

Narrow-band transmission spectroscopy from high dispersion spectra

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PlanetS

Overview

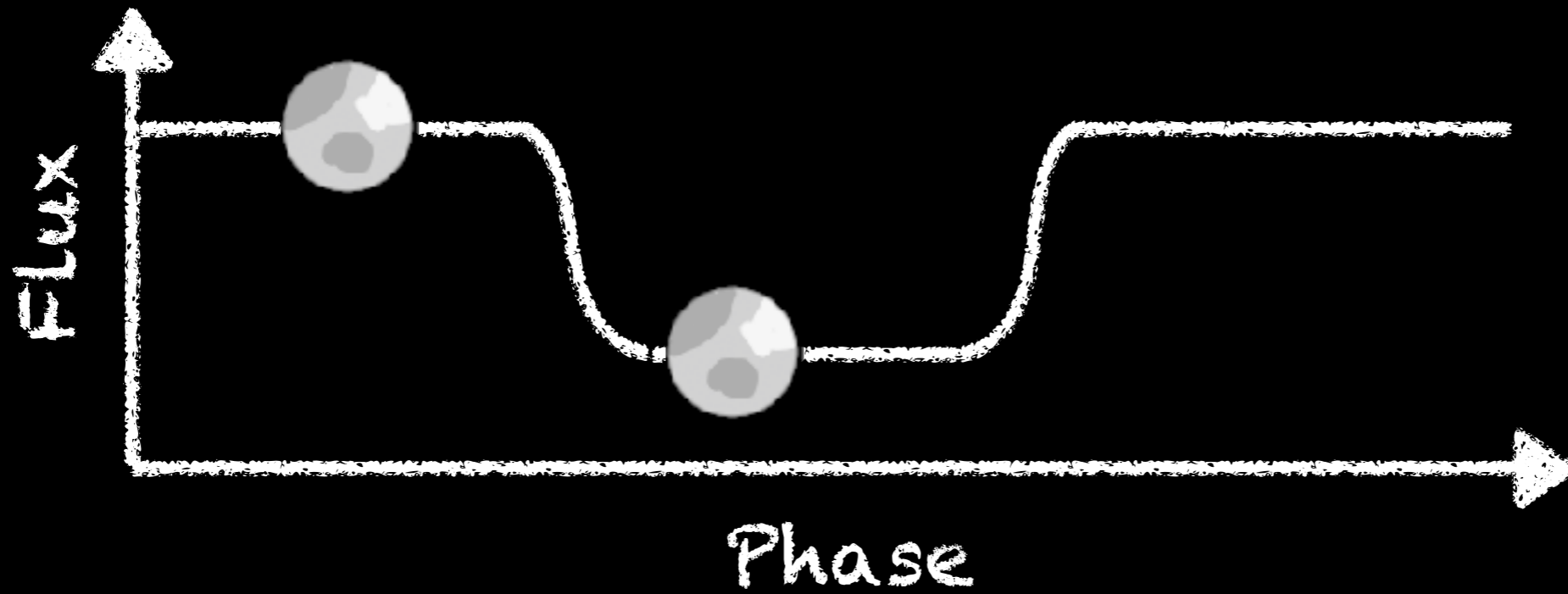
- The theory
- Theory vs reality
- (Biased) overview of spectrographs
- Resolved lines detected to date
- What can we do with them?
- Outlook



