Transit Spectroscopy of Exoplanets

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ESO Santiago
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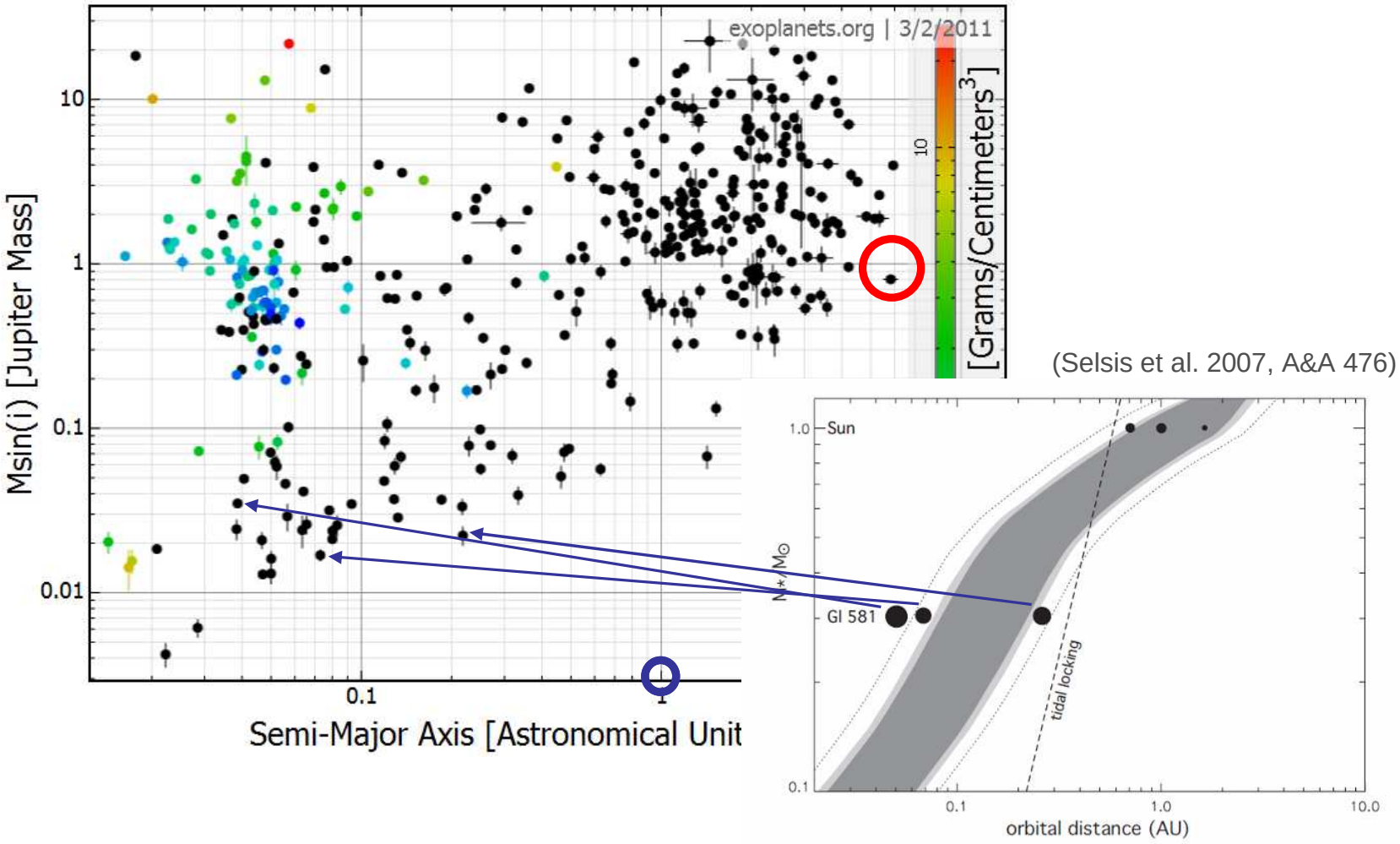
Outline

- Transiting Exoplanets
- Transit spectroscopy
- CoRoT-2 An extremely active planet host star *(UVES)*

