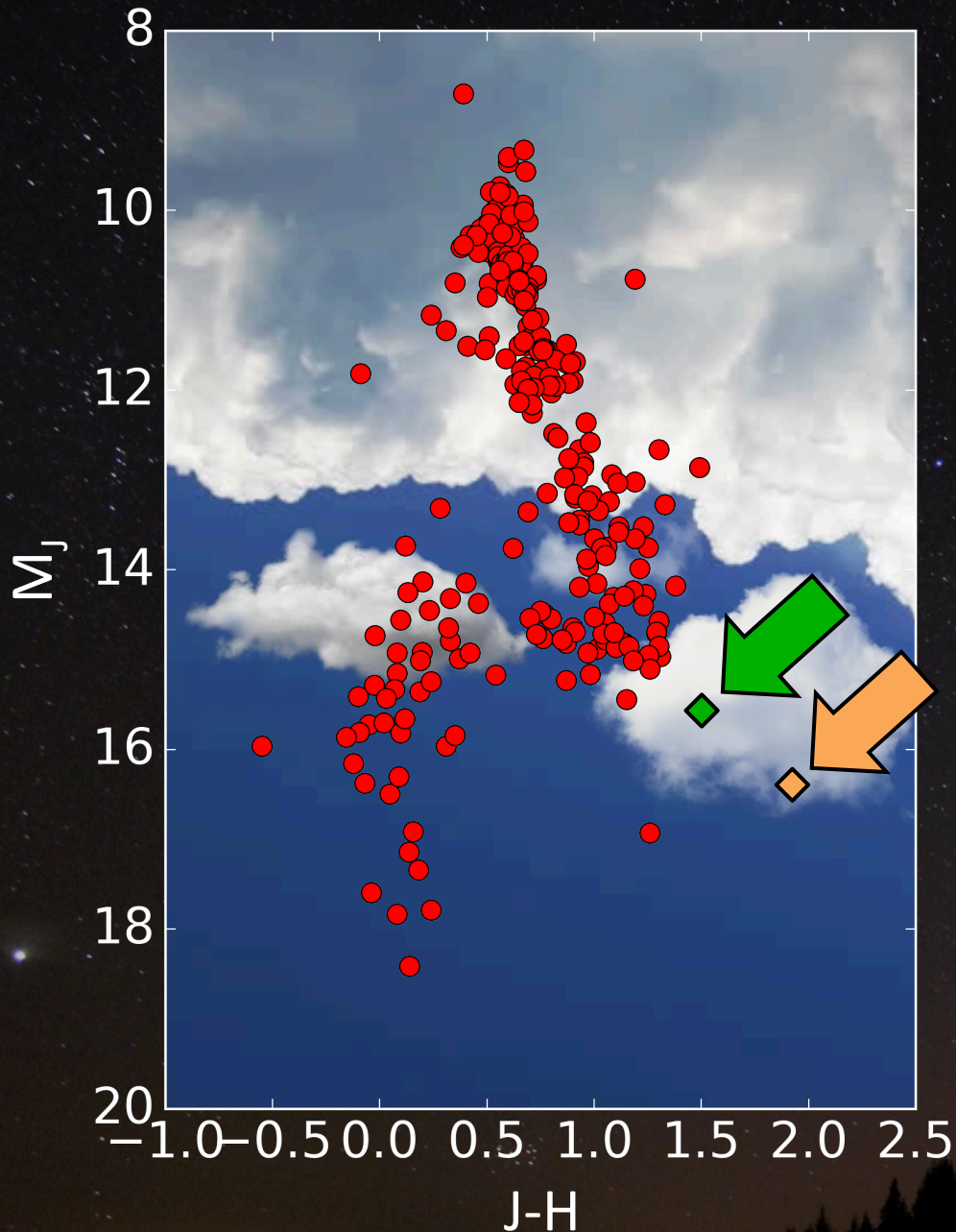


Evidence for cloud clearing at L/T trans.

- Enhanced photometric variability
- J-band brightening at constant  $T_{\text{eff}}$
- Doppler imaging

Evidence for cloud clearing in directly imaged exoplanet atmospheres

- HR8799c requires patchy cloud models to fit its SED



Evidence for cloud clearing at L/T trans.

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Evidence for cloud clearing in directly imaged exoplanet atmospheres

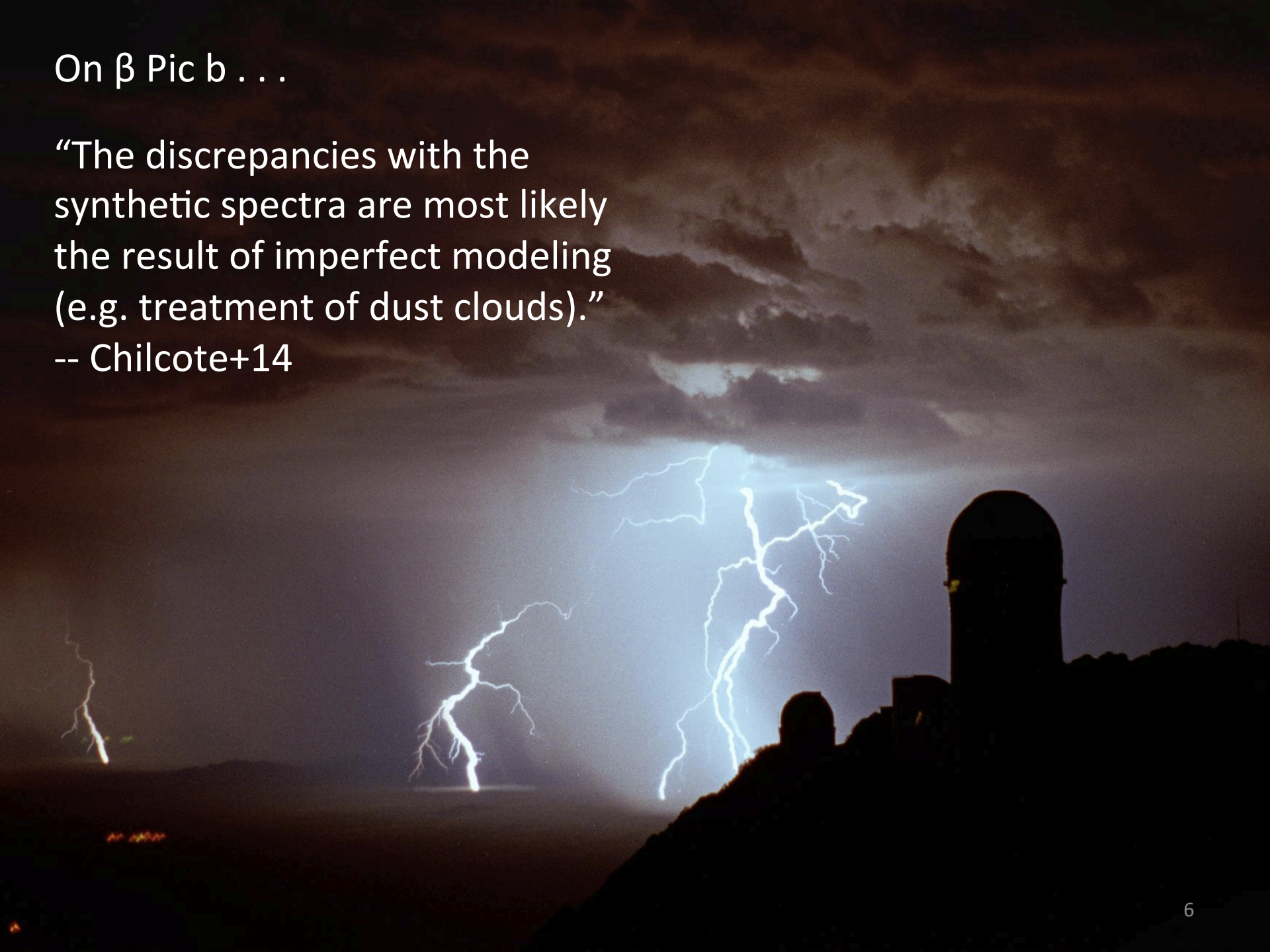
- HR8799 c requires patchy cloud models to fit its SED
- 2M1207 b shows periodic photometric variability



On  $\beta$  Pic b . . .

