Evaporating exoplanets: the new deal

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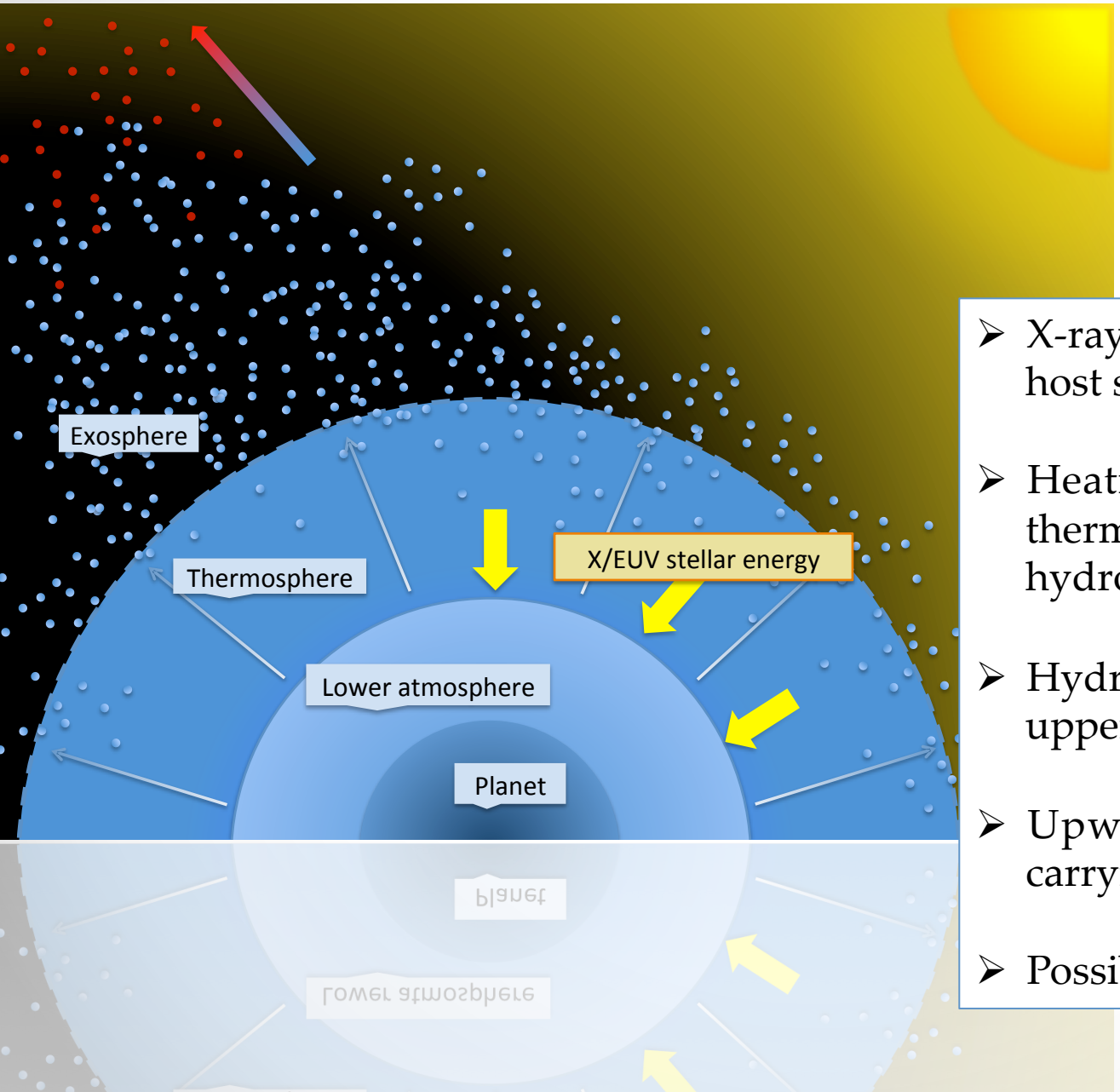
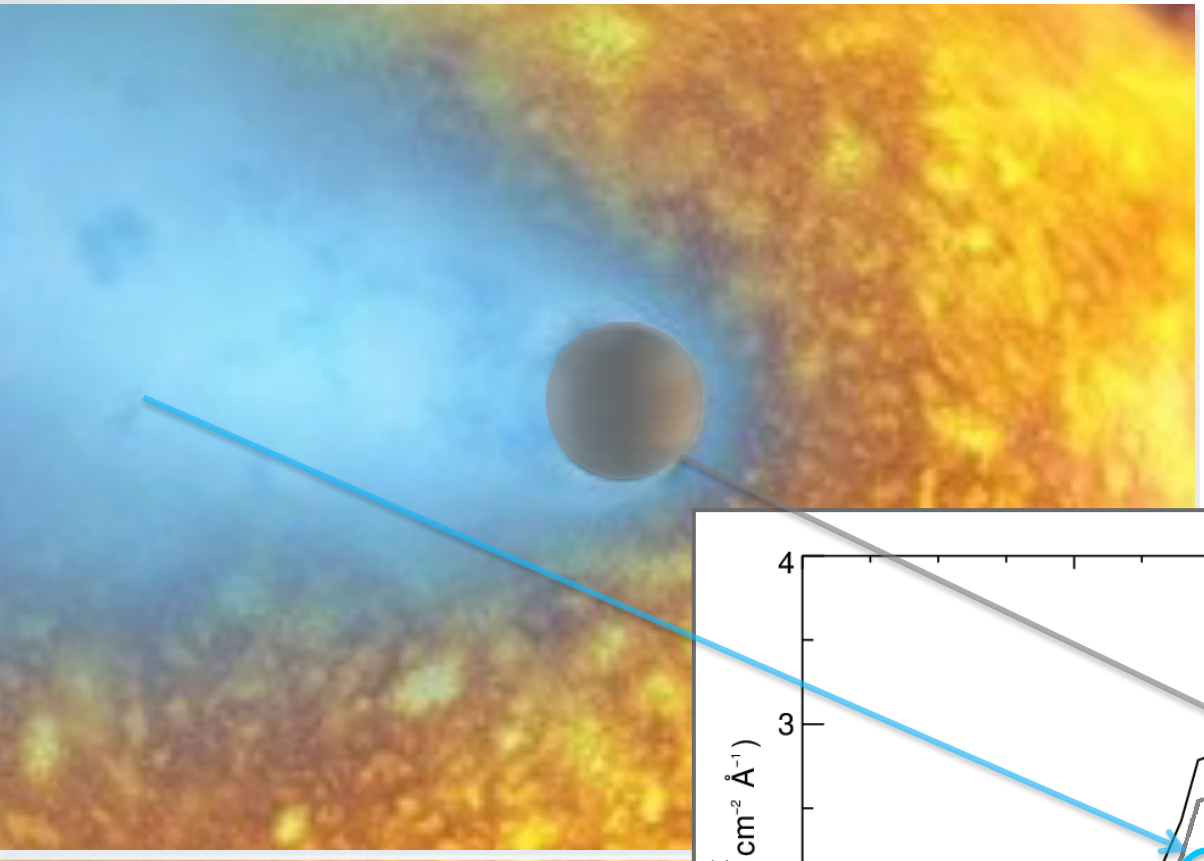
3rd CHEOPS Science Meeting – Madrid (June 2015)