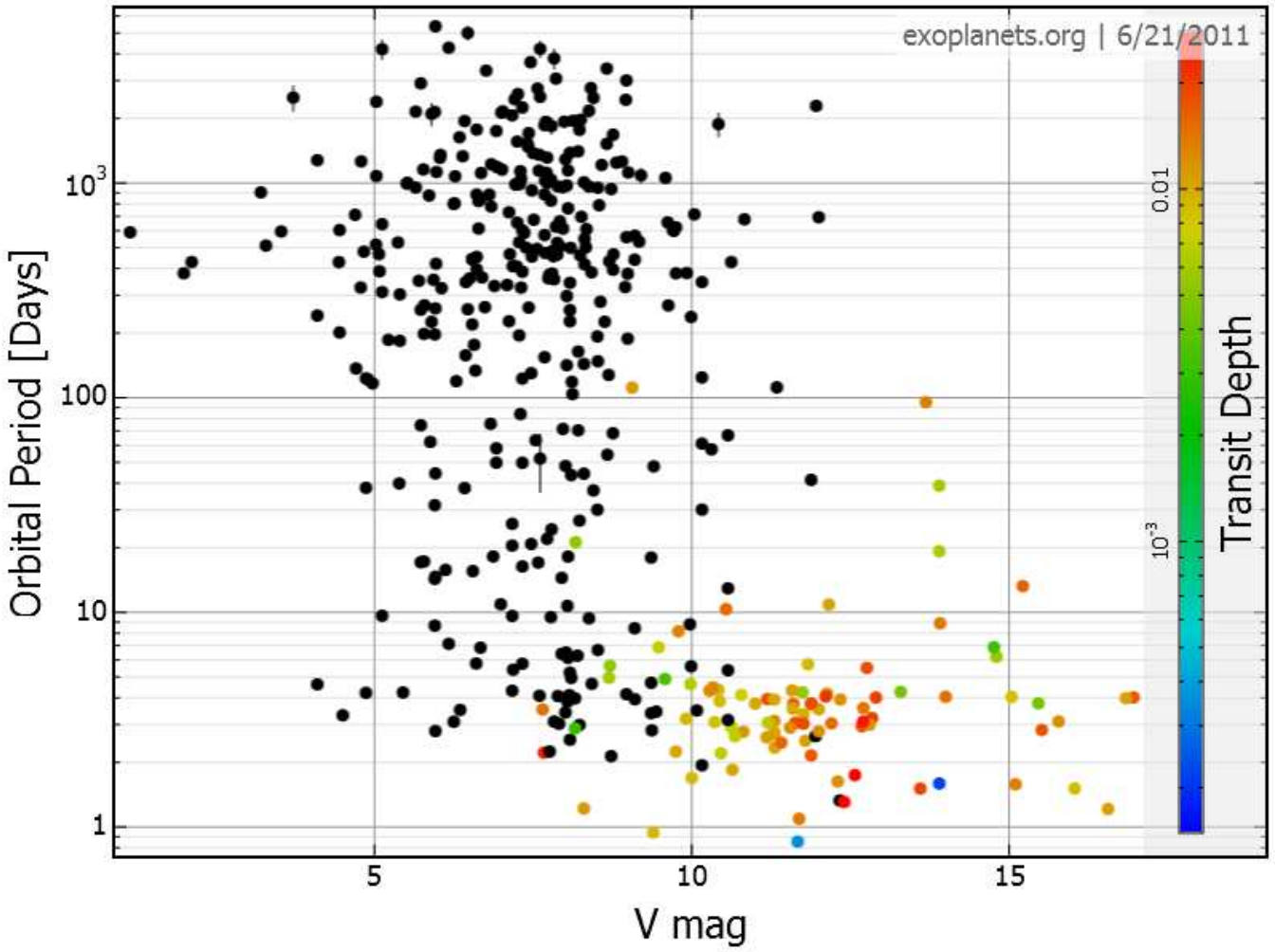
- MN Lup and other matters

Exoplanet science



(Selsis et al. 2007, A&A 476)

Transiting Exoplanets



≈ 550 Exoplanets known, ≈ 25 % transiting (exoplanet.eu, June 2011)

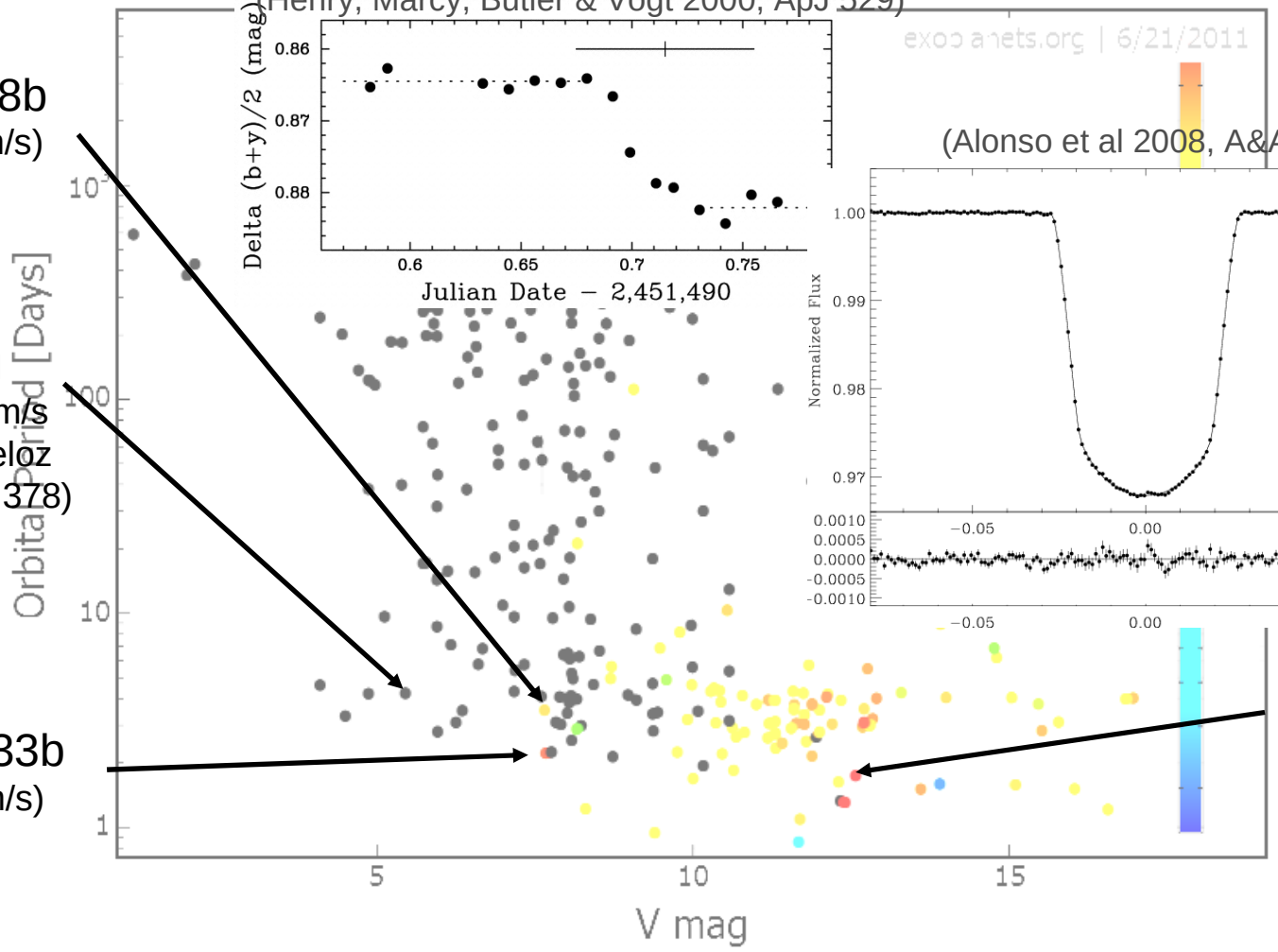
Hot Jupiters

(Henry, Marcy, Butler & Vogt 2000, ApJ 529)

HD 209458b
(G0V, 4.5 km/s)

51 Peg
(G0V, 2.6 km/s
Mayor & Queloz
1995, Nature 378)

HD 189733b
(K2V, 4 km/s)



(Alonso et al 2008, A&A 482)

CoRoT-2b
(G6V, 12 km/s)