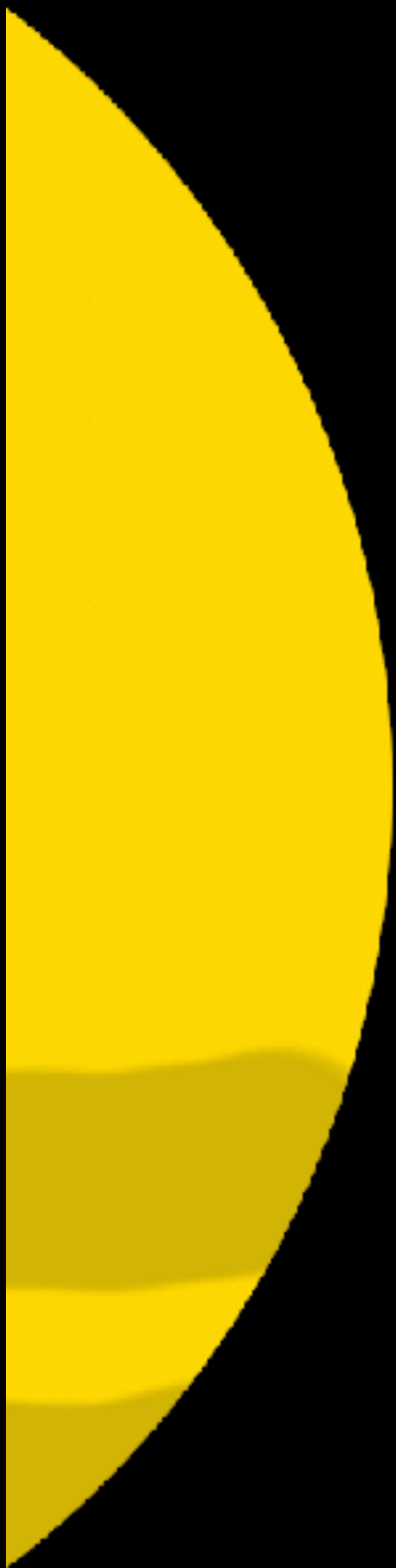
Transiting Planets



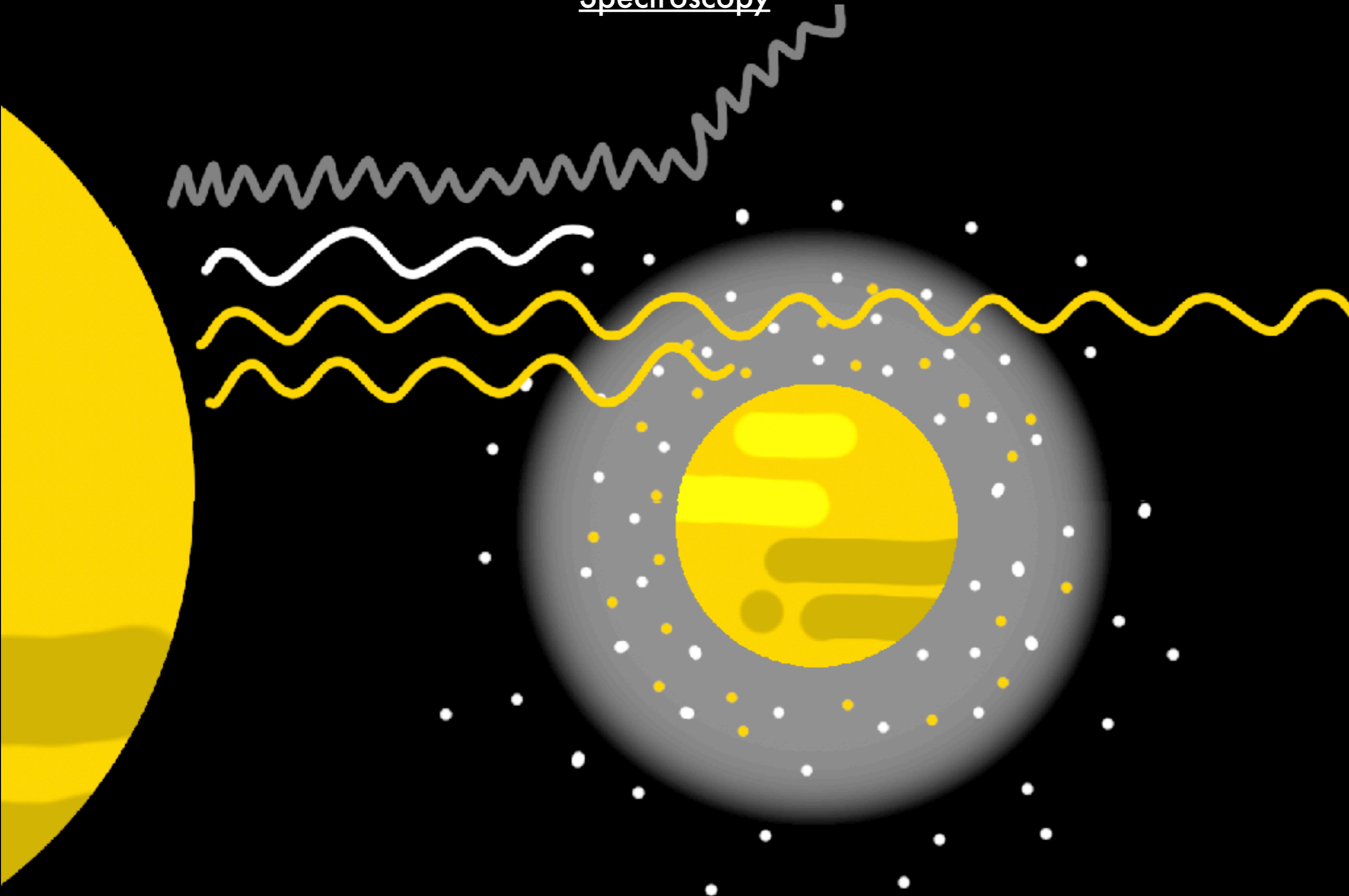
$$\sim \frac{R_p^2}{R_s^2}$$



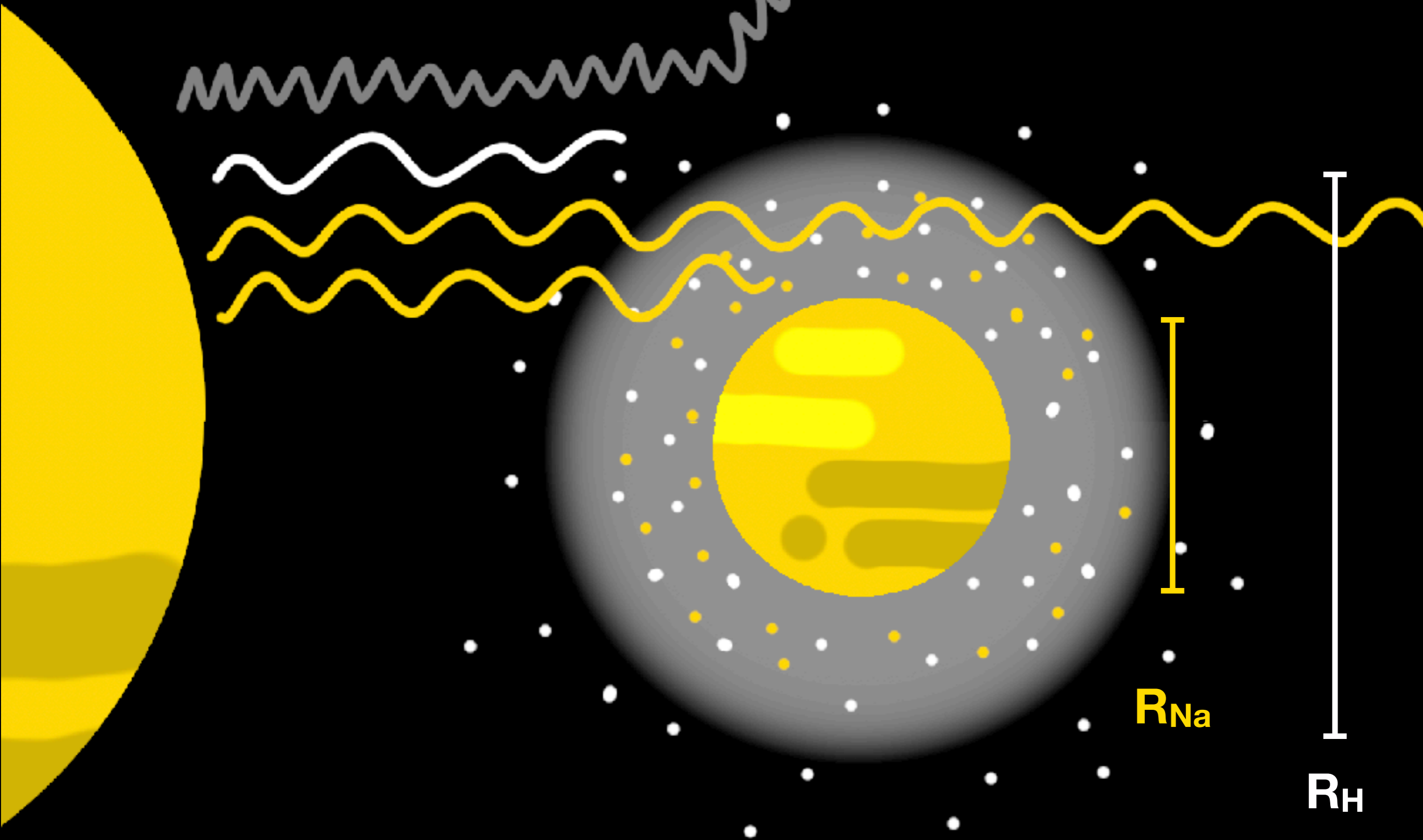
Spectroscopy