“The discrepancies with the synthetic spectra are most likely the result of imperfect modeling (e.g. treatment of dust clouds).”

-- Chilcote+14



On the HR8799 planets . . .

“This exploration of the model degeneracies calls for more fine tuning of the cloud properties.”

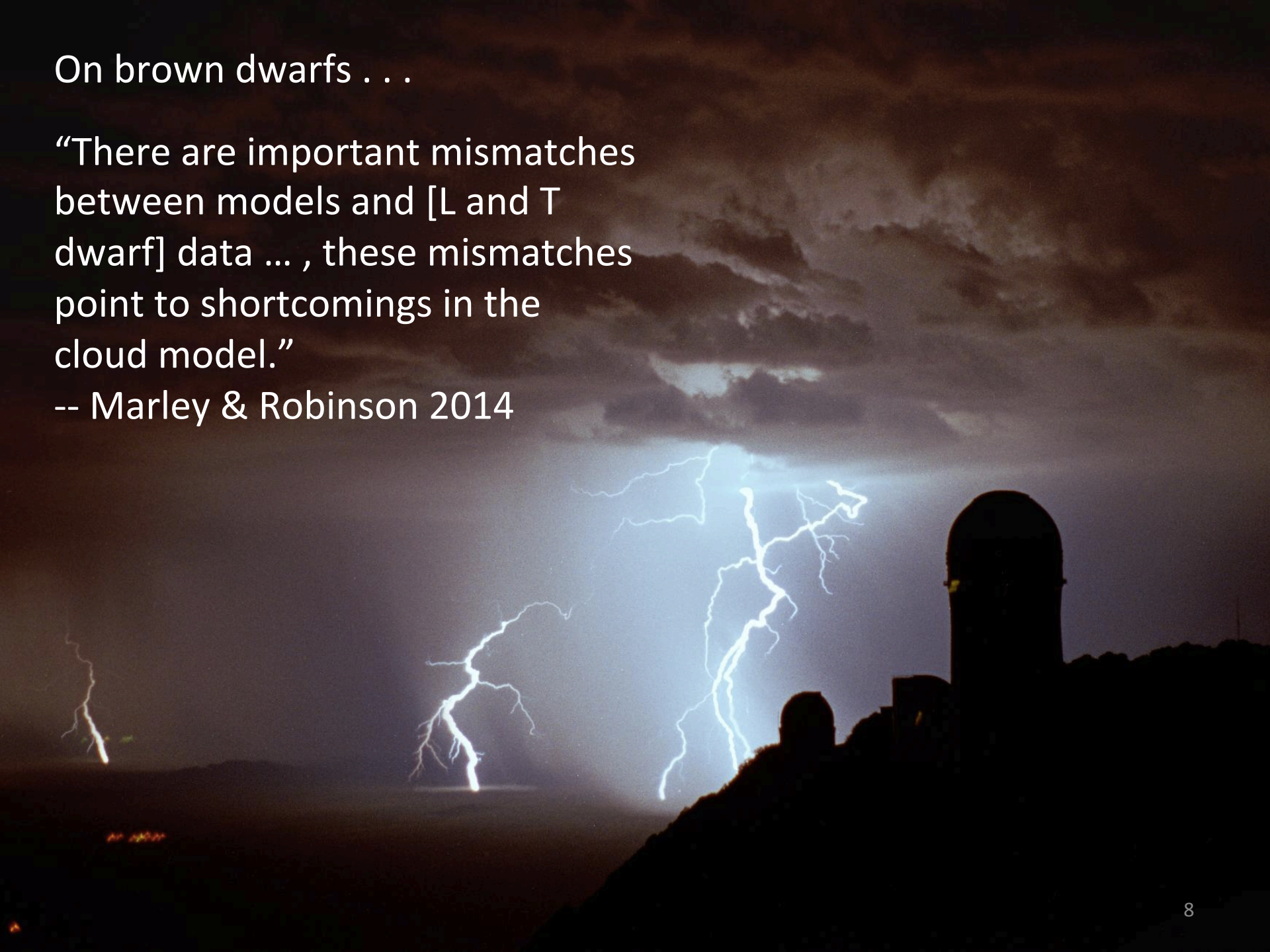
-- Bonnefoy+16



On brown dwarfs . . .

“There are important mismatches between models and [L and T dwarf] data ... , these mismatches point to shortcomings in the cloud model.”