Exoplan ters

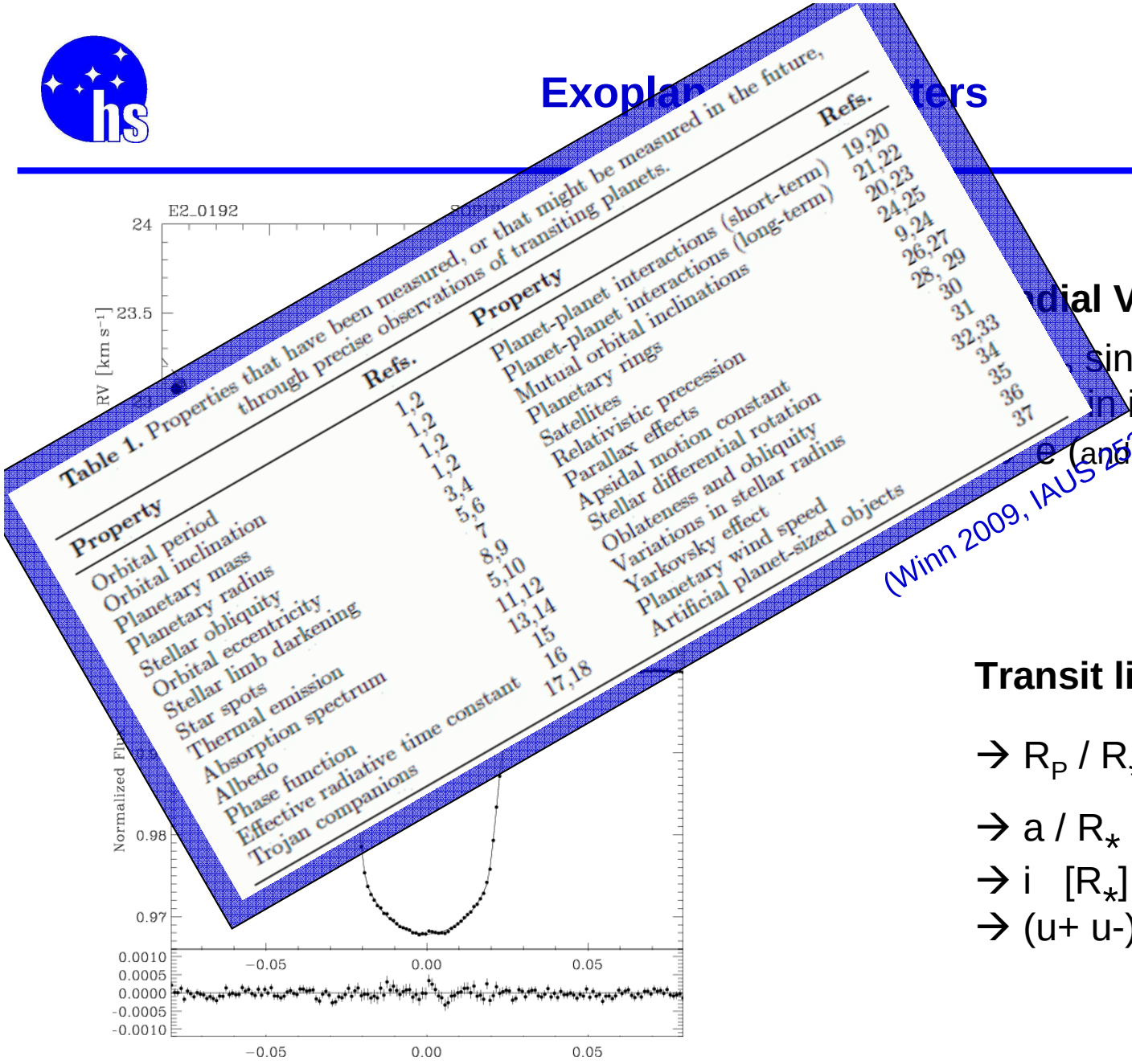


Table 1. Properties that have been measured, or that might be measured in the future, through precise observations of transiting planets.

Property	Refs.	Property	Refs.
Orbital period	1,2	Planet-planet interactions (short-term)	19,20
Orbital inclination	1,2	Planet-planet interactions (long-term)	21,22
Planetary mass	1,2	Mutual orbital inclinations	20,23
Planetary radius	1,2	Planetary rings	24,25
Stellar obliquity	3,4	Satellites	9,24
Orbital eccentricity	5,6	Relativistic precession	26,27
Stellar limb darkening	7	Parallax effects	28, 29
Star spots	8,9	Apsidal motion constant	30
Thermal emission	5,10	Stellar differential rotation	31
Absorption spectrum	11,12	Oblateness and obliquity	32,33
Albedo	13,14	Variations in stellar radius	34
Phase function	15	Yarkovsky effect	35
Effective radiative time constant	16	Planetary wind speed	36
Trojan companions	17,18	Artificial planet-sized objects	37

dial Velocity (‚Sb I‘)

sin i [M*]

in i

e (and sin ω)

(Winn 2009, IAUS 253)

Transit lightcurve

→ R_P / R_*

→ a / R_*

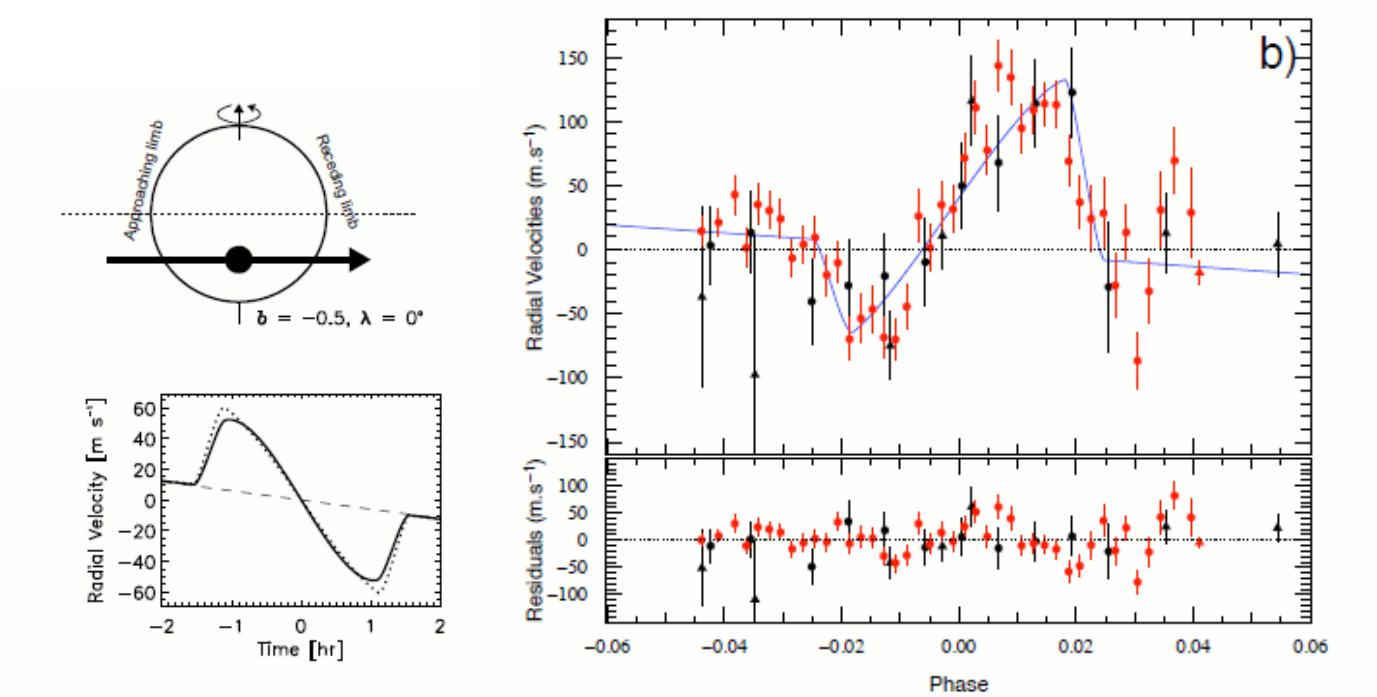
→ i [R_*]

→ (u+ u-)

(Alonso et al. 2008, A&A TBD, Bouchy et al. 2008, A&A TBD)

