FROM THE STAR TO THE TRANSITING EXOPLANET: CHARACTERISATION OF 55 CNC AND HD219134

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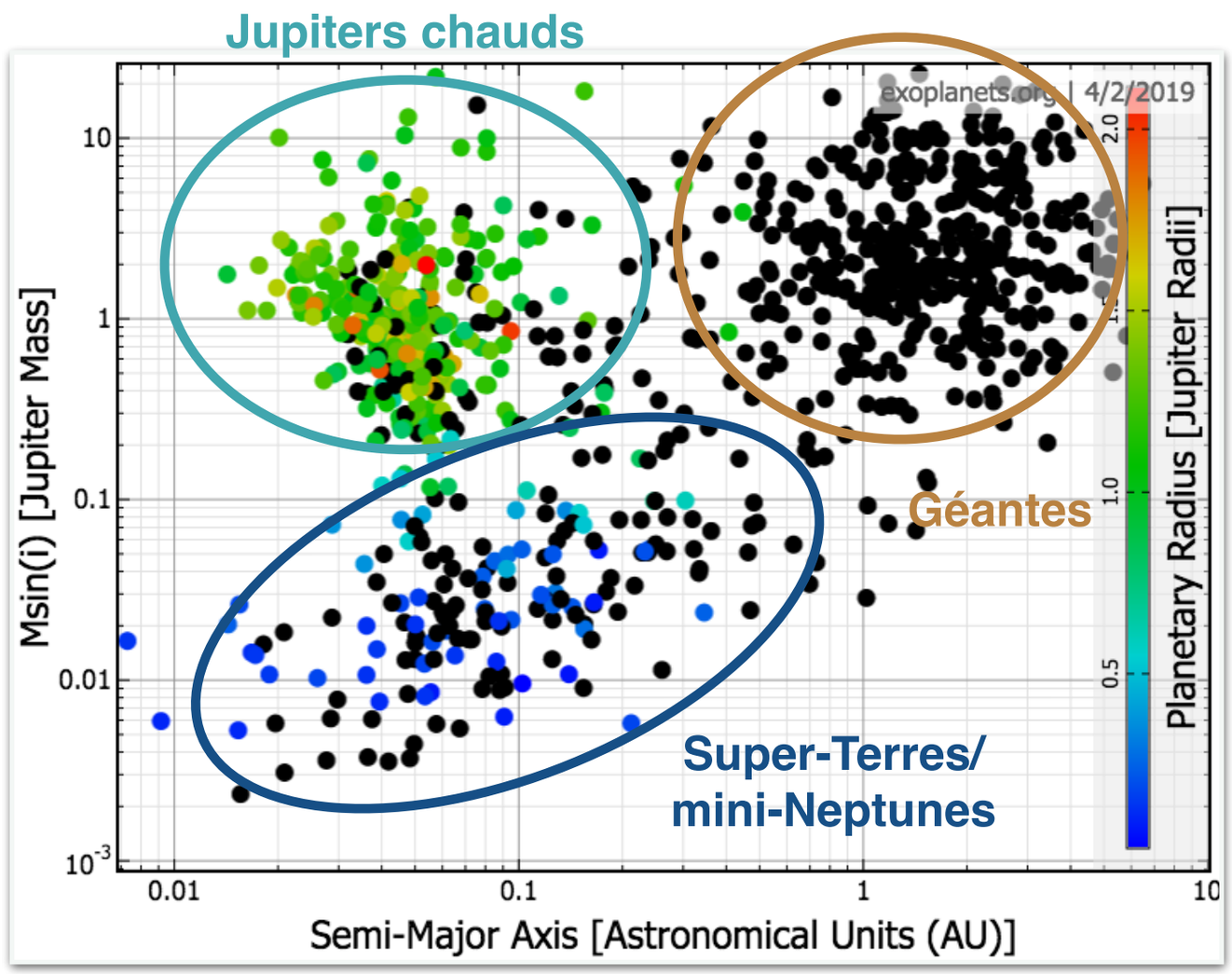
Nice, 4ème jour

Thousands of exoplanet discoveries…



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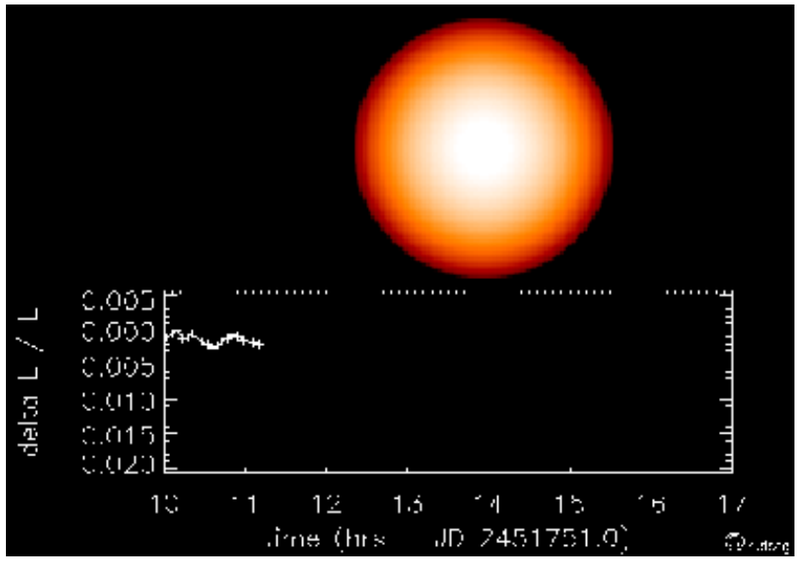
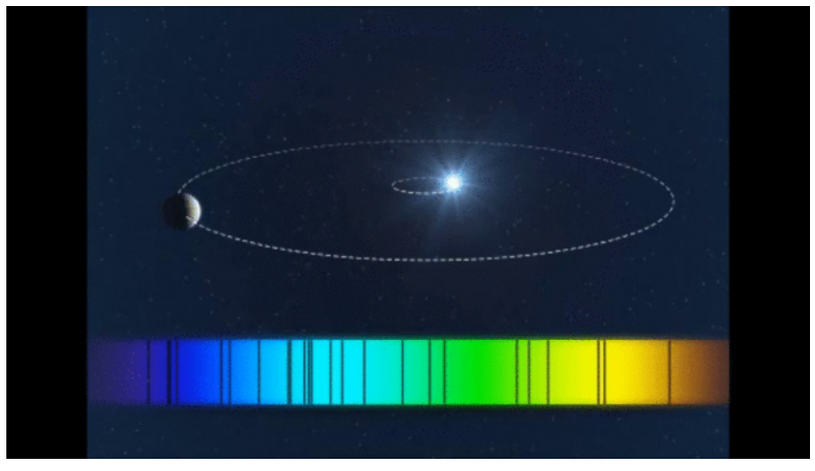
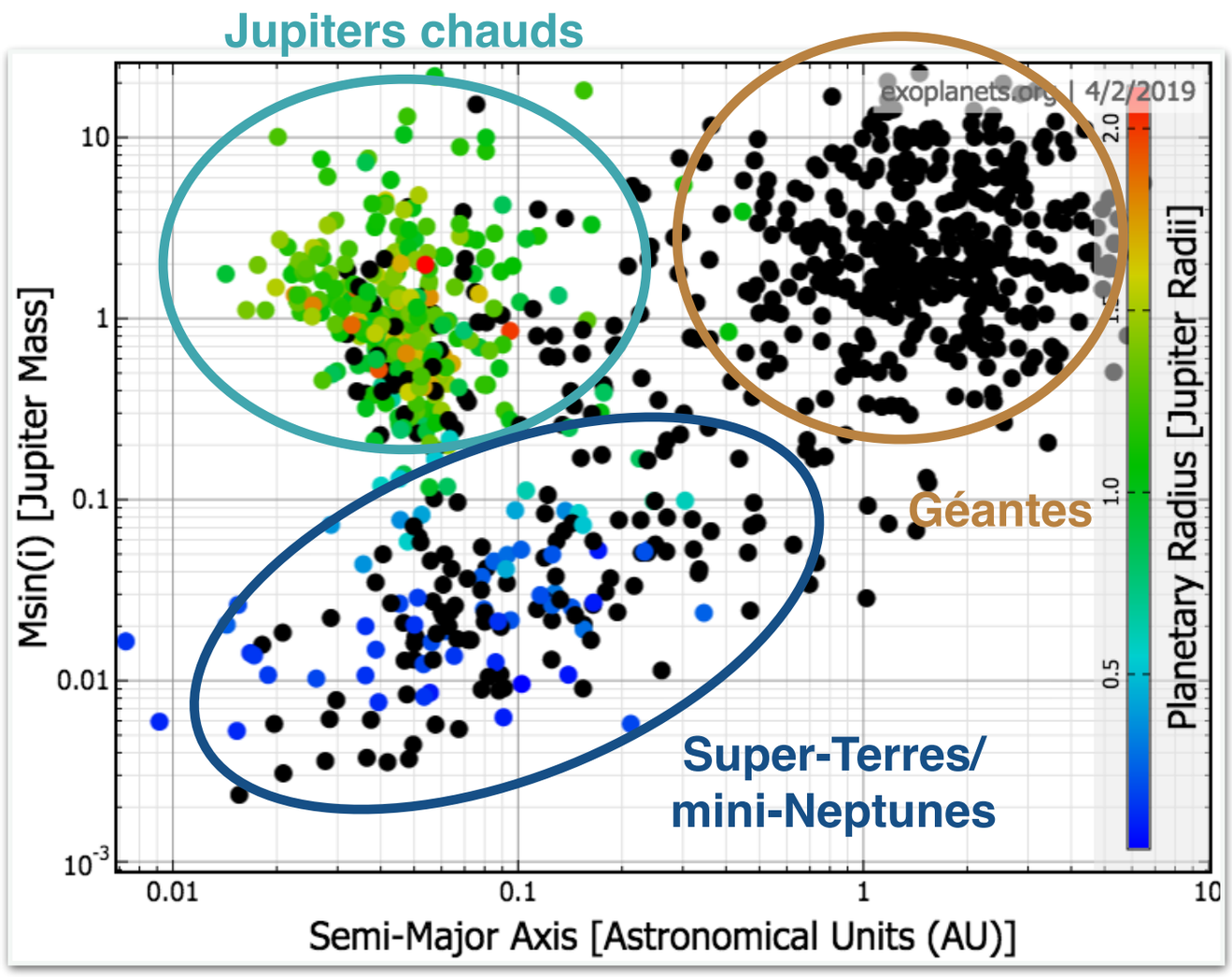


$$\frac{\Delta F}{F} = \left(\frac{R_P}{R_\star}\right)^2$$



$$\frac{\left(m_p \sin i\right)^3}{\left(M_\star + m_p\right)^2} = \frac{P}{2\pi G} K^3 (1-e)^{3/2}$$



→ M_p and R_p dependent on **R★** and **M★**

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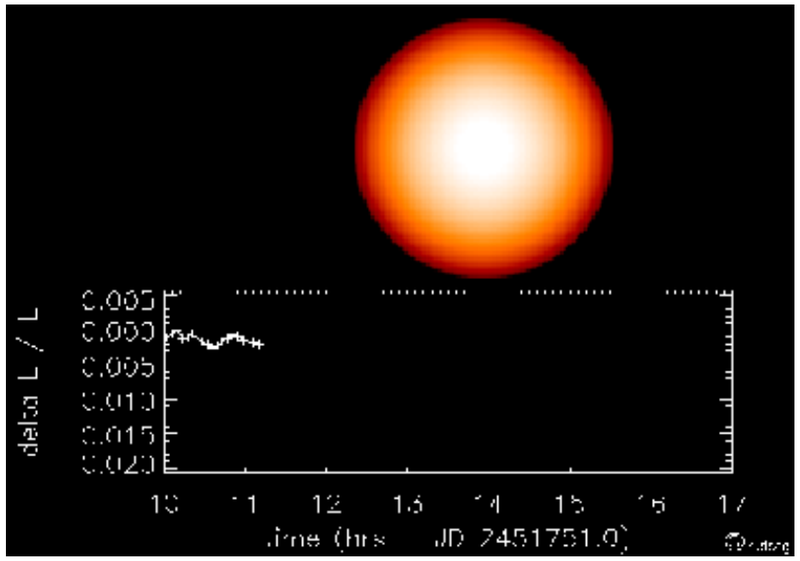