The upper atmosphere of irradiated planets

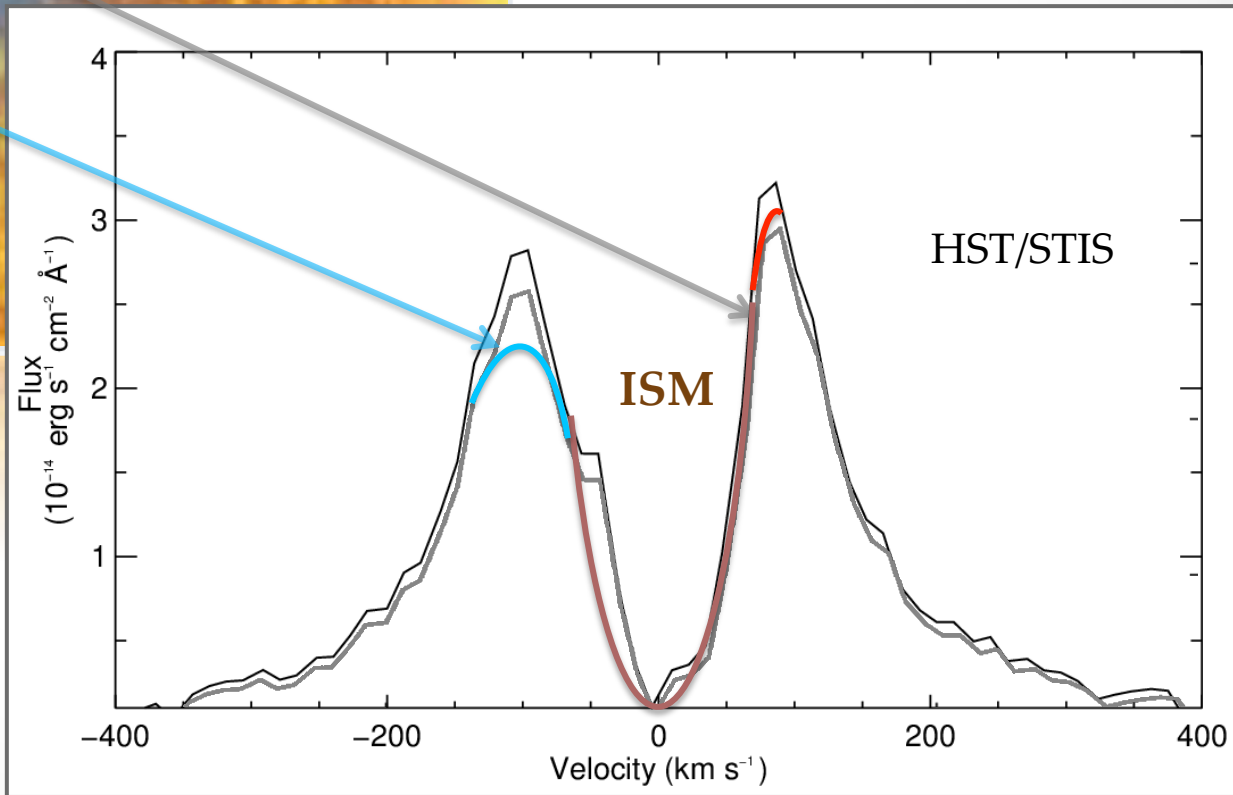


- X-ray + EUV radiation from the host star
- Heating at the base of the thermosphere : departure from hydrostatic state
- Hydrodynamic inflation of the upper layers of the atmosphere
- Upward flow of hydrogen, carrying along heavy elements
- Possible escape

UV transmission spectroscopy of the exosphere

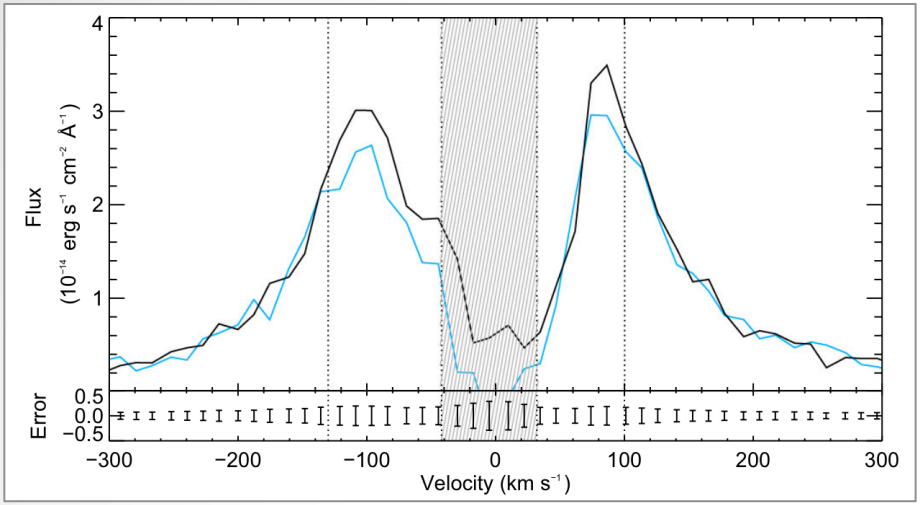


Planetary occultation~ 1%

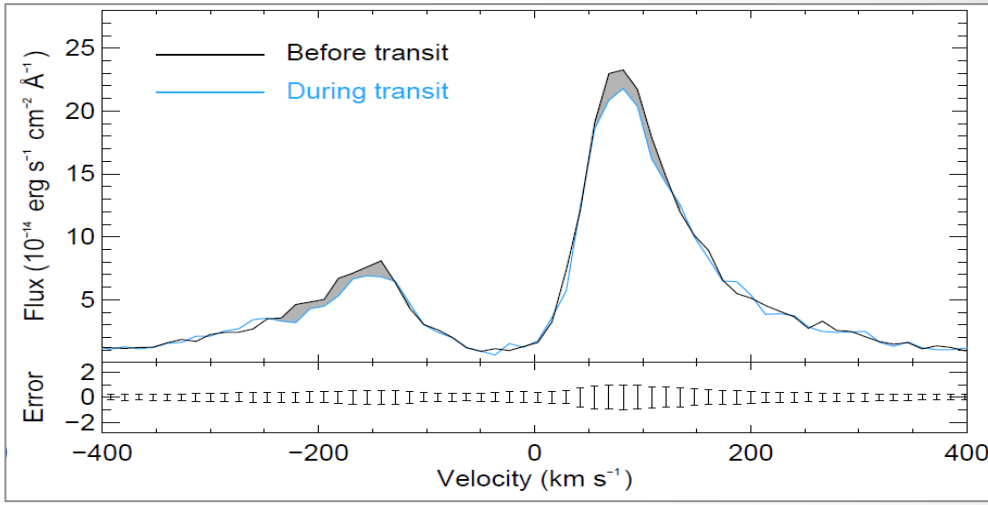


Evaporating hot-Jupiters

HD209458b



HD189733b



Absorption:
15 ± 4 % in **[-130 ; -40] km/s**

Vidal-Madjar et al. (2003),
Ben-Jaffel (2007, 2008)
Vidal-Madjar et al. (2008)