Rossiter – Mc Laughlin Effect

(Schlesinger 1910, Rossiter 1924, Mc Laughlin 1924)



Transit RV curve

→ λ

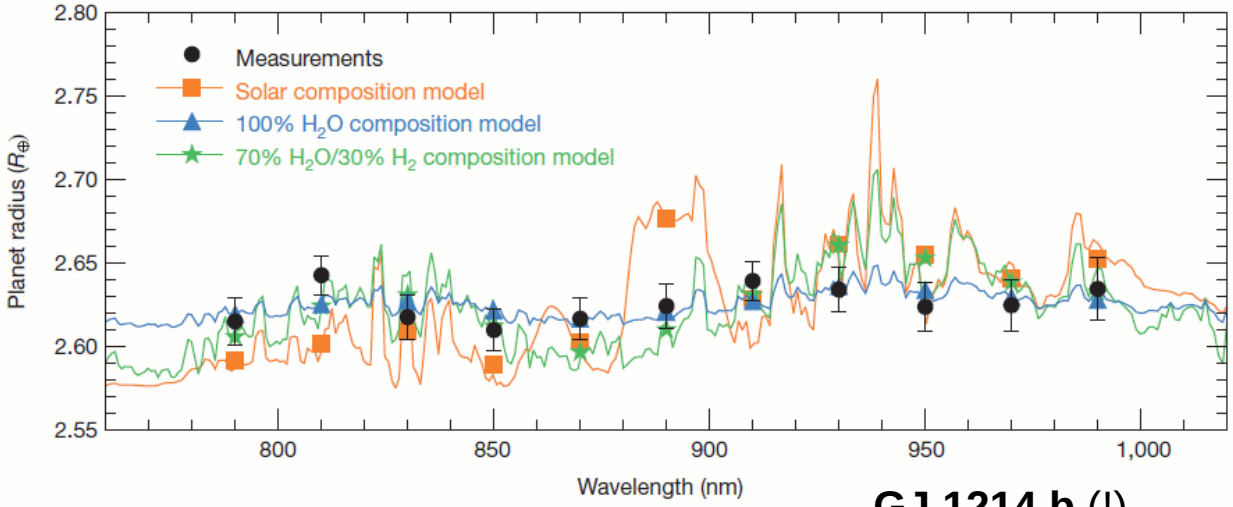
→ i [R ⋆]

→ (u+ u-)

Retrograde planetary orbits !

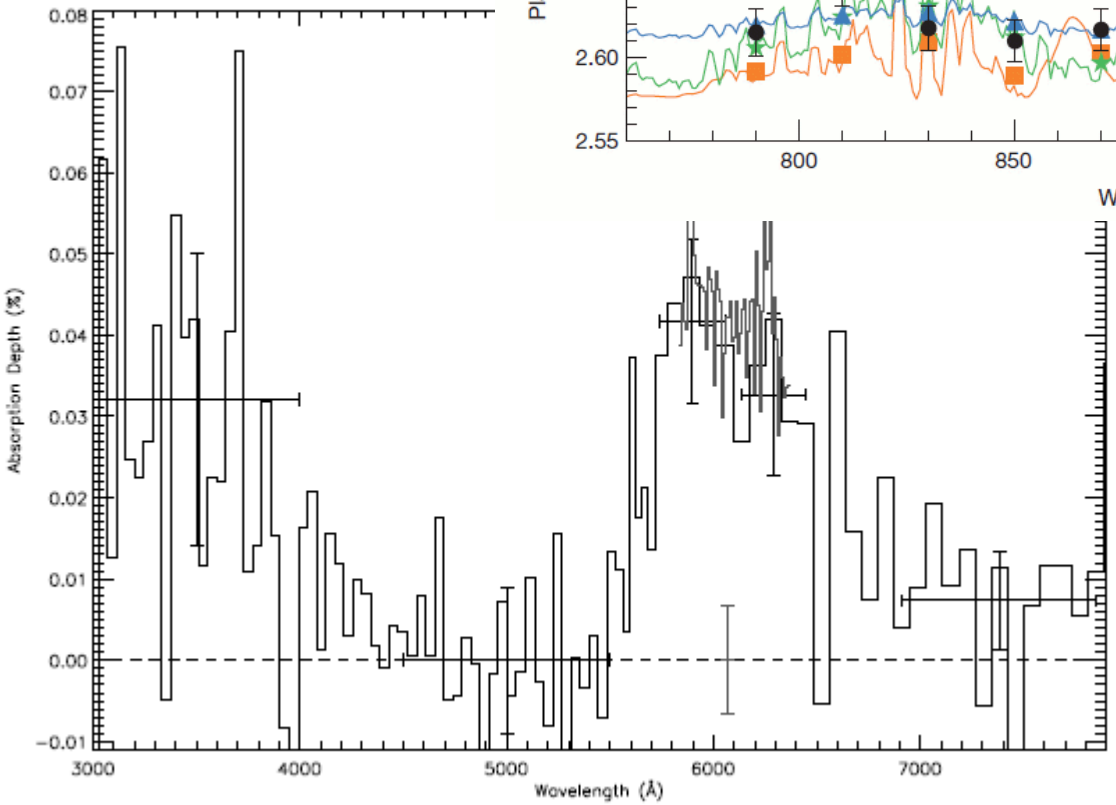
(WASP-17b, Triaud et al. 2010, A&A 524)