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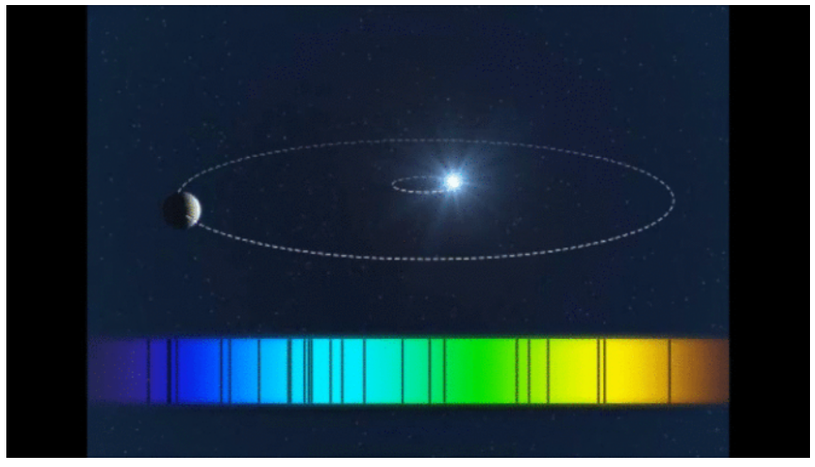

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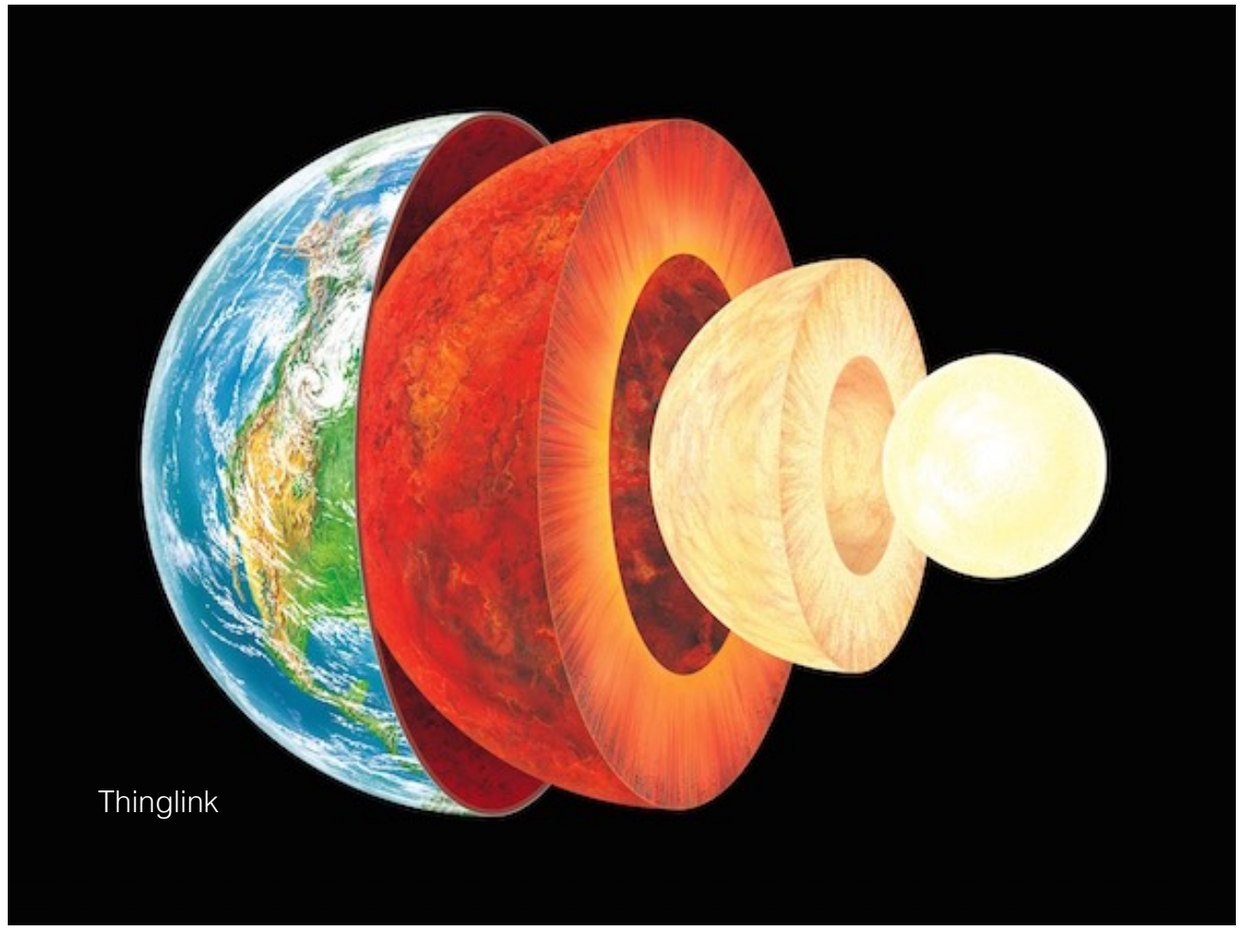
Internal composition



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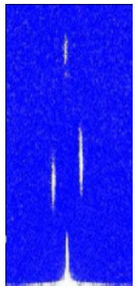
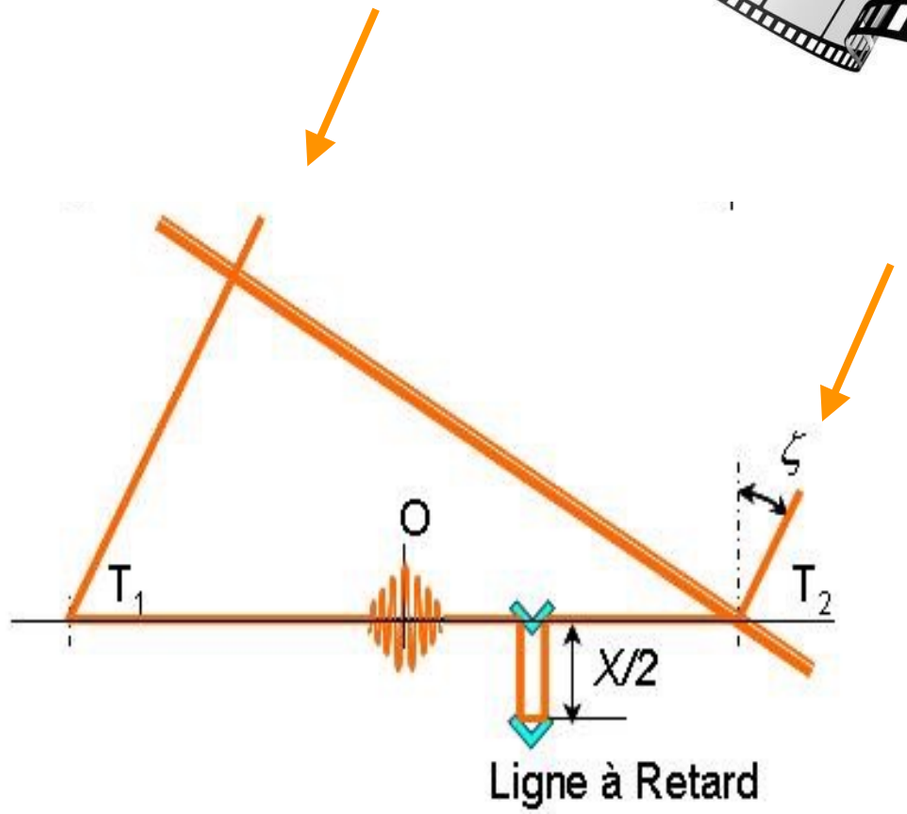
Basics of interferometry



Mode 3T

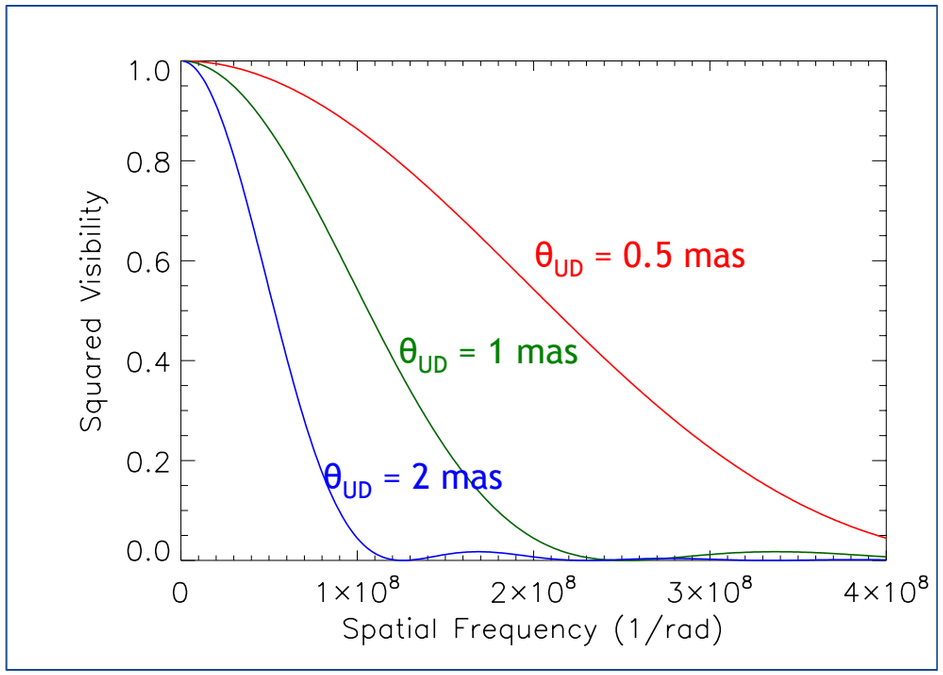


Contrast of fringes (V^2)
= TF of the surface brightness distribution of the star

Directly linked to the stellar angular diameter

Uniform disk:

$$V_\lambda{}^2 \left(\frac{B}{\lambda}\right) = 4 \left|\frac{J_1(z)}{z}\right|^2 \quad \text{with} \quad z = \pi\theta_{UD} B/\lambda$$



