Evaporating exoplanets: the new deal

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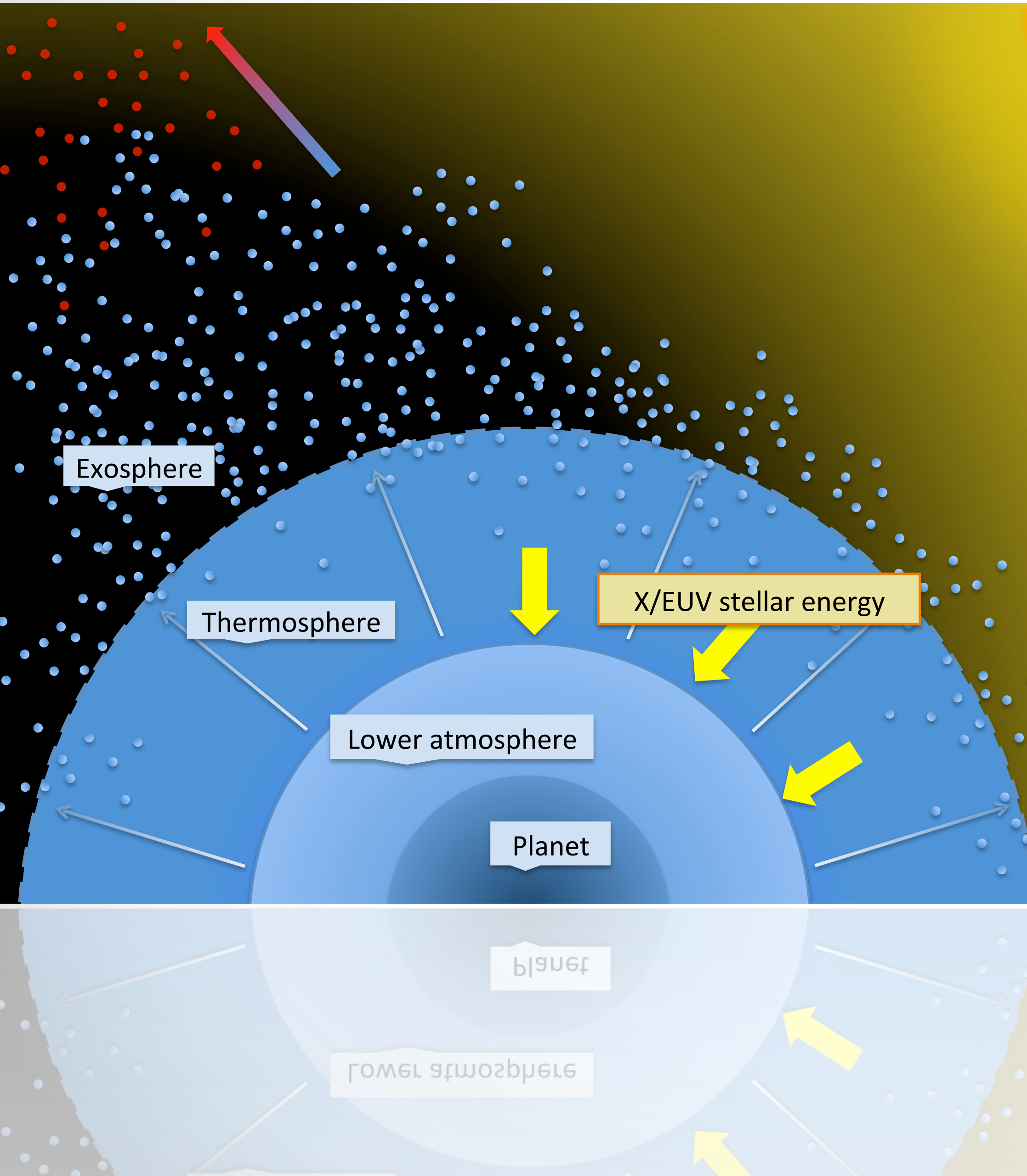
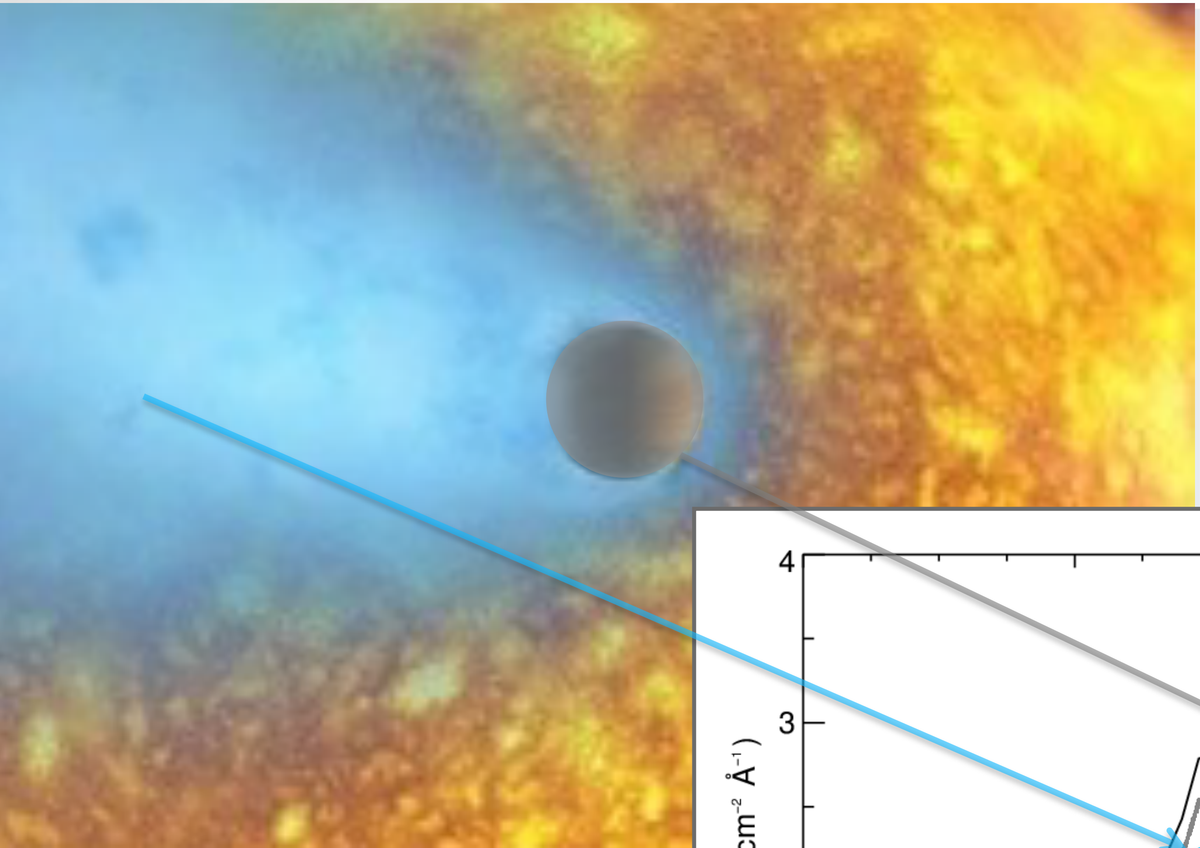
From super-Earths to brown dwarfs: Who's Who?
31st International IAP Colloquium
3 July 2015