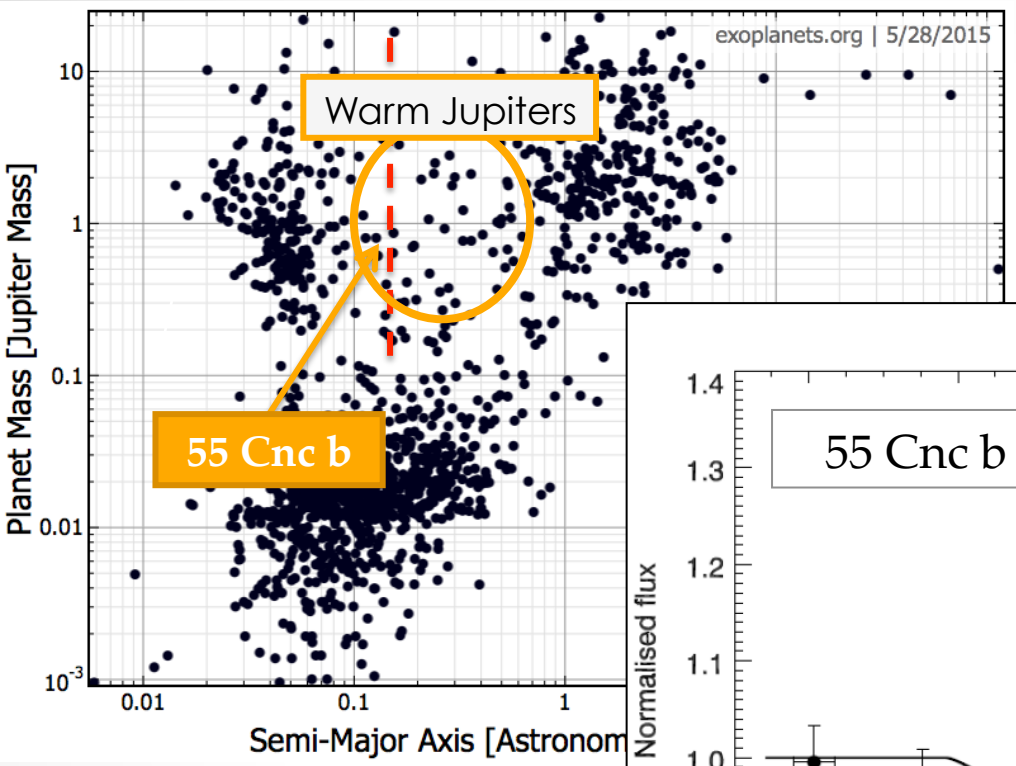
Absorption:
14.4 ± 3,6 % in **[-220 ; -140] km/s**