-- Marley & Robinson 2014



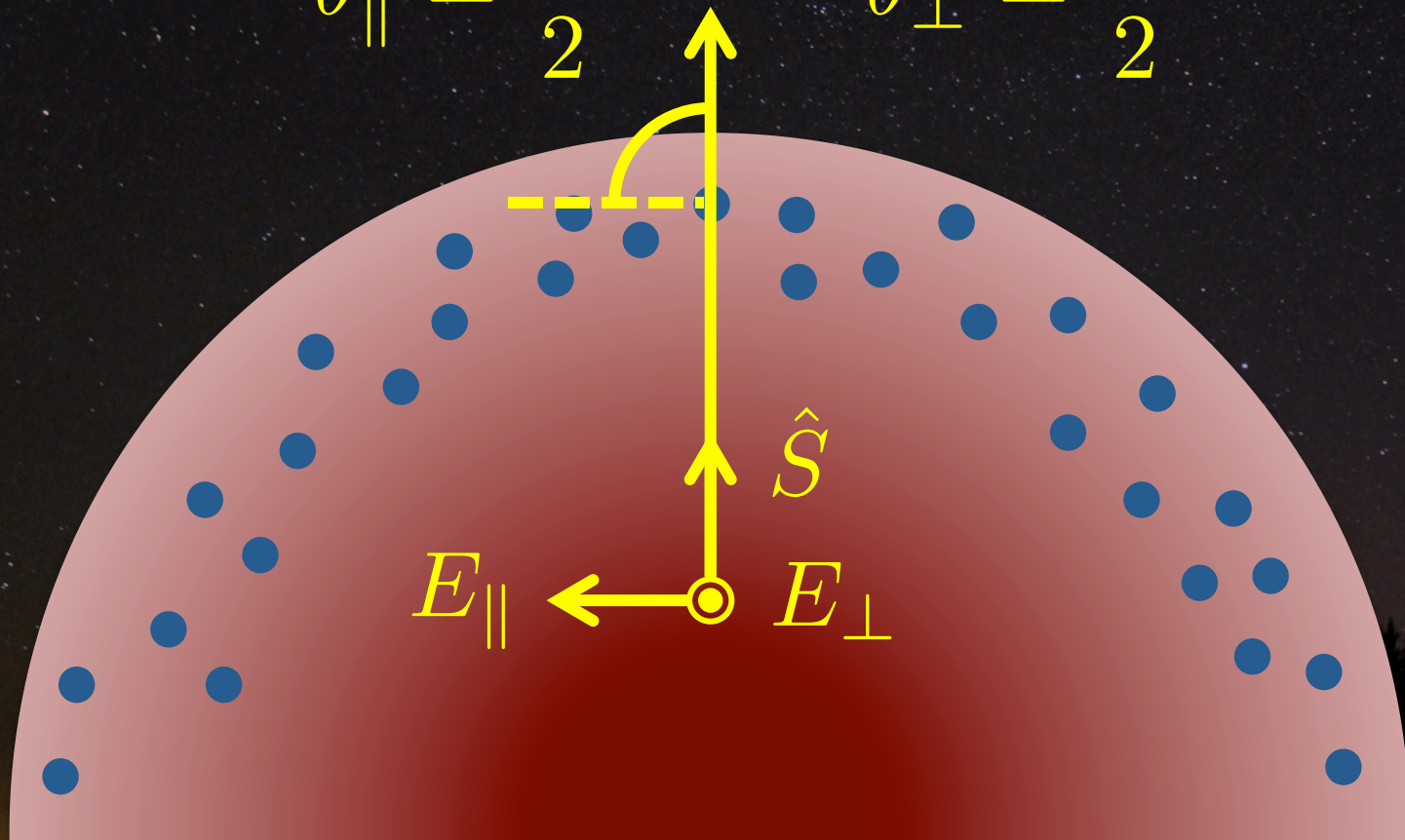


Consider an unpolarized beam as the superposition of two linearly polarized beams



Light reaching the observer from the center of the planet remains unpolarized

$$\theta_{\parallel} = \frac{\pi}{2} \qquad \theta_{\perp} = \frac{\pi}{2}$$



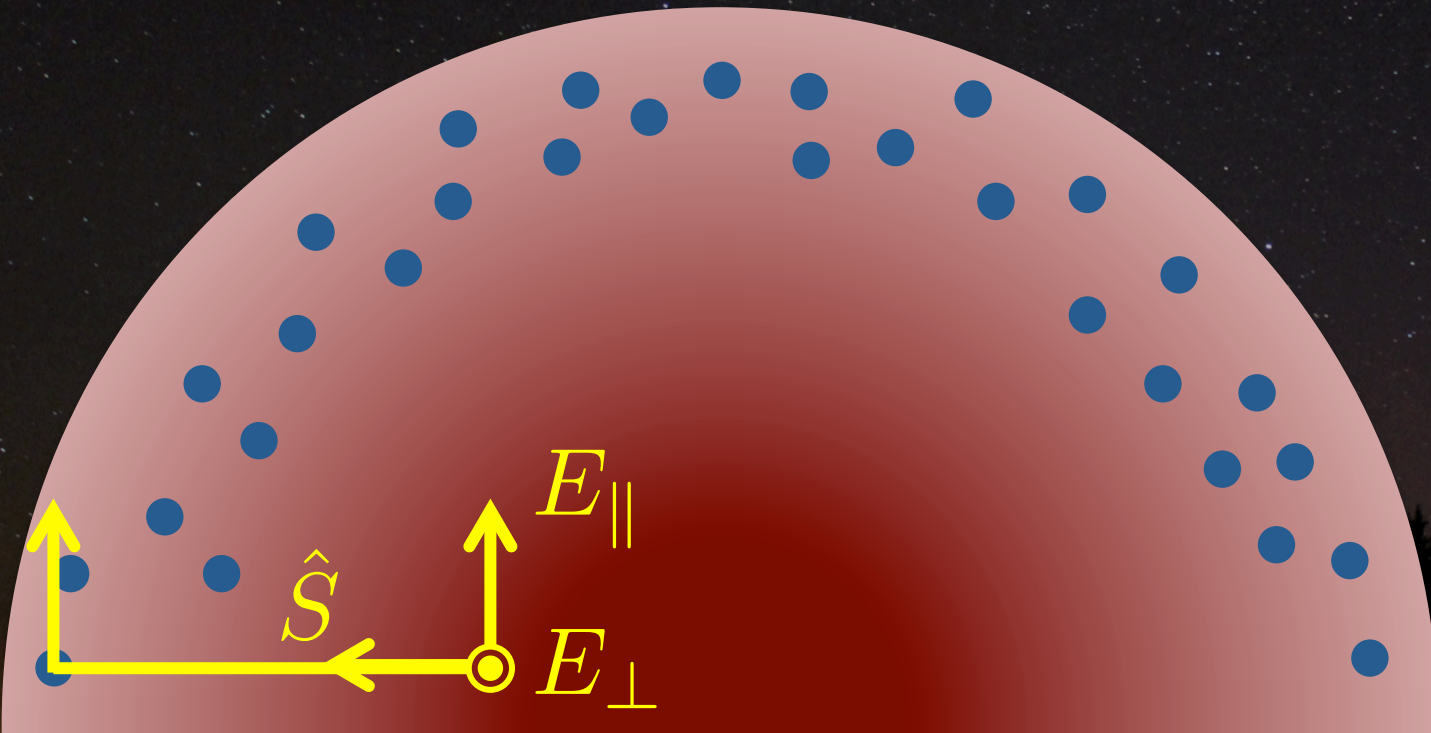
Consider an unpolarized beam as the superposition of two linearly polarized beams



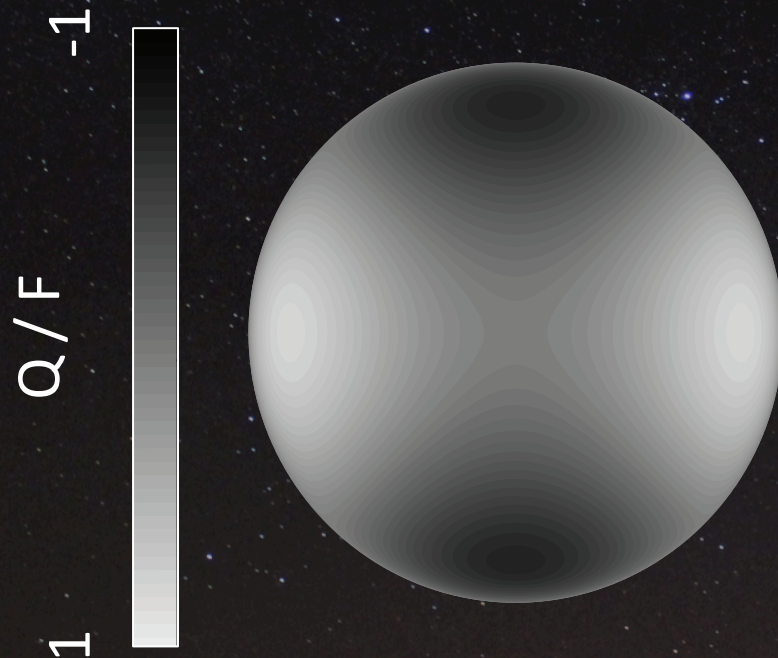
Light reaching the observer from the limb includes only  $E_{\perp}$ , and hence is linearly polarized

