

The puzzling nature of the hot super-Earth 55 Cancri e

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Collaborators for this work

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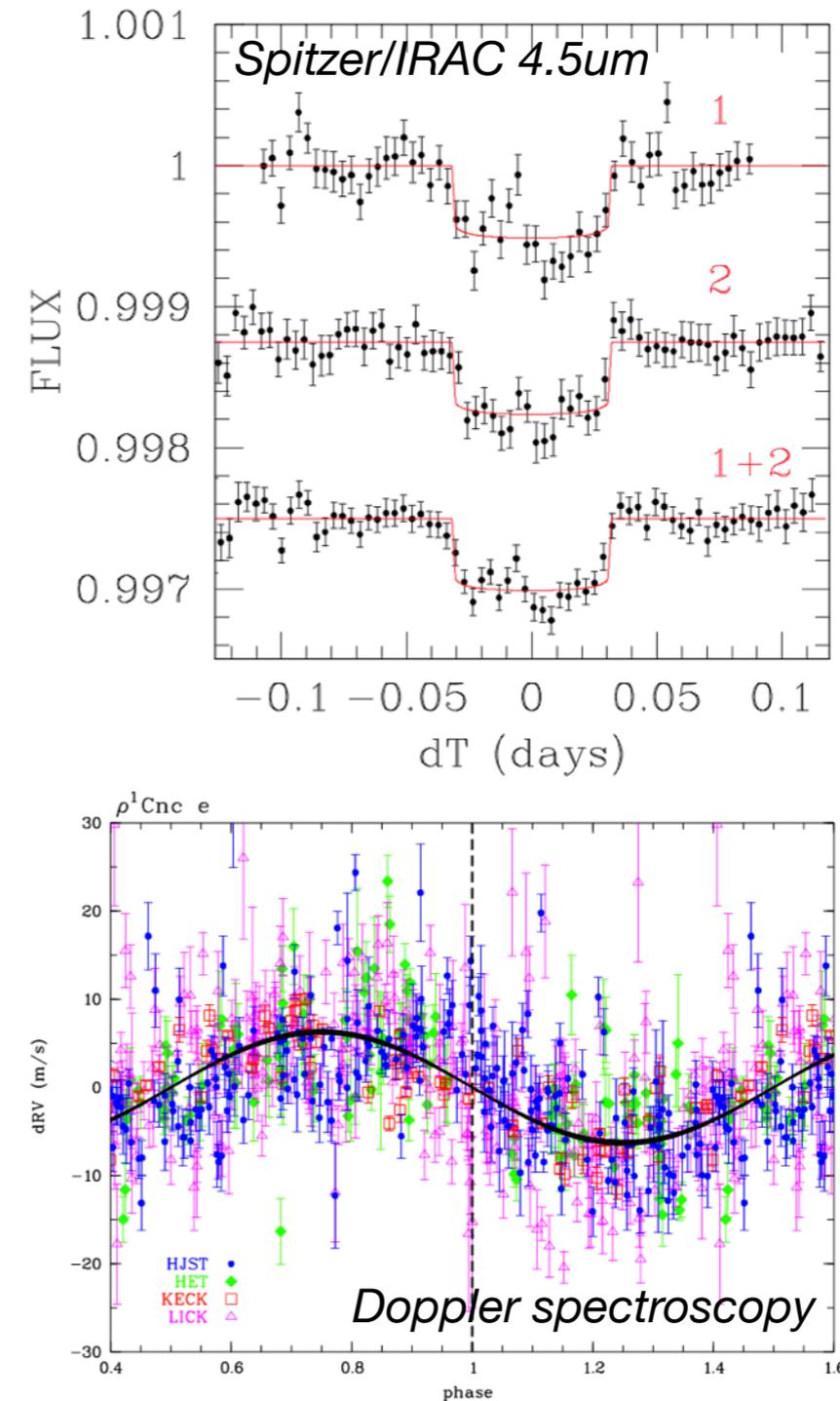
55 Cancri e at UK Exom 2016

- **E. de Mooij: Ground-based search for the atmosphere of 55Cnc e**
- **A. Tsiaras: An atmosphere around the super-Earth 55 Cnc e**

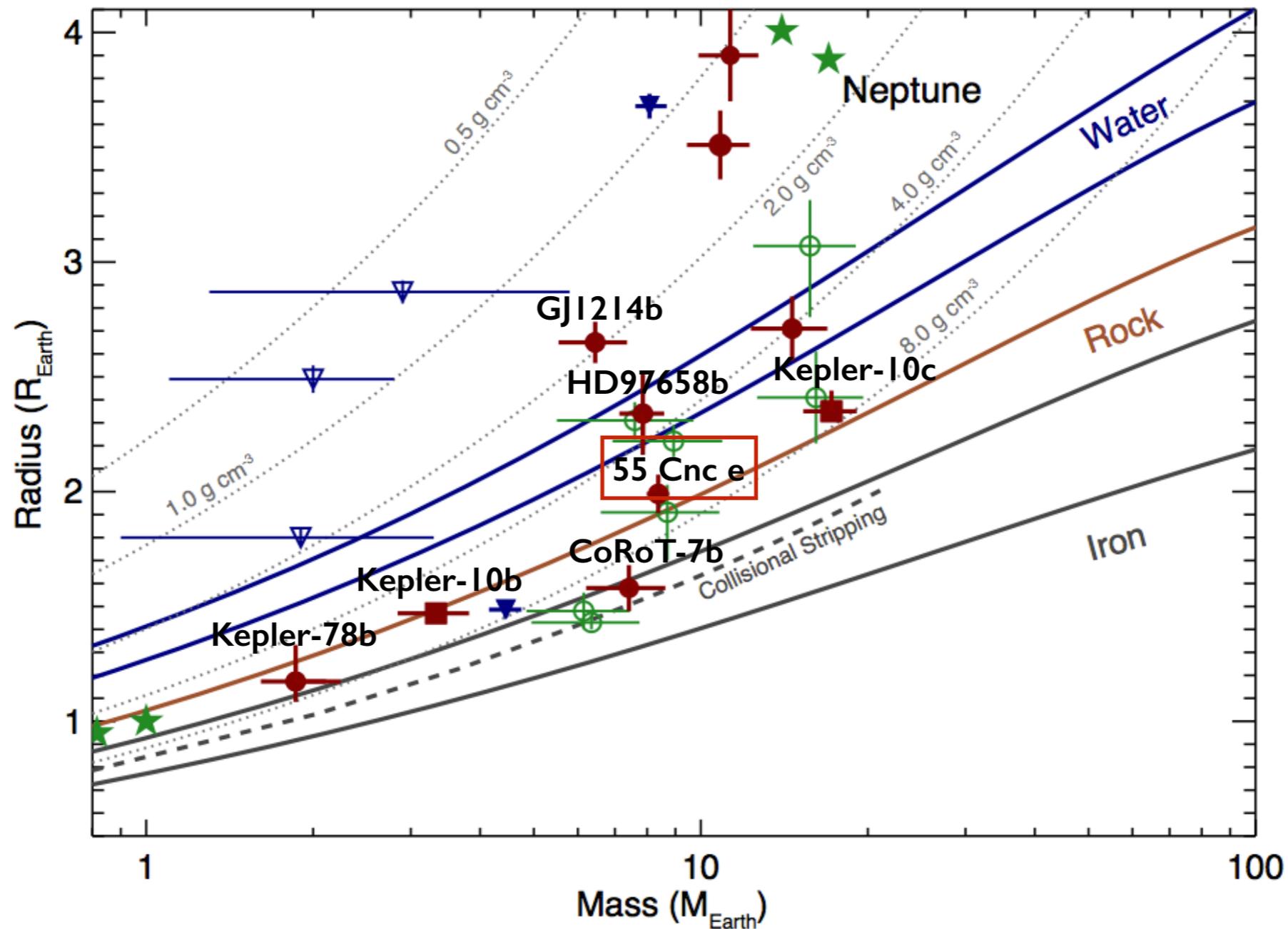
The super-Earth 55 Cnc e in 2012

- Discovered (transit) in 2011
- Host star: **V=6**, $0.90 M_{\text{Sun}}$, $0.94 R_{\text{Sun}}$
- Period : 0.74 days
- Radius : $2.17 \pm 0.10 R_{\oplus}$
- Mass : $8.37 \pm 0.38 M_{\oplus}$
- Density : $4.5 \pm 0.9 \text{ g/cm}^3$
- Eq. Temp. : 2380 K ($A_b=0$)