Stellar radius and effective temperature

Interferometric angular diameter

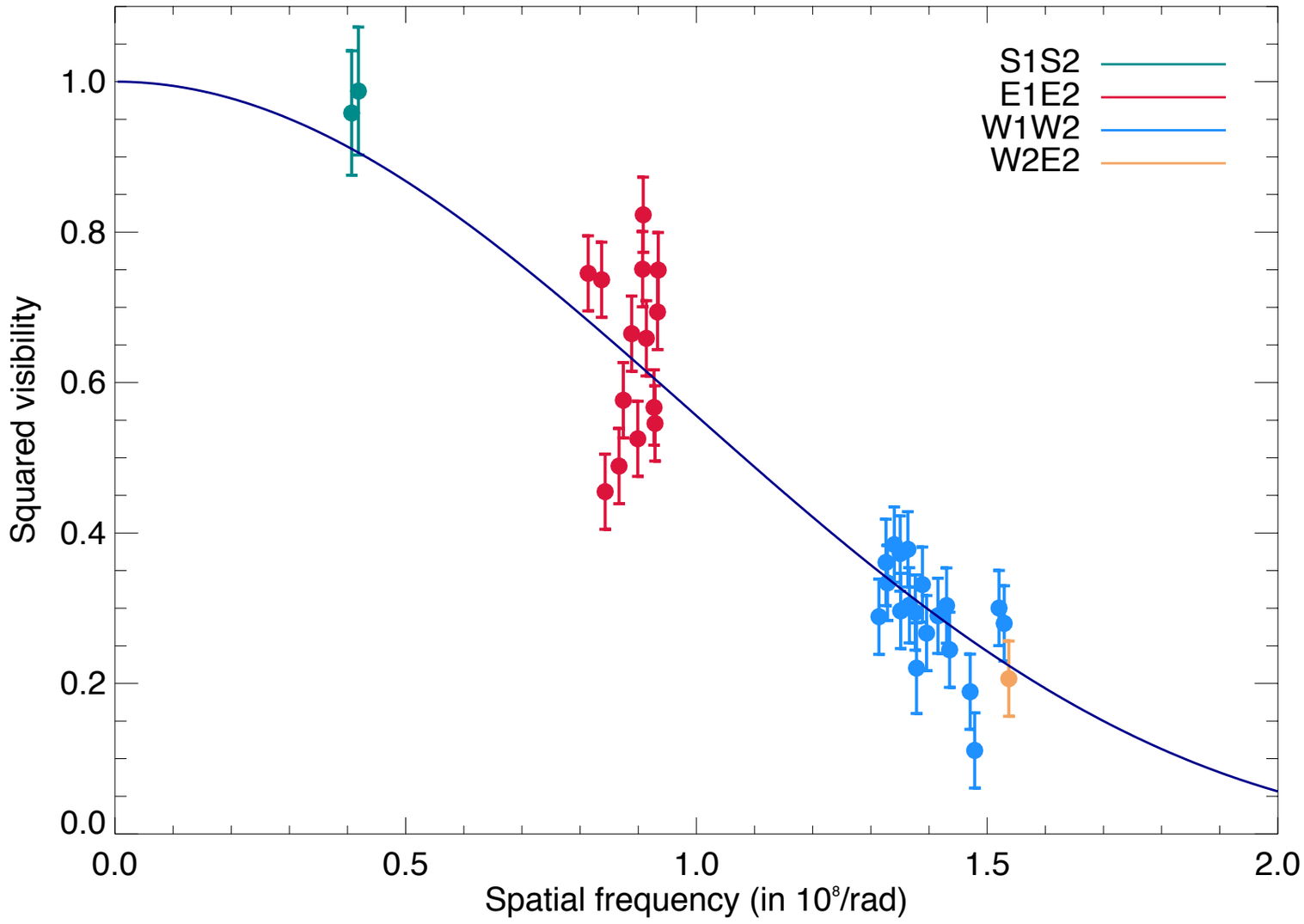
Gaia distance

$$R_{\star[R_\odot]} = \frac{\theta_{\mathrm{LD[mas]}} \times d_{[\mathrm{pc}]}}{9.305} .$$

SED

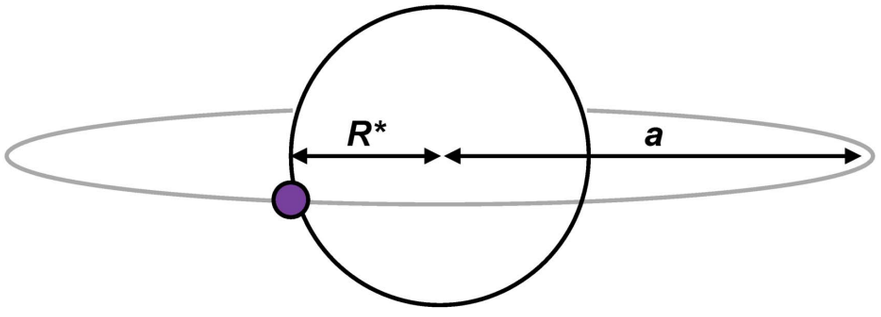
$$T_{\mathrm{eff},\star} = \left(\frac{4 \times F_{\mathrm{bol}}}{\sigma_{\mathrm{SB}} \theta^2_{\mathrm{LD}}} \right)^{0.25}$$

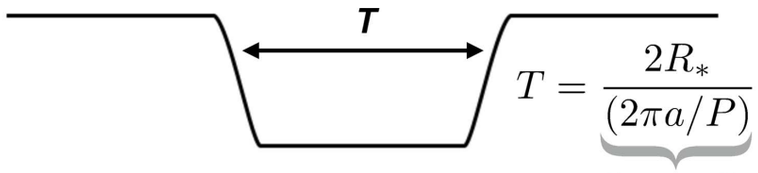
Interferometric angular diameter



HD219134
Ligi et al., in prep.

Stellar density from transit light curve





$$T = \frac{2R_*}{\underbrace{(2\pi a/P)}_{\lim e \to 0}}$$

3rd Kepler law

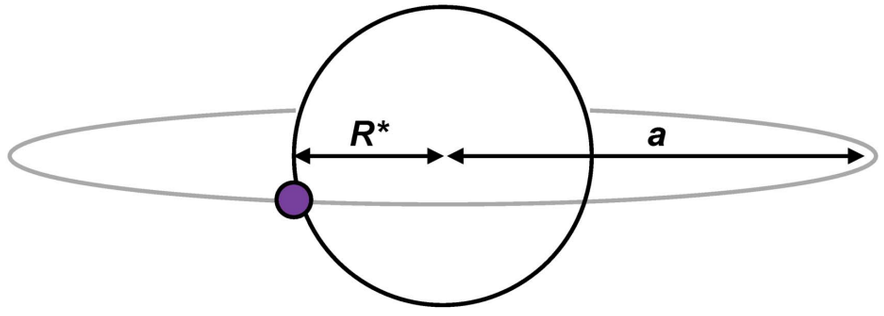
$$\frac{P^2}{4\pi^2} = \frac{a^3}{G(M_* + M_p)} \simeq \frac{a^3}{GM_*}$$

Measure of stellar density $\rho_\star$

(Maxted et al. 2015, Seager & Mallén-Ornelas 2003)

$$P/T^3 = (\pi^2 G/3)\,\rho_\star$$

Stellar density from transit light curve



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interferometry

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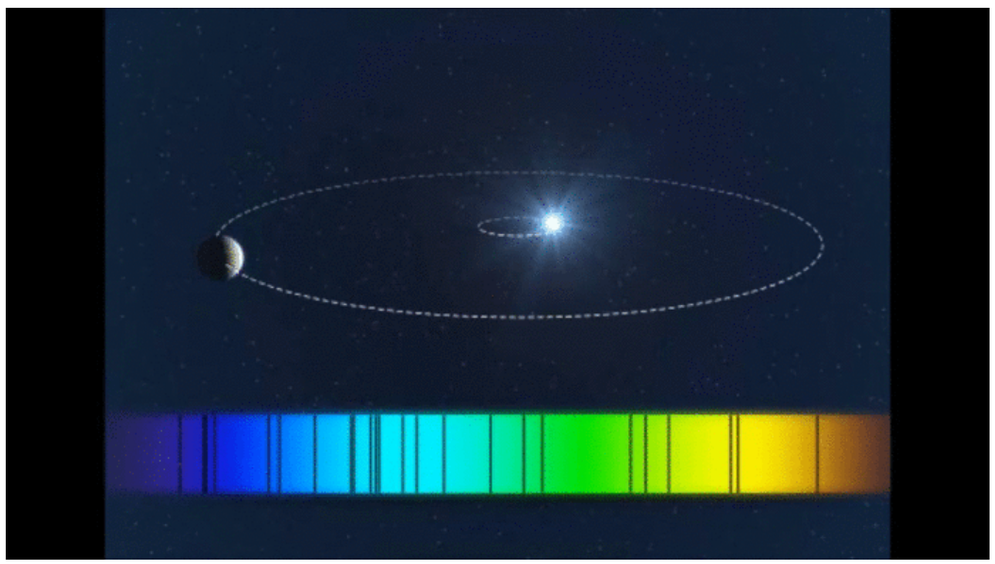

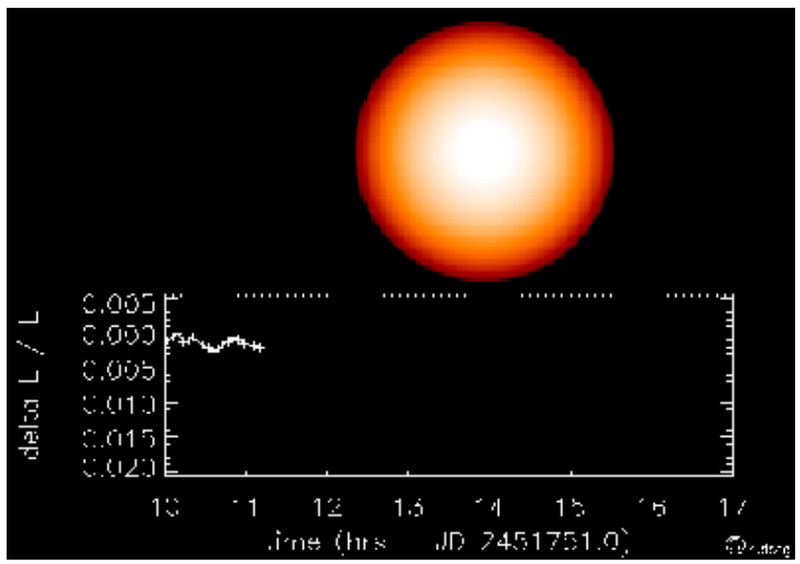

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$$\frac{\Delta F}{F} = \left(\frac{R_P}{R_\star}\right)^2$$