The upper atmosphere of irradiated planets

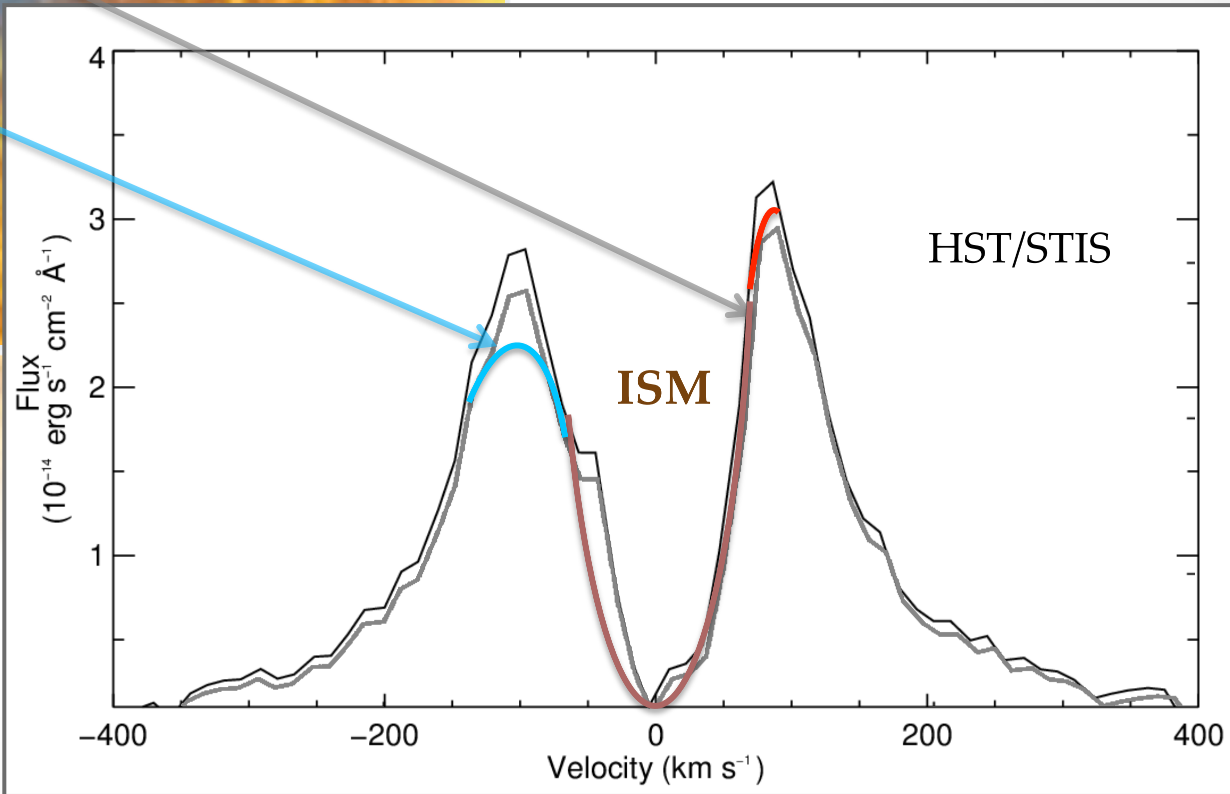


- X-ray + EUV radiation from the host star
- Heating at the base of the thermosphere : departure from hydrostatic state
- Hydrodynamic inflation of the upper layers of the atmosphere
- Upward flow of hydrogen, carrying along heavy elements
- Possible escape

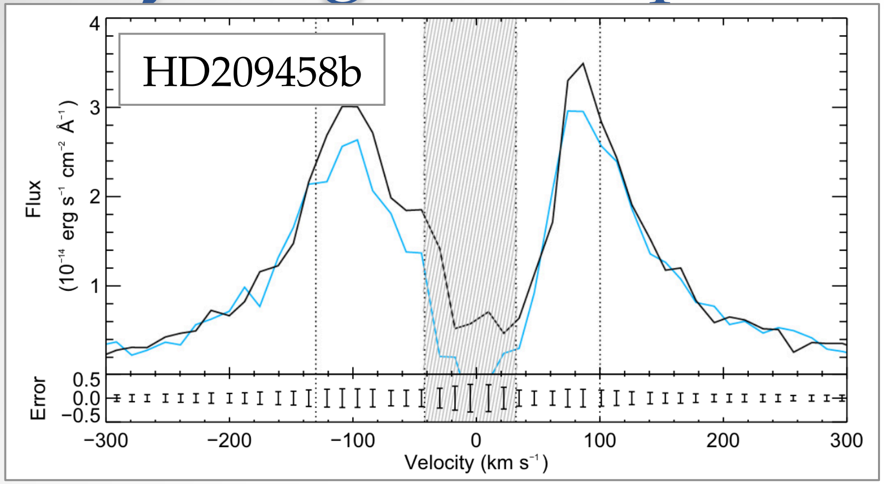
UV transmission spectroscopy of the exosphere