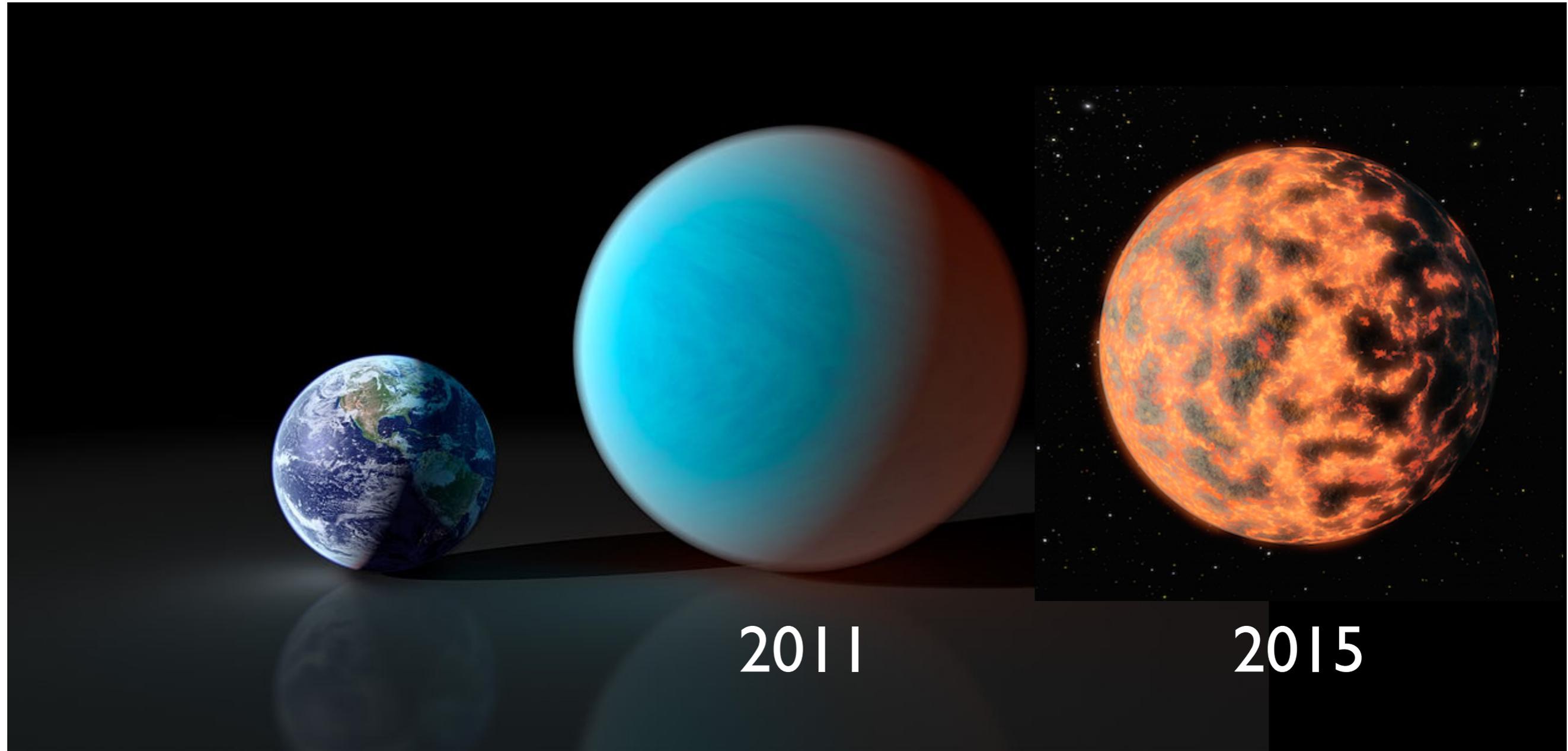
Dawson et al., 2010
Demory et al. 2011
Winn et al. 2011
von Braun et al., 2011
Gillon et al. 2012
Endl et al. 2012



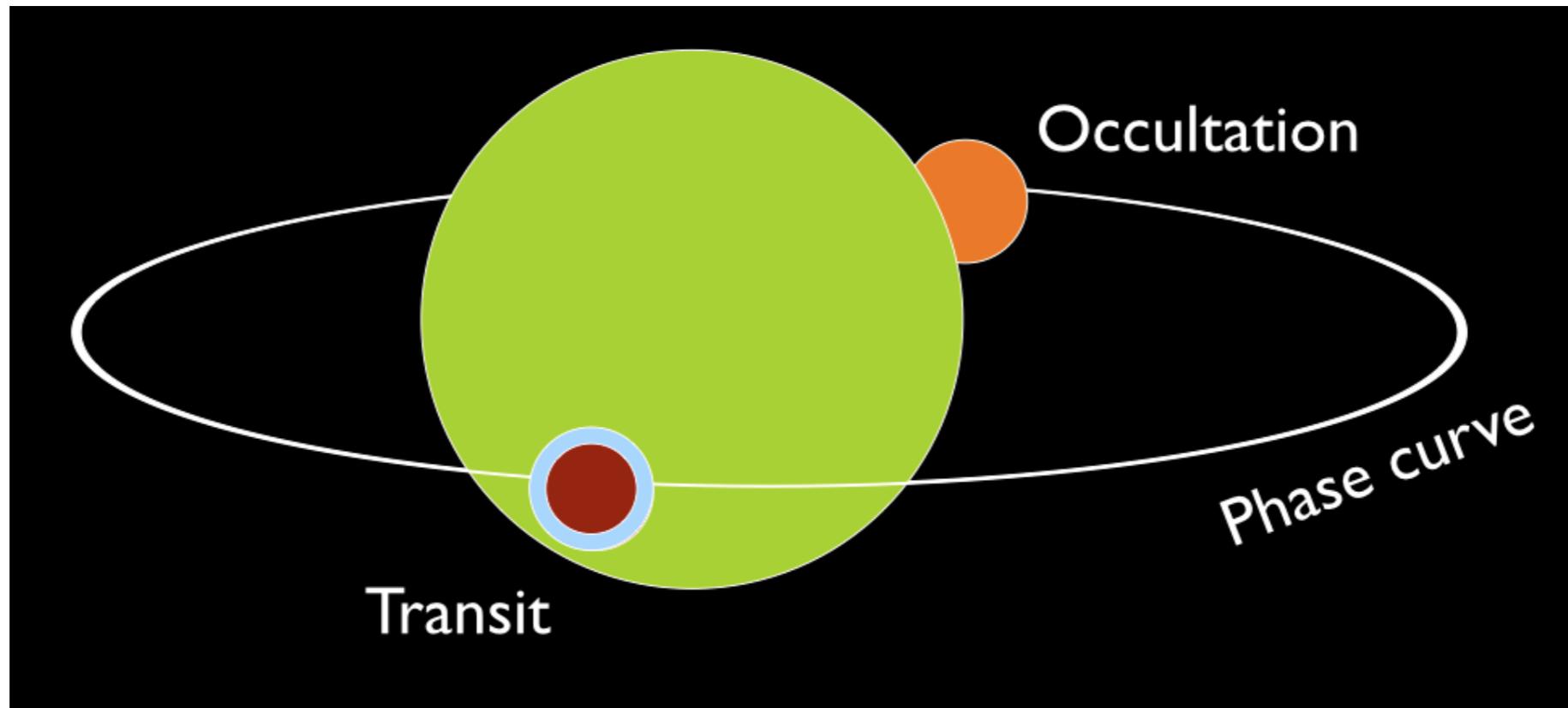
Density alone is not enough



Is 55 Cnc e rocky or volatile-rich?