Transit spectroscopy II - Planetary atmospheres



GJ 1214 b (!)
FORS2

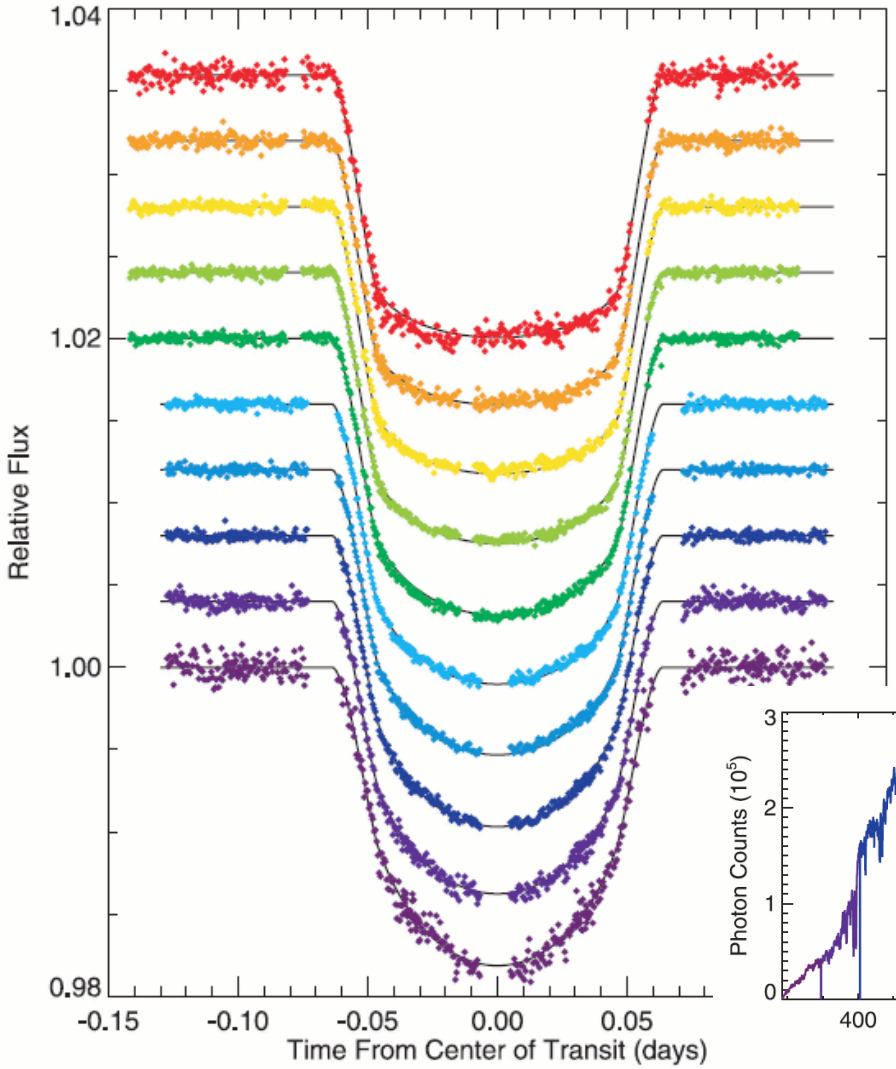
(Bean et al. 2010
Nature 468)

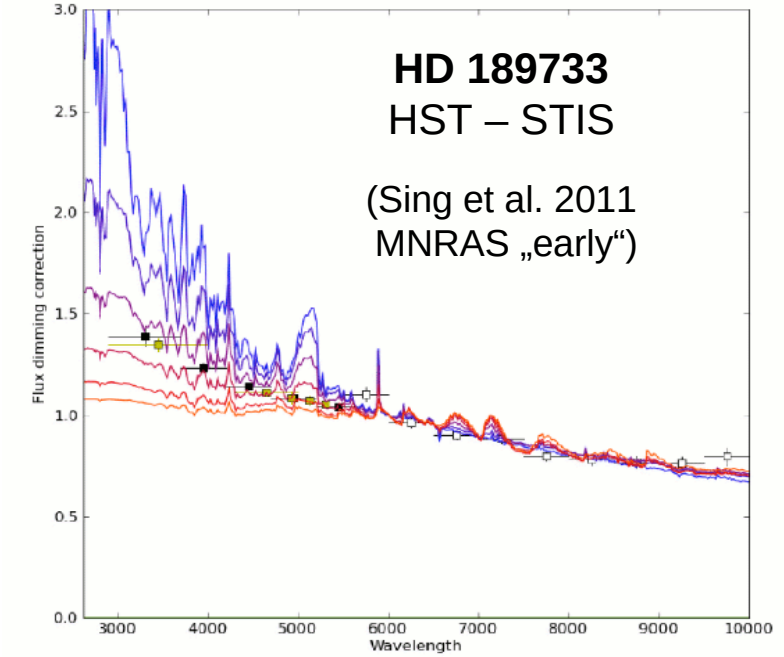


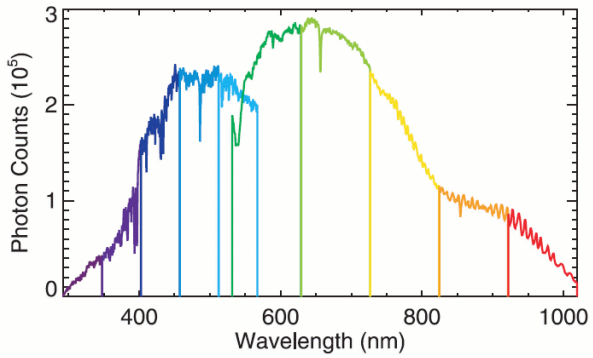
HD 209458 b (!)
HST – STIS

(Sing et al. 2008
ApJ 686)

Transit spectroscopy III - Host star atmospheres

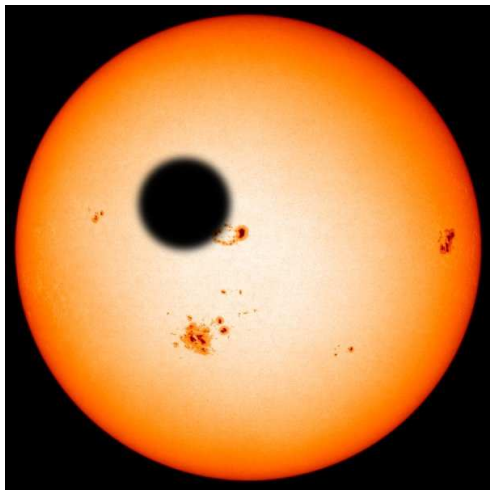


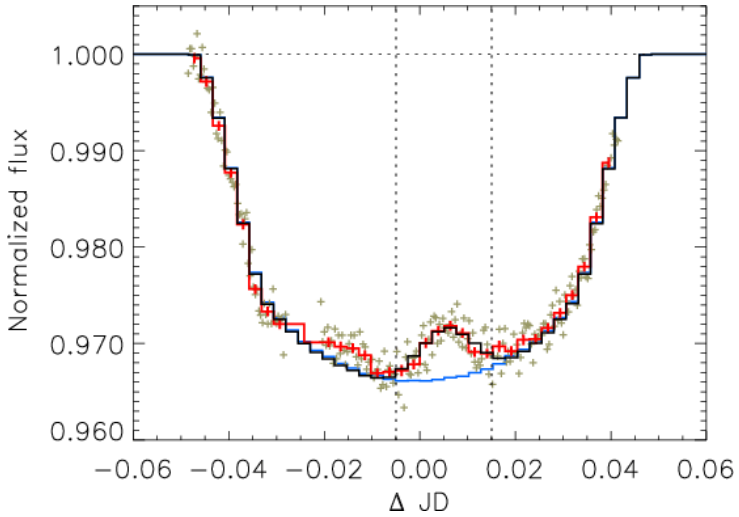




HD 209458
HST – STIS
(Knutson et al. 2007
ApJ 655)