Planetary occultation~ 1%

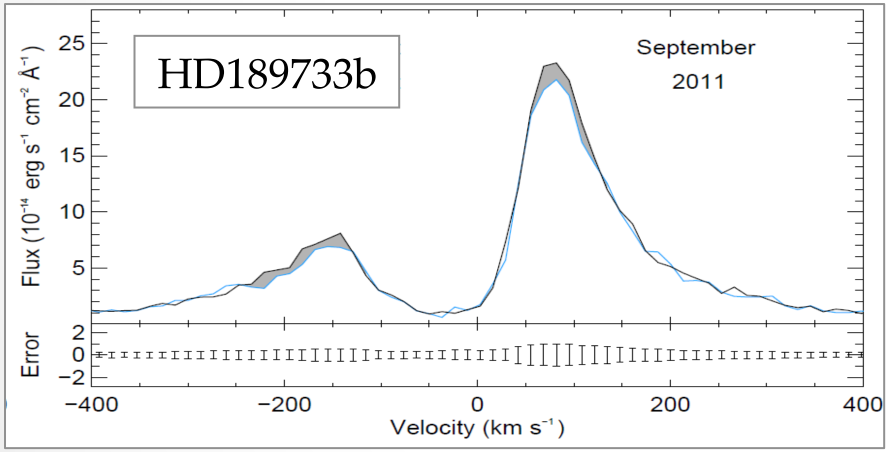


Hydrogen exospheres of Jupiter-mass planets



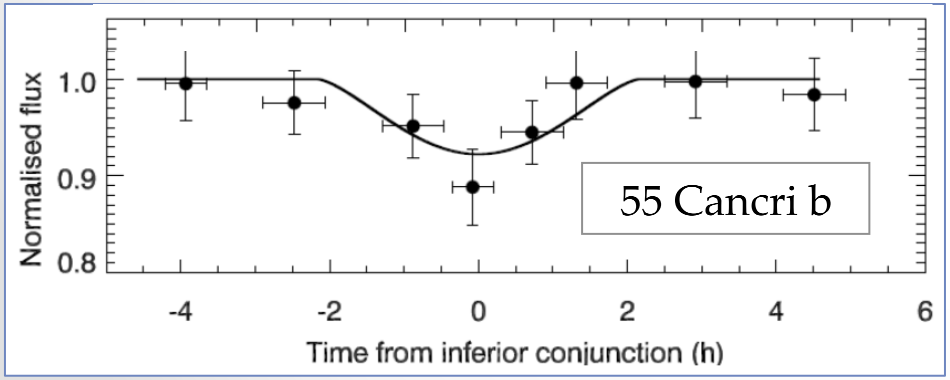
Hot-Jupiter:
15 ± 4 % in [-130 ; -40] km/s

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



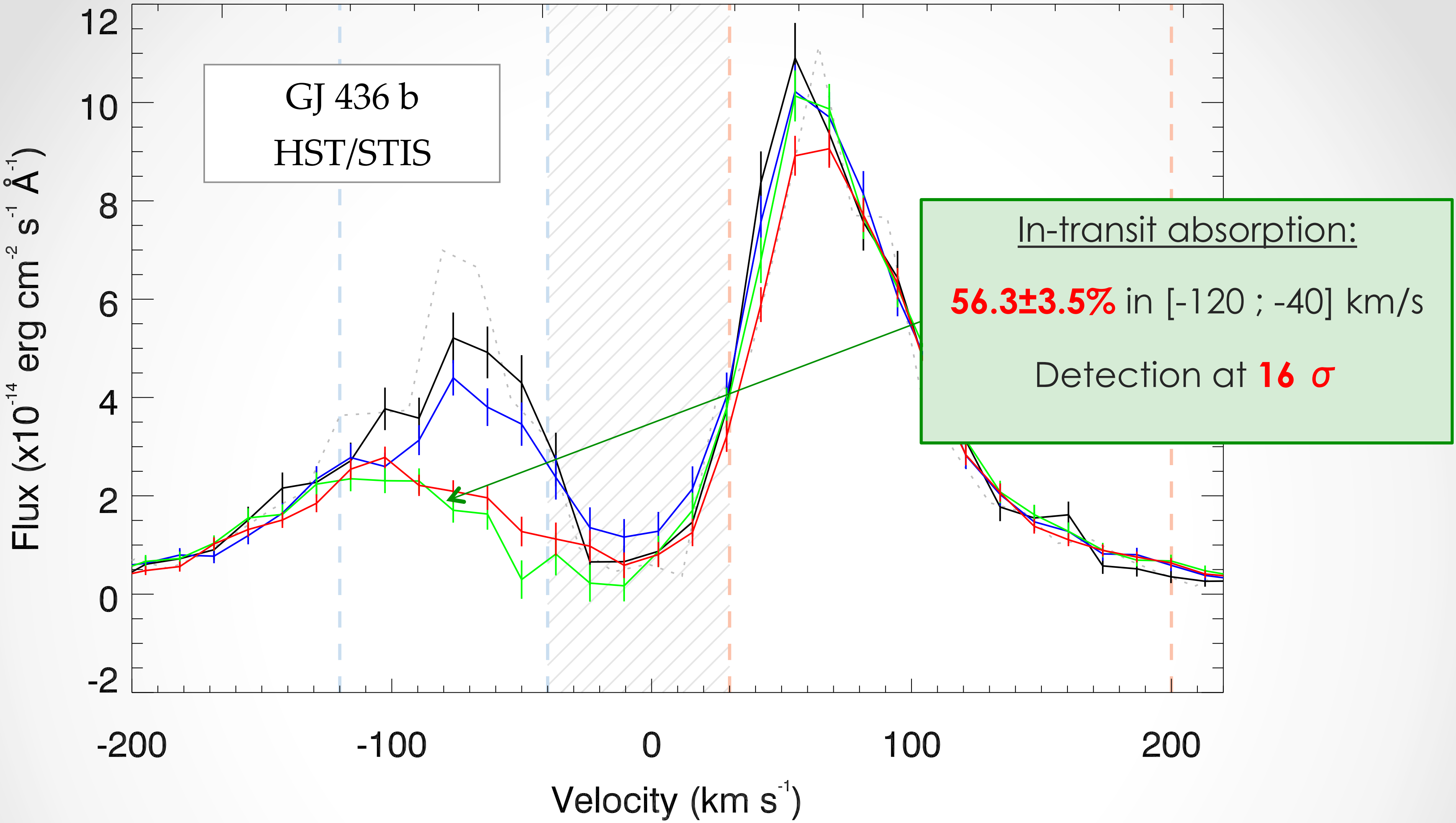
Hot-Jupiter:
14.4 ± 3,6 % in [-220 ; -140] km/s