M_p R_p

Model-independent parameters

Measure of stellar mass $M_\star = (4\pi/3) R_\star^3 \rho_\star$

interferometry

The star: 55 Cnc

PDF

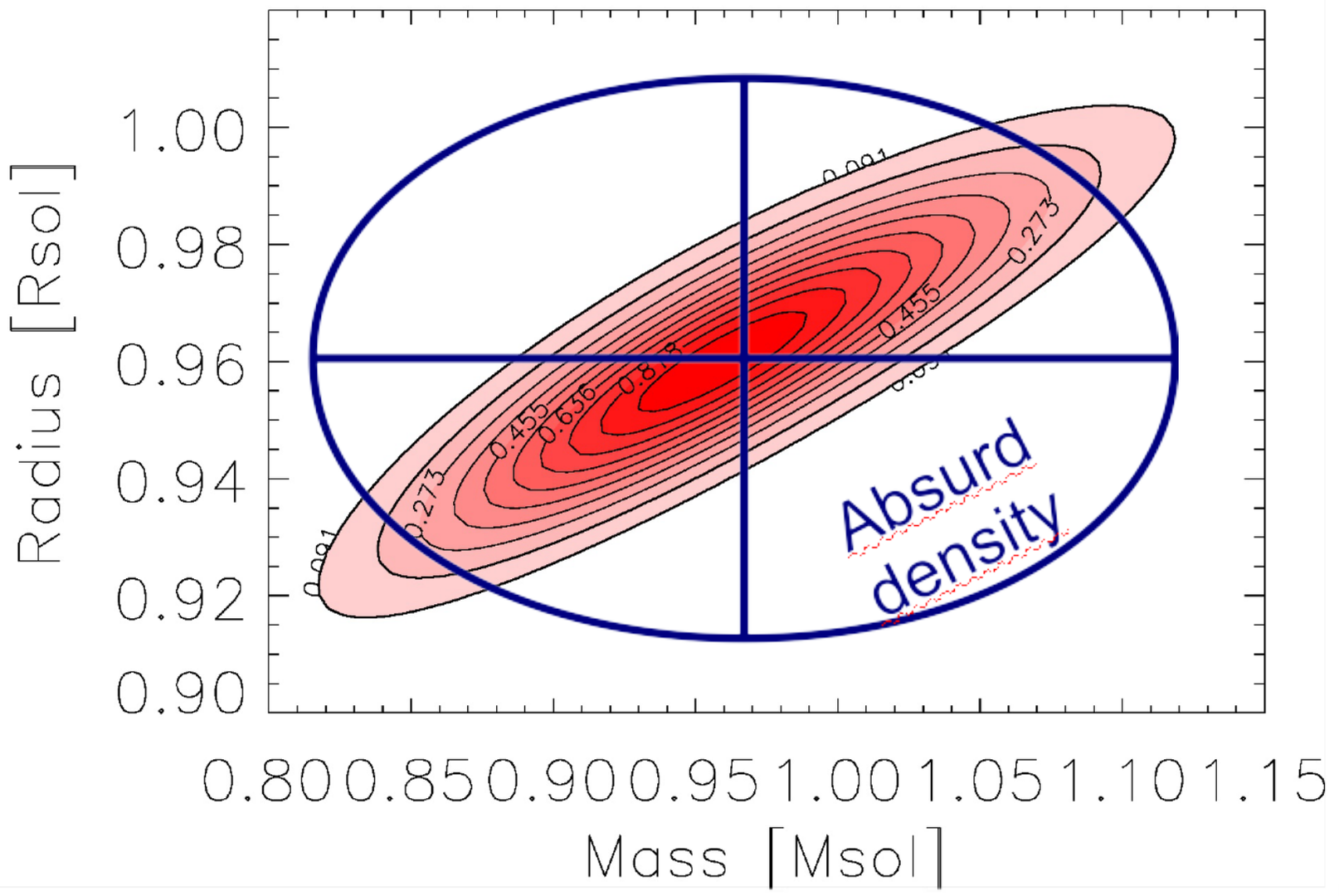
$R_\star$ =0.980±0.016 $R_\odot$

$\rho_\star$ =1.015±0.051 $\rho_\odot$

Joint PDF

$M_\star$ =1.015±0.051 $M_\odot$

Correlation ($M_\star$ - $R_\star$) = 0.995!



Crida, Ligi et al. 2018 a,b
Ligi et al. 2016

The transiting planet: 55 Cnc e

PDF

R_p = 1.947±0.038 $R_\oplus$

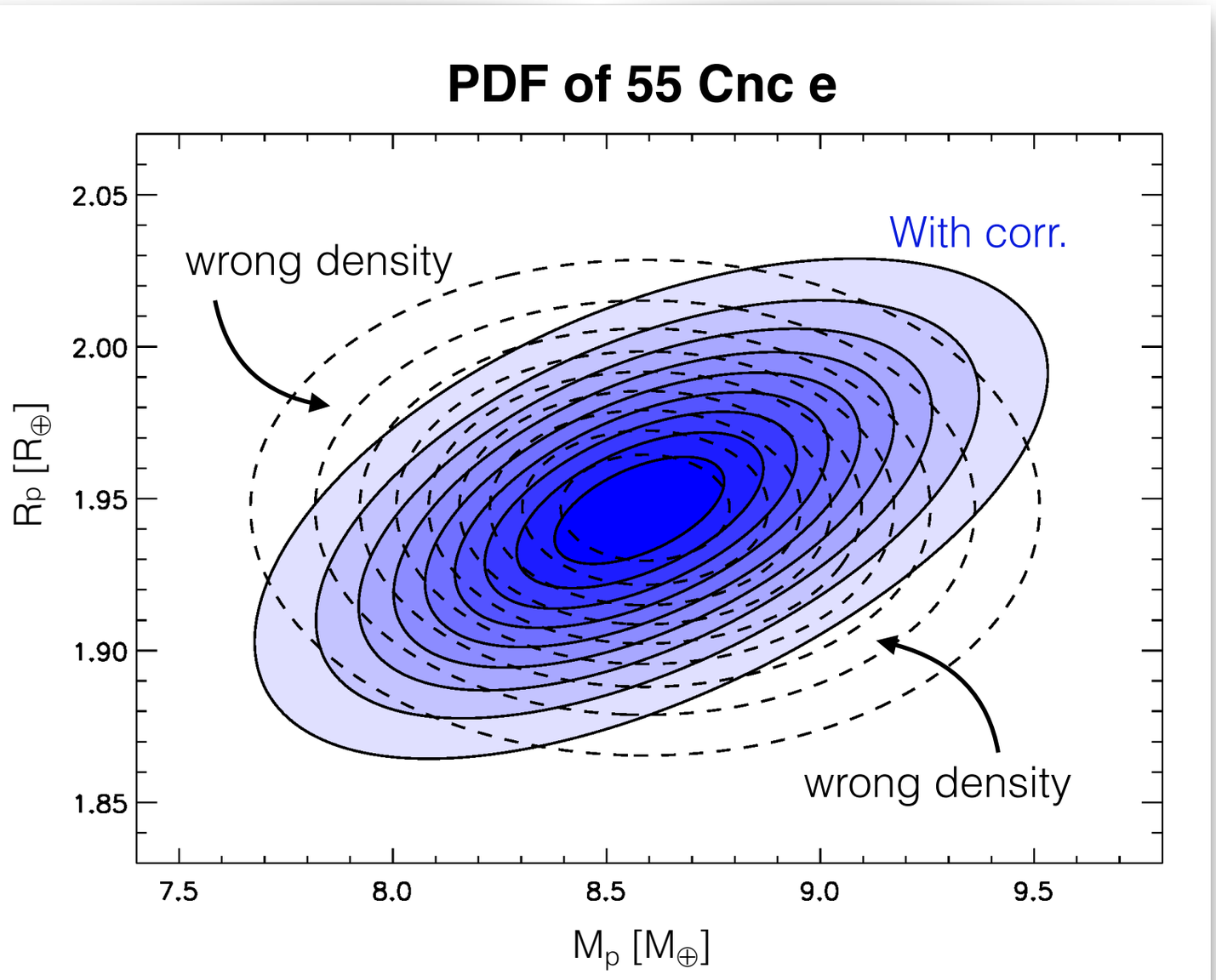
M_p = 8.59±0.43 $M_\oplus$

Joint PDF

ρ_p =1.164±0.062$\rho_\oplus$

= 6421±342 kg.m^3

Correlation (M_p - R_p)=0.54



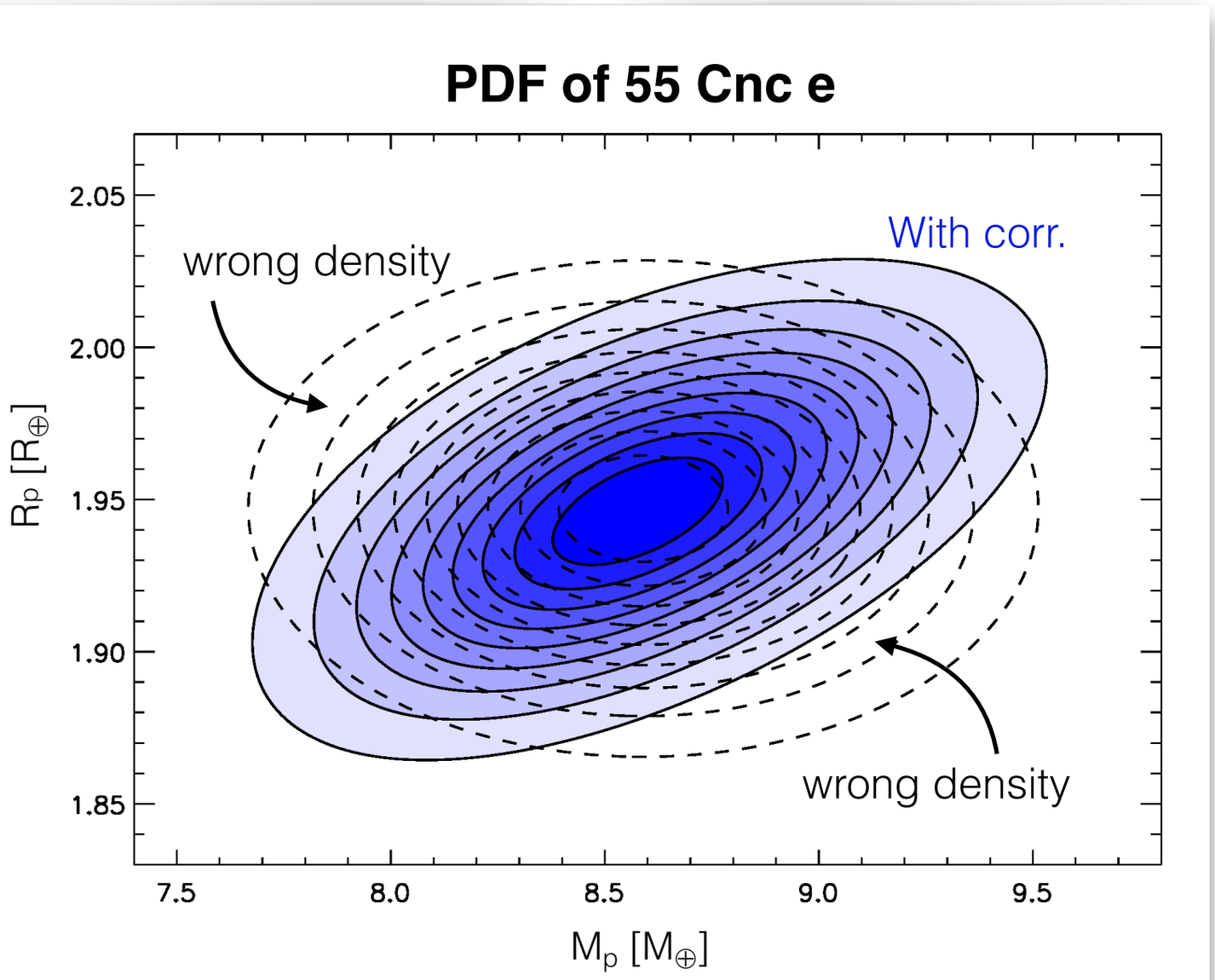
Crida, Ligi et al. 2018 a,b
Dorn et al. 2017