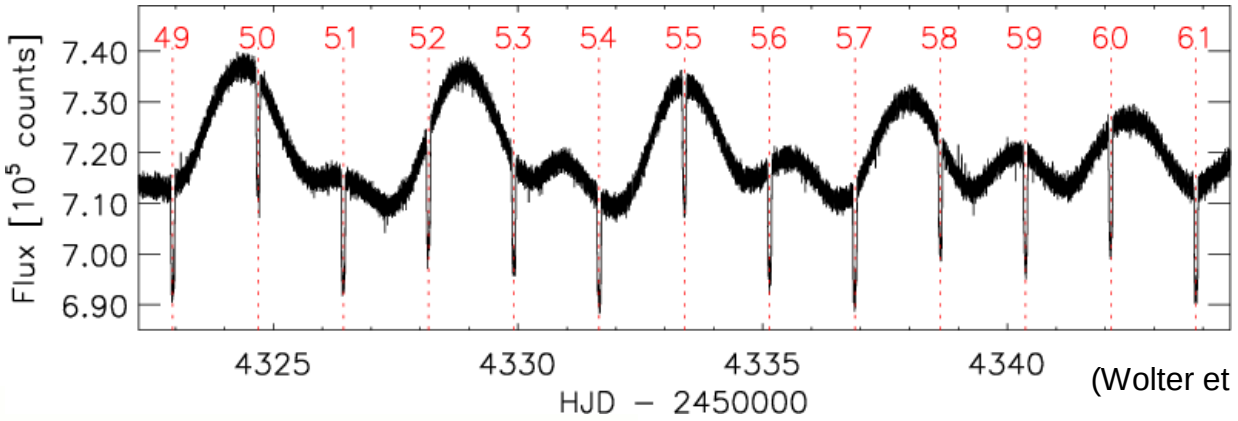
CoRoT–2A, 2b and 2B



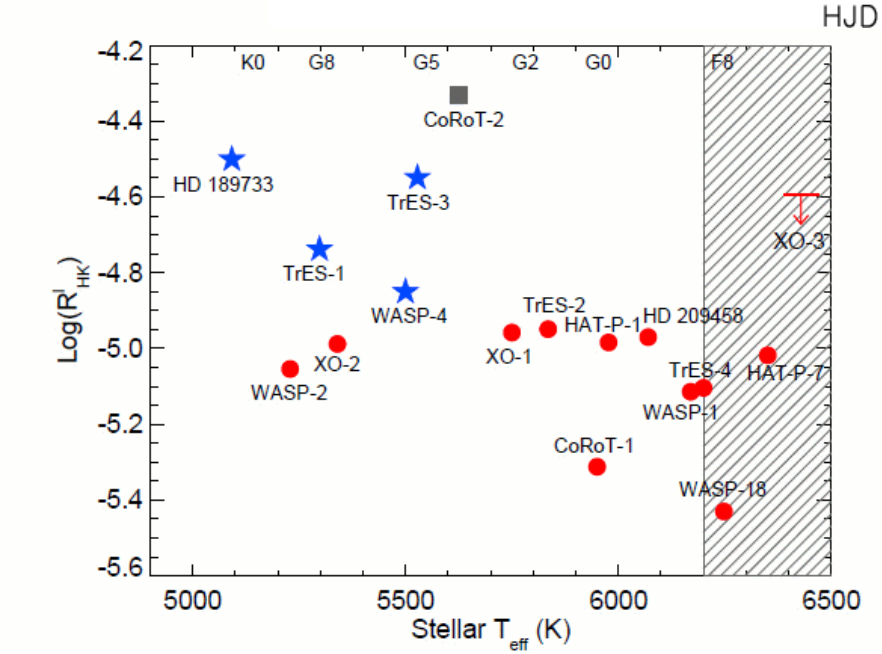


(Wolter et al. 2009, A&A 504)

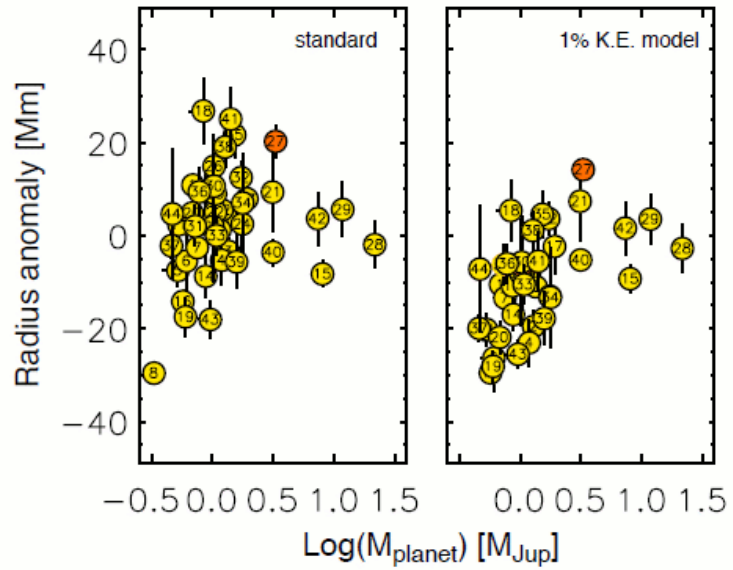
CoRoT-2 -- What's special ?



(Wolter et al. 2009, A&A 504)



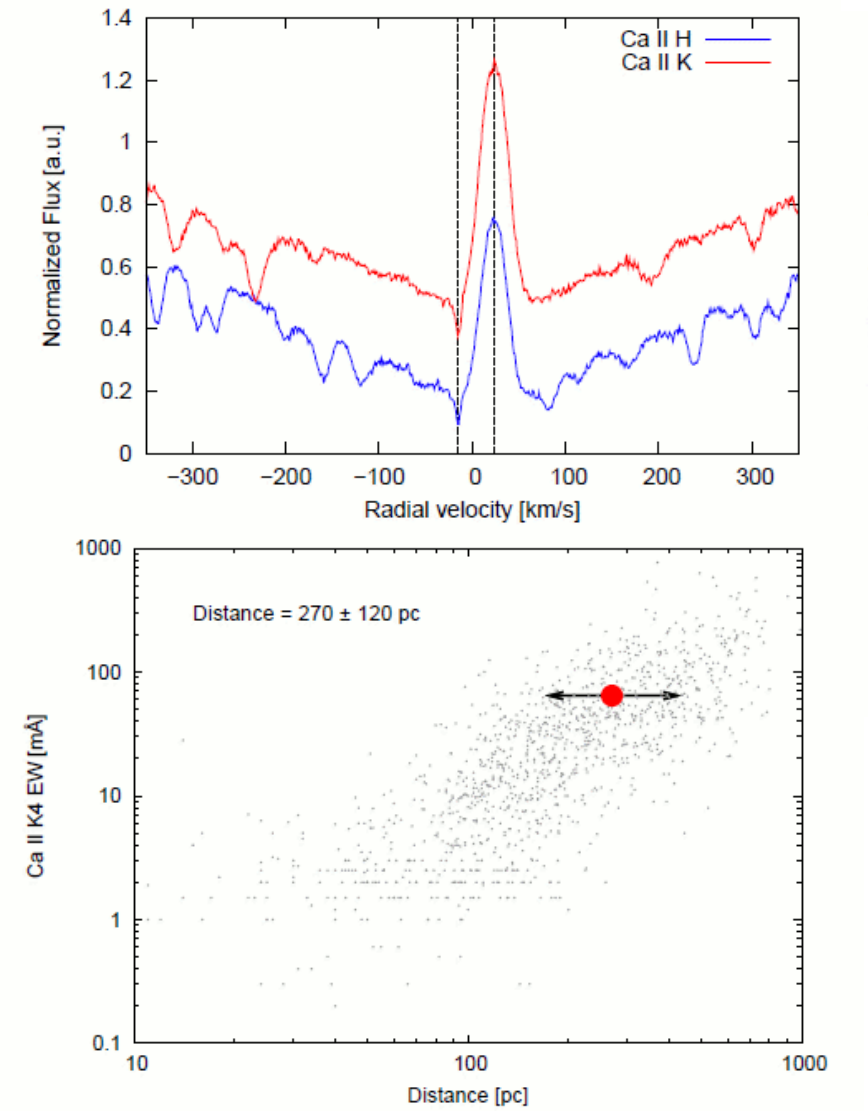
(Knutson et al. 2010, ApJ 720)