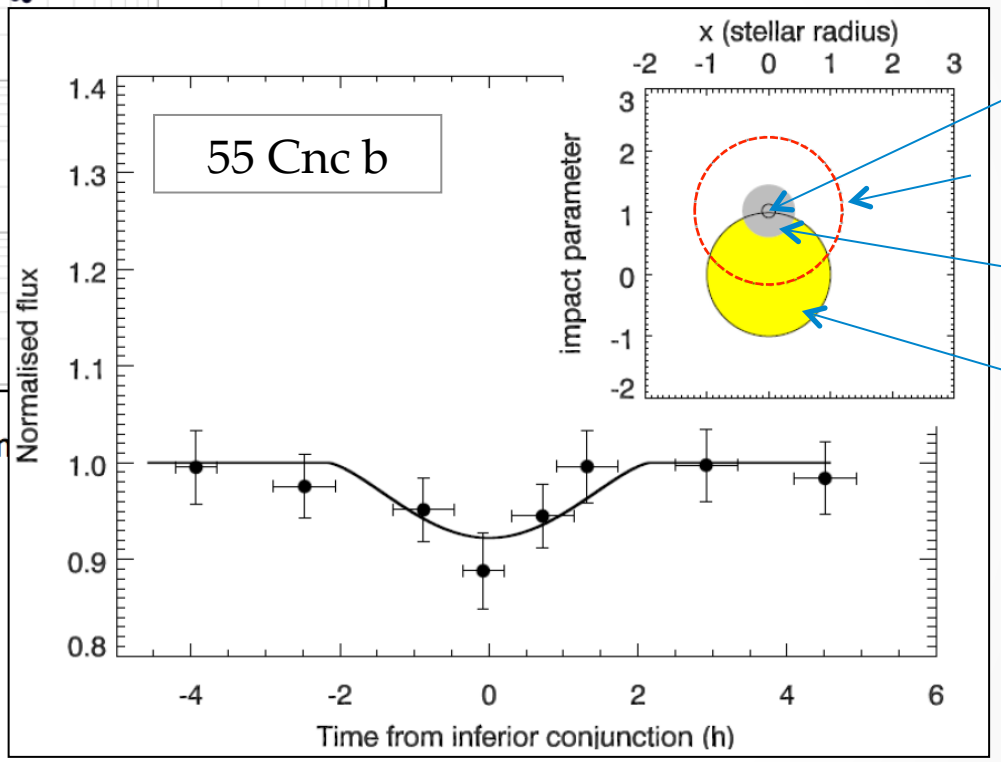
Lecavelier et al. 2012

altitudes > $R_{Roche\ lobe}$

velocities > escape velocity

Evaporating warm Jupiter

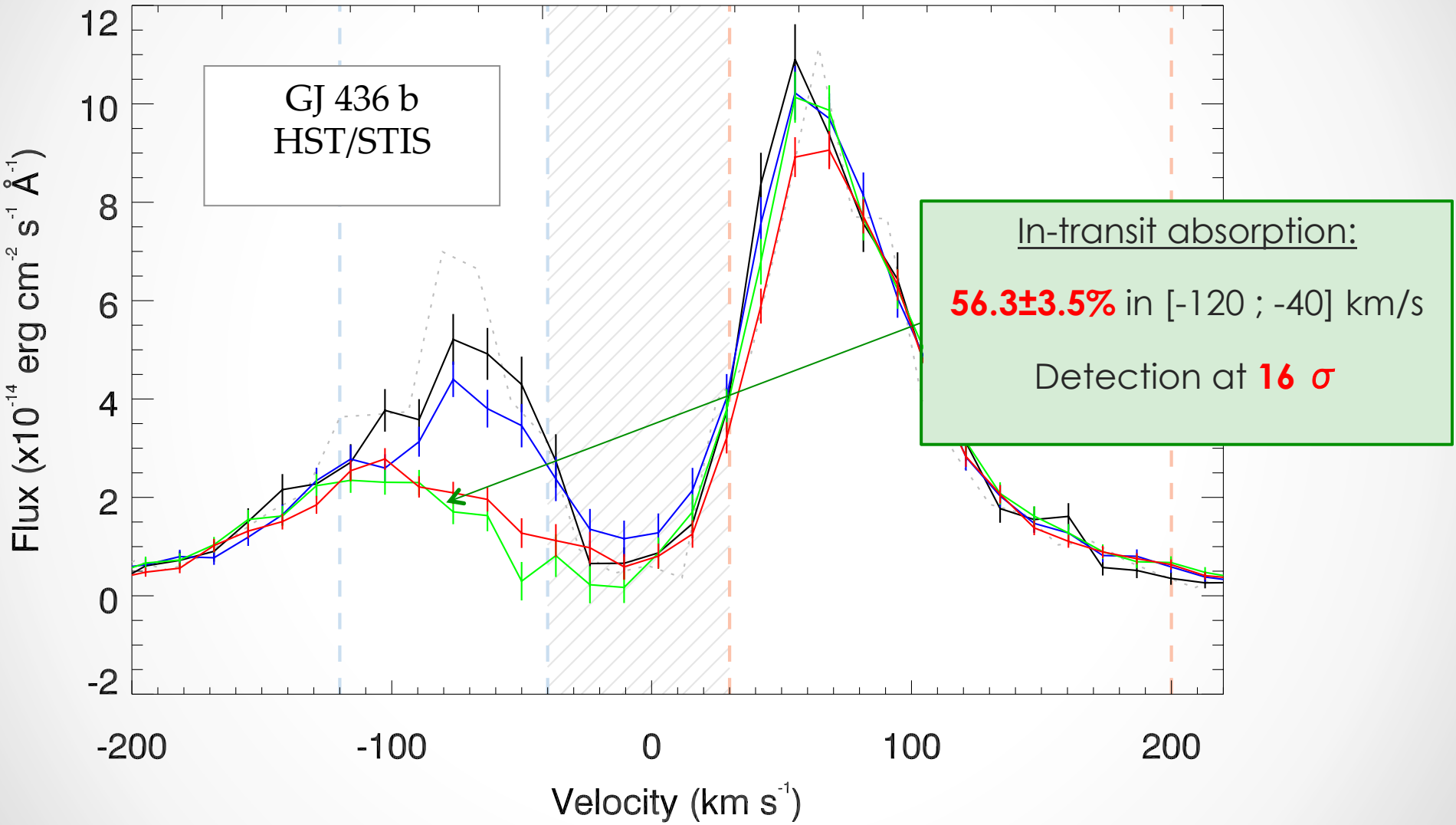




Absorption:
7,5 ± 1,8 % in **[-76 ; 0] km/s**

- 1st detection of a transit by the atmosphere alone (Ehrenreich, et al. 2012)
- Limit of atmospheric stability? (Koskinen et al. 2007)
- **Moderate irradiation but extended atmosphere!**

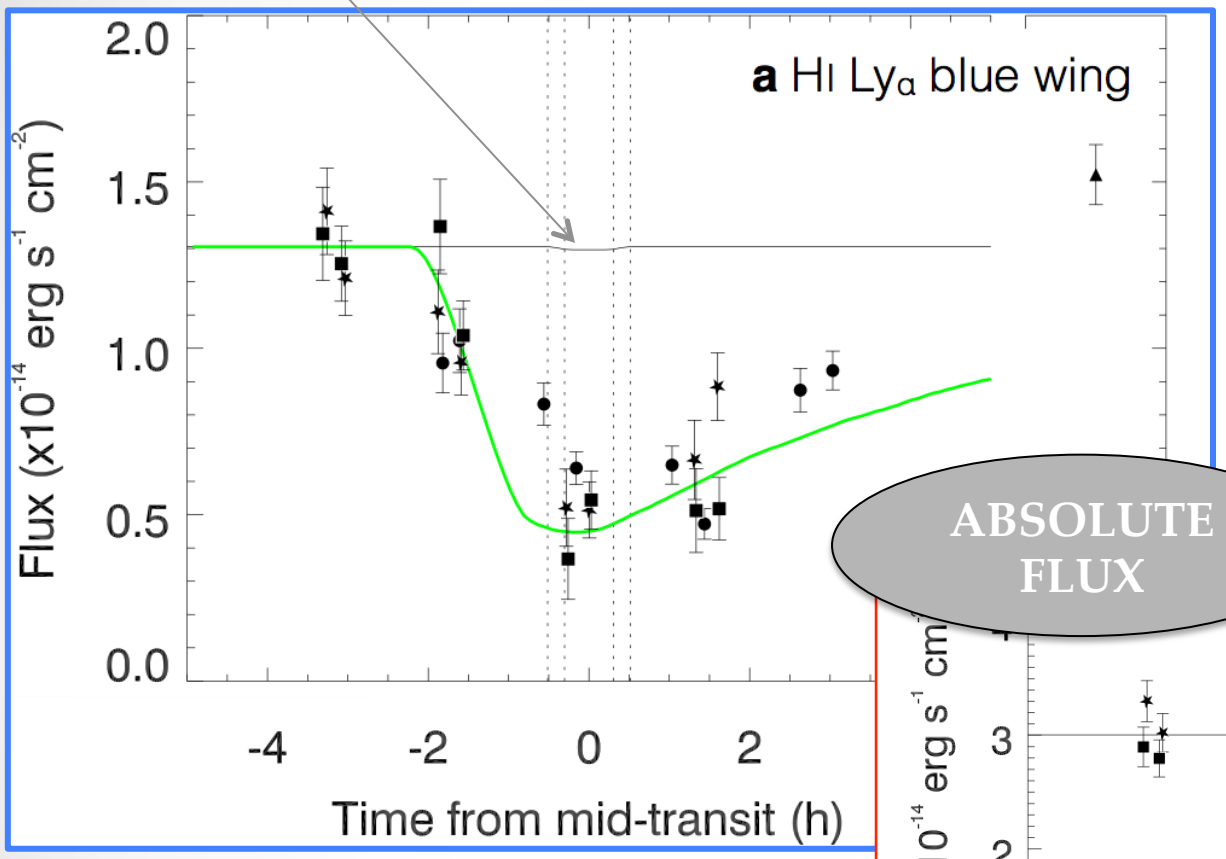
The warm Neptune GJ436b



Ehrenreich, Bourrier et al. 2015, *Nature*

Repeatable transit variations

Planetary disk= 0.7%



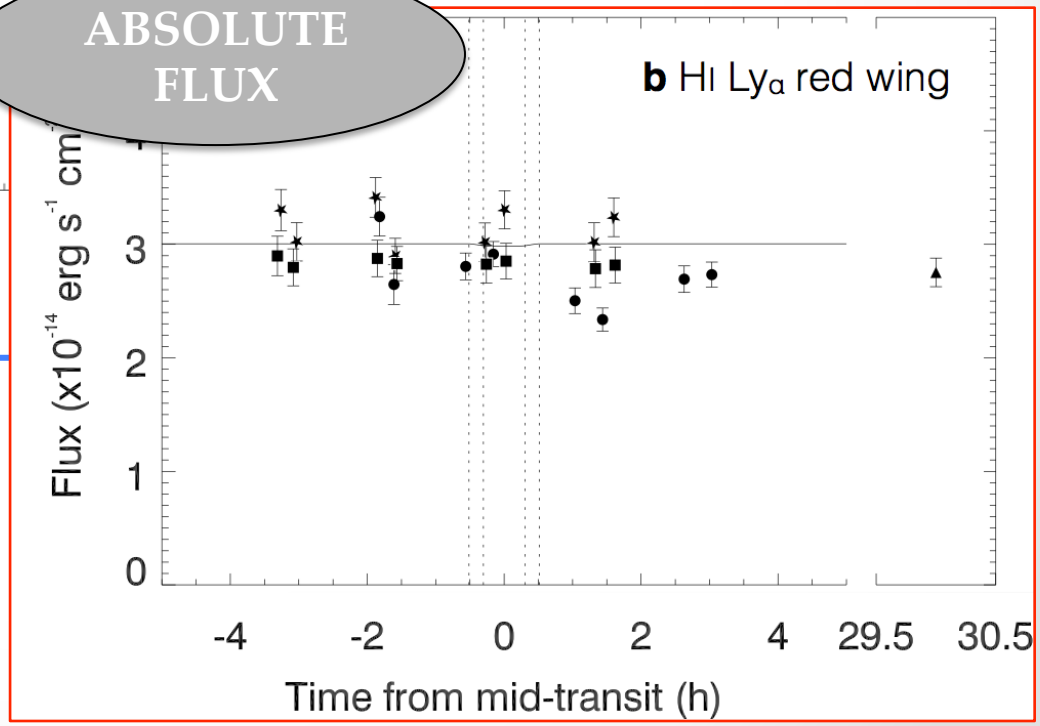
Three different epochs:

December 2012 ●

June 2013 ★

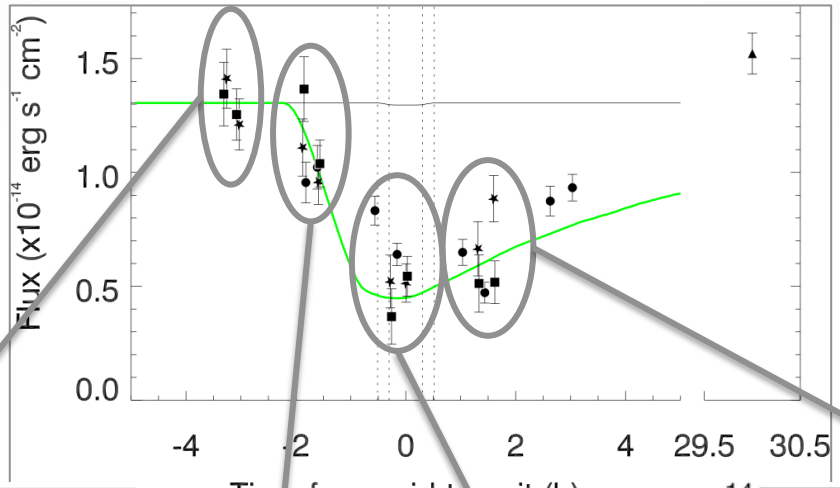
June 2014 ■

ABSOLUTE FLUX

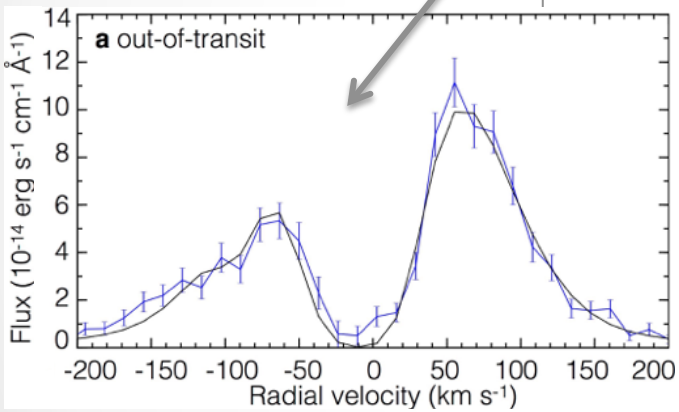


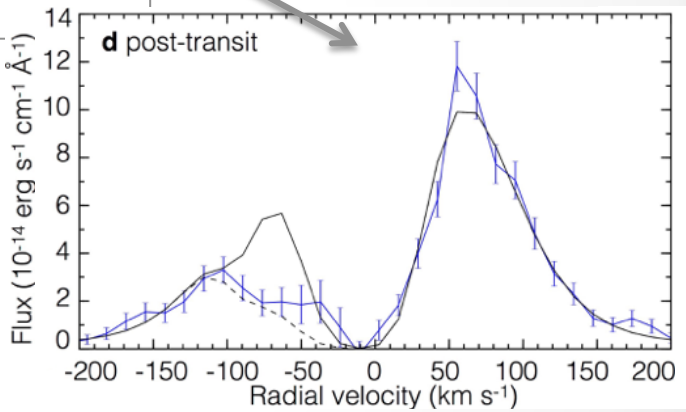
Stellar line stable

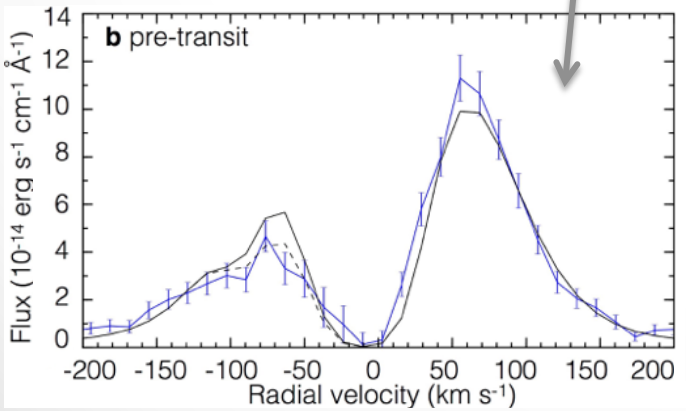
Fitting the data with the EVaporating Exoplanet code