Lecavelier, Bourrier et al. 2012



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

Ehrenreich, Bourrier et al. 2012

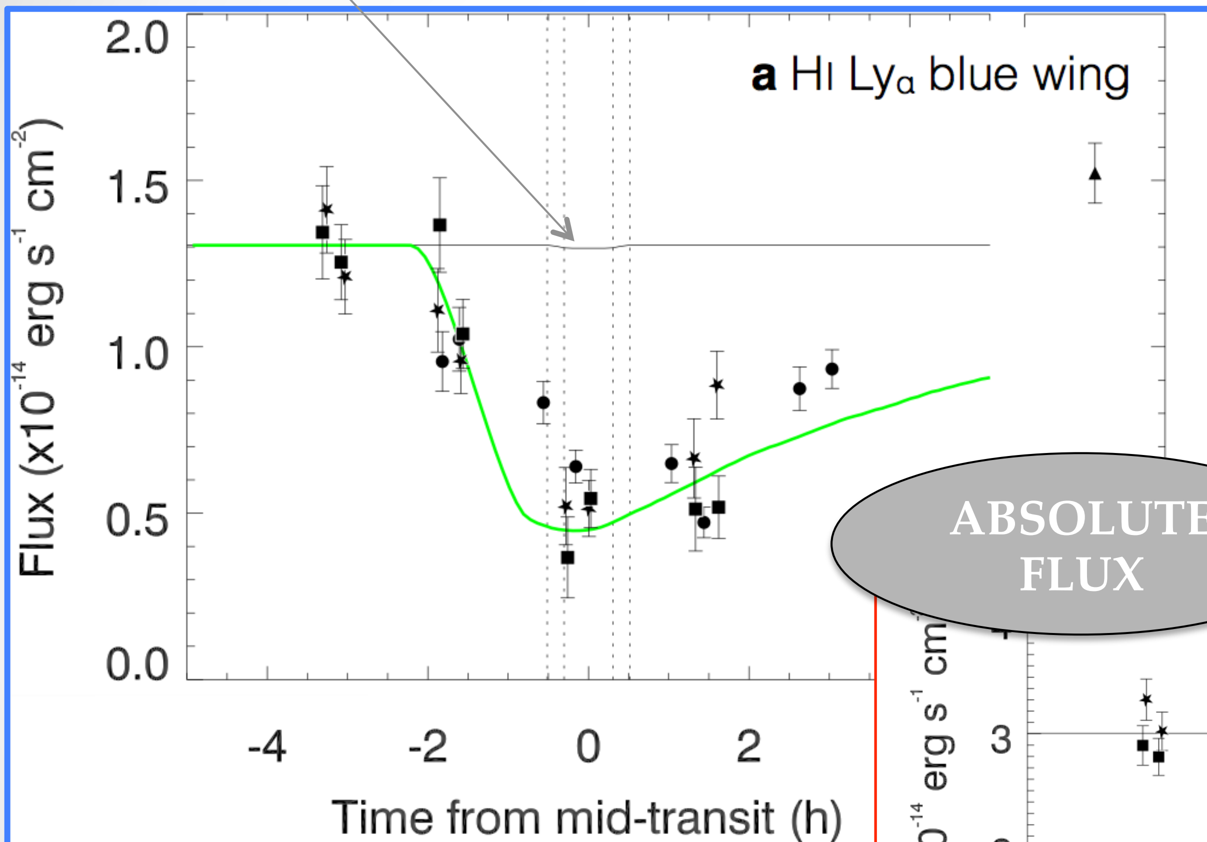


Ehrenreich, Bourrier et al.
Nature 522, 459–461 (25 June 2015)

Peter J. Wheatley, Alain Lecavelier des Etangs, Guillaume Hébrard, Stéphane Udry, Xavier Bonfils, Xavier Delfosse, Jean-Michel Désert, David K. Sing, & Alfred Vidal-Madjar

Repeatable transit variations

Planetary disk= 0.7%

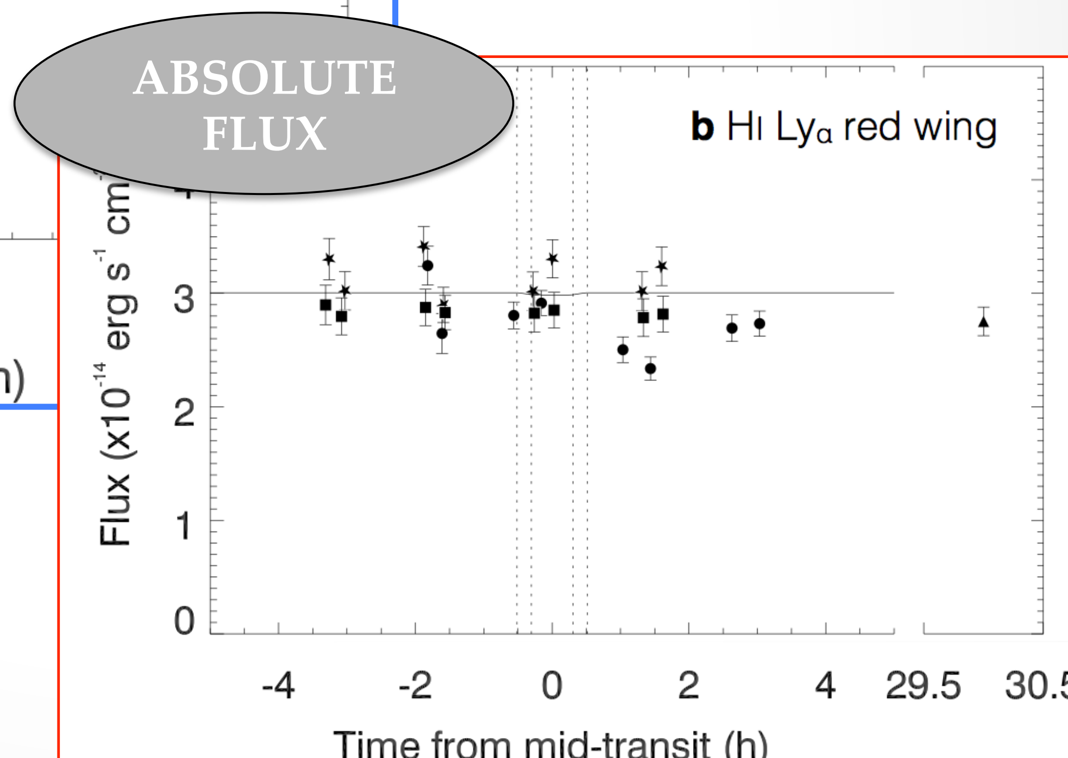


Three different epochs:

December 2012 ●
(Kulow et al. 2014)

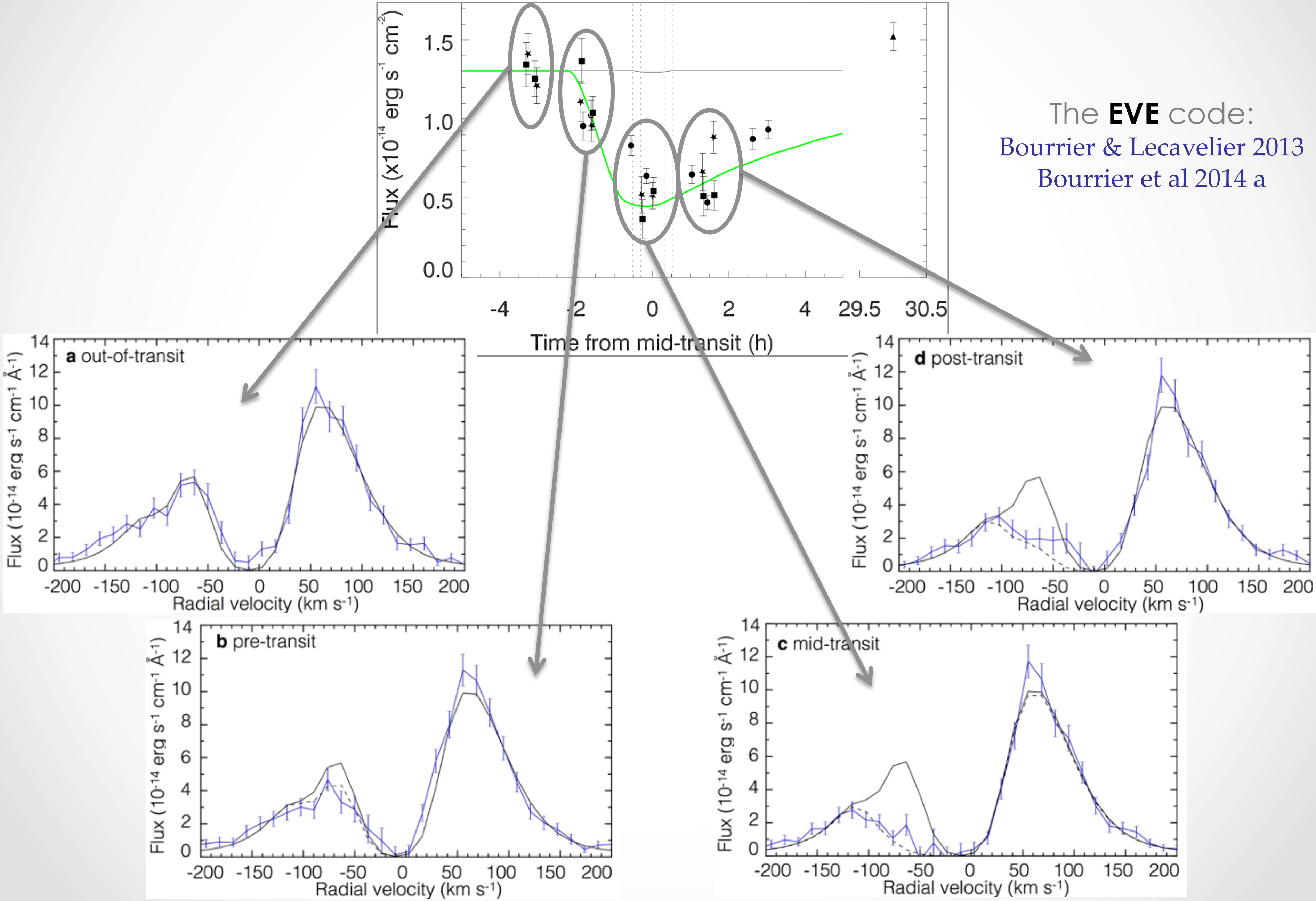
June 2013 ★

June 2014 ■



Stellar line stable

Fitting the data with the EVaporating Exoplanet code

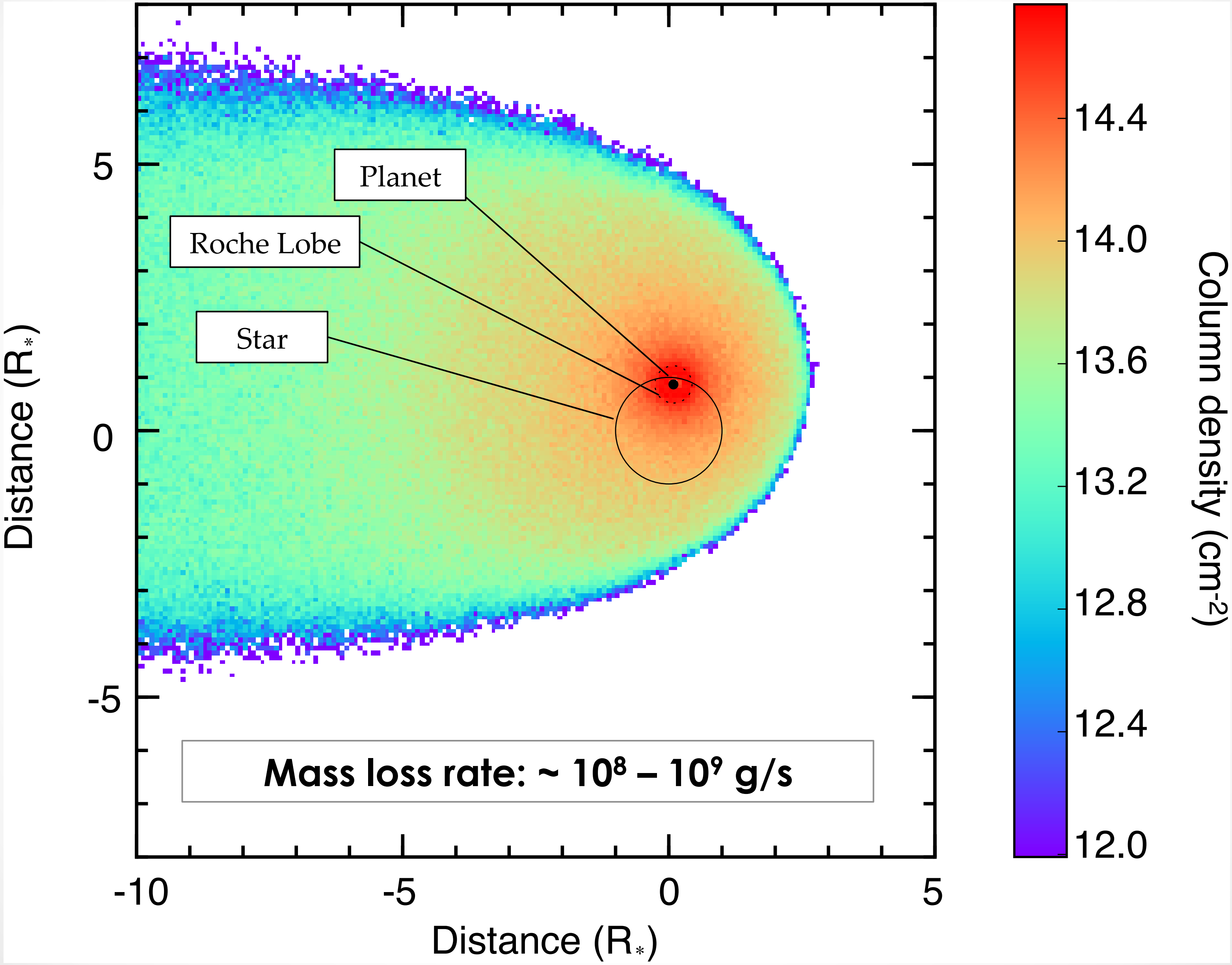


The **EVE** code:

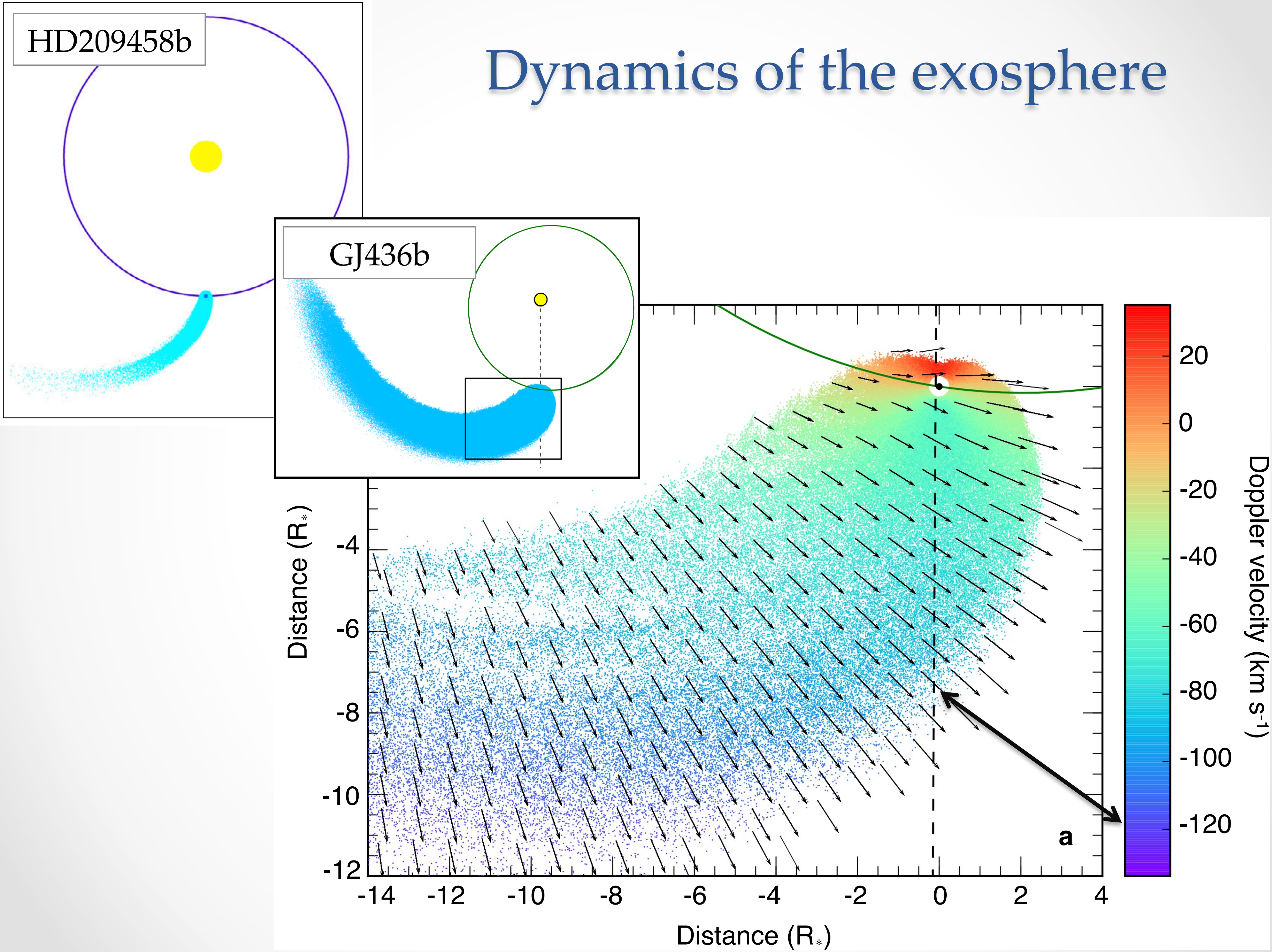
Bourrier & Lecavelier 2013

Bourrier et al 2014 a

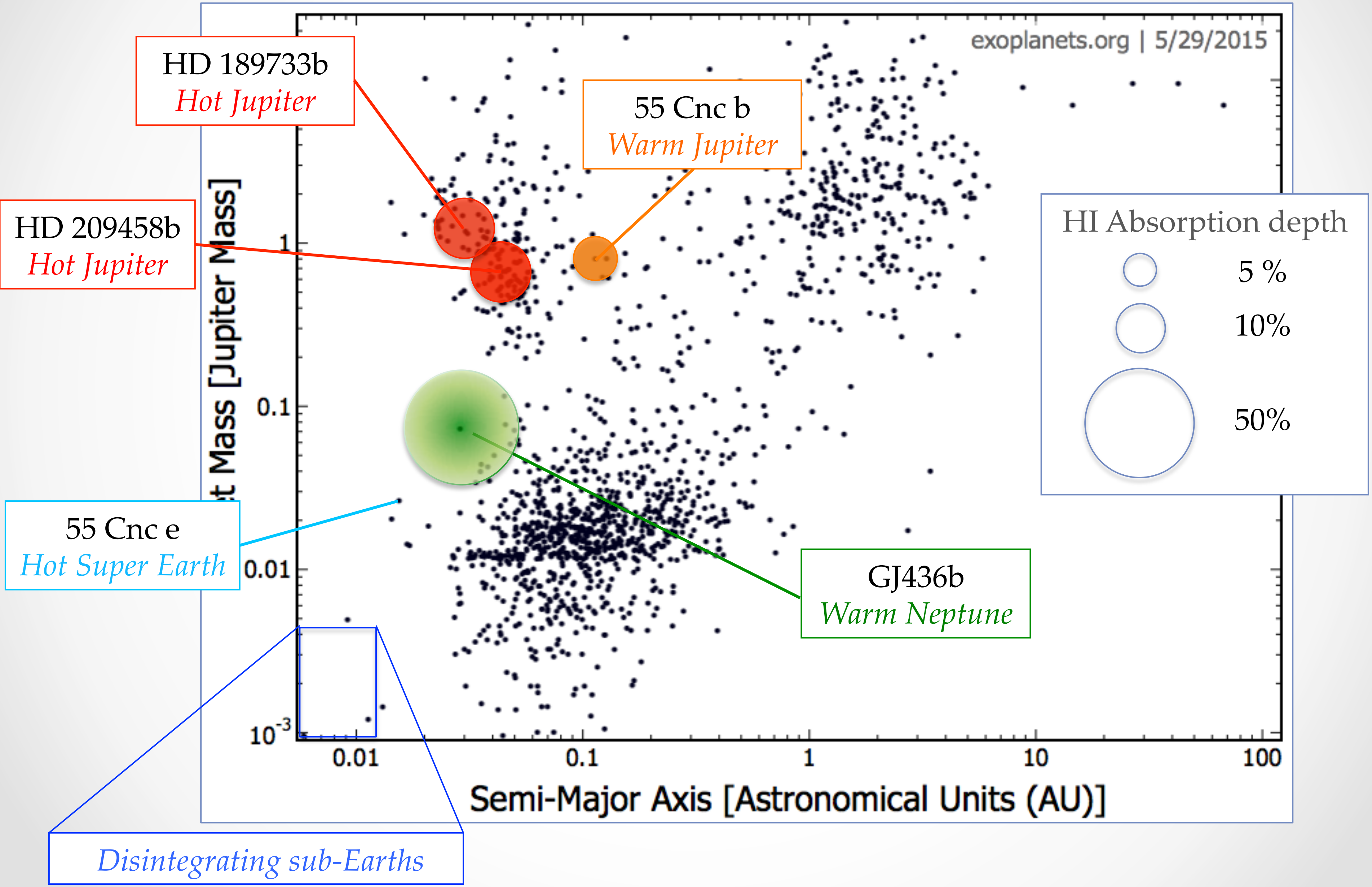
Transit of a behemoth exosphere



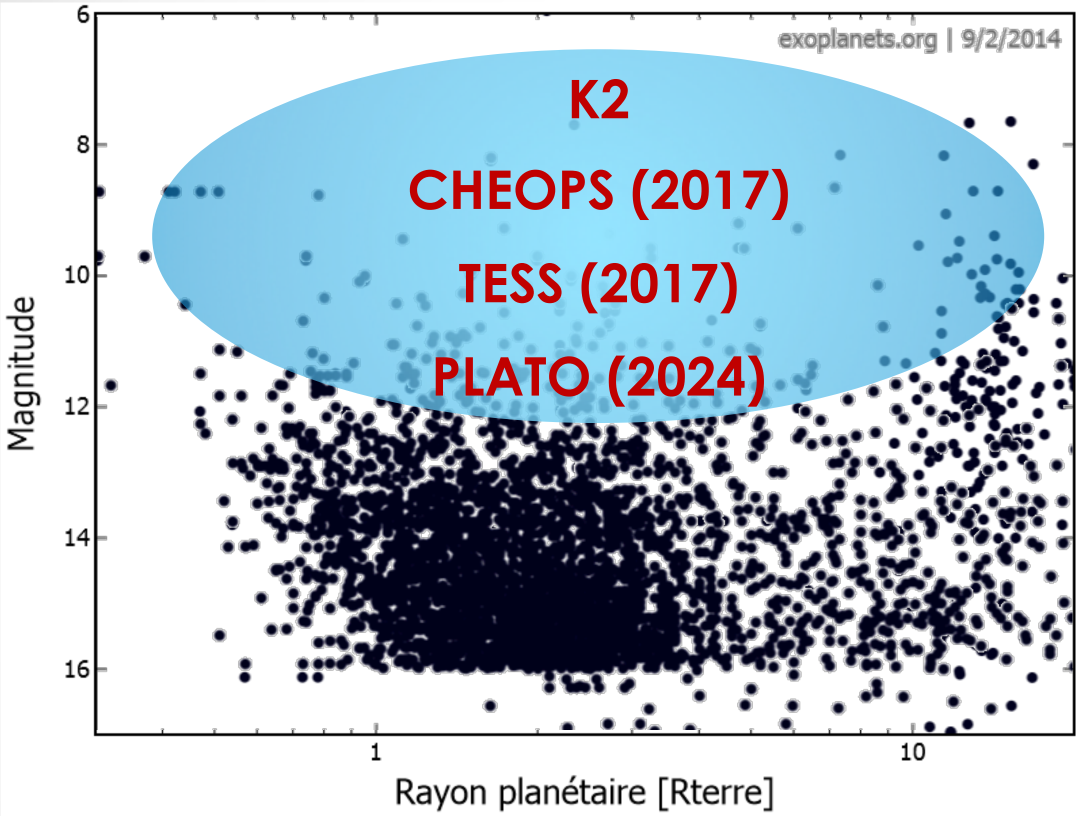
Dynamics of the exosphere