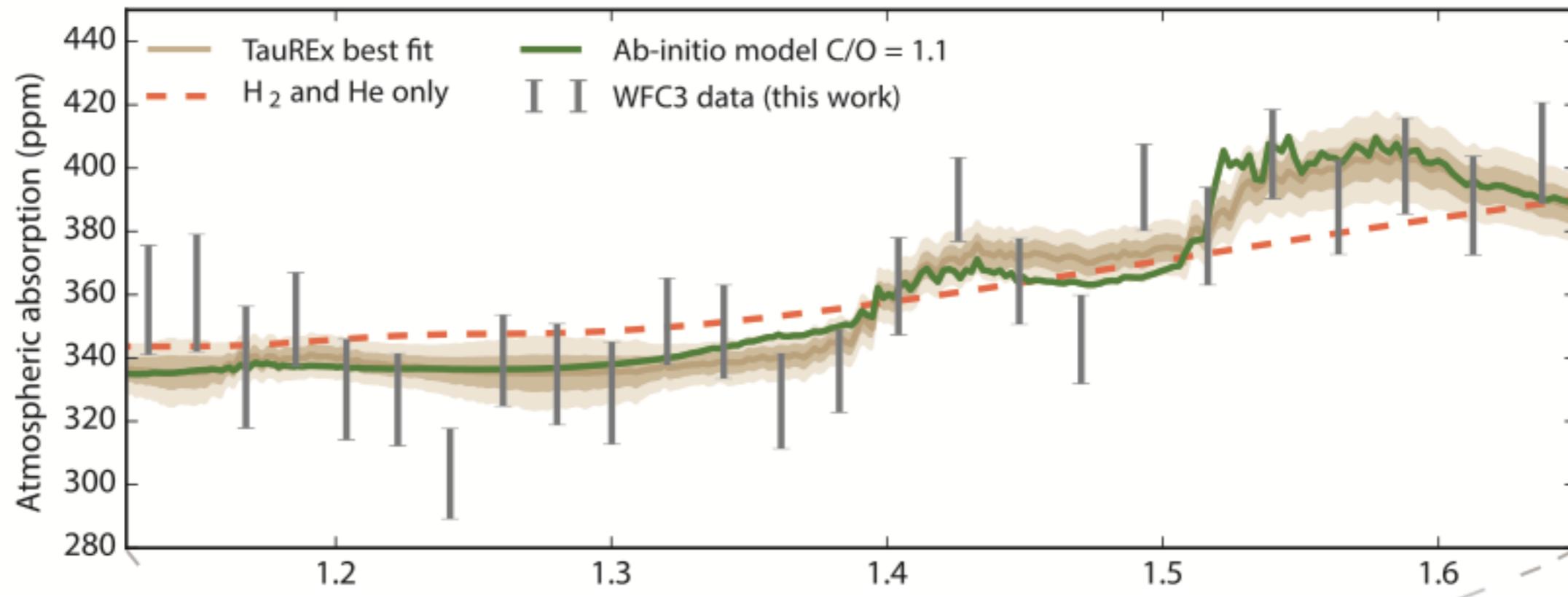


Probing atmospheric properties of super-Earths



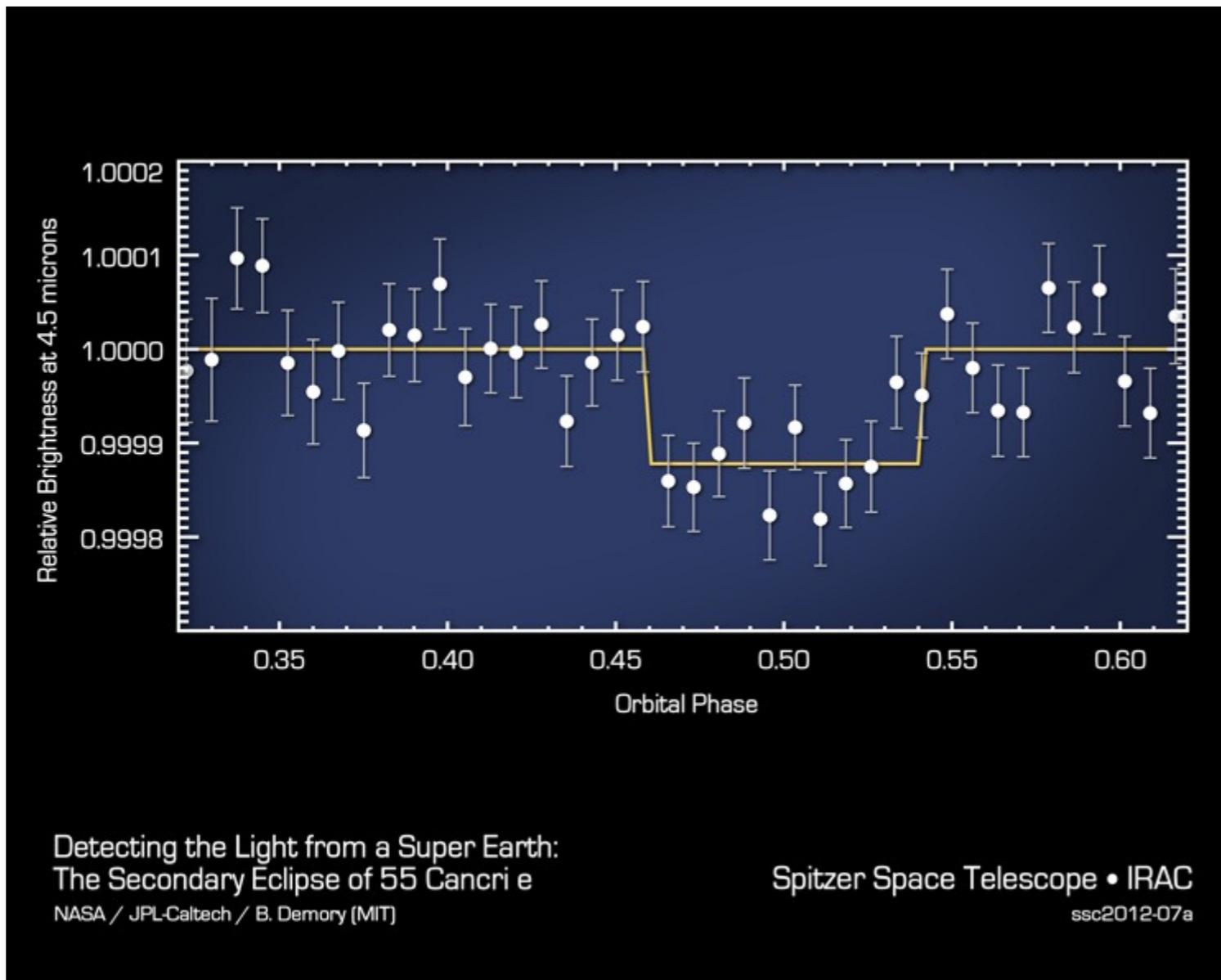
- Transmission spectroscopy (probes the atmospheric limb)
- Emission spectroscopy (probes the averaged dayside emission)
- Phase-curve photometry (probes longitudinal variations of the emergent spectrum)