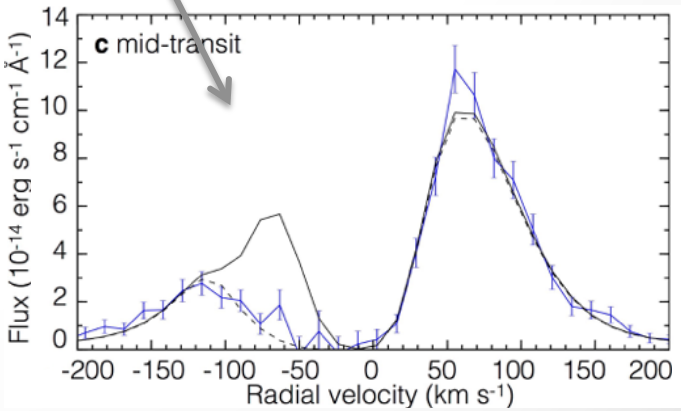


The **EVE** code:
Bourrier & Lecavelier 2013
Bourrier et al 2014 a

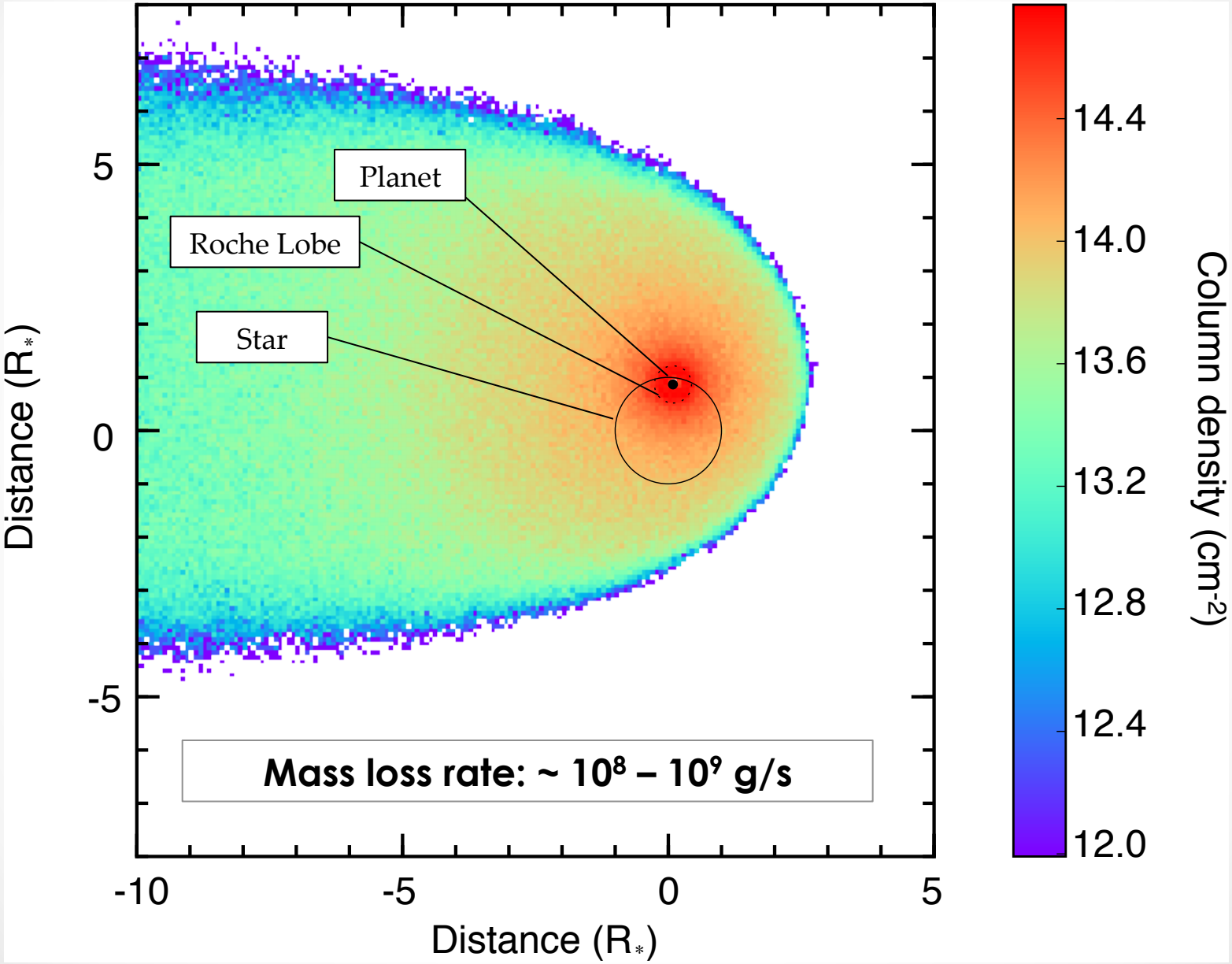




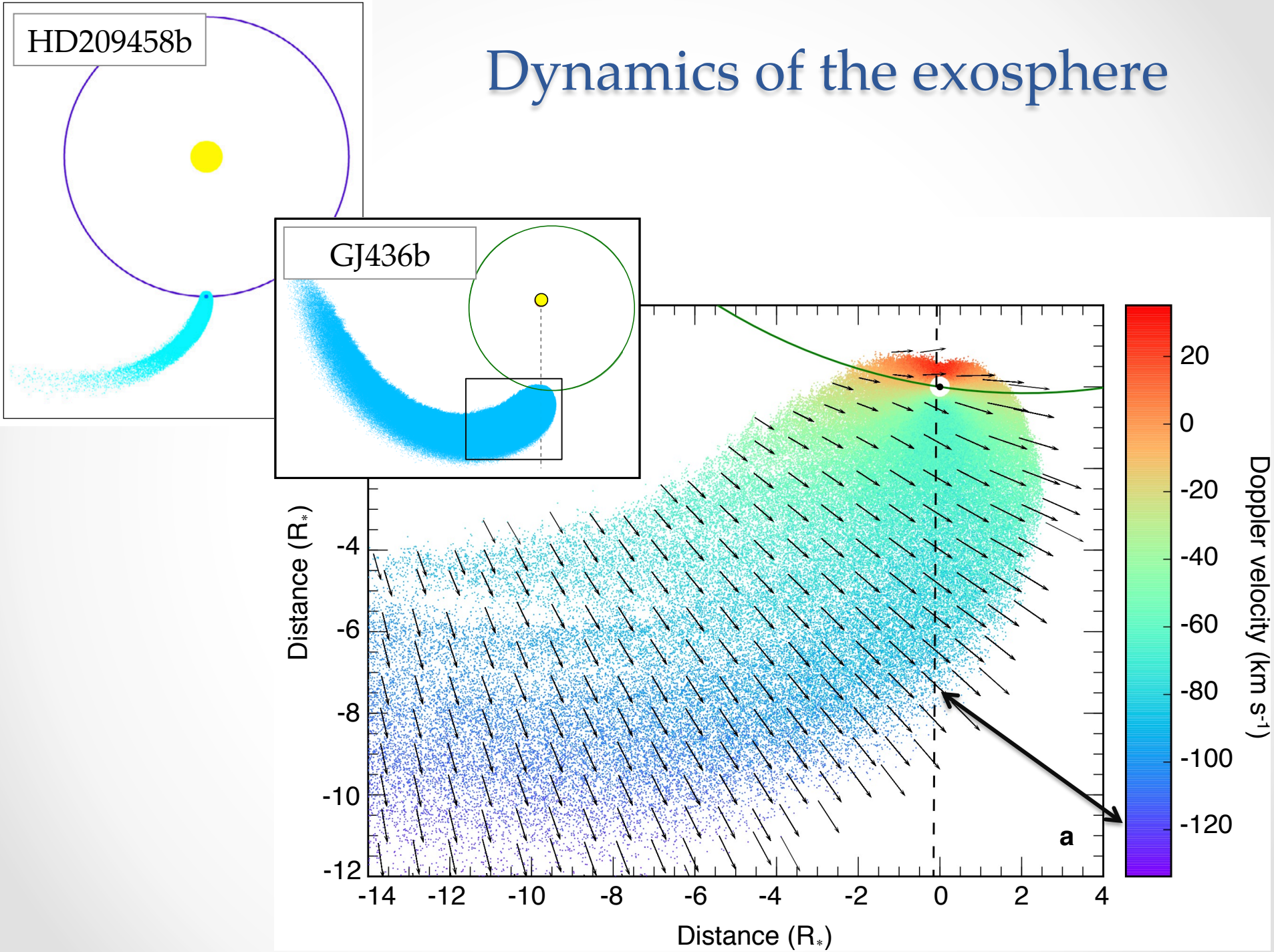




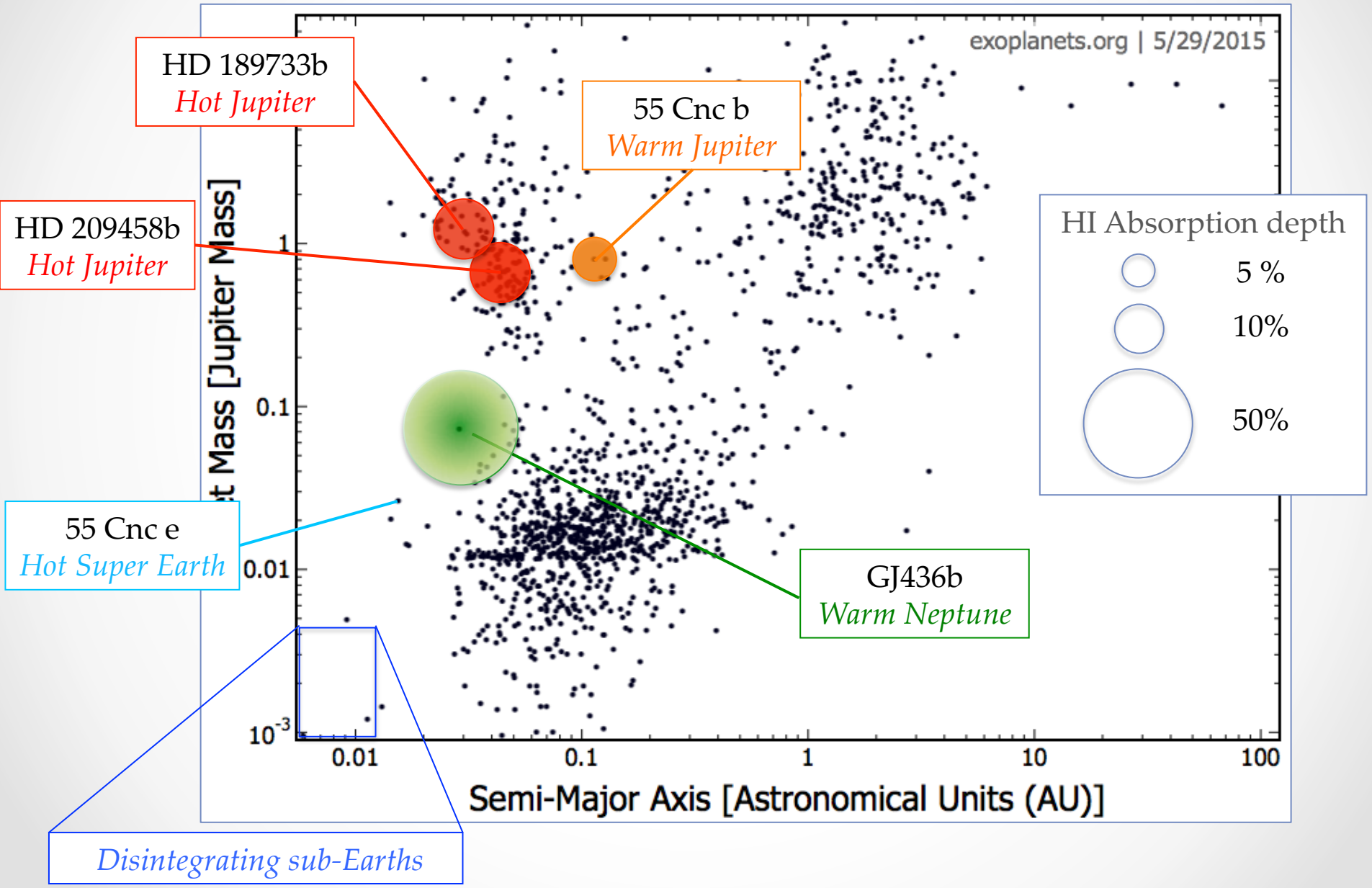