The transiting planet: 55 Cnc e

Atmosphere thickness
= **3% of R_p**

➔ not a good target for transmission spectroscopy

➔ chemistry of the interior non necessarily carbon-rich



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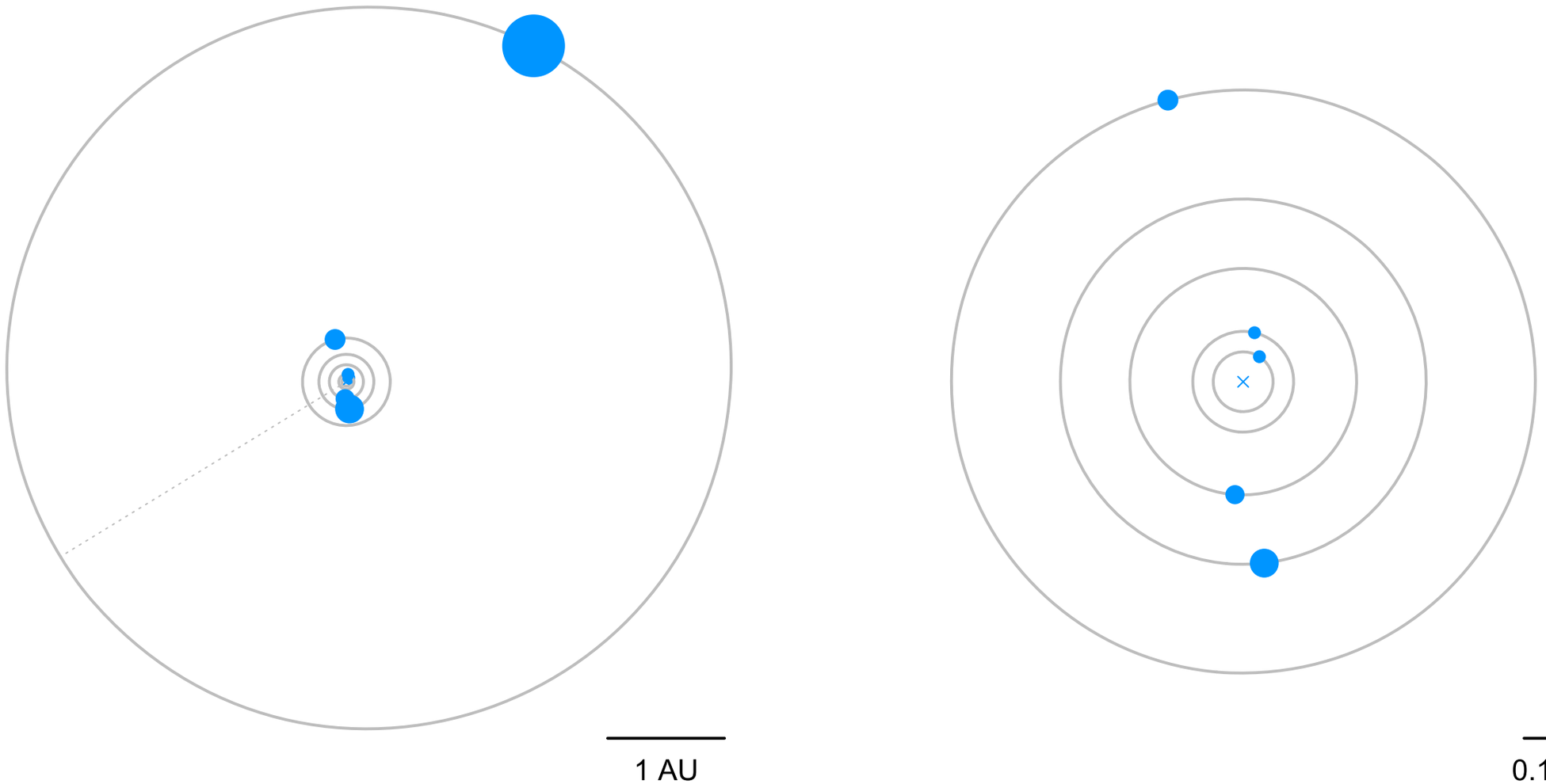
The star: HD219134



Vogt et al. 2015

The star: HD219134

PDF

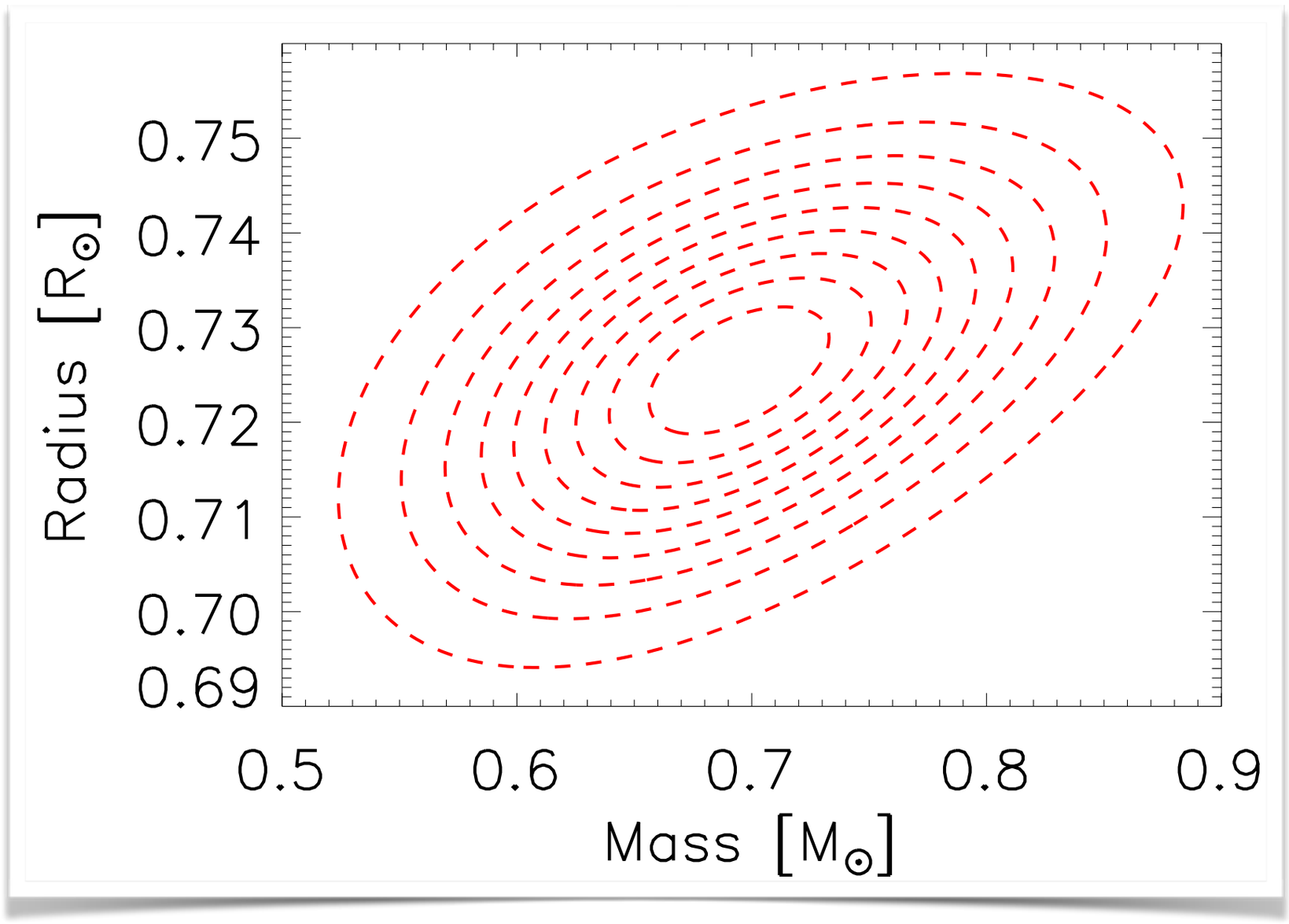
$R_\star = 0.726 \pm 0.014\ R_\odot$

$\rho_\star = 1.74 \pm 0.22\ \rho_\odot$

Joint PDF

$M_\star = 0.696 \pm 0.078\ M_\odot$

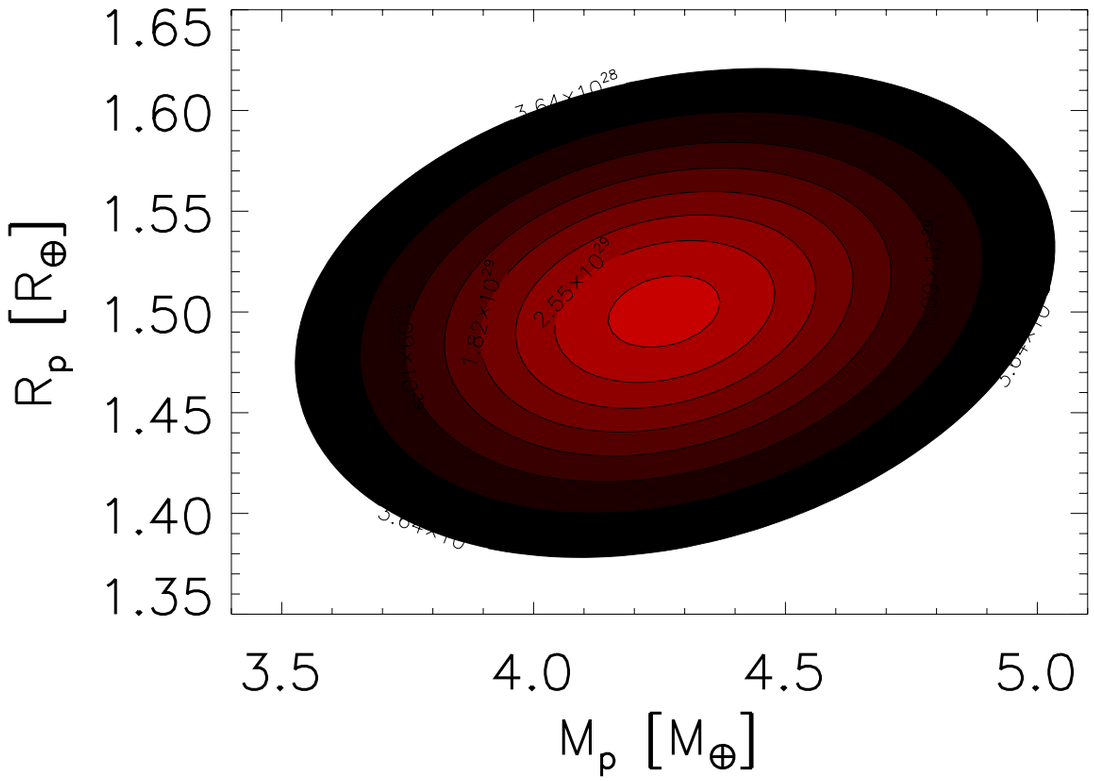
Correlation ($M_\star$ - $R_\star$) = 0.46



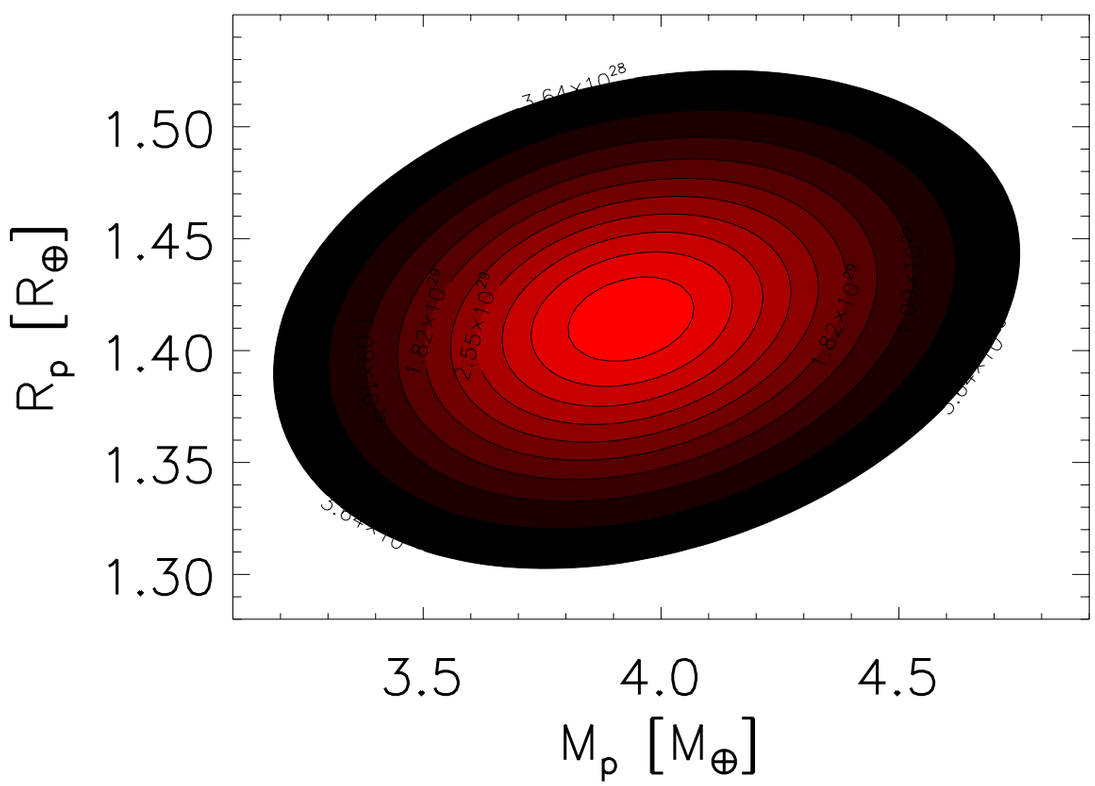
Ligi et al., in prep.