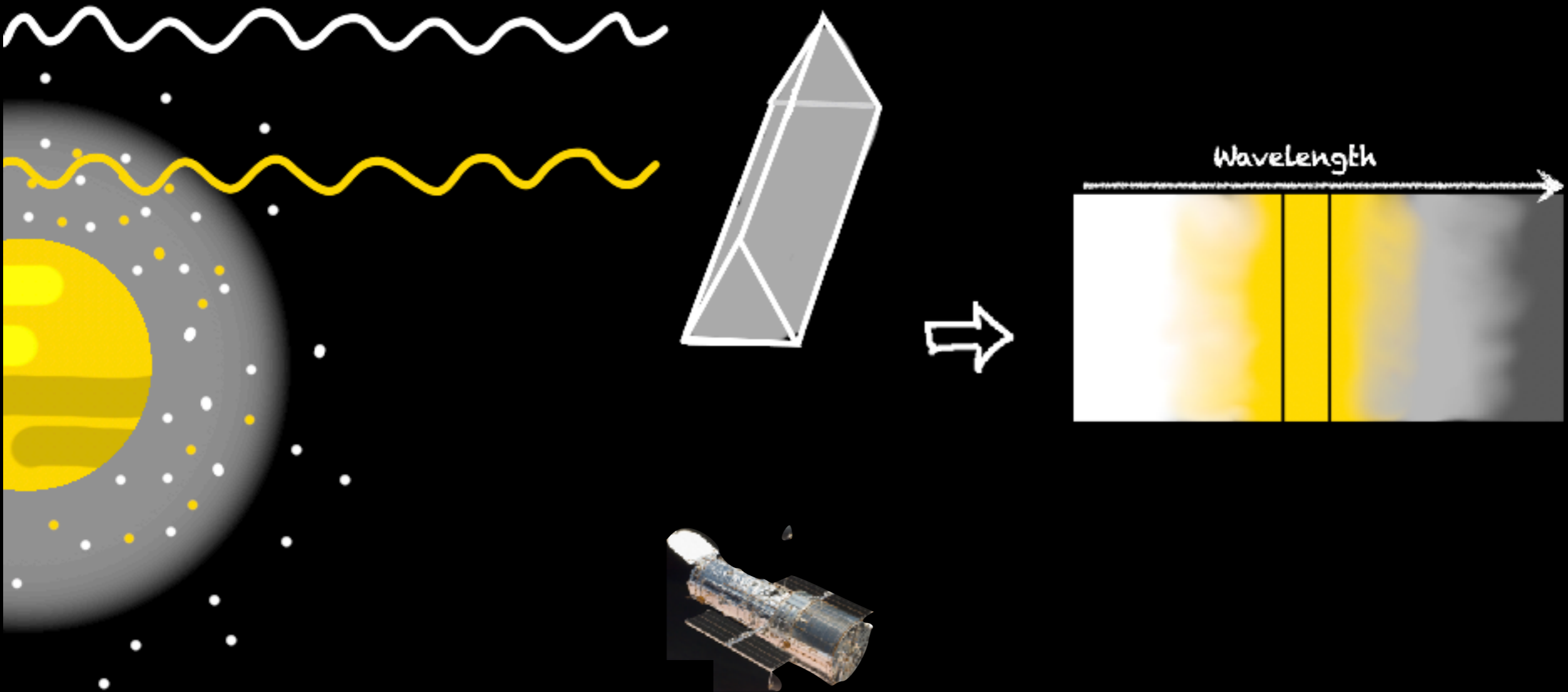
Spectroscopy



Spectroscopy

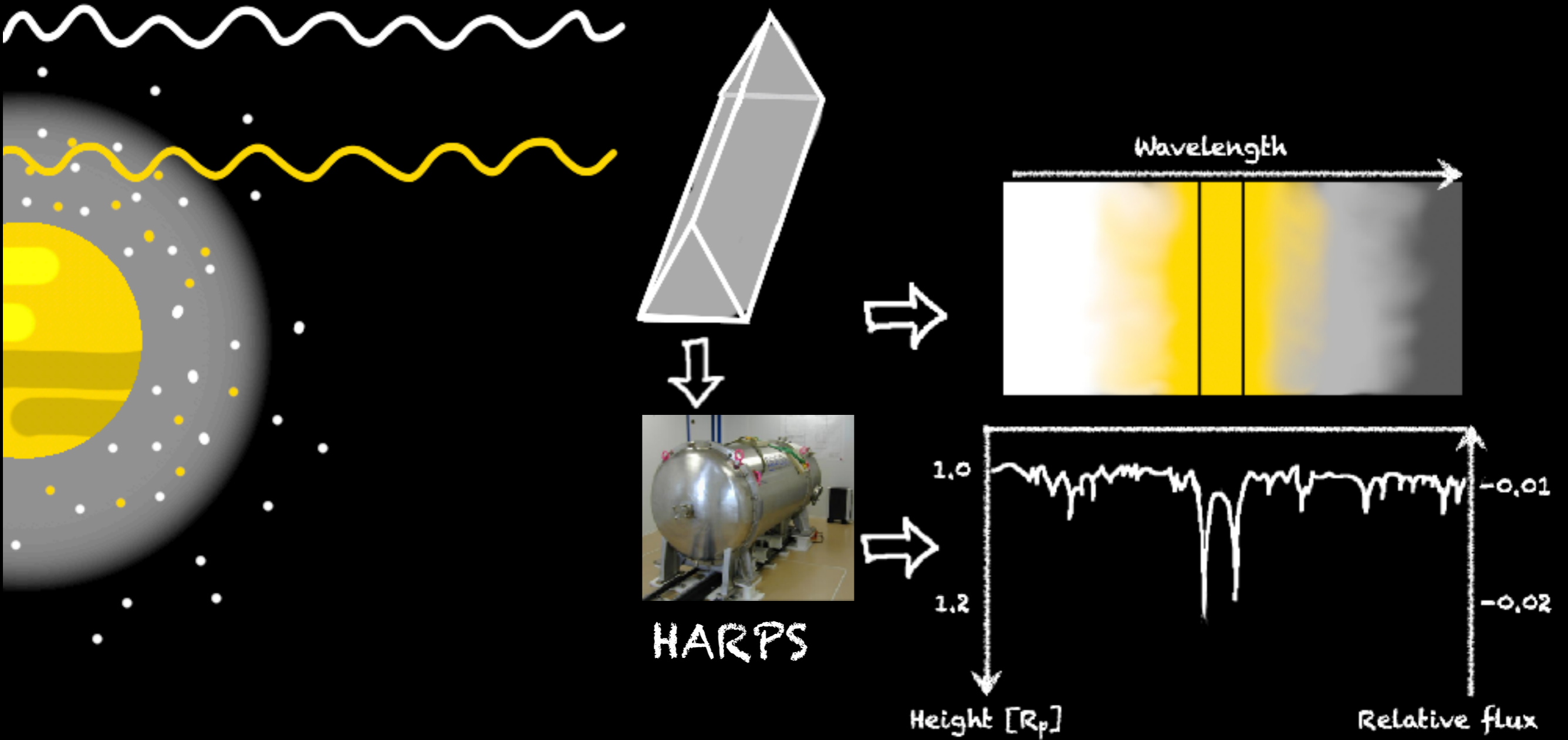


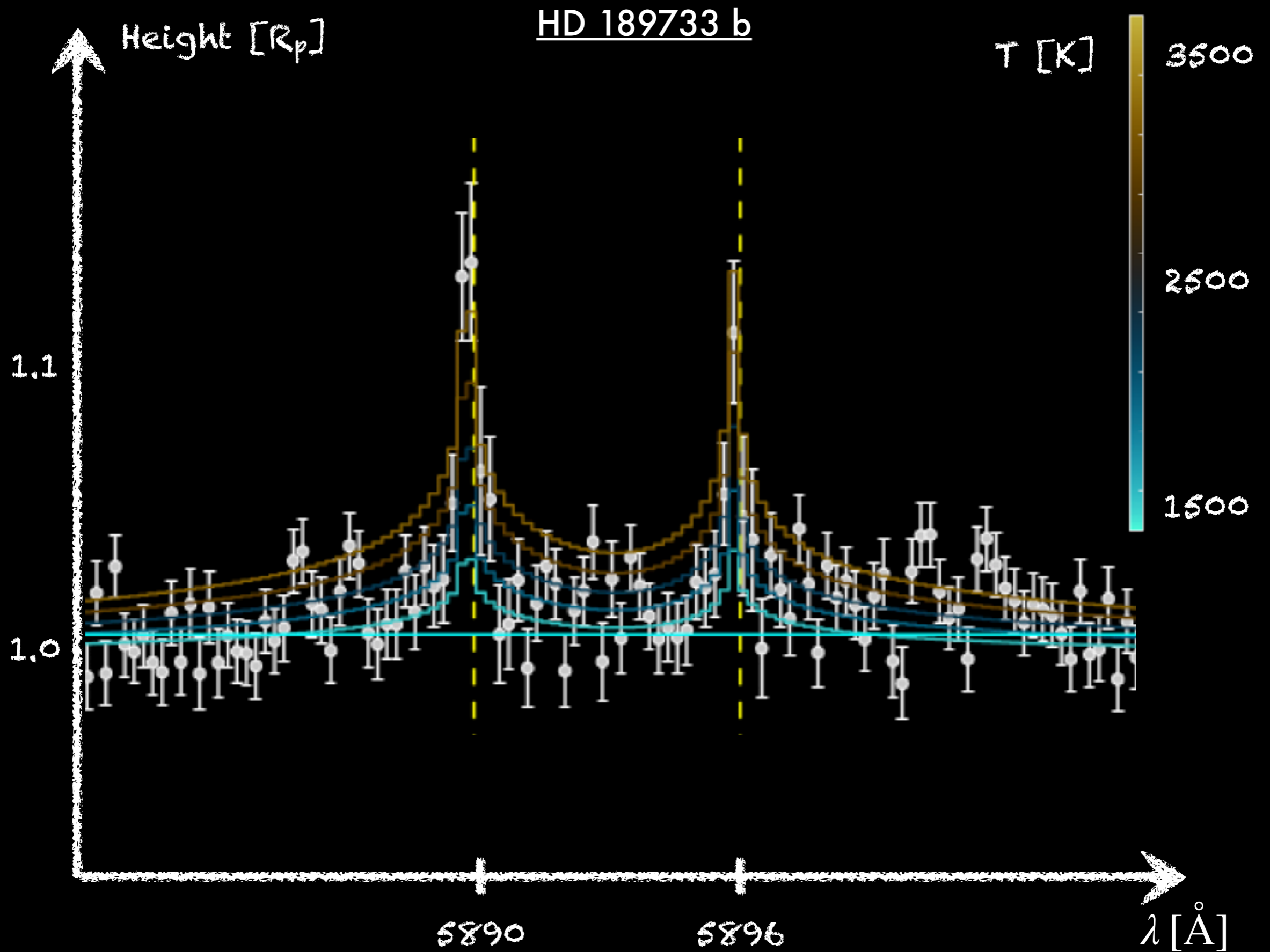
Spectroscopy



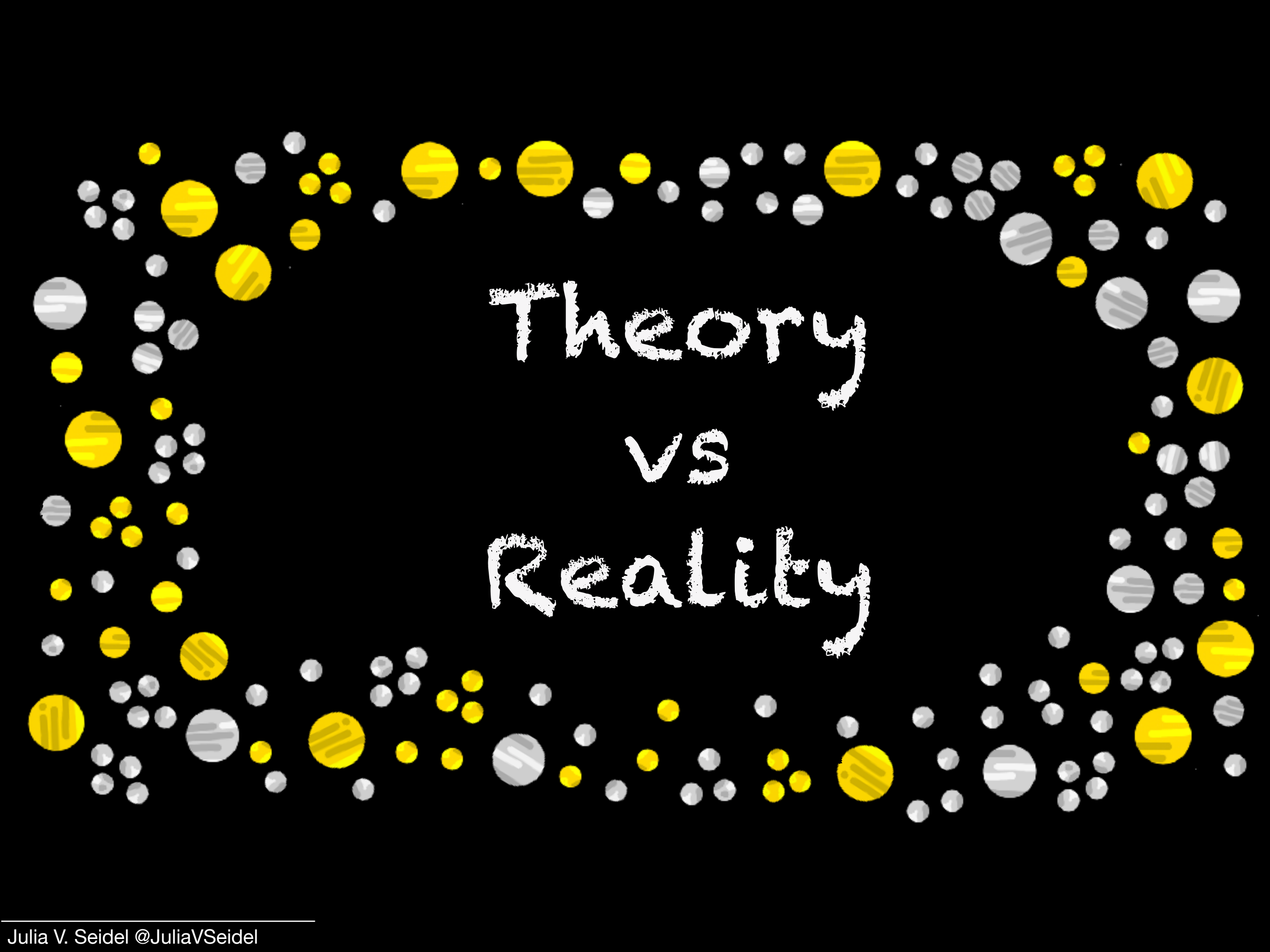