Transit of a behemoth exosphere



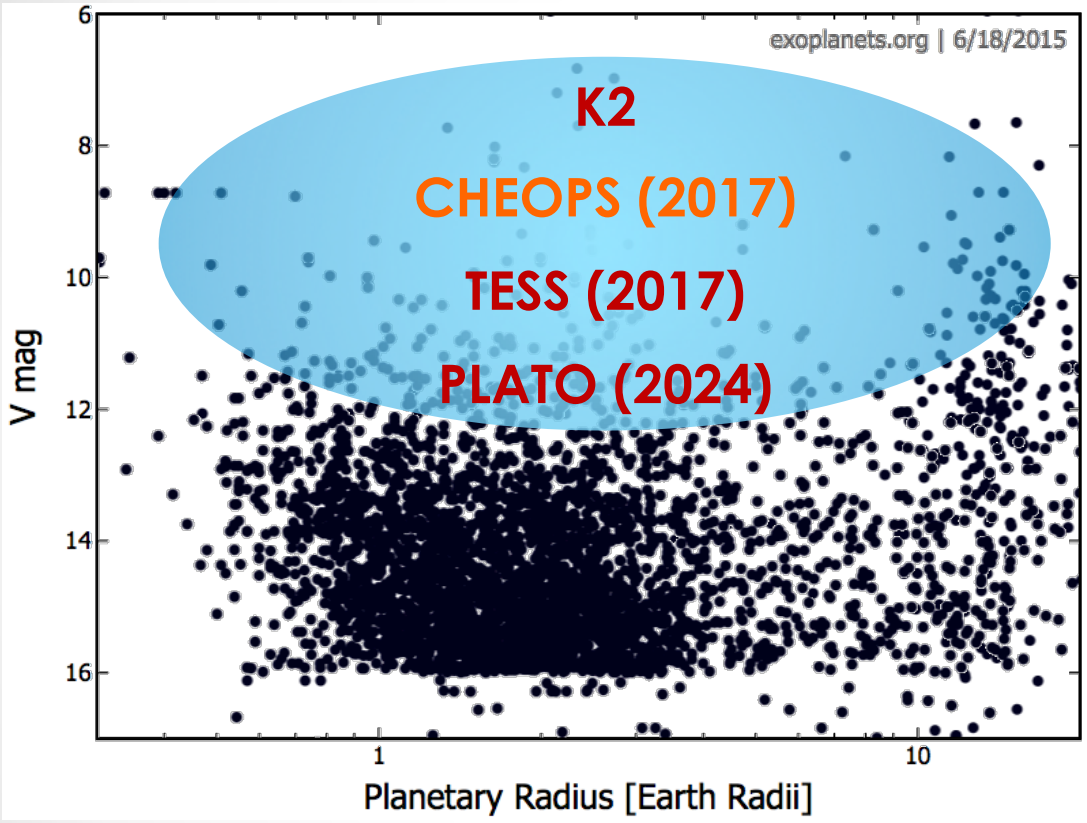
Dynamics of the exosphere

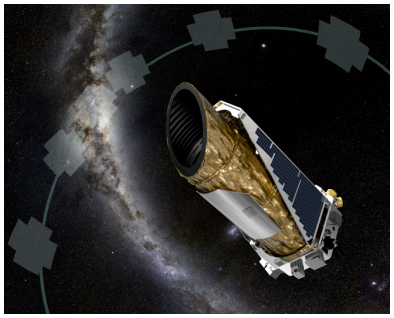


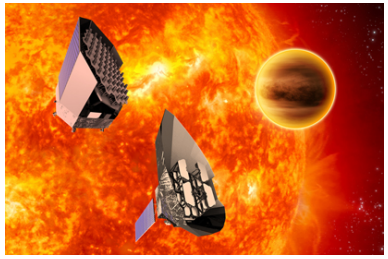
From hot Jupiters to warm Neptunes, and beyond