The two transting planets: HD219134 b & c

Planet b



Planet c

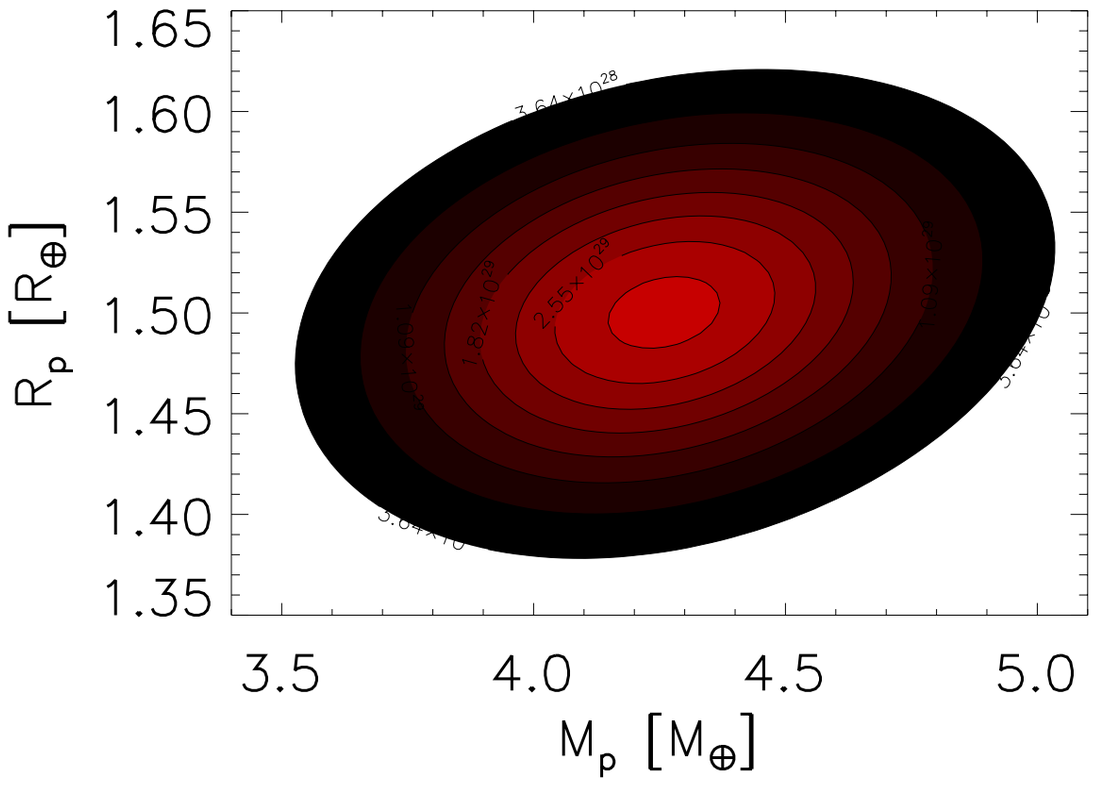


	PLANET B	PLANET C
Radius	1.50 ± 0.06 $R_\oplus$	1.41 ± 0.05 $R_\oplus$
Mass	4.27 ± 0.34 $M_\oplus$	3.96 ± 0.34 $M_\oplus$
Density	1.27 ± 0.16 $\rho_\oplus$	1.41 ± 0.17 $\rho_\oplus$
Corr. (M_p - R_p)	0.22	0.23

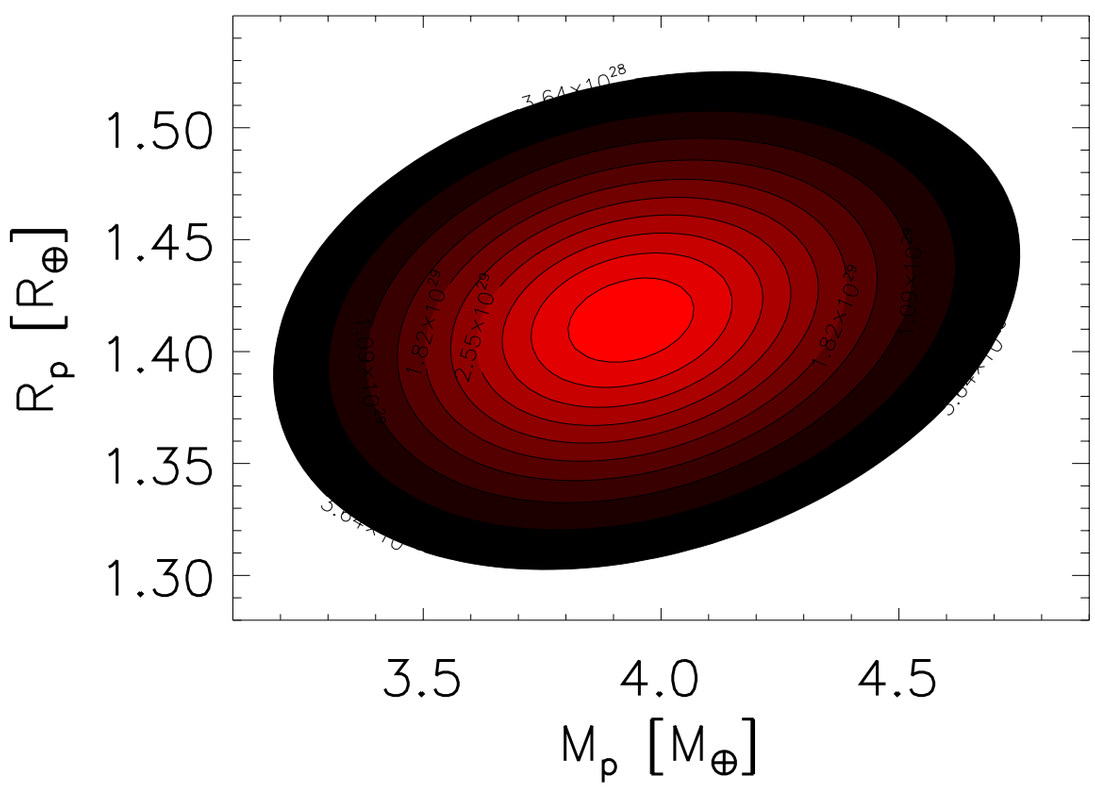
Ligi et al., in prep.

The two transting planets: HD219134 b & c

Planet b



Planet c



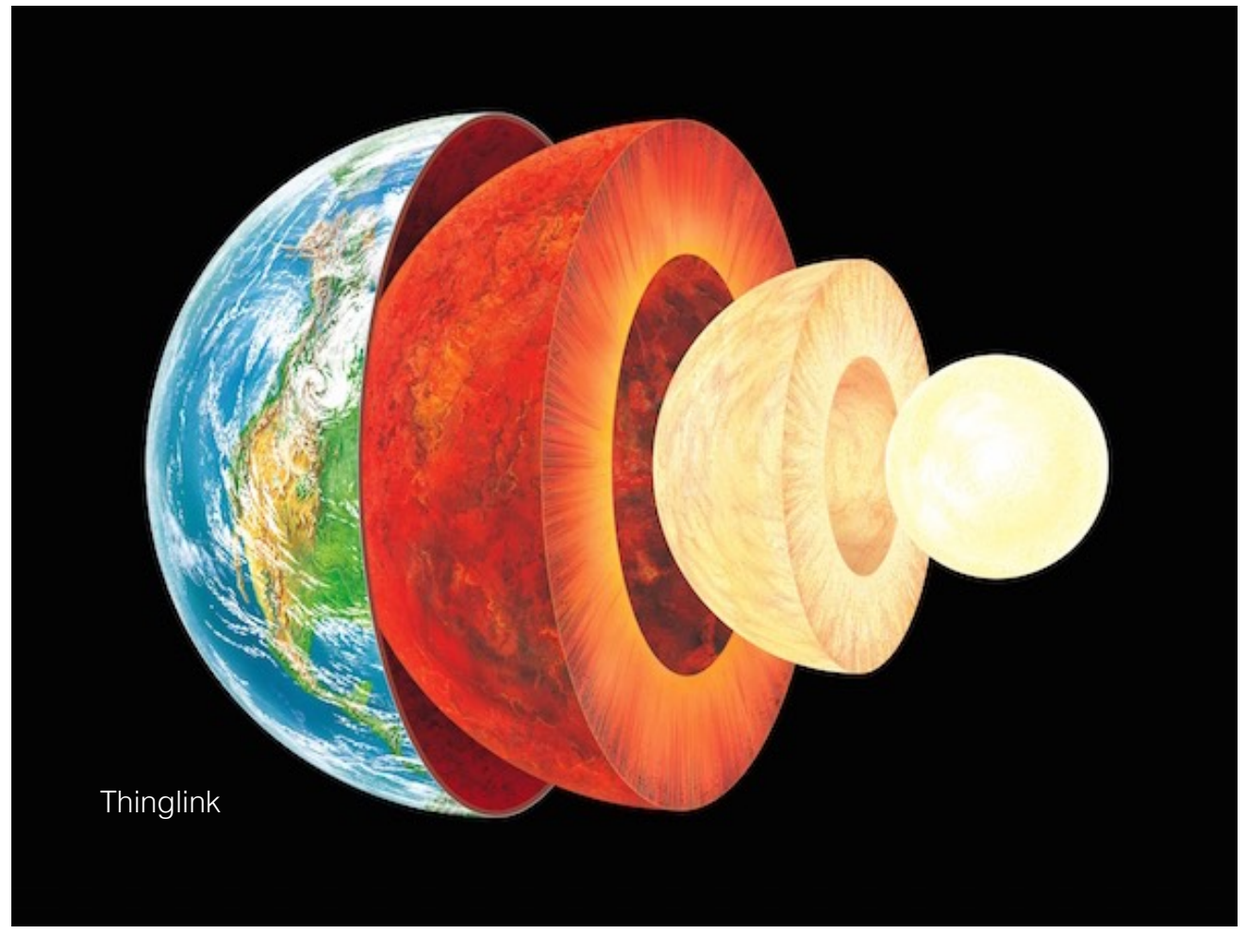
Different densities.
How to explain it?

Ligi et al.,
in prep.

The two transting planets: HD219134 b & c

Three hypothesis:

- Different volatile content
- Different rock composition
- Different state of rock



Ligi et al.,
in prep.