$$\theta_{\parallel} = 0$$

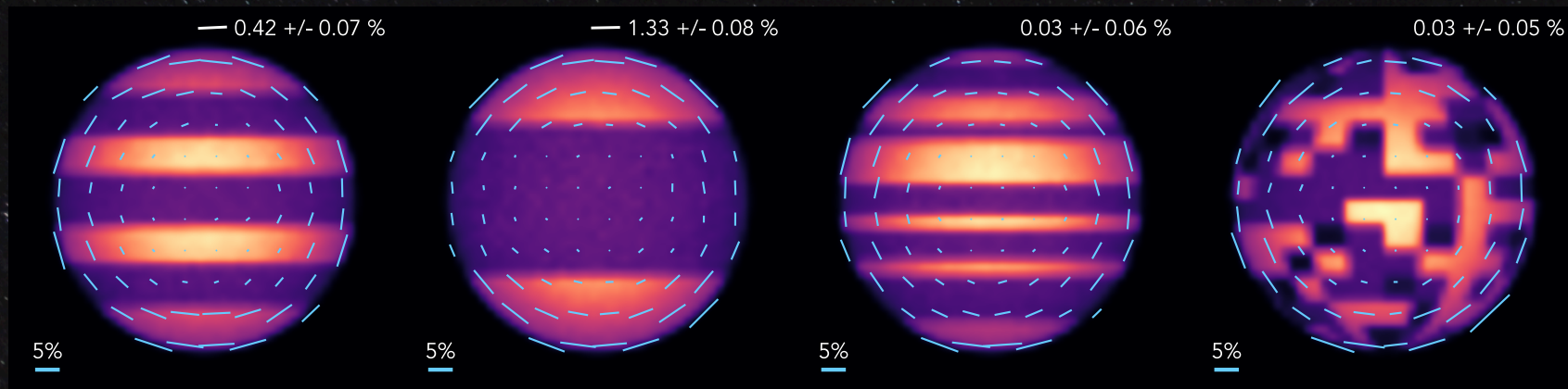
$$\theta_{\perp} = \frac{\pi}{2}$$



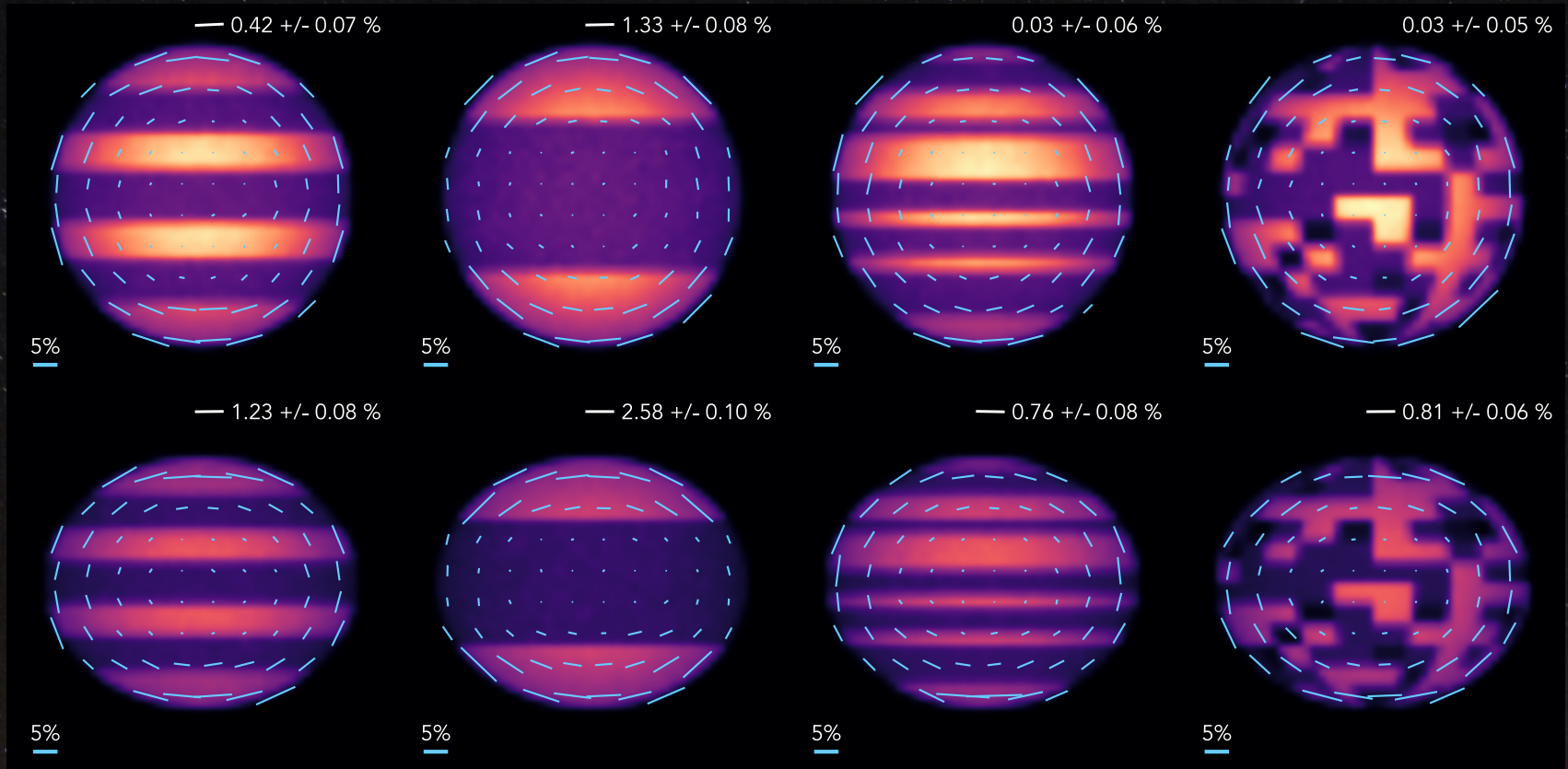
# Clouds can Polarize Near-IR Radiation from Brown Dwarfs and Self-Luminous Exoplanets