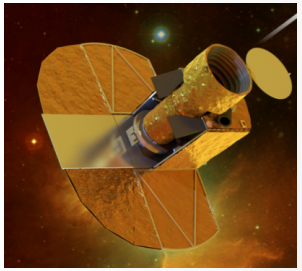


Follow-up spectroscopy of upper atmospheres



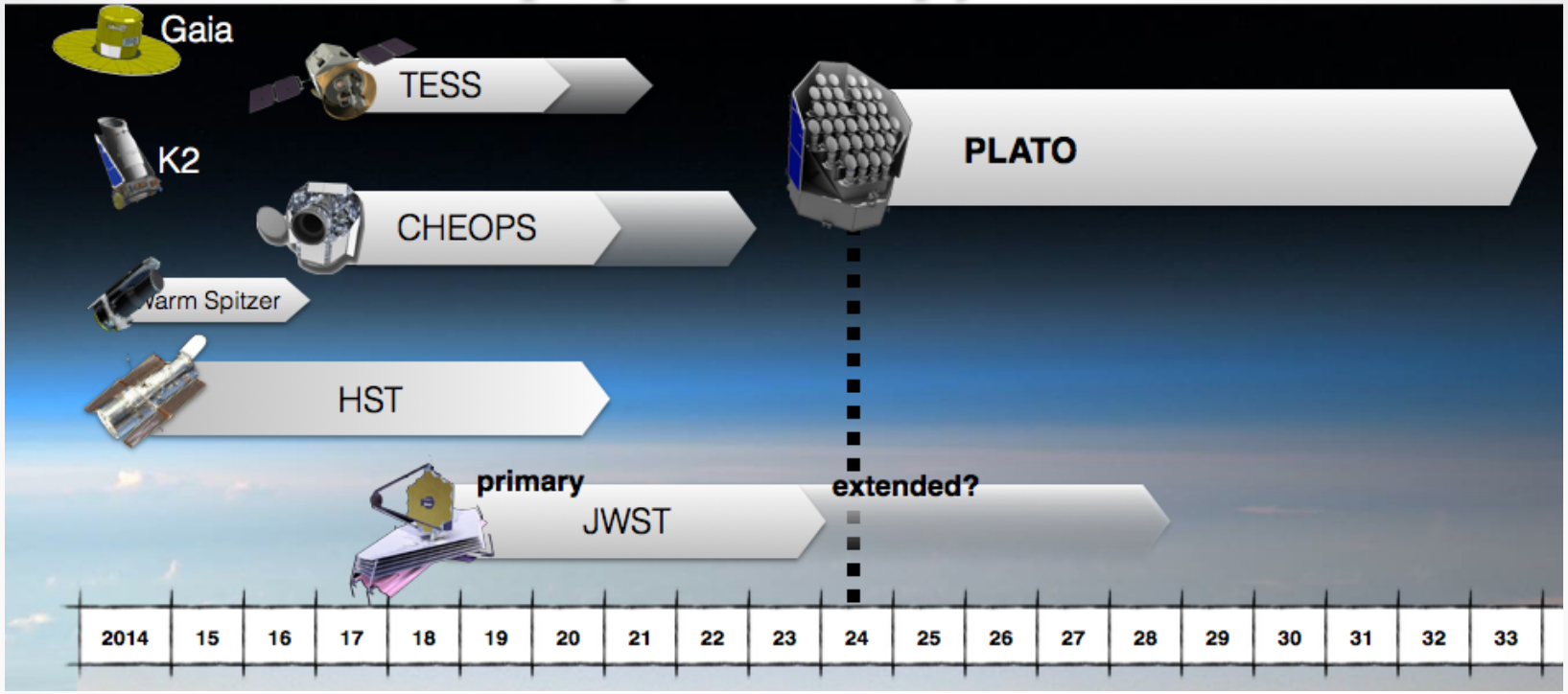






Detection of many small planets around bright stars:
golden targets for transit observations of their upper atmospheres

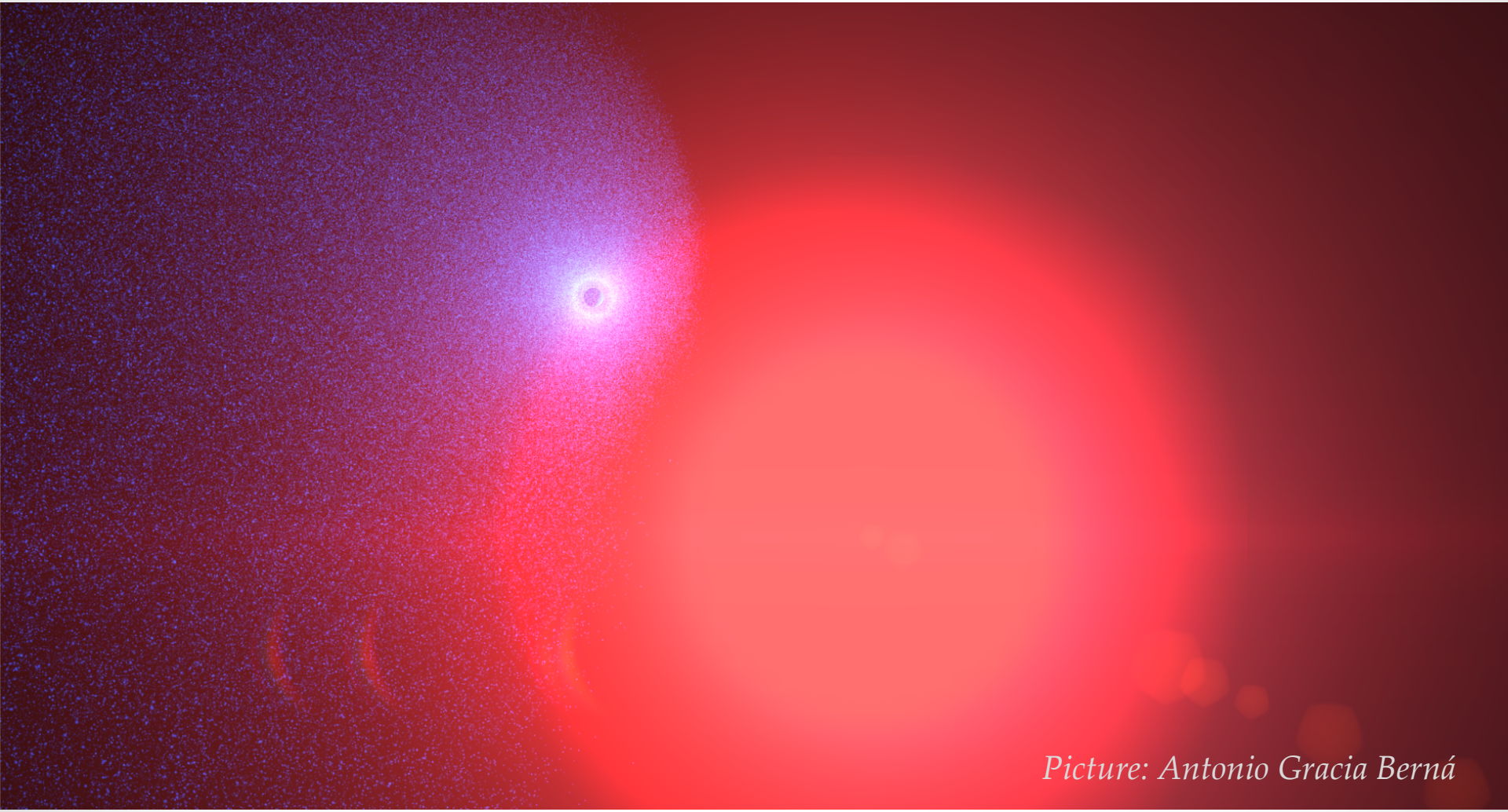
Follow-up spectroscopy with HST



$$\text{Absorption signal of 1 scale height} \propto \frac{T_p}{\rho_p \mu_{atm} R_\star^2}$$

- **Importance of UV** (see "*Characterising exoplanets and their environment with UV transmission spectroscopy*", Fossati et al. 2015) and …
- **… potential of observations at longer wavelengths** (e.g. sodium with HARPS, Wyttenbach et al. 2015; dust with CHEOPS, …)

Thank you for your attention



Picture: Antonio Gracia Berná