Charbonneau et al. 2002

Spectroscopy





Wytttenbach et al. 2015
Ehrenreich et al. 2006



Theory
vs
Reality

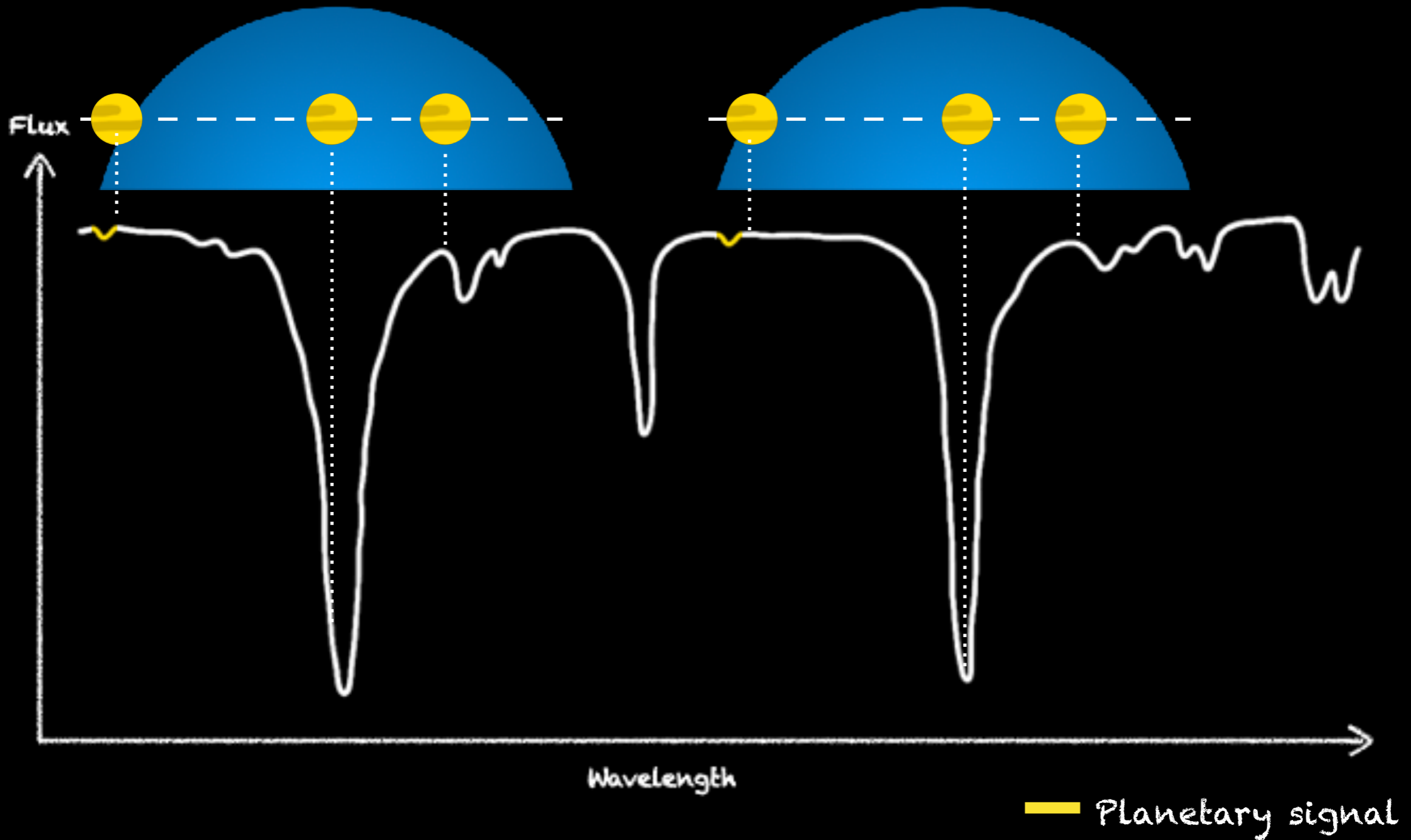


I found a resolved spectral line!