WFC3 transmission spectrum of 55 Cnc e



Paper suggests H/He dominated atmosphere

Thermal Emission from 55 Cnc e



Spitzer 4.5-micron
occultations

Occultation depth:
128 +/- 30 ppm

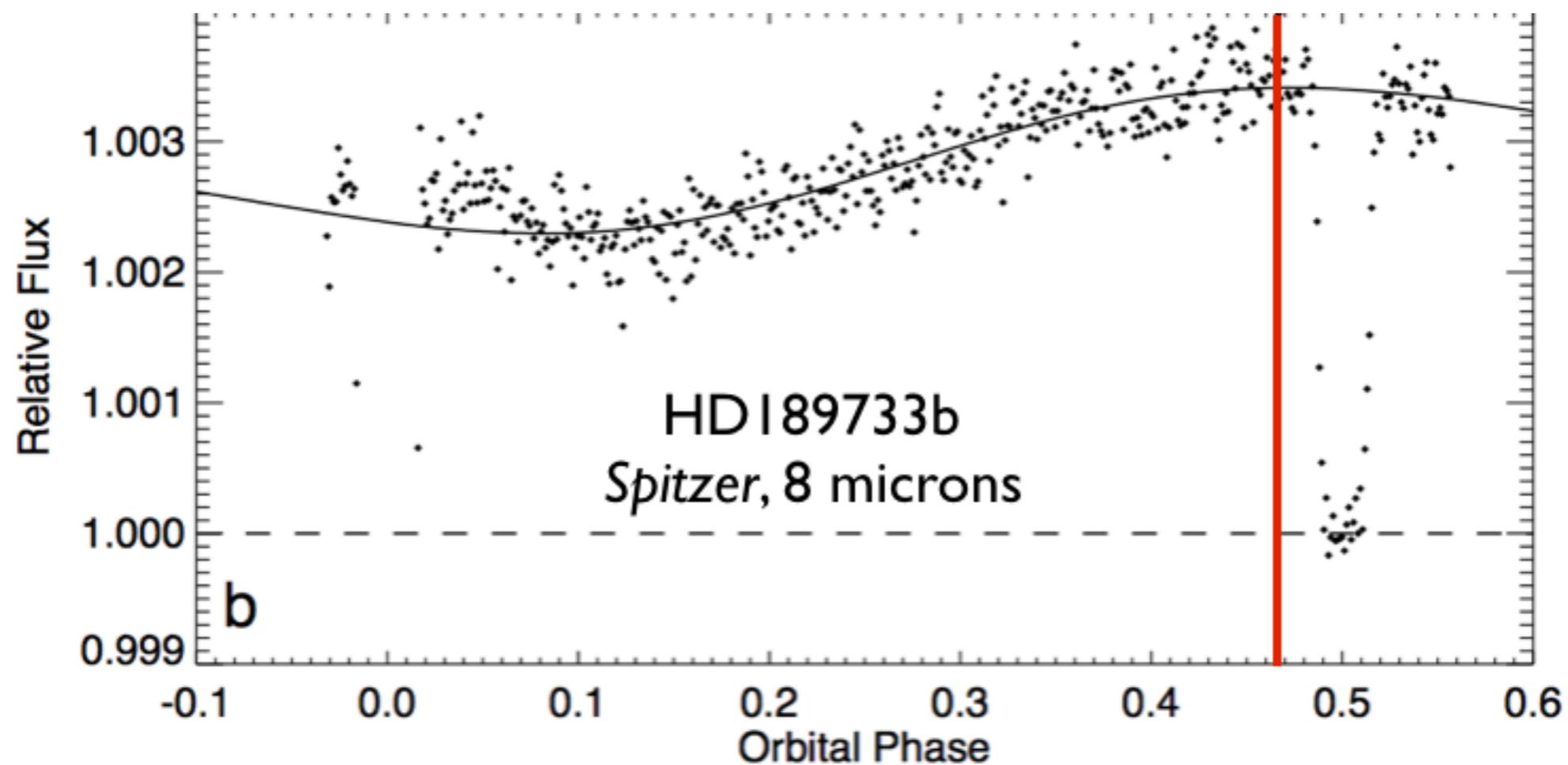
Translates to
 $T_B = 2000 \pm 300\text{K}$
using a 55 Cnc stellar
spectrum (Crossfield 2012)

Updated parameters reveal a denser planet

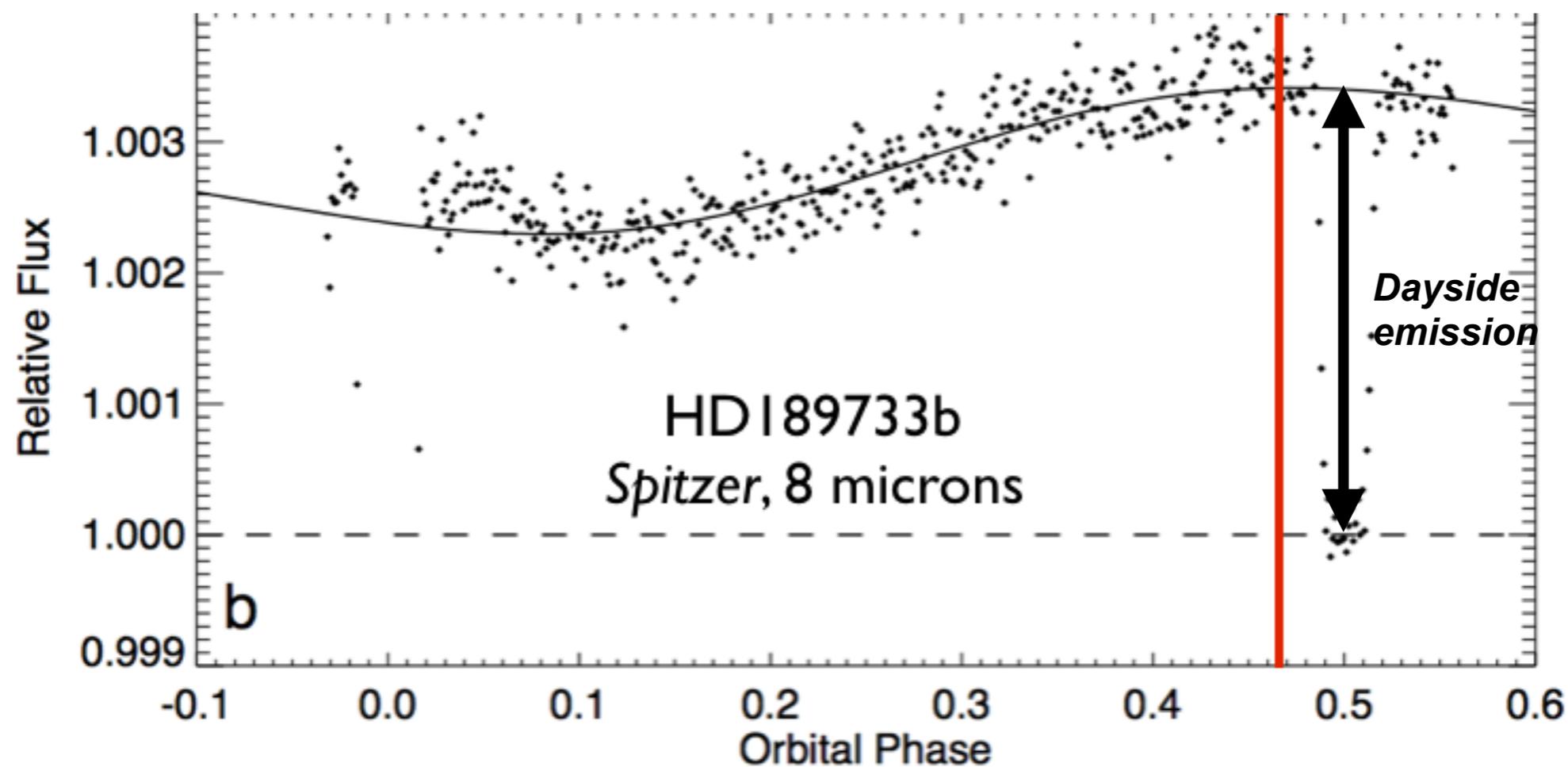
Planet/star area ratio R_p/R_s	$0.0187^{+0.0007}_{-0.0007}$	
$b = a \cos i/R_\star [R_\star]$	$0.36^{+0.07}_{-0.09}$	
$T_0 - 2,450,000 [\text{BJD}_{\text{TDB}}]$	$5733.008^{+0.002}_{-0.002}$	
Orbital semi-major axis a [AU]	$0.01544^{+0.00009}_{-0.00009}$	
Orbital inclination i [deg]	83^{+2}_{-1}	
Mean density ρ_p [g cm^{-3}]	$6.3^{+0.8}_{-0.7}$	$(4.5 \pm 0.9 \text{ g/cm}^3)$
Surface gravity $\log g_p$ [cgs]	$3.33^{+0.04}_{-0.04}$	
Mass $M_p [M_\oplus]$	$8.08^{+0.31}_{-0.31}$	
Radius $R_p [R_\oplus]$	$1.92^{+0.08}_{-0.08}$	

Water envelope not required anymore.