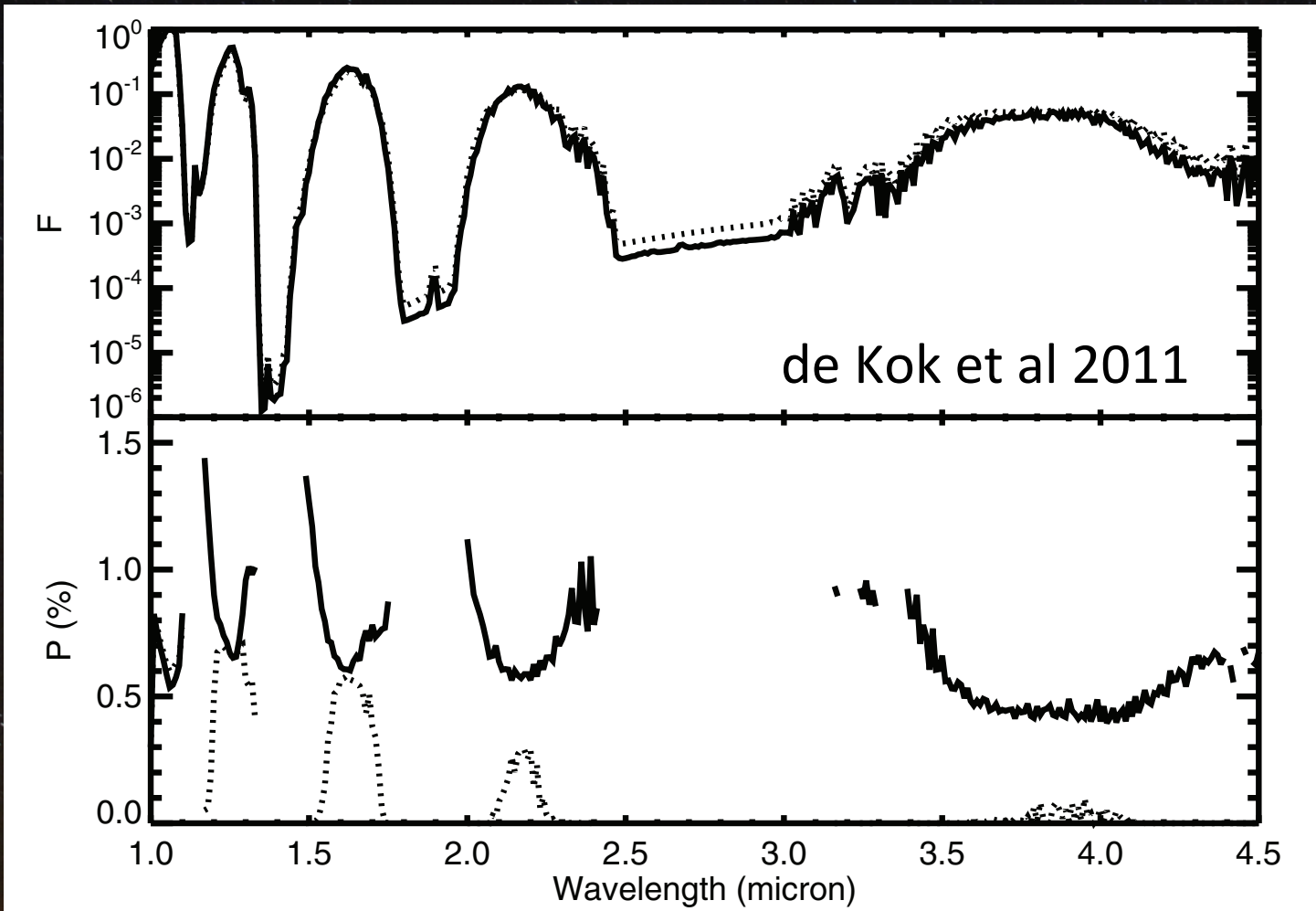
# Stolker+17: Patchy Cloud Polarization Models



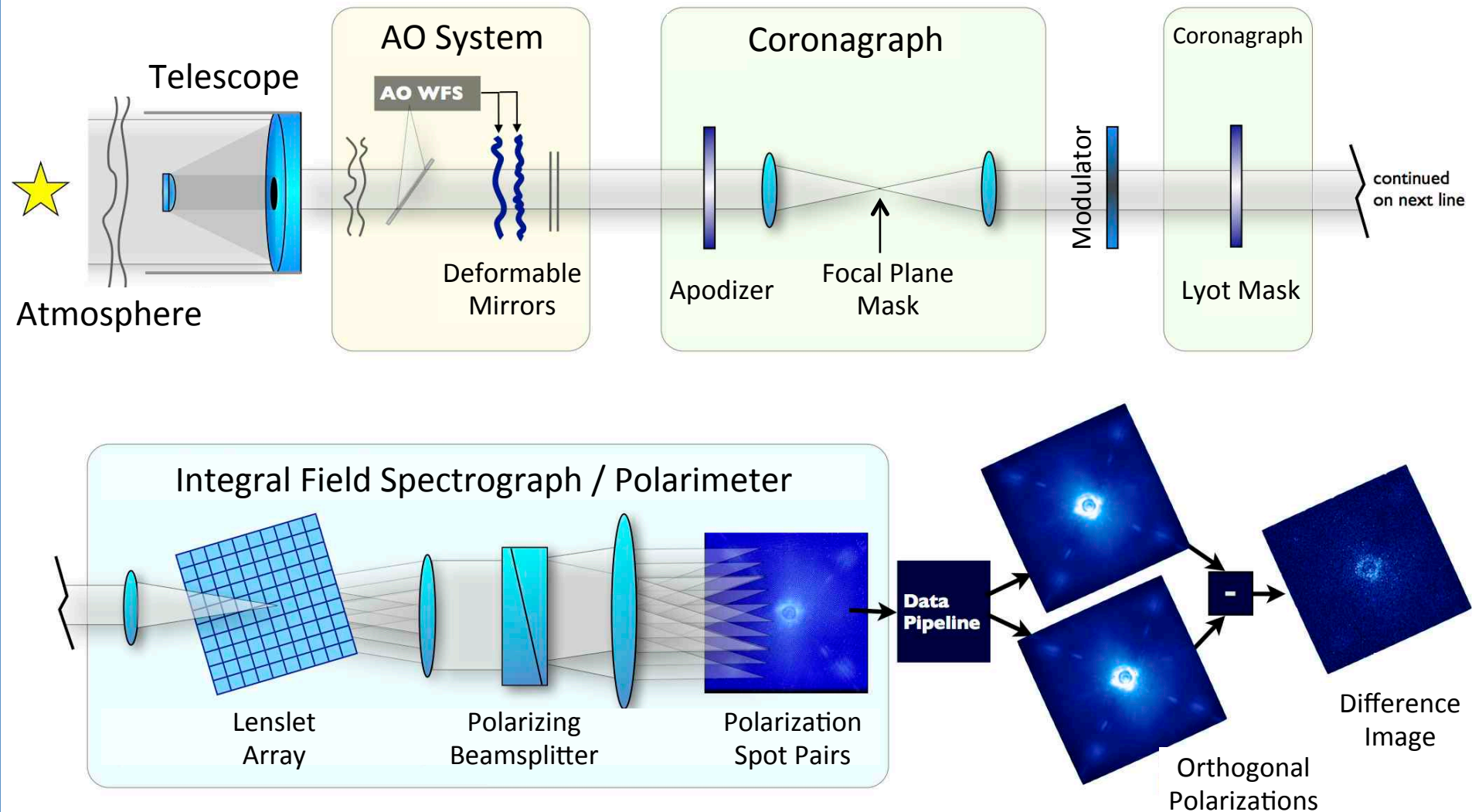
# Stolker+17: Patchy Cloud Polarization Models