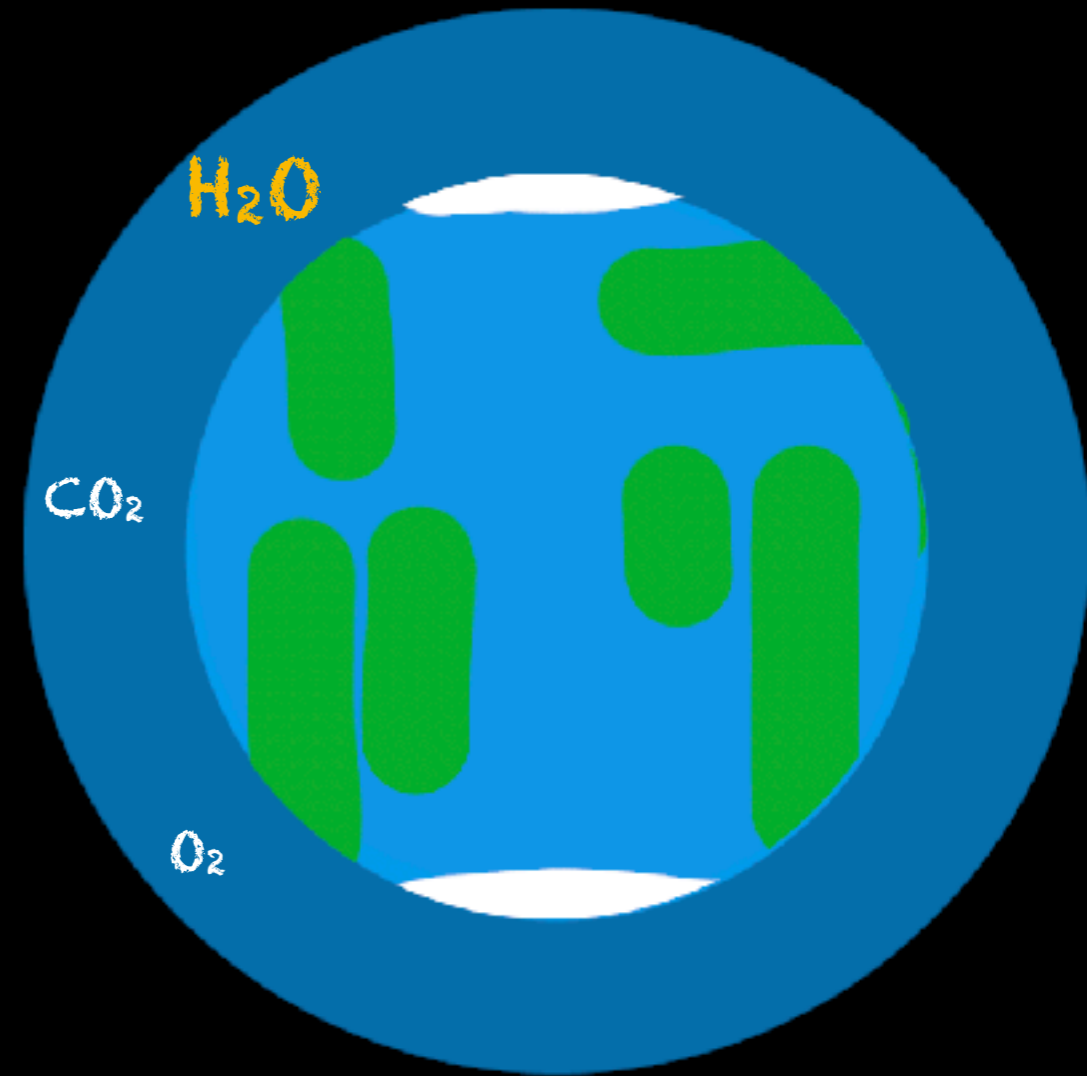
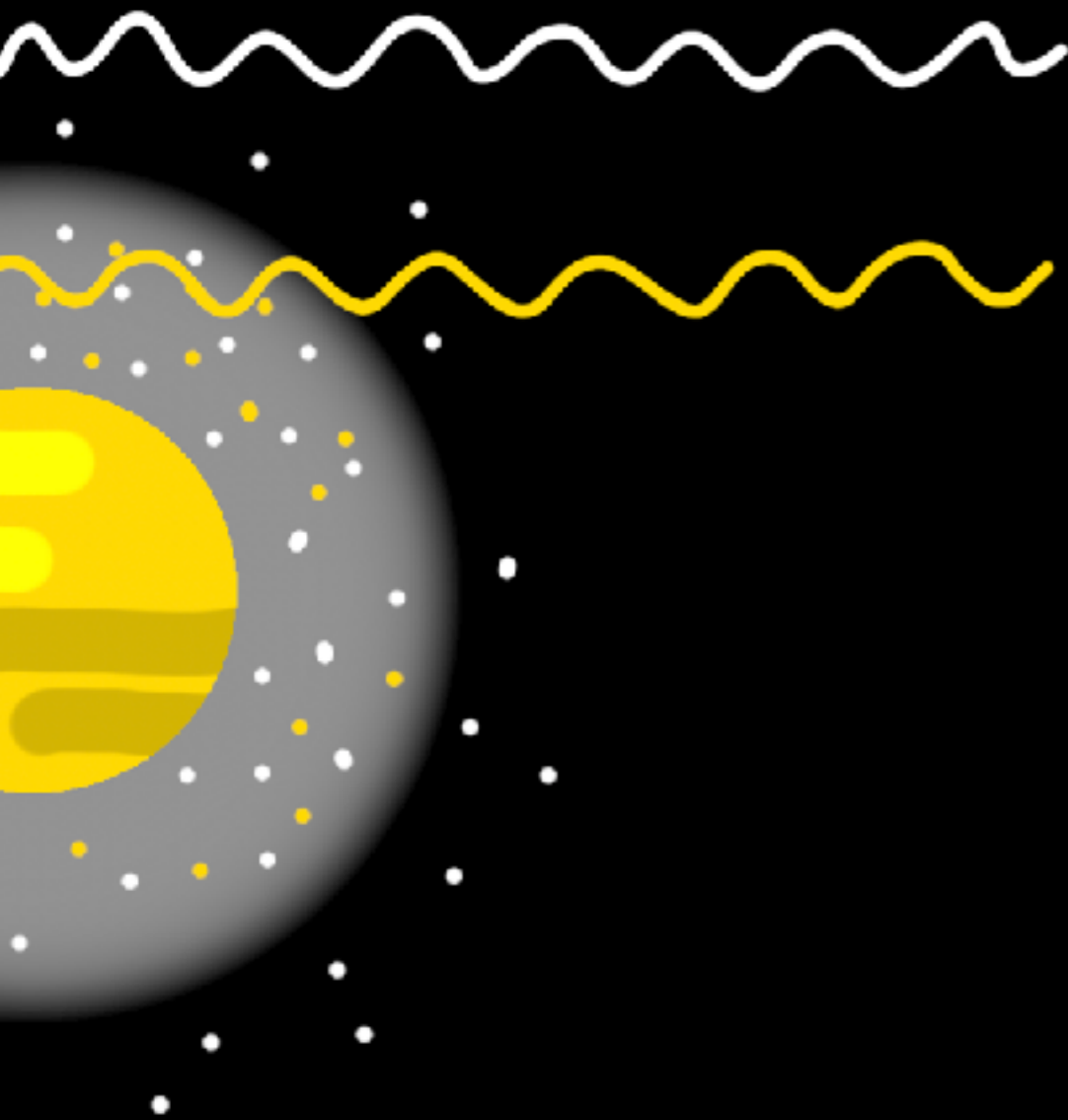


It's contamination!