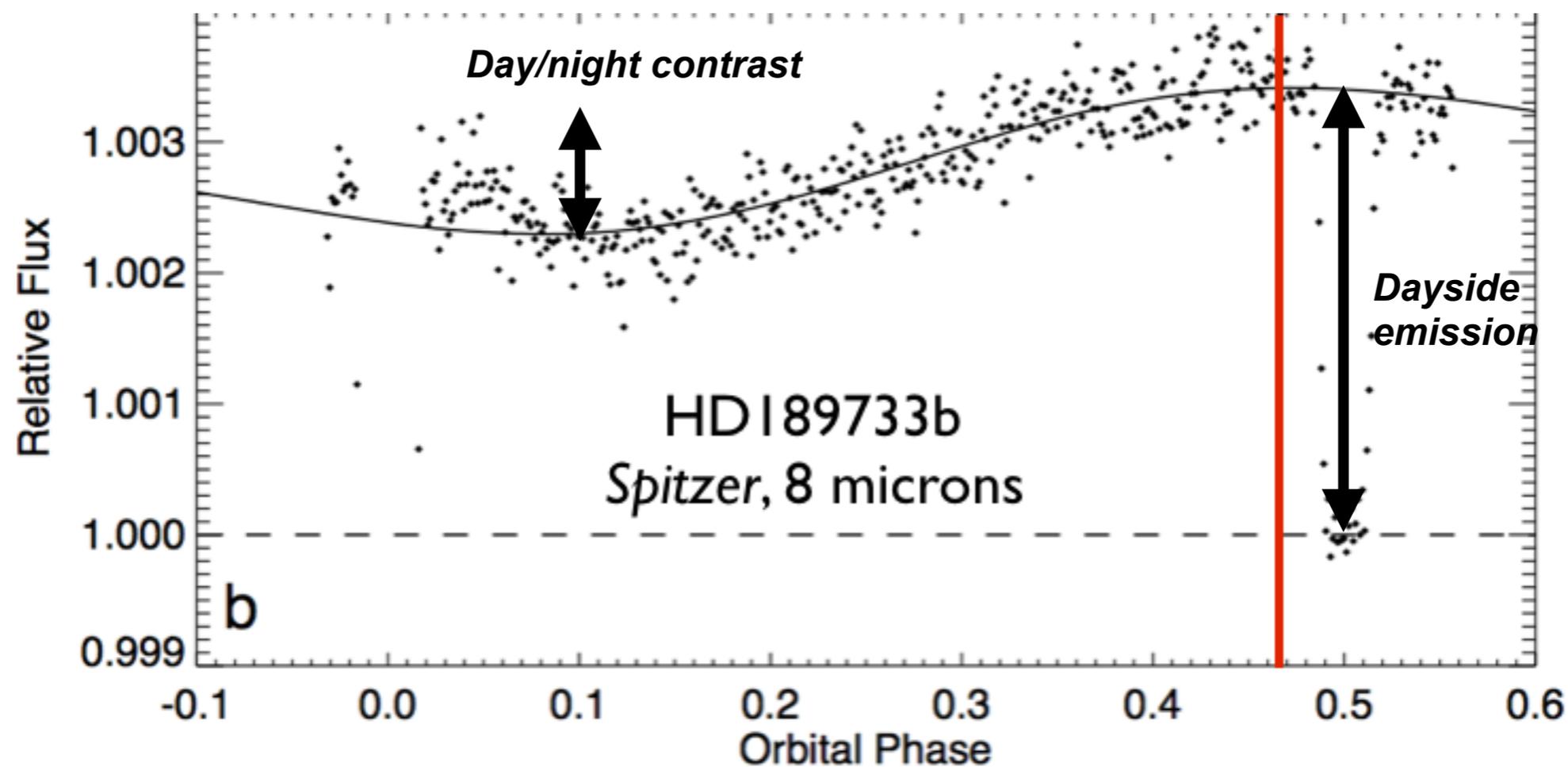
Efficient heat transport in HD189733b



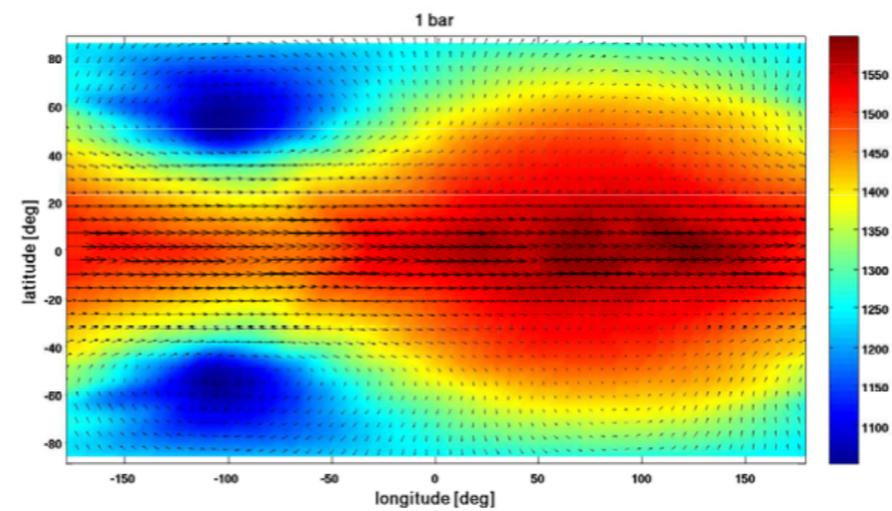
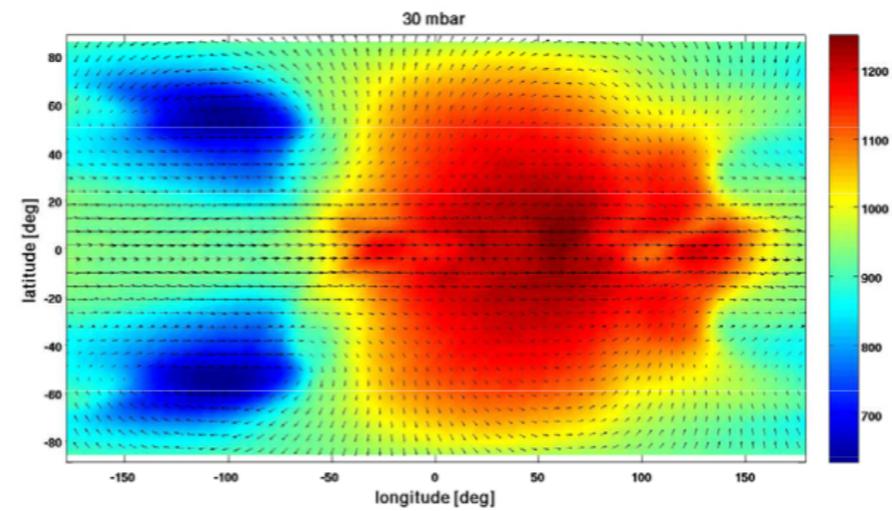
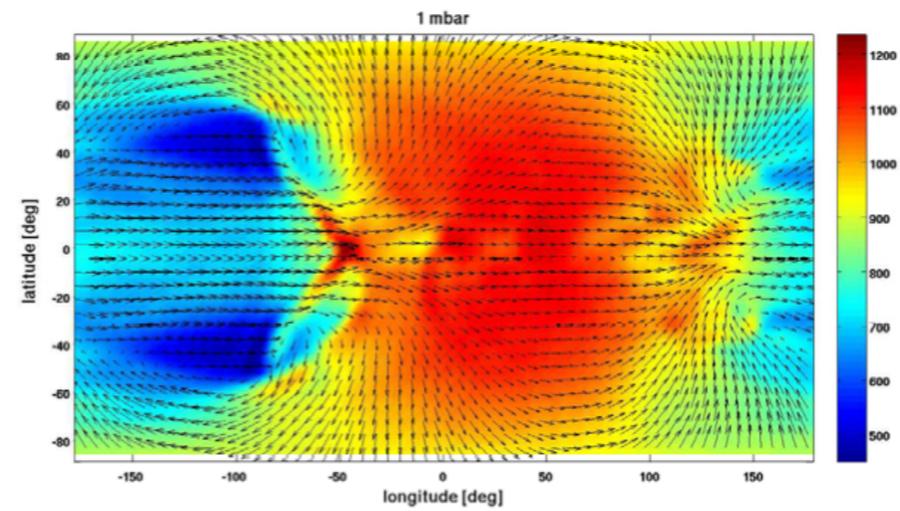
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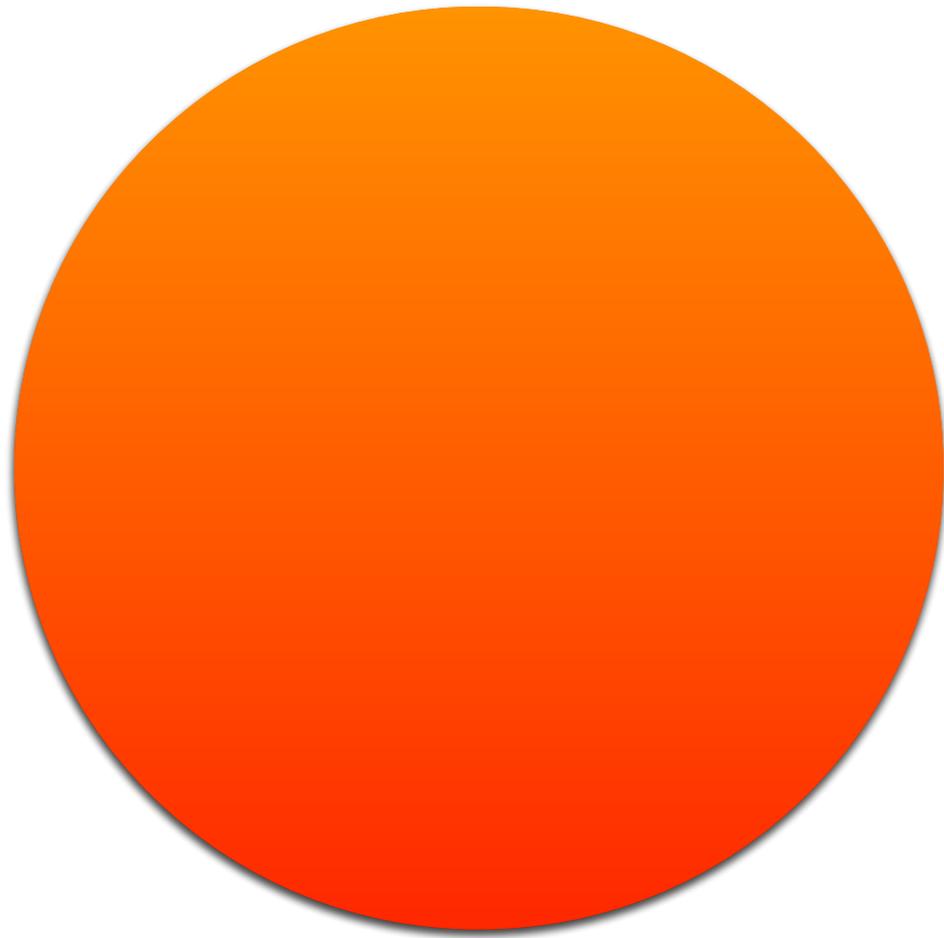
Efficient heat transport in HD189733b