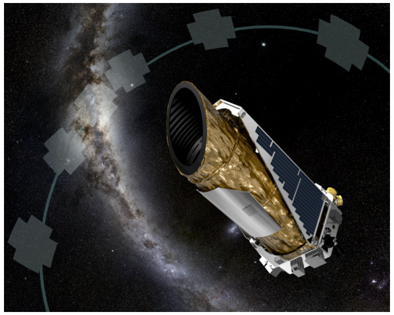


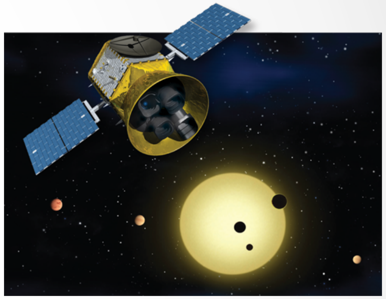
From hot Jupiters to warm Neptunes, and beyond

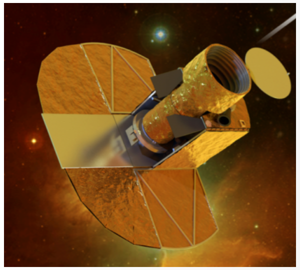


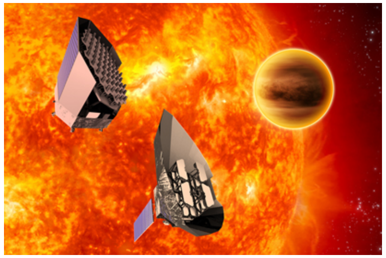
Follow-up spectroscopy of upper atmospheres