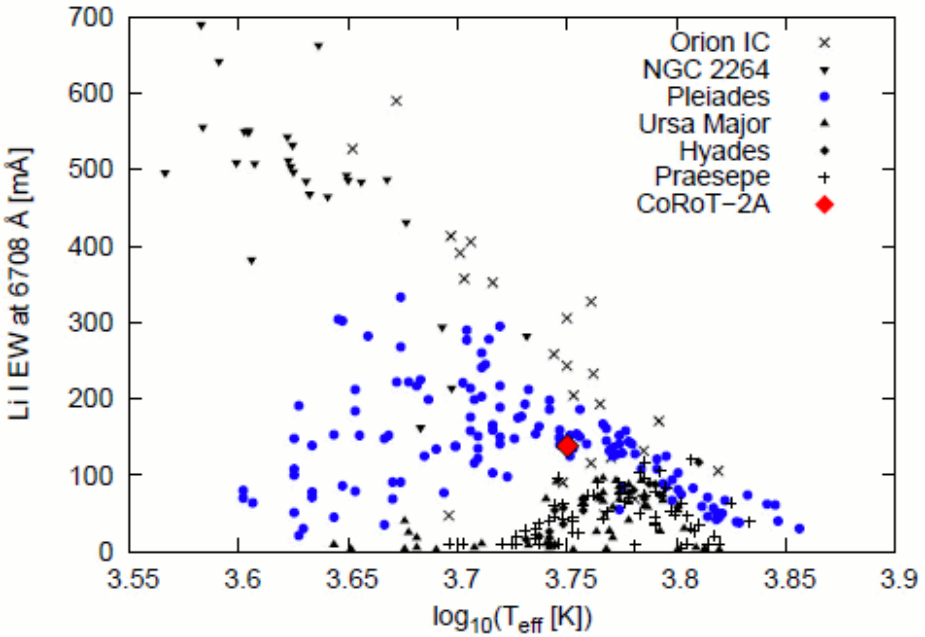


(Guillot & Havel 2011, A&A 527)

Understanding the host: CoRoT-2A

UVES spectroscopy 2010





Schröter, Czesla, Wolter et al. 2011
A&A 532

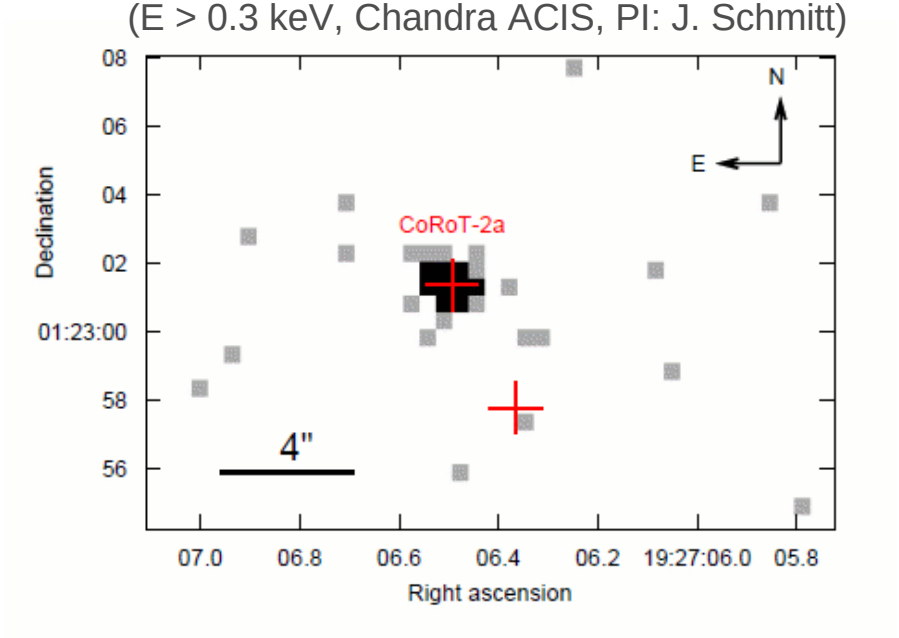
Corona and companion of CoRoT-2A

Insights from X-rays and optical spectroscopy

A likely stellar companion: CoRoT-2B

Serendipitous UVES spectroscopy II

(E > 0.3 keV, Chandra ACIS, PI: J. Schmitt)



CoRoT-2A

$L_X \approx (1.9 \pm 1.2) \cdot 10^{29}$ erg/s (at 270 pc)

(≈ 100 solar L_X, ≈100 000 Earth' s f_X for CoRoT-2b)

CoRoT-2B

$L_X < 10^{27}$ erg/s

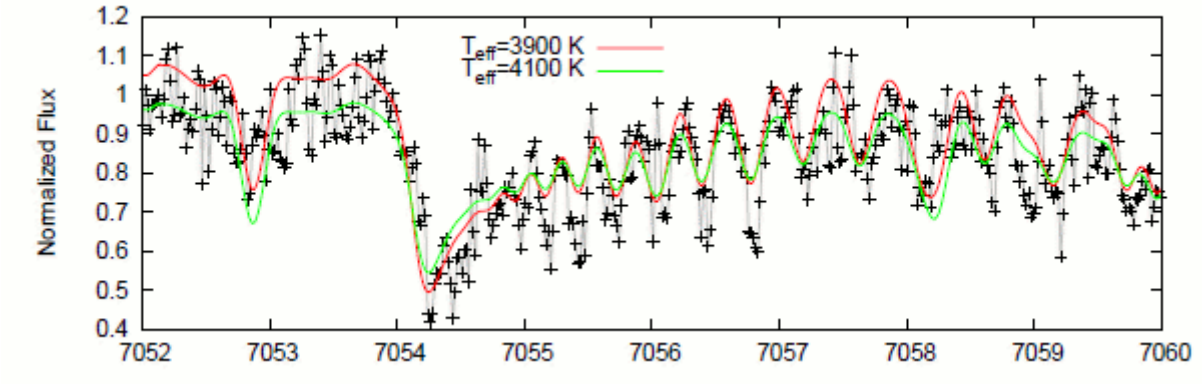
23.9 ± 0.4 km/s

(compared to 23.25 ± 0.01 km/s)