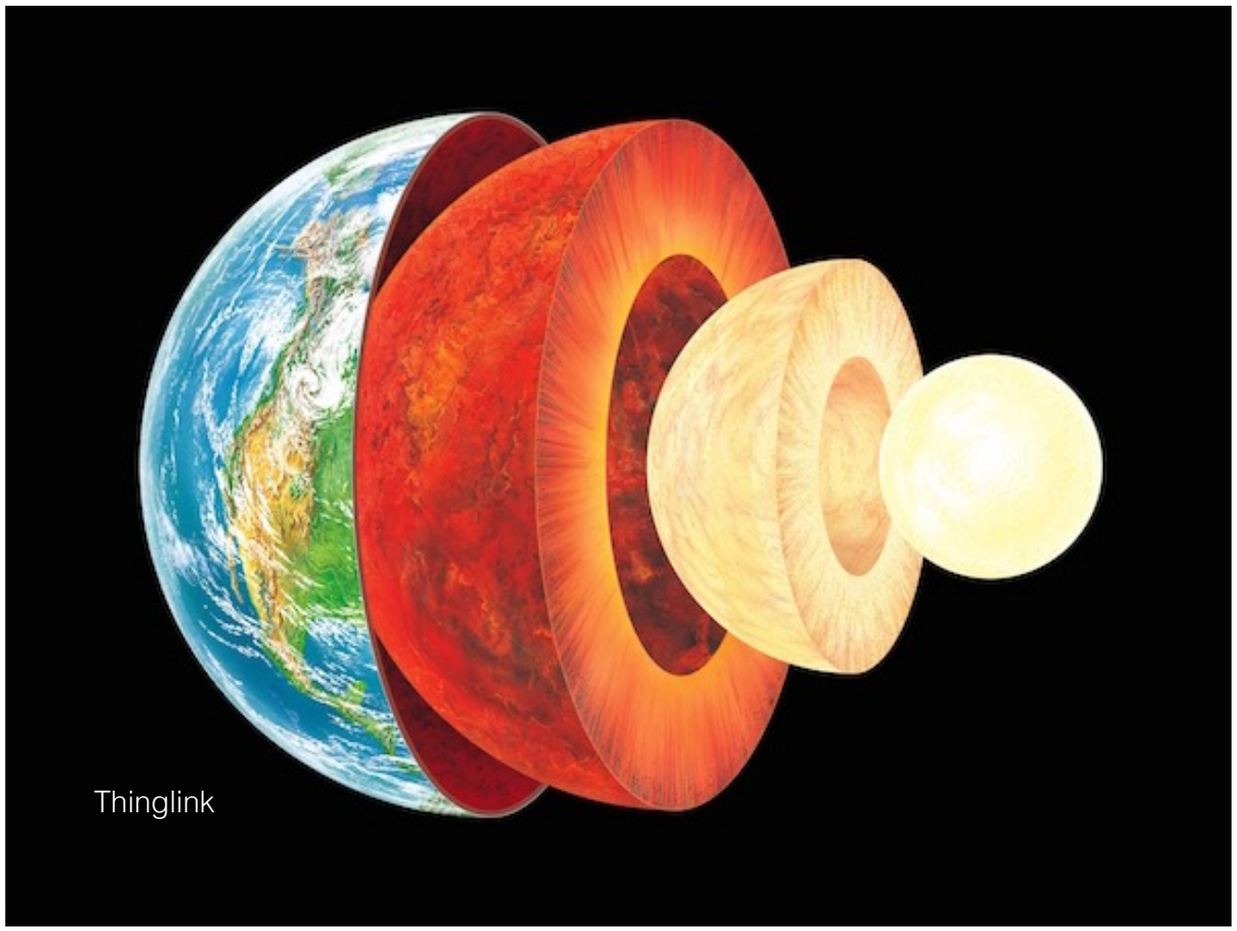
The two transting planets: HD219134 b & c

Three hypothesis:

- Different volatile content
- Different rock composition
- Different state of rock

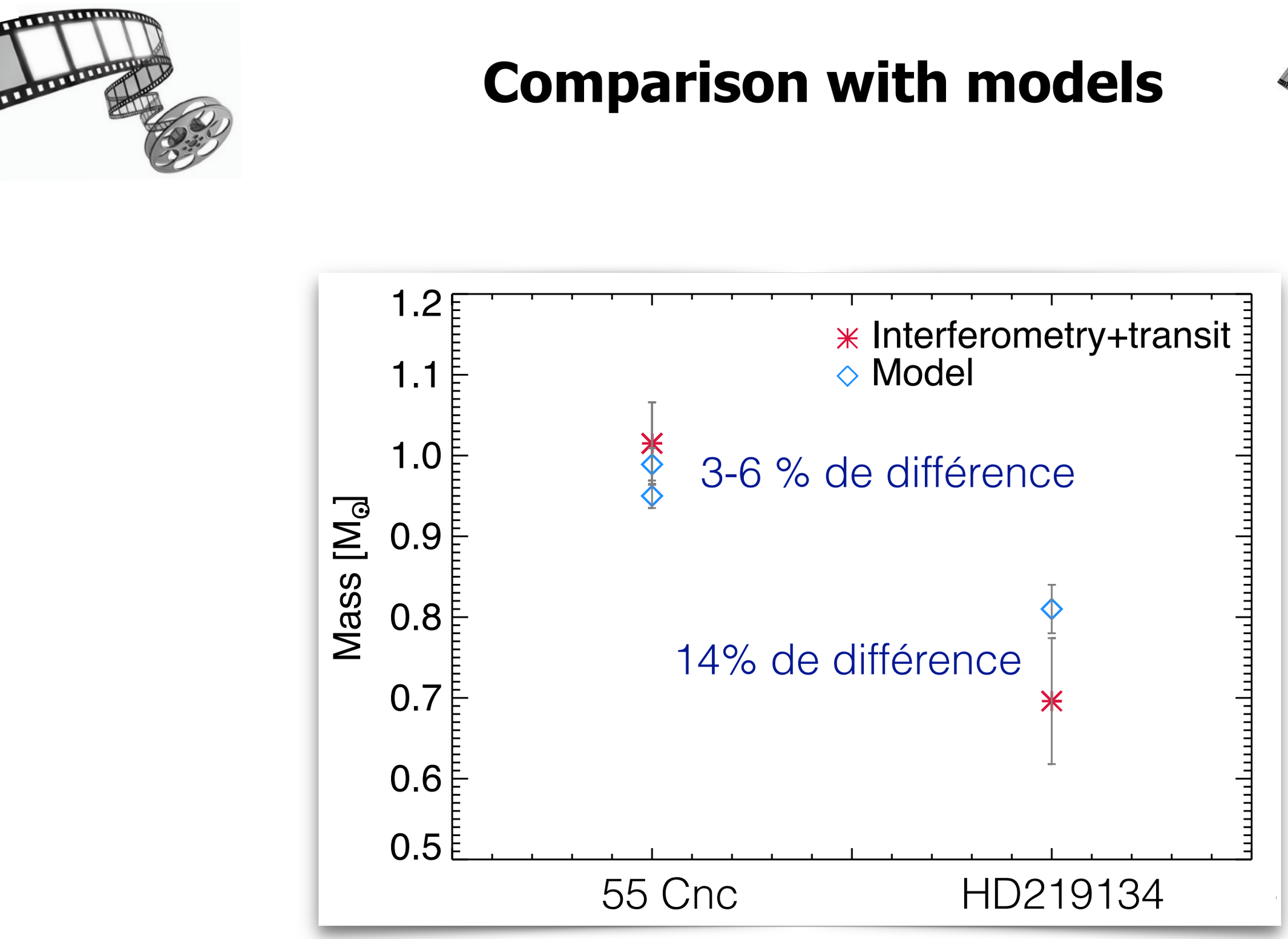
One could be molten

N-body simulations



Ligi et al., in prep.

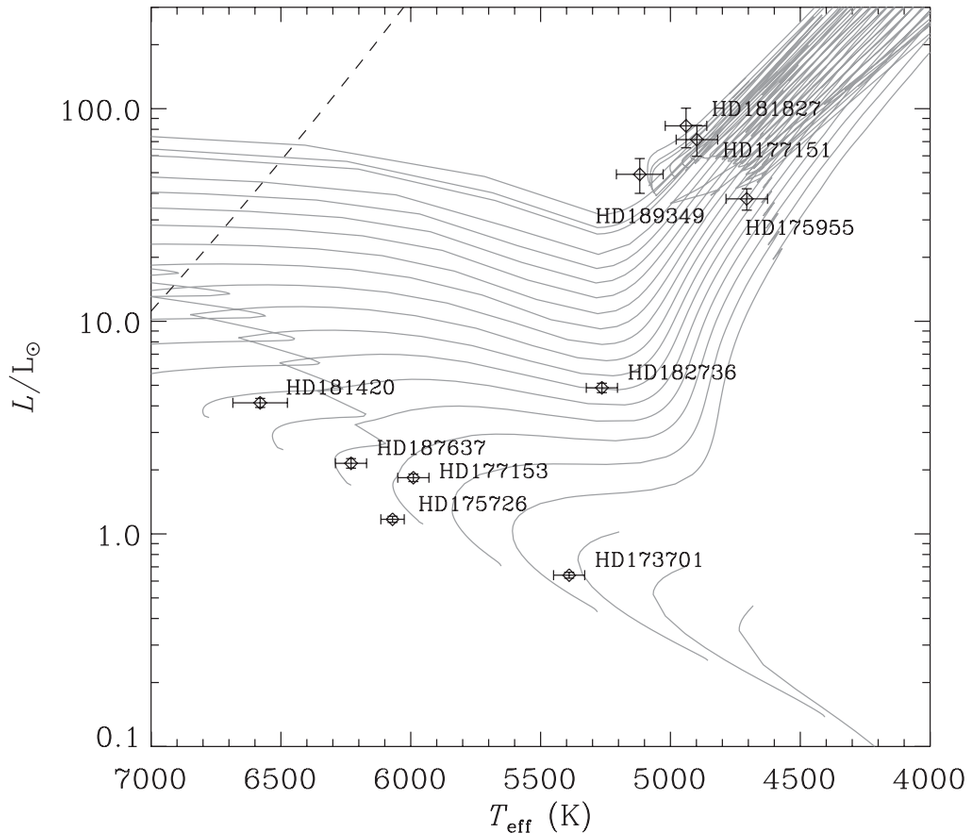
Comparison with models



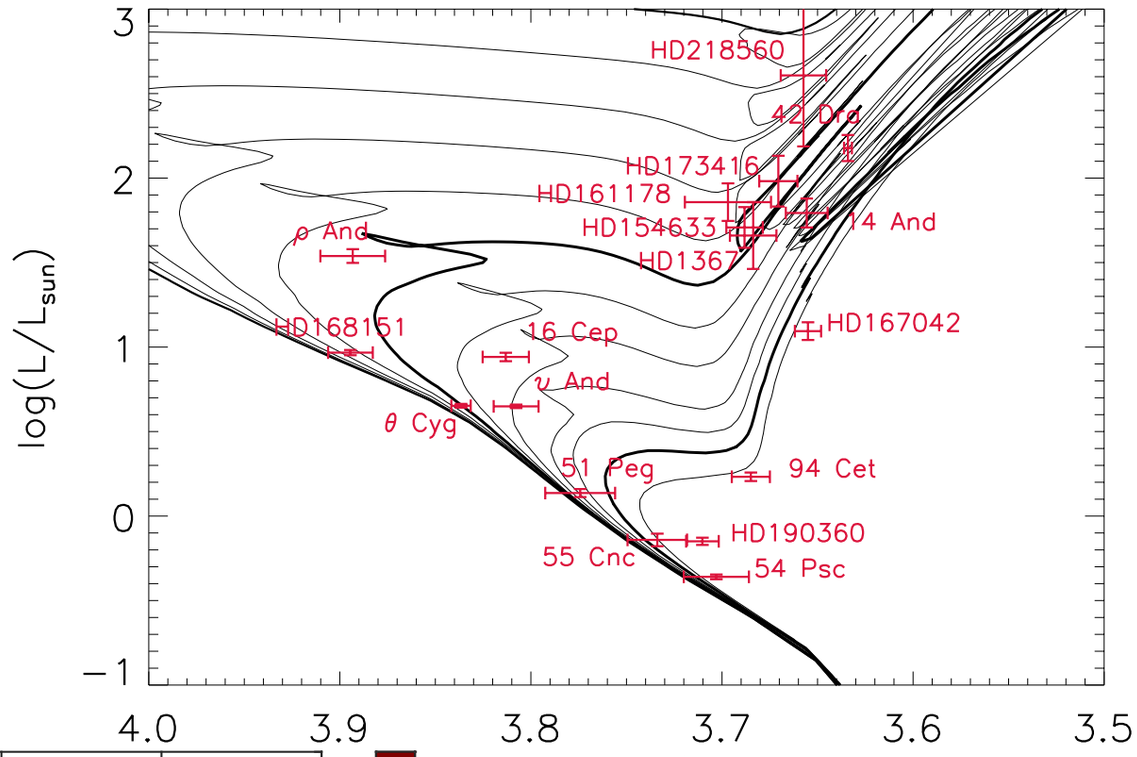
Ligi et al.,
in prep.