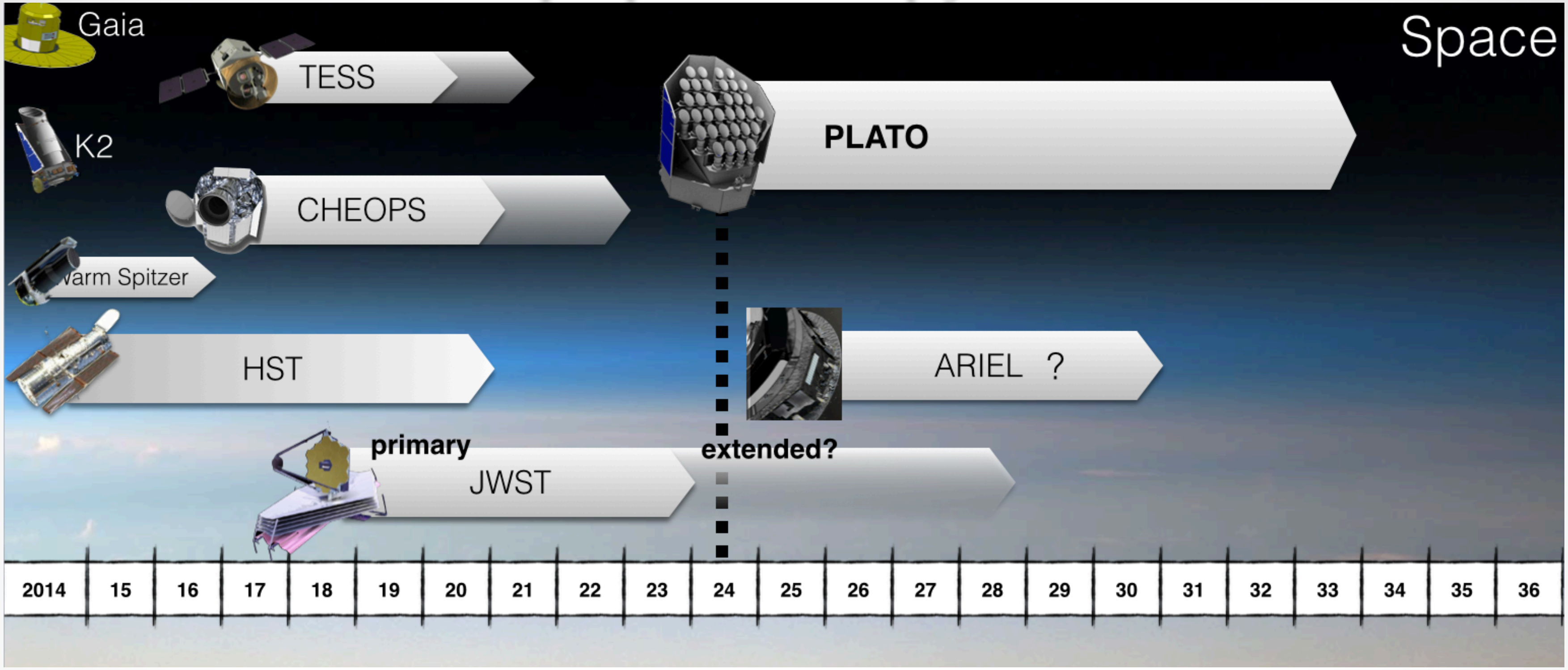






> ➢ Detections of moderately irradiated, low-mass exoplanets (around bright stars)

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: Mark Garlick/University of Warwick