The hot spot indicates heat recirculation

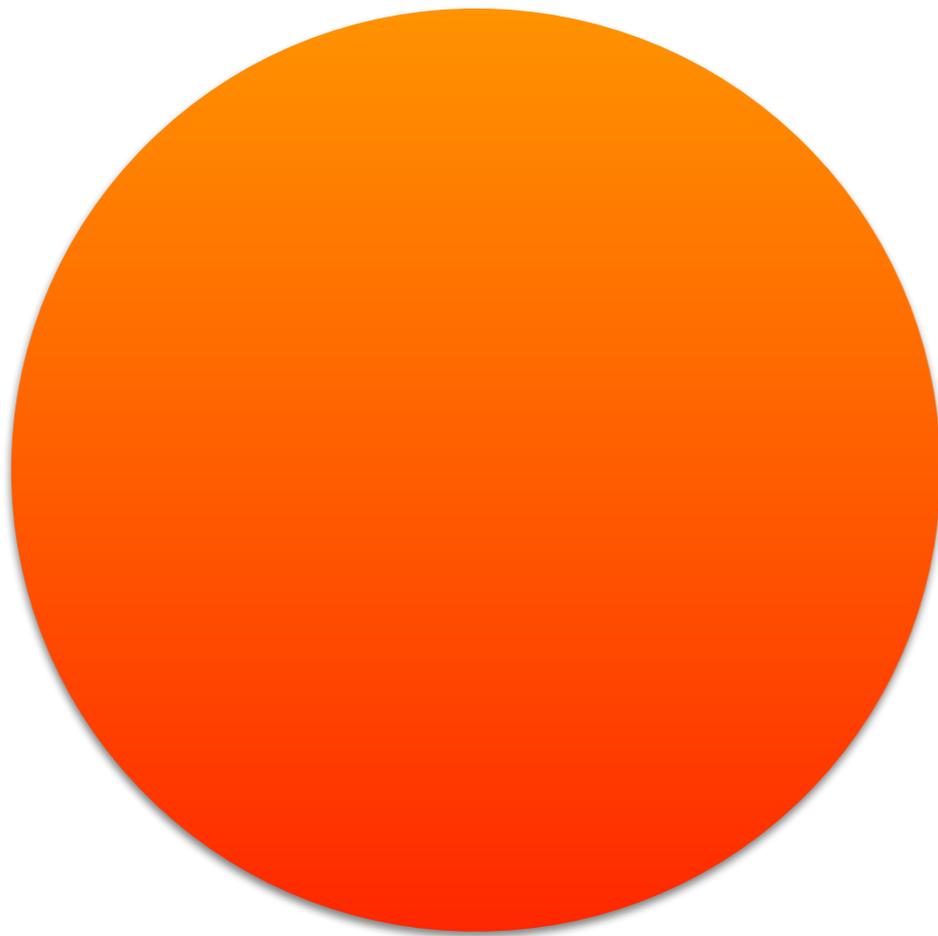


Phase-curves of super-Earth exoplanets



HD 189733b

Phase-curves of super-Earth exoplanets

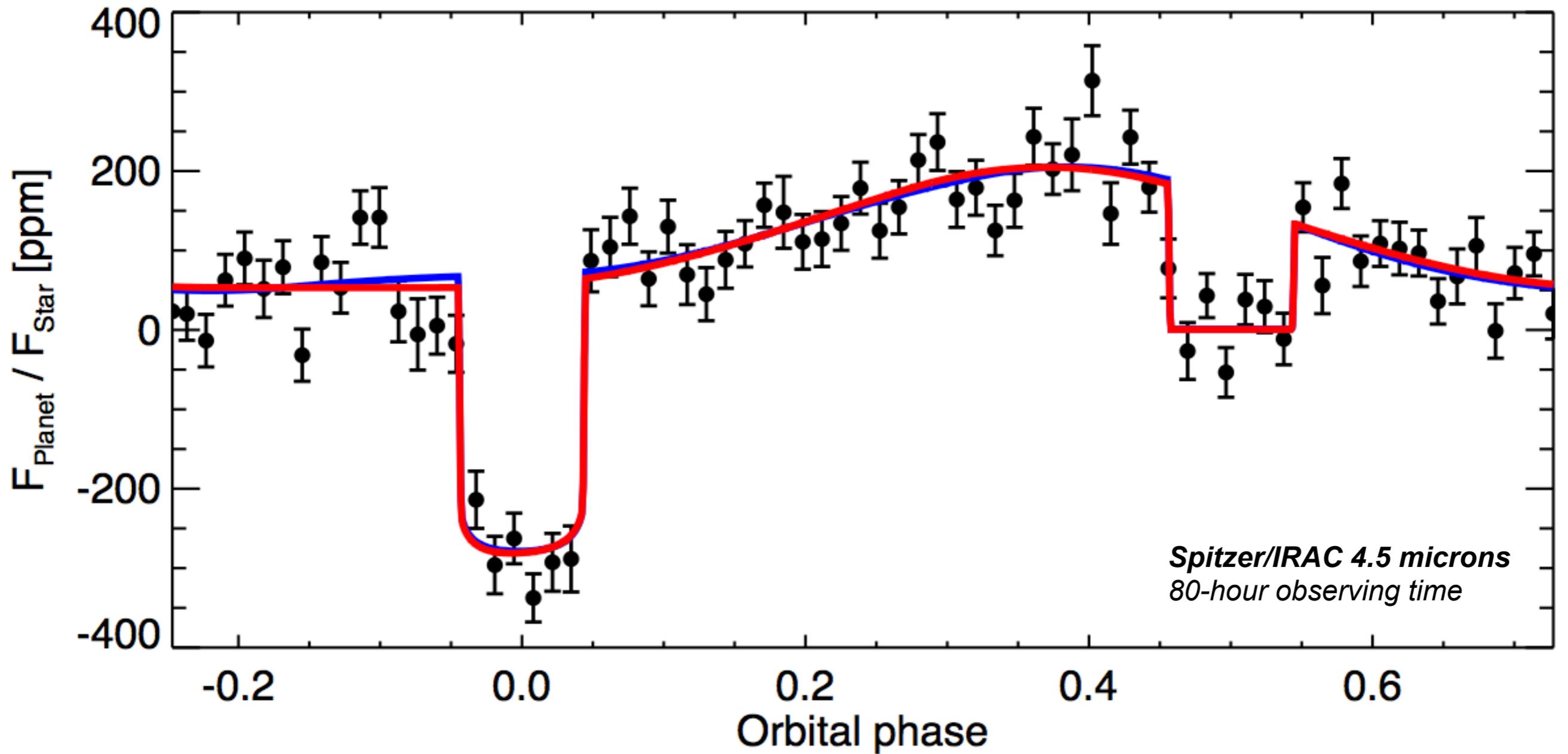


HD 189733b

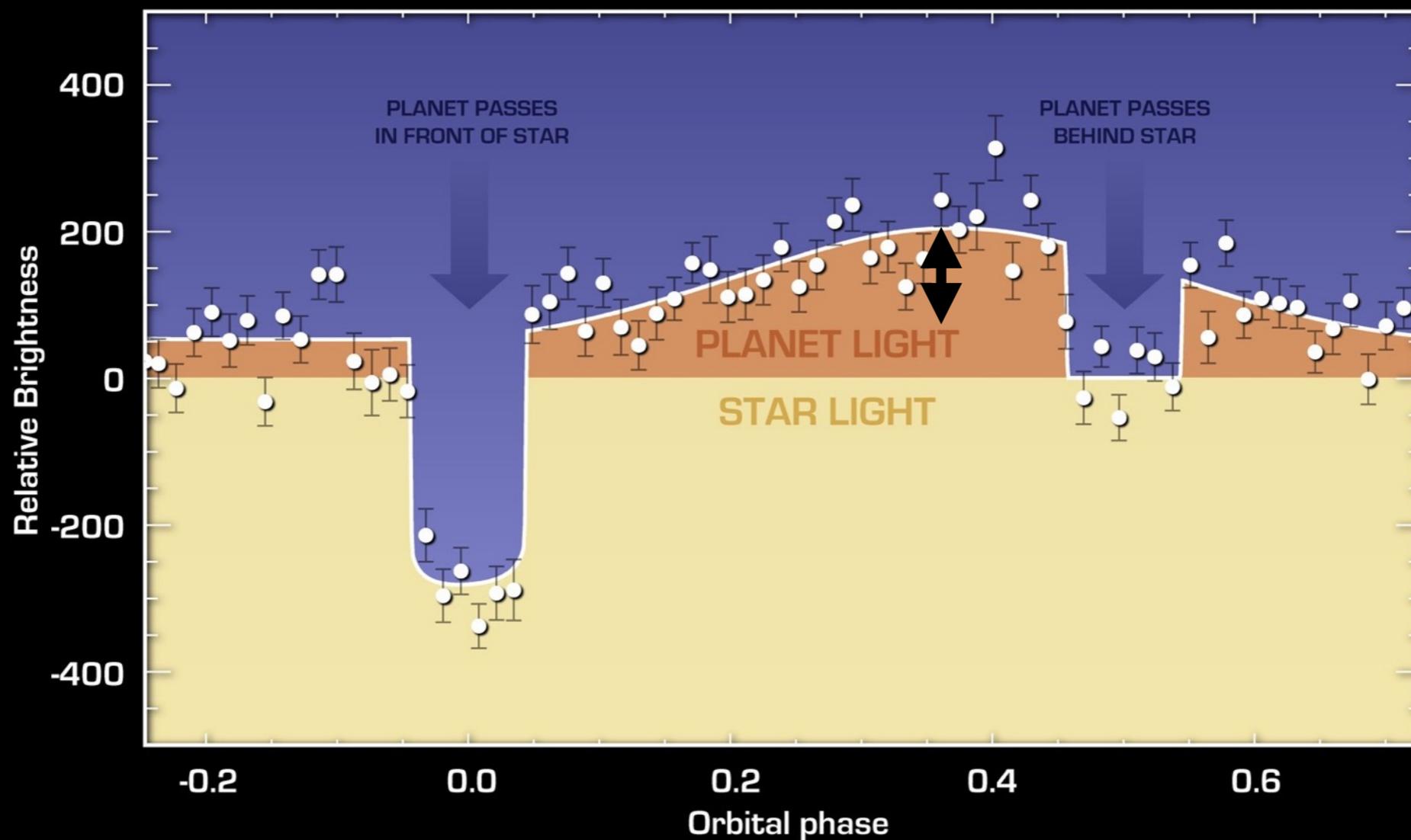


55 Cancri e

Temperature variations with longitude



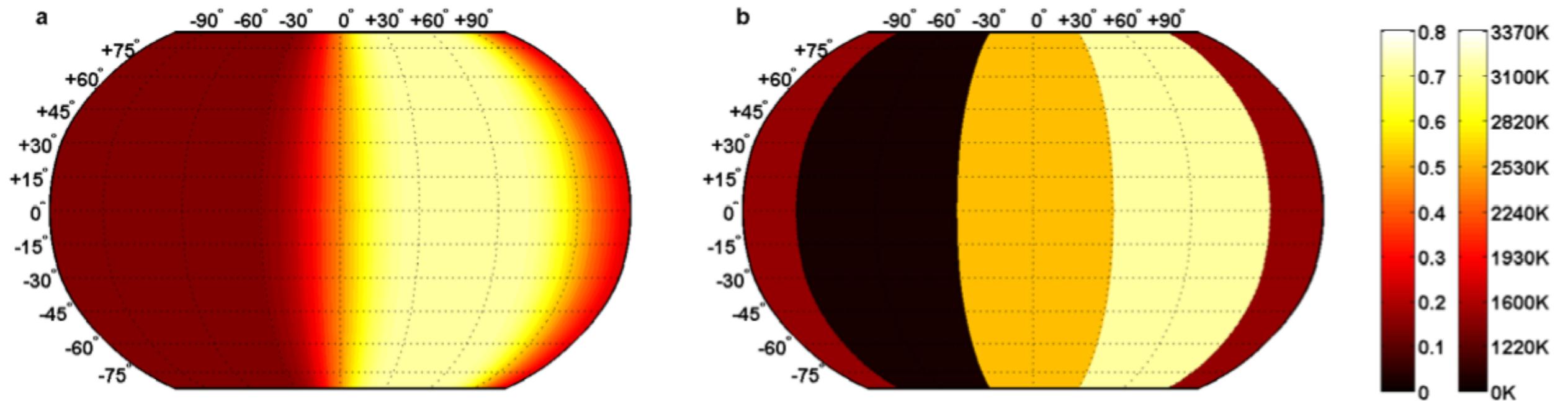
Temperature variations with longitude