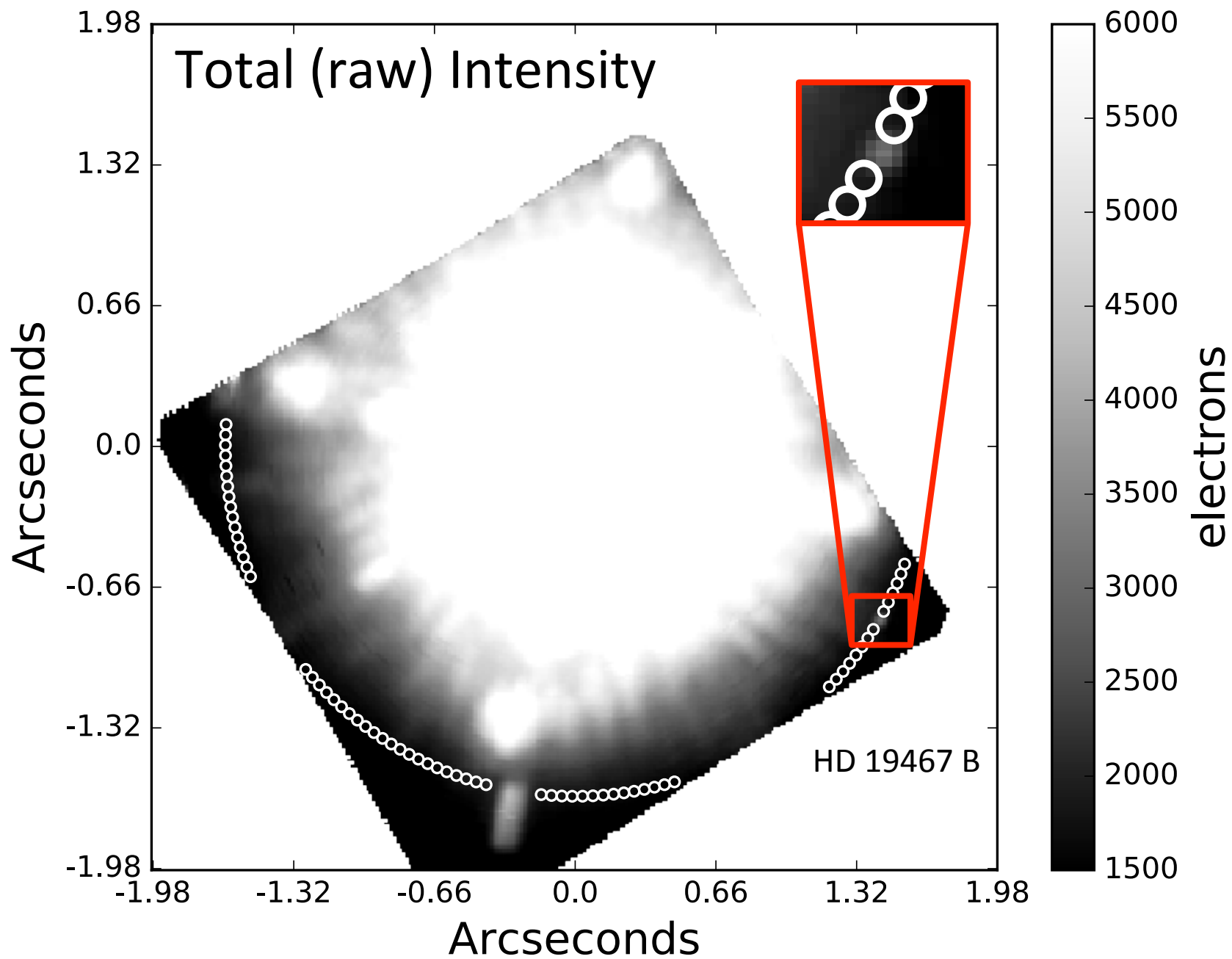


# Clouds can Polarize Near-IR Radiation from Brown Dwarfs and Self-Luminous Exoplanets

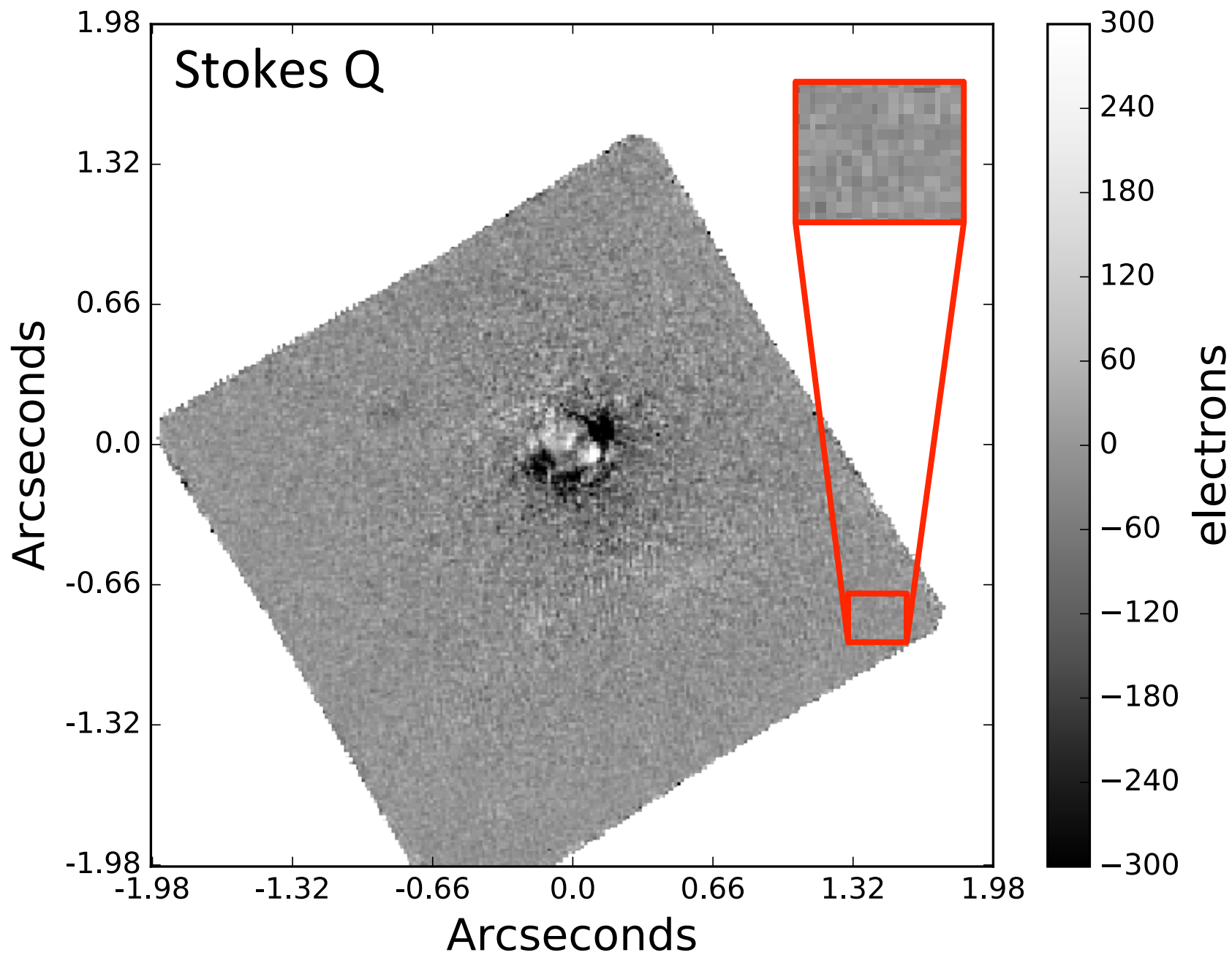


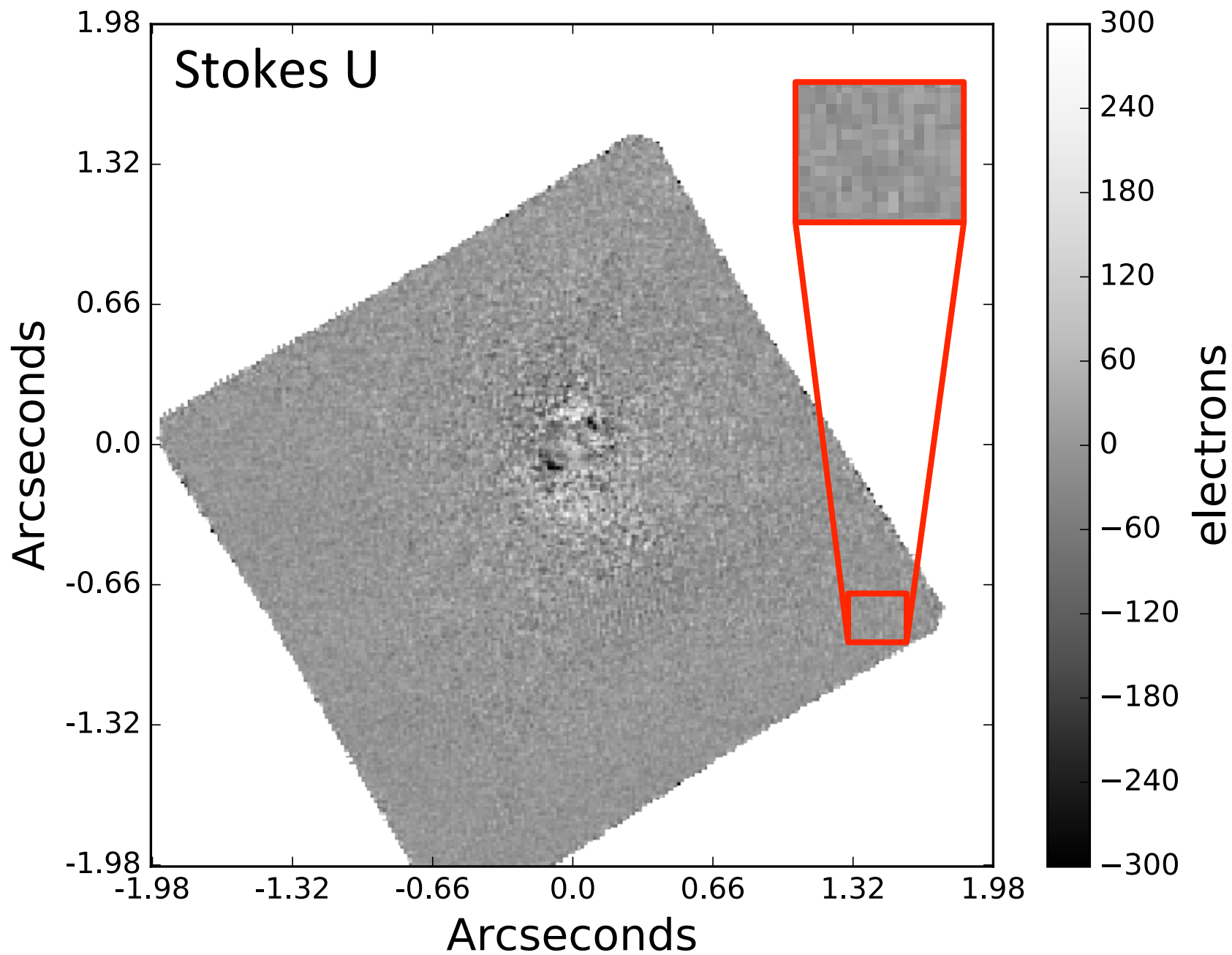
# Integral Field Polarimetry with GPI

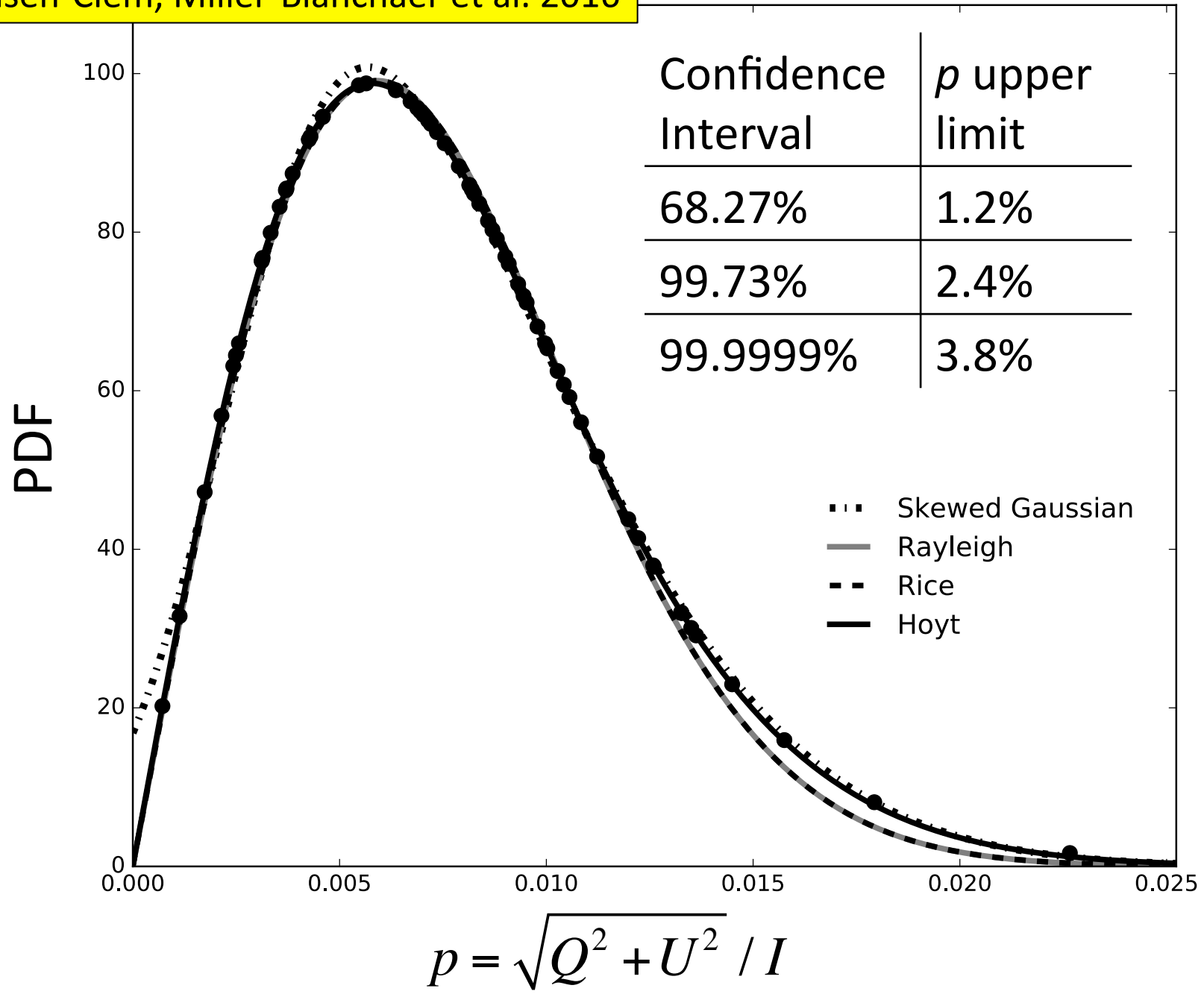






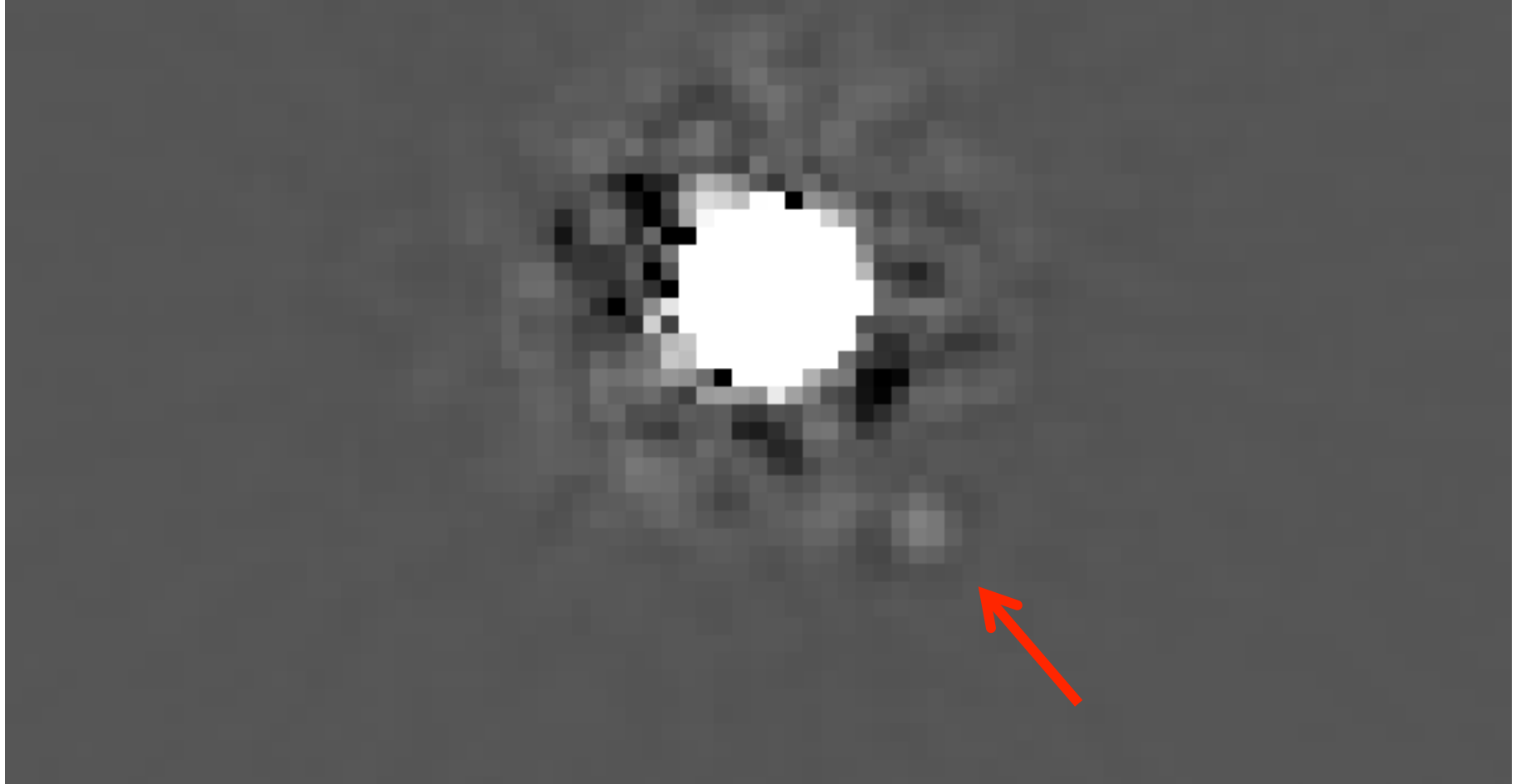






# $\beta$ Pictoris b

0.25"