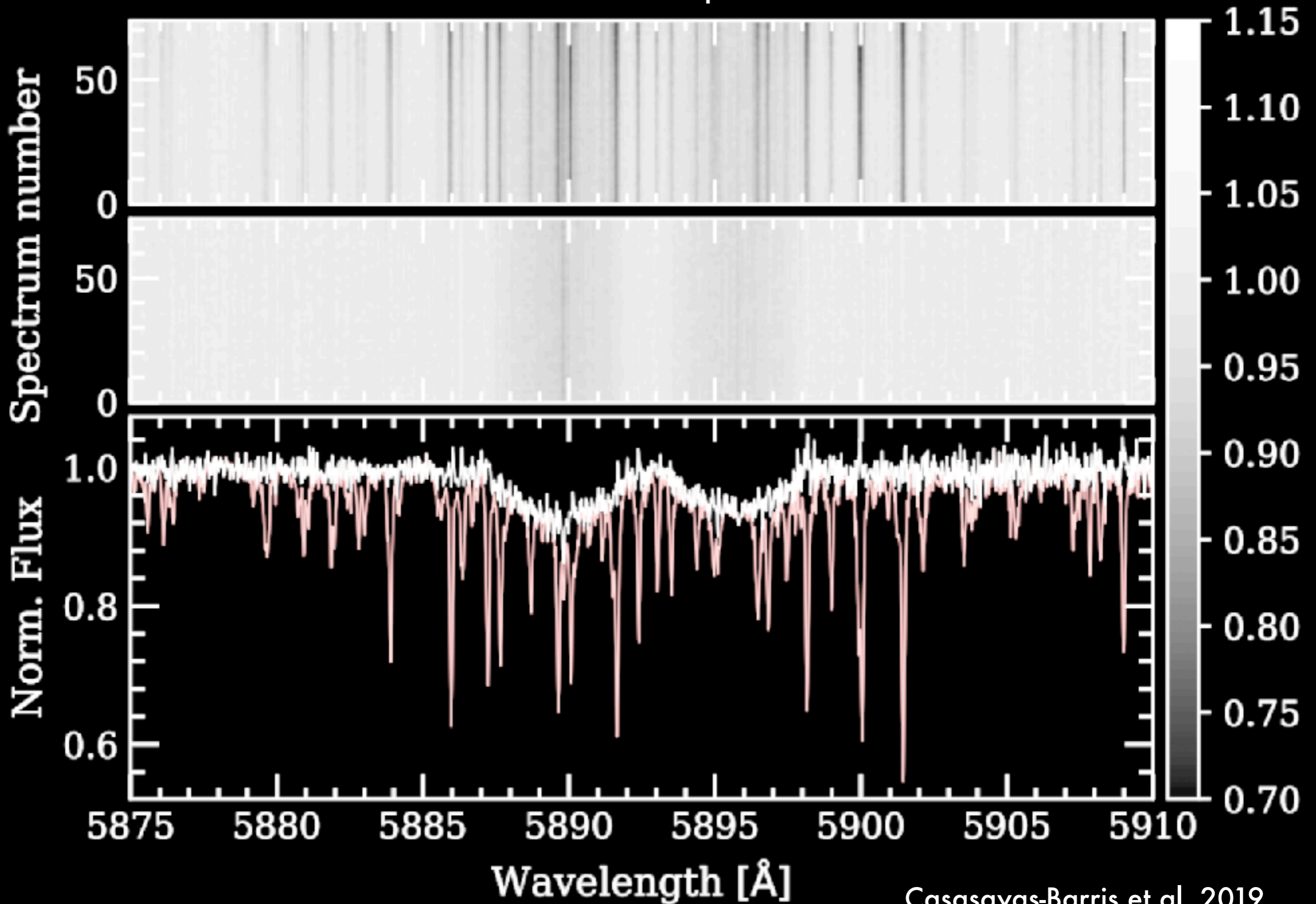
Planetary vs stellar signal



Telluric lines

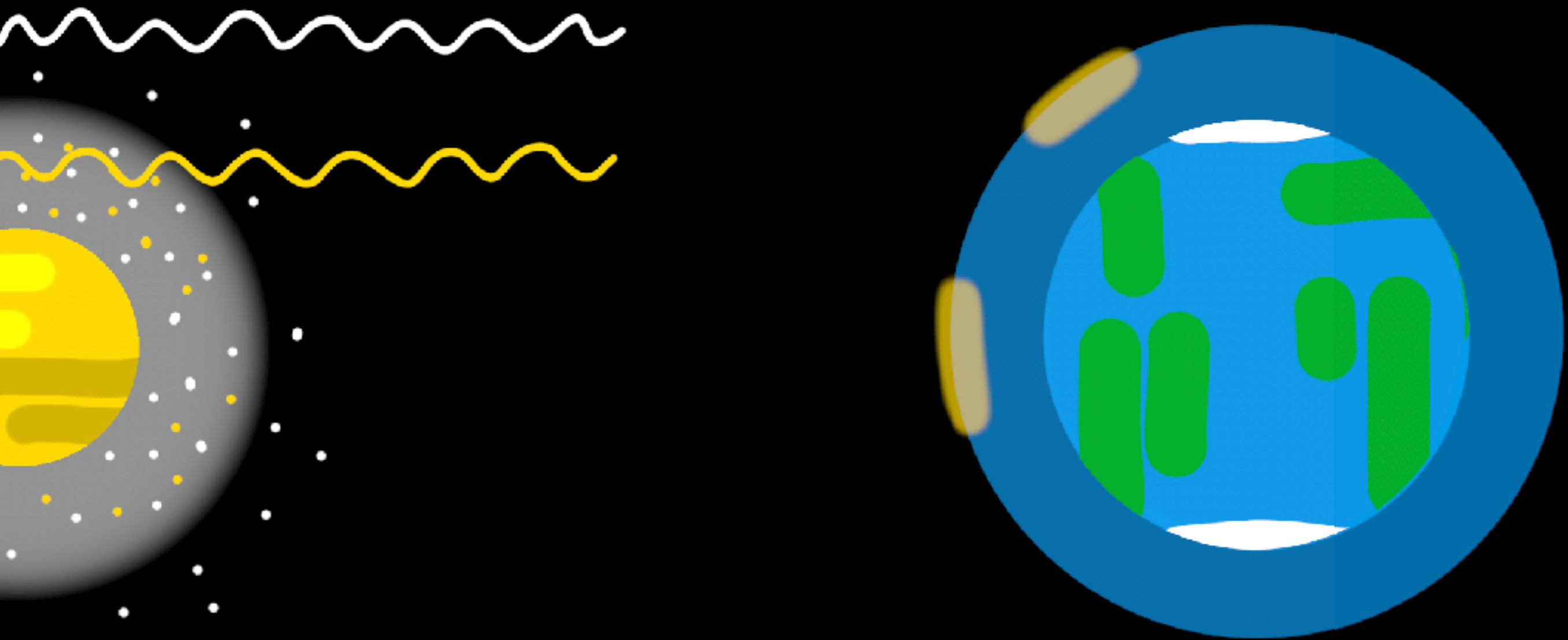


Telluric lines: the hot Jupiter Mascara-2 b

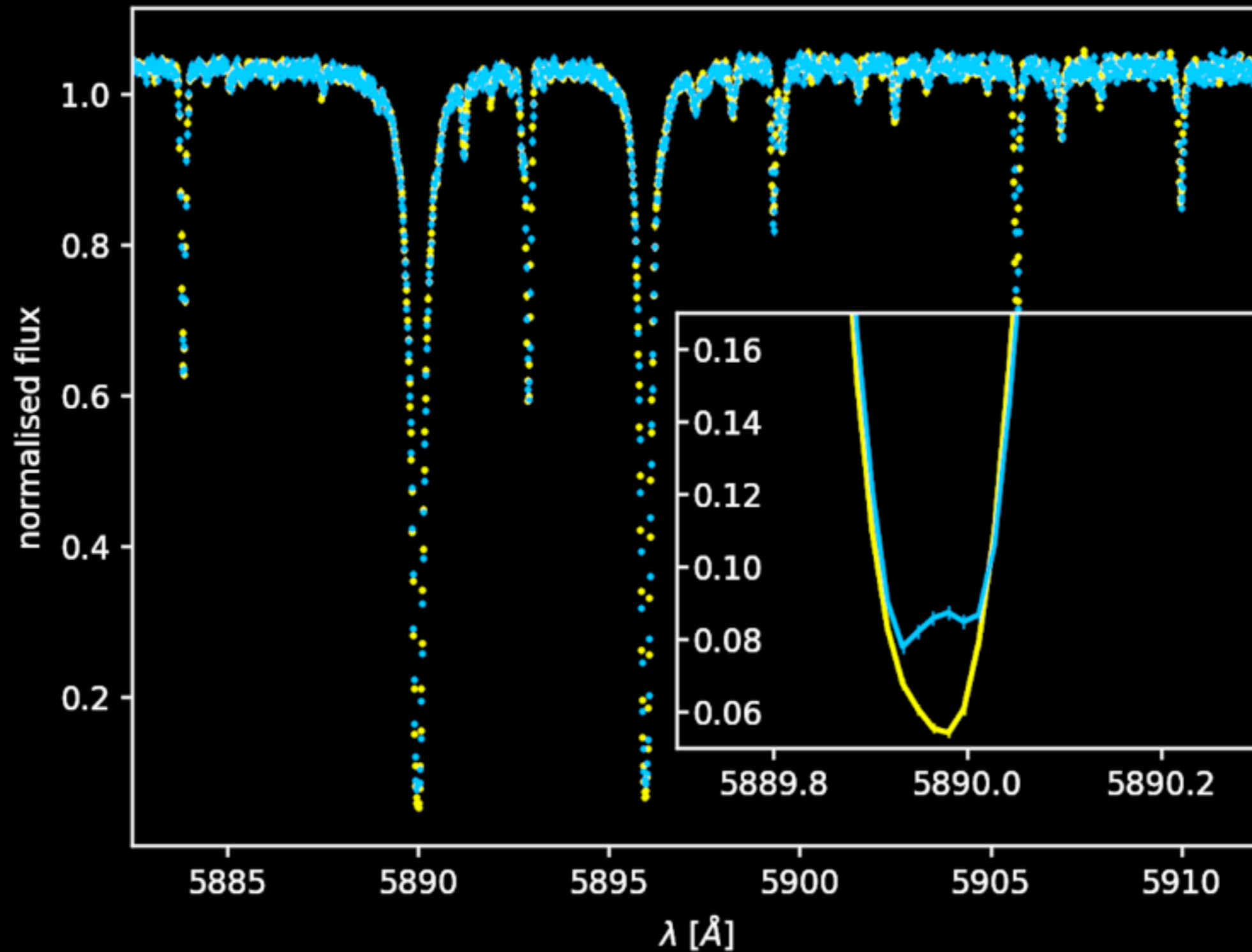


Casasayas-Barris et al. 2019

Telluric sodium emission



Telluric sodium emission