T_{eff} = 4000 ±100 K log g ≈ 4.7

(i.e. spectral type ≈ K9 V)

Schröter et al. 2011
A&A 532

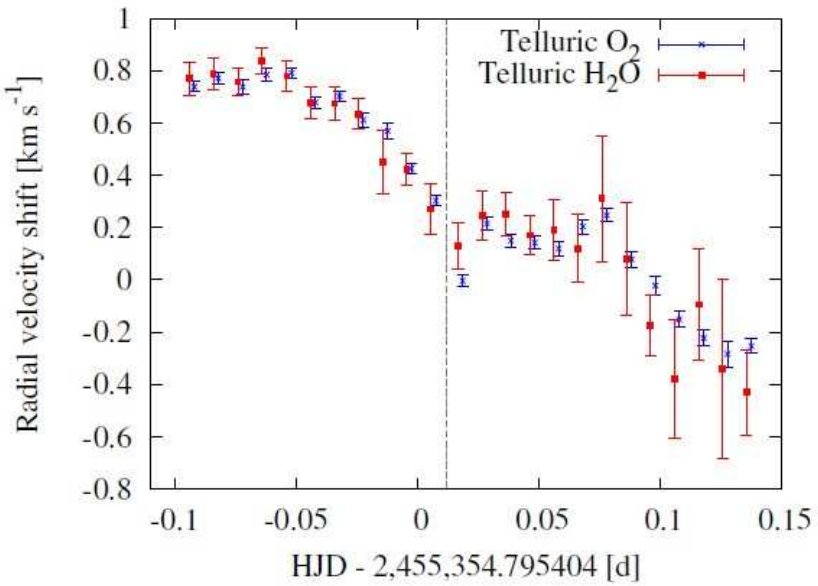


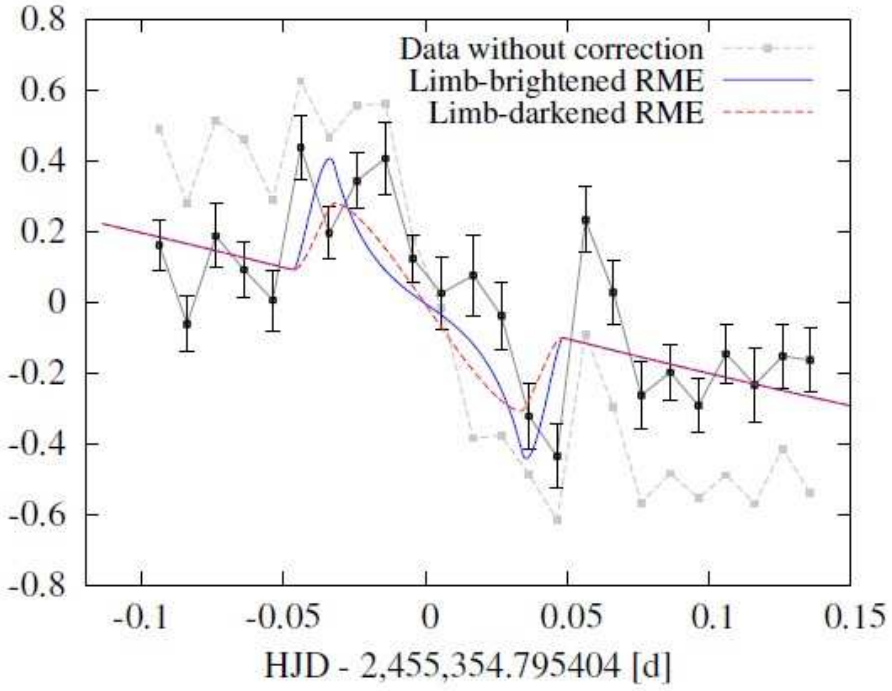
Scanning the host star CoRoT-2A

UVES spectroscopy of the planetary transit

First detection of the chromospheric Rossiter McL. effect

Czesla, Schröter, Wolter et al.
2011 A&A subm.





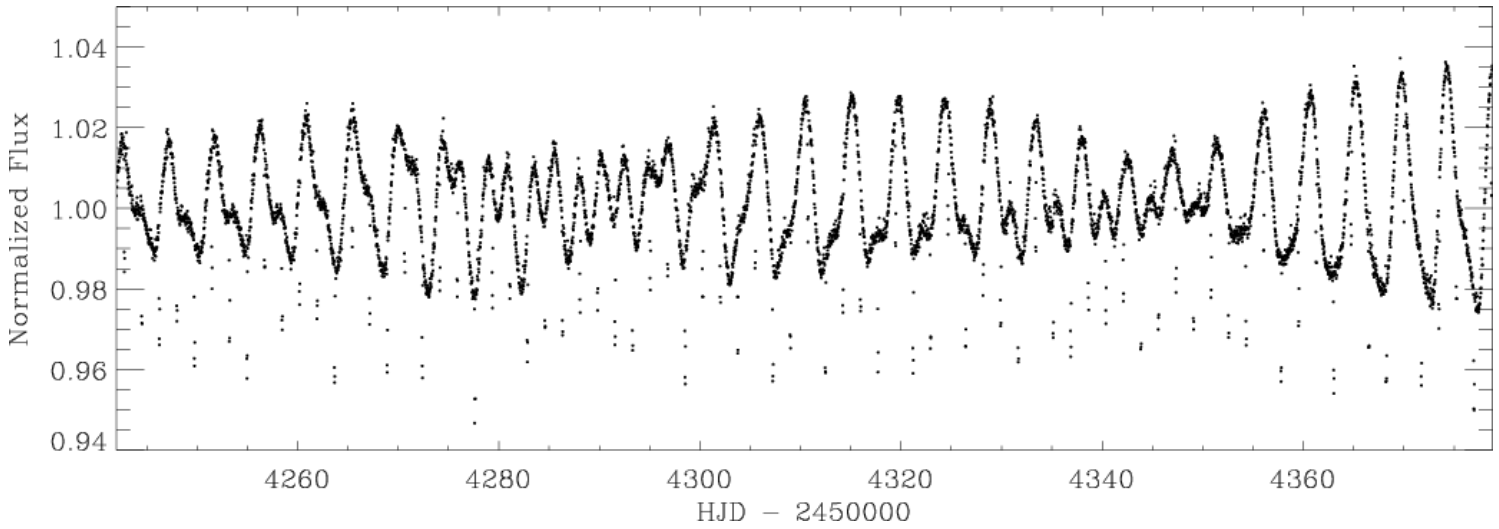
Summary

- (Transiting) Exoplanets
- Transit spectroscopy
- CoRoT-2 An remarkable & active planet host star

- HD 189733 (HST-STIS, Christian Schneider)
- WASP-33 (HET, Carolina v. Essen)
- MN Lup (UVES + XMM, Moritz Günter)

Empty

TBD Corot-2 PMAS



(Alonso et al. 2008, A&A TBD)