-17111    -17042    -16902    -16624    -16064    -14957    -12751    -8301    503    20



WIRC-POL

SPHERE

Polarimetric observations of bound and field brown dwarfs are complimentary

- The ages and metallicities of bound BDs can be constrained by their host stars
- Some bound BDs have dynamical mass measurements (see TRENDS survey)
- Bound BDs and giant exoplanets may share formation pathways

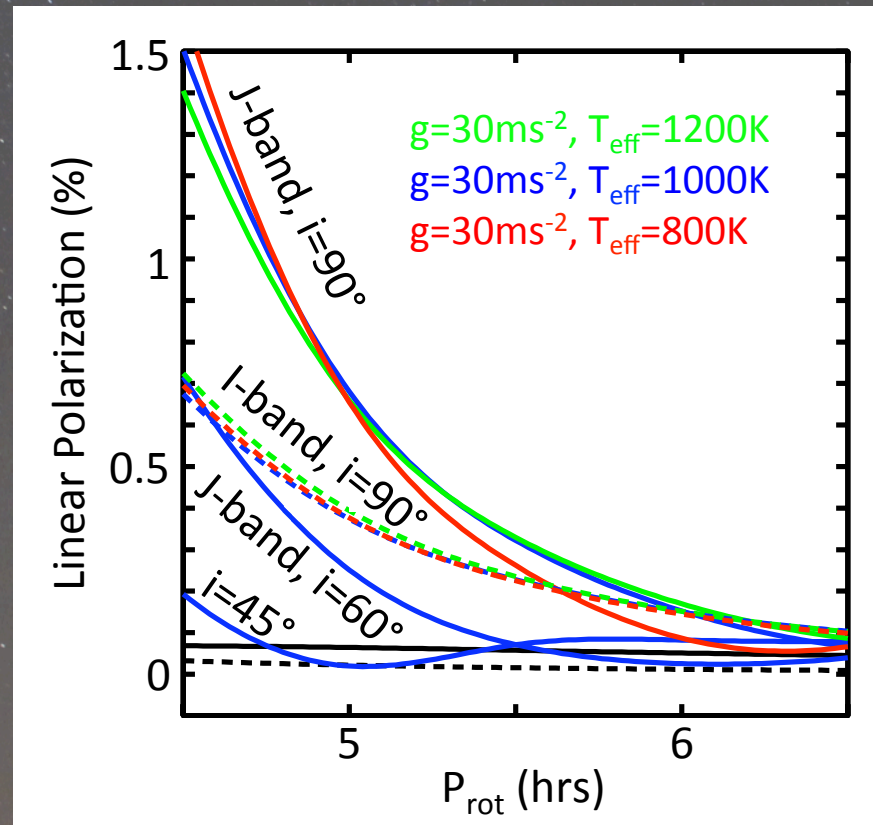
GPI

# Summary: exoplanet polarimetry is ready for prime time!

- Polarimetry is an untapped method for probing exoplanet and brown dwarf atmospheres
- Proof of concept accomplished
- Observations and analysis underway

# Backup

Short Rotation Period and low  $g \rightarrow$   
Higher Oblateness  $\rightarrow$  Higher Polarization





# HD 19467 B: T5.5 dwarf companion to a G3 main sequence star