The hot sub Saturn WASP-127 b

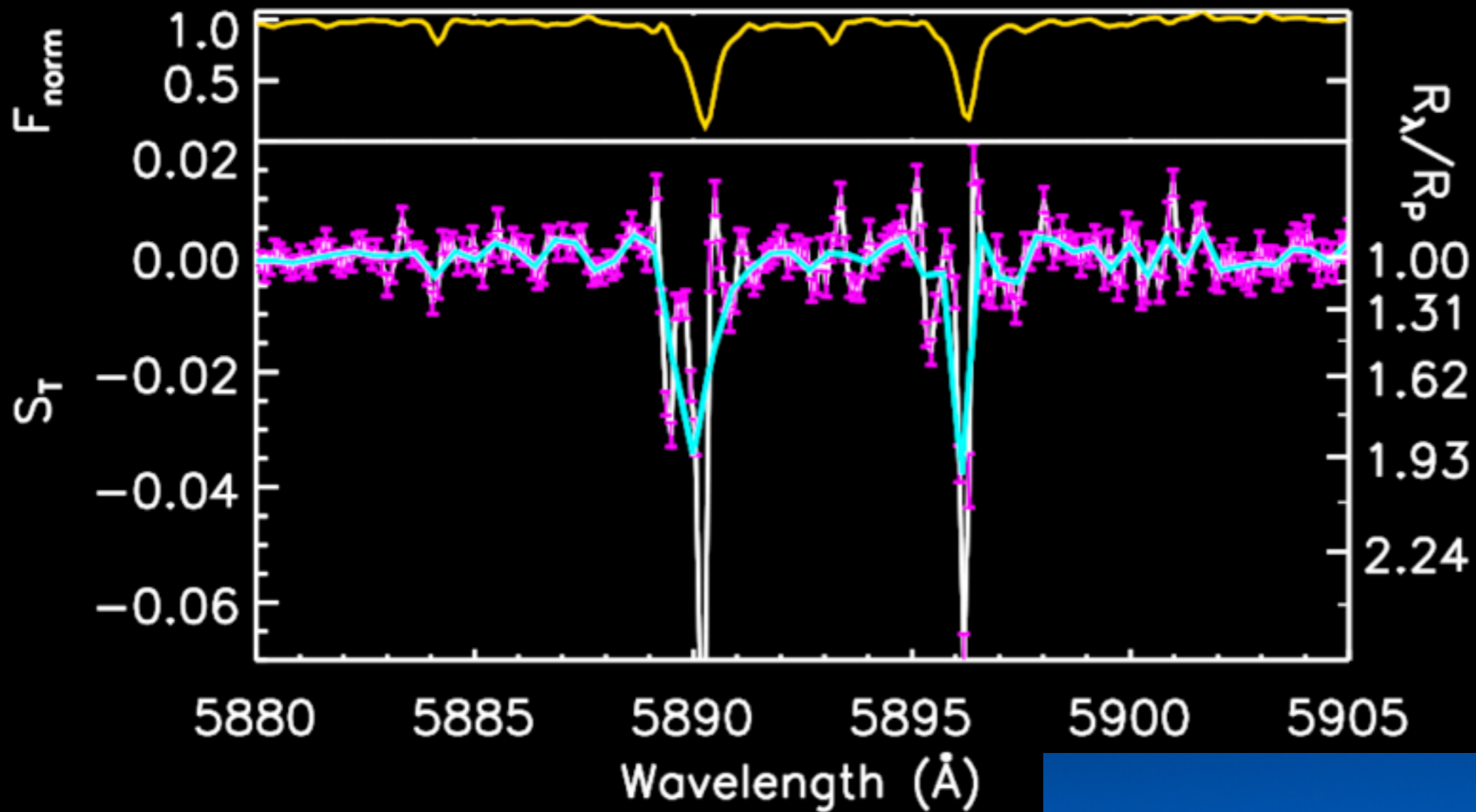


Seidel et al. 2020c

A decorative border composed of numerous circles of varying sizes, colors (yellow and grey), and patterns (solid and with horizontal lines) arranged in a roughly rectangular frame around the central text.