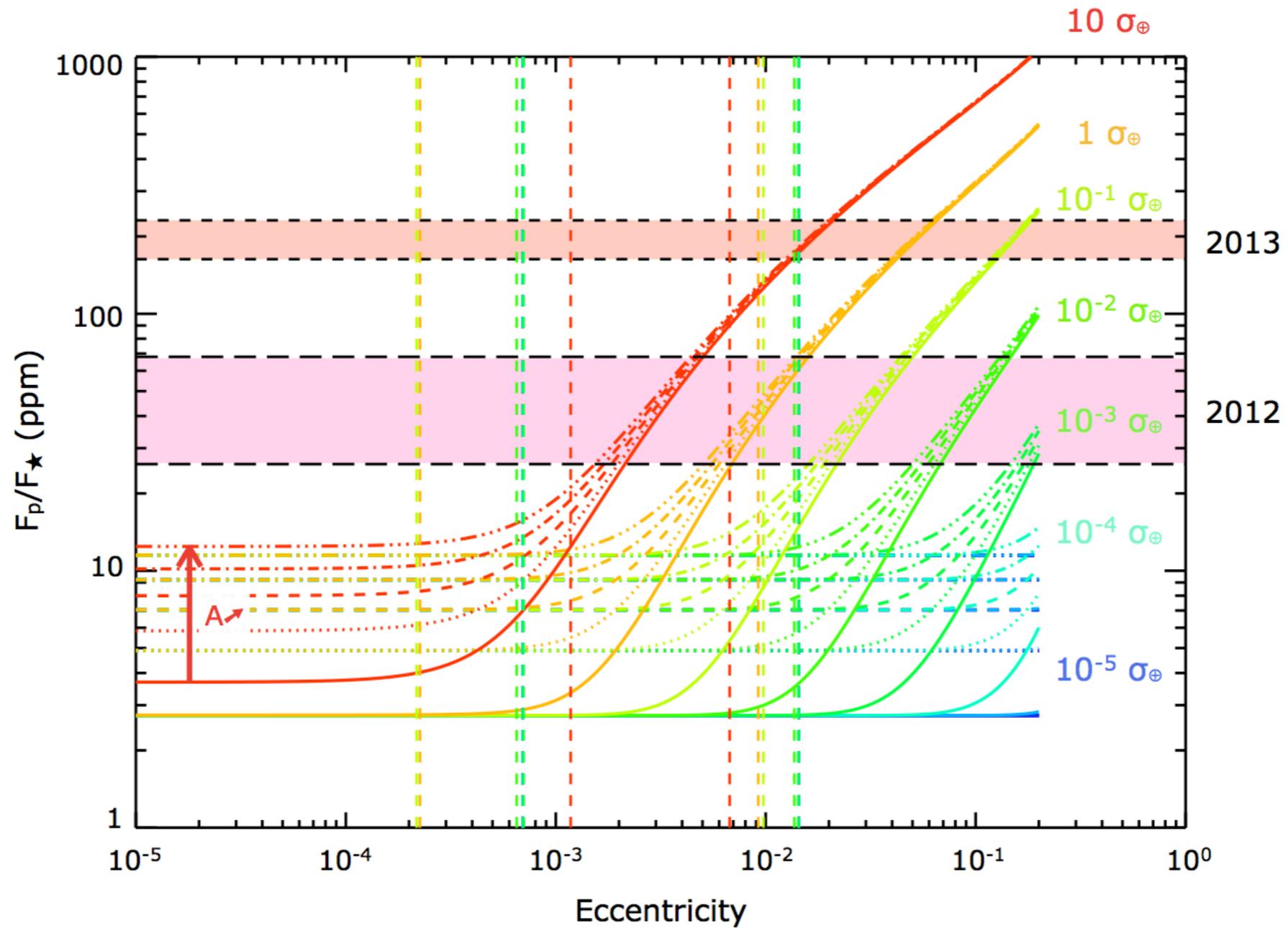
Light From Super-Earth 55 Cancri e
NASA / JPL-Caltech / B. Demory (Cavendish Laboratory)

Spitzer Space Telescope • IRAC
ssc2016-01a

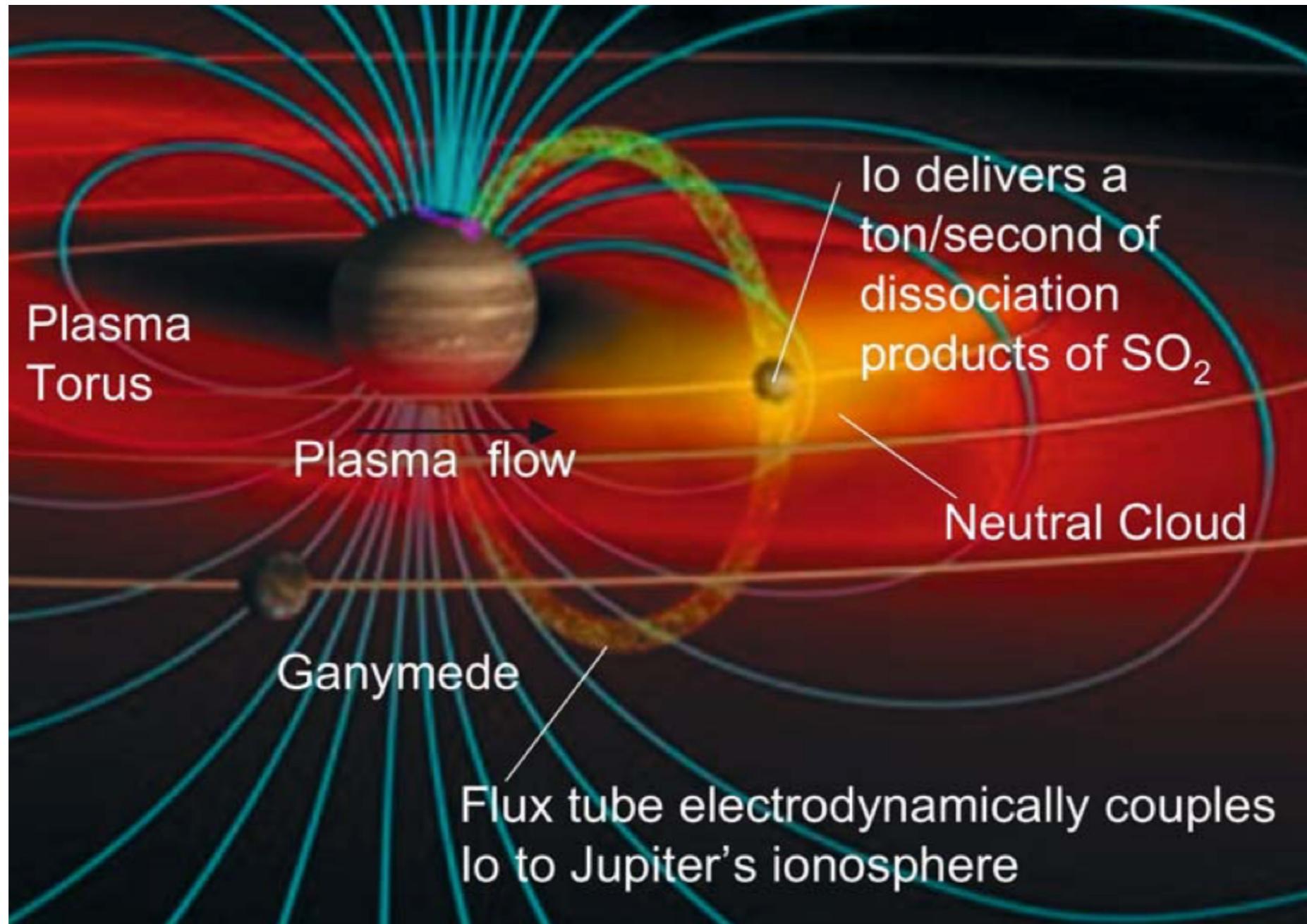
A strong day-night temperature contrast



Tidal heating is insufficient



Could 55 Cnc e share similarities with Io/Jupiter?



Summary

- **Data analysis for shallow signals is challenging.** Good understanding of systematics is crucial. Some systematics are SNR-regime-dependent.
- Exoplanets **are not immutable**
- Despite having « benchmark » **small planets orbiting bright stars**, characterisation is extremely difficult.
- 55 Cancri e **does not circulate heat efficiently** from the dayside to the nightside, suggesting an atmosphere-less planet.

Paper and data (raw+corrected) available on [nature.com](https://www.nature.com) tonight.