Conclusion and perspectives

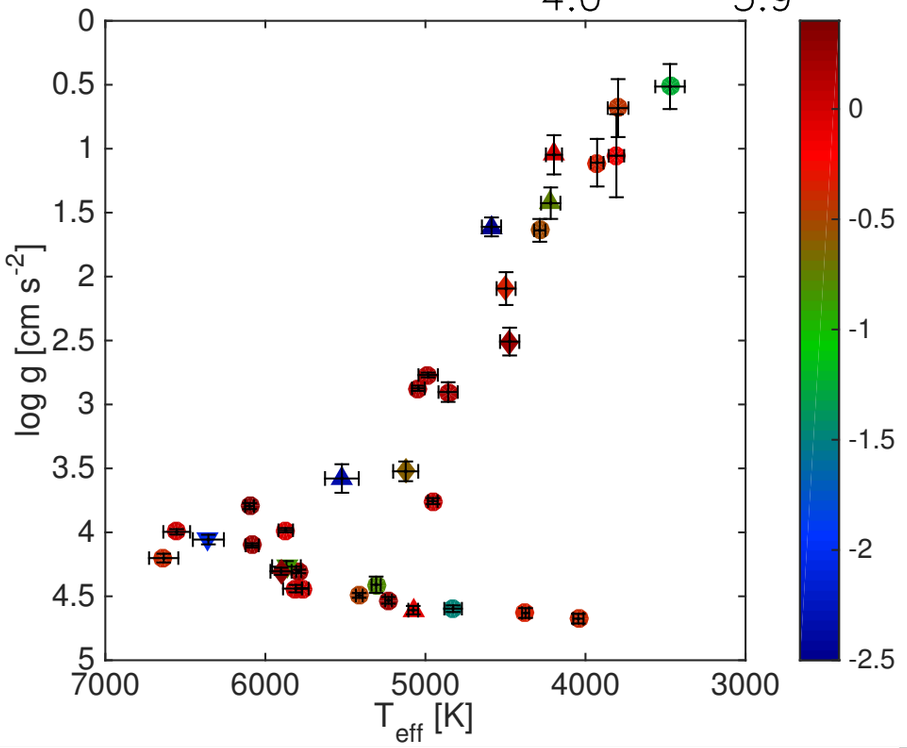
- Stars to study exoplanets (M_p, R_p)
- Exoplanets to study stars ($M_\star$, $R_\star$, $\rho_\star$)
- And exoplanetary systems in general



Astero + interfero
Huber et al. 2012

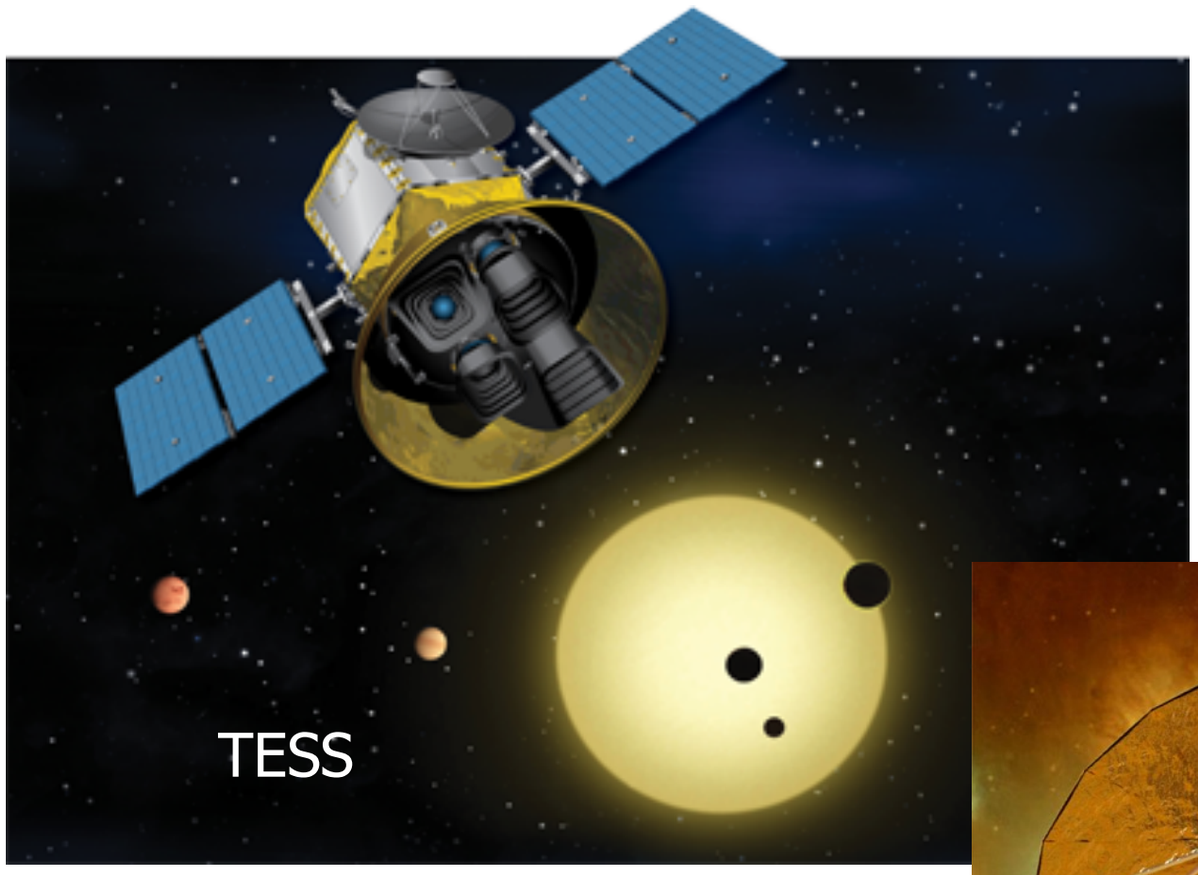


Interfero
Ligi et al. 2016

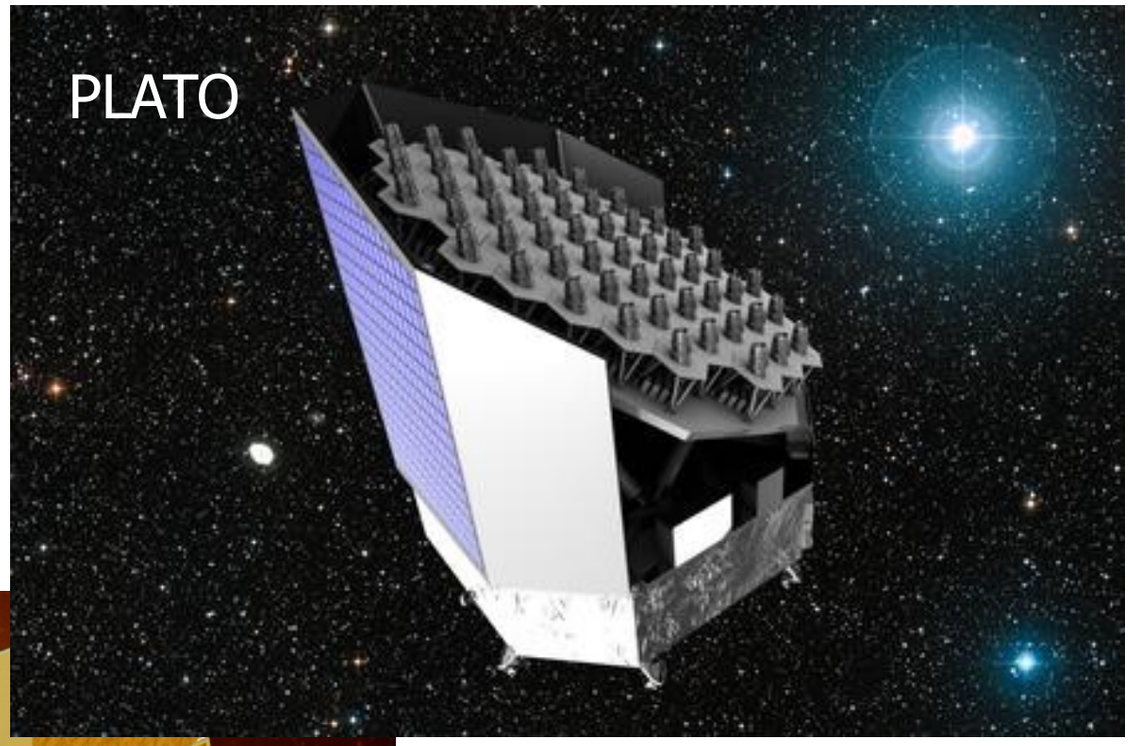


Benchmarks Gaia
Heiter et al. 2015

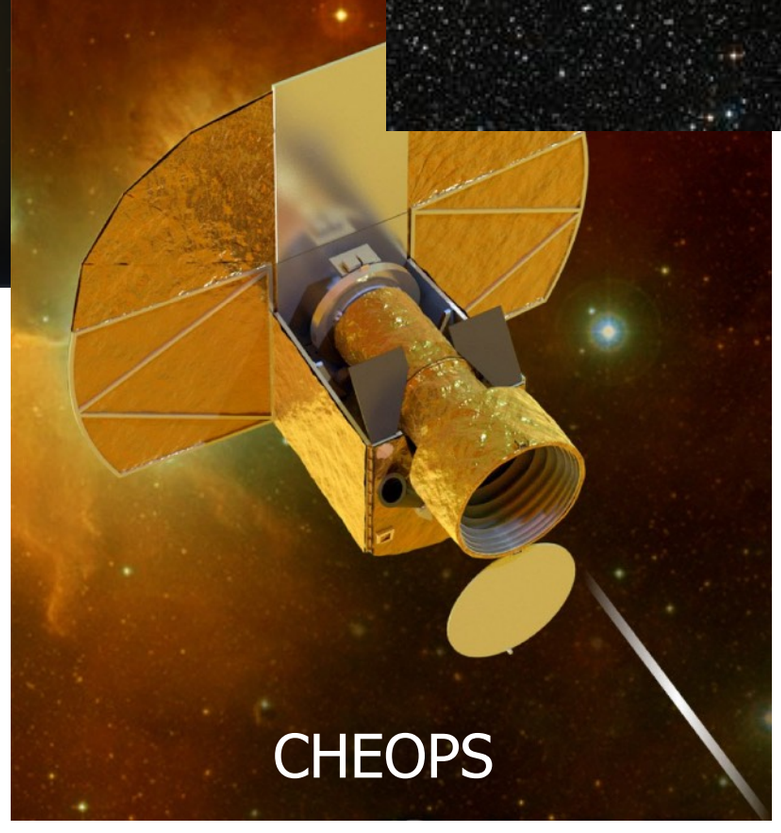
Conclusion and perspectives



Launched in 2018
Started with Southern hemisphere



Launch forseen
in 2026



Launch forseen
for end 2019


The End