Spectrograph Overview

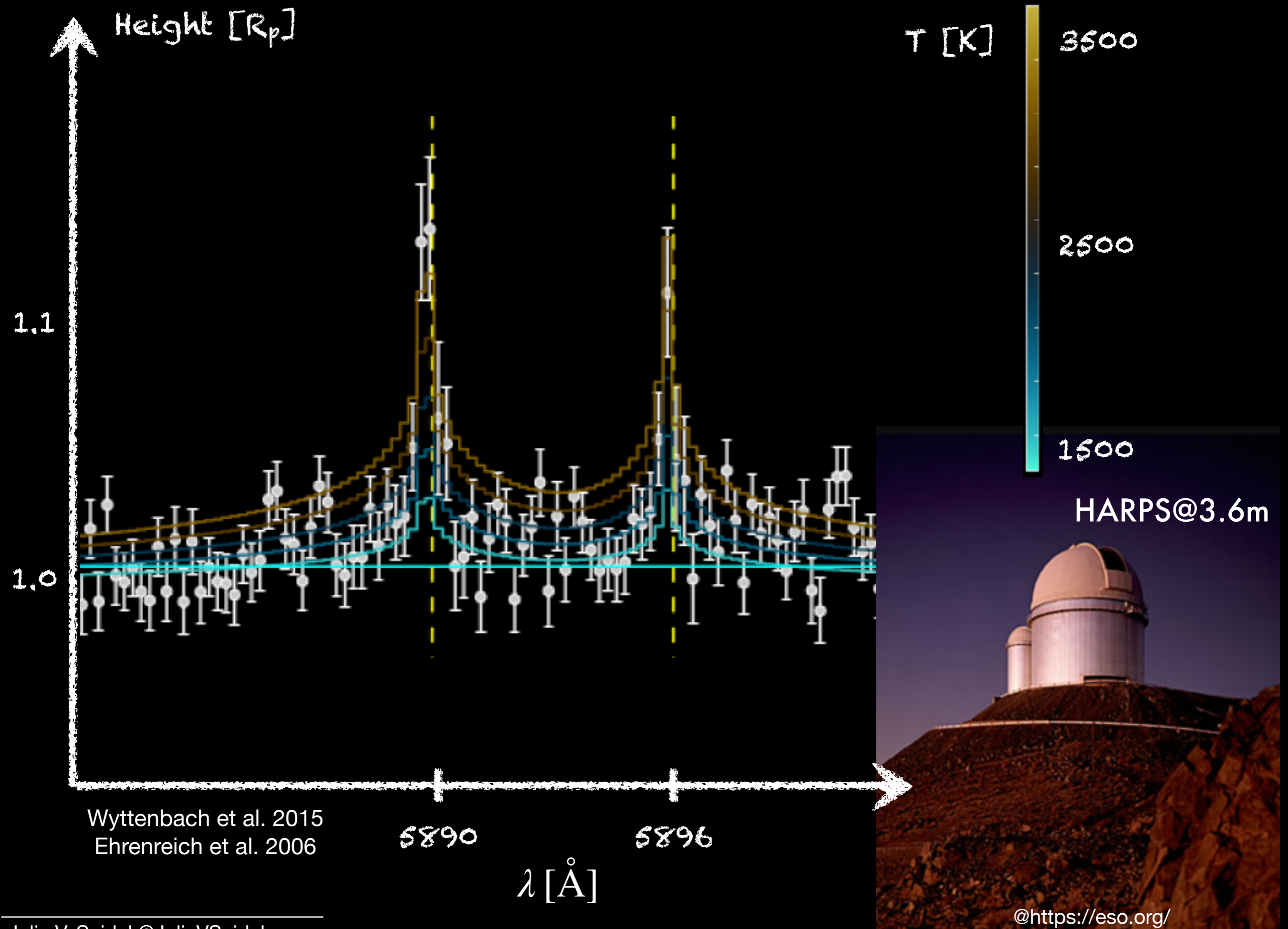
Sodium in the hot Jupiter WASP-12 b



HRS@HET

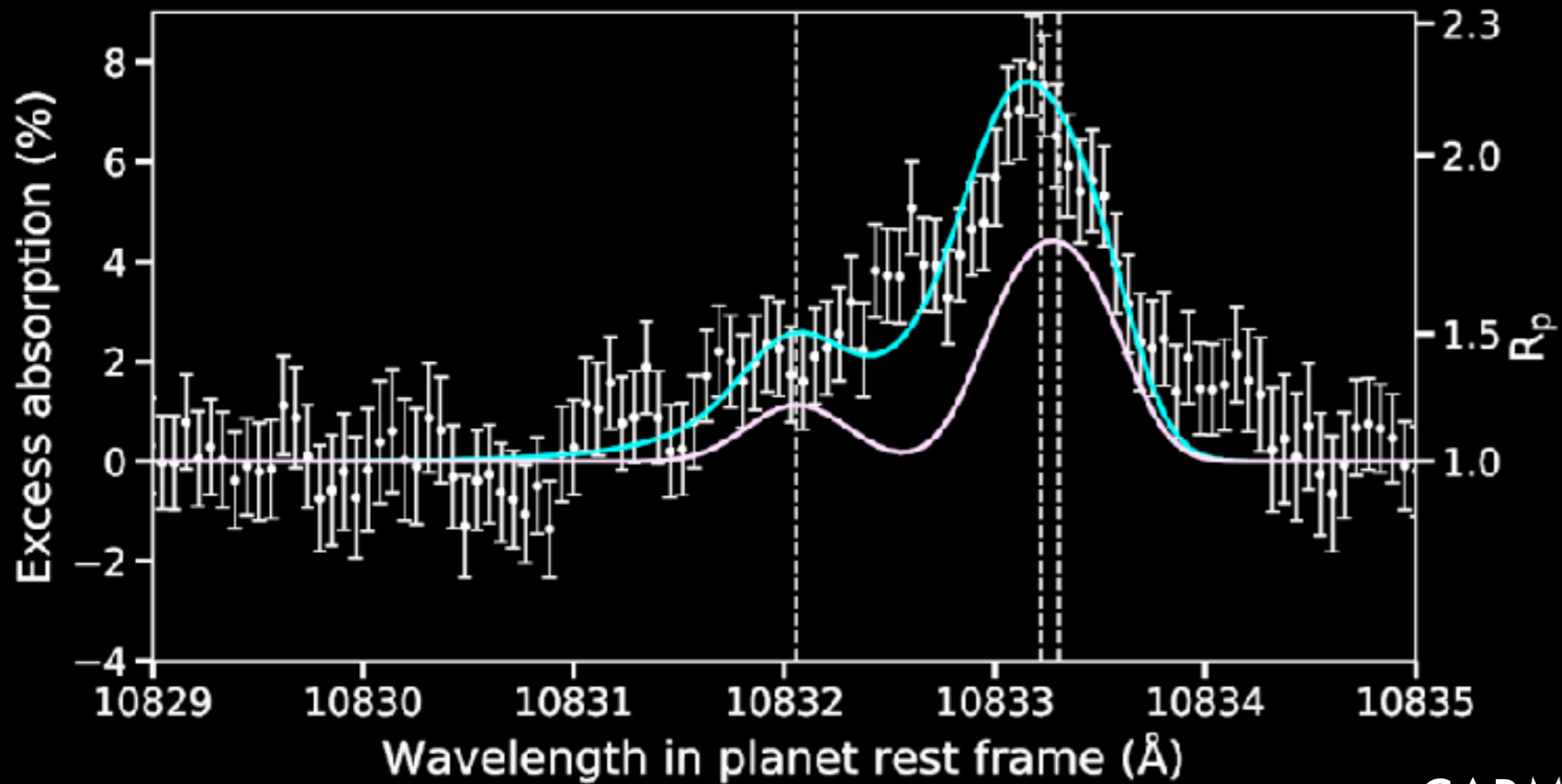
Jensen et al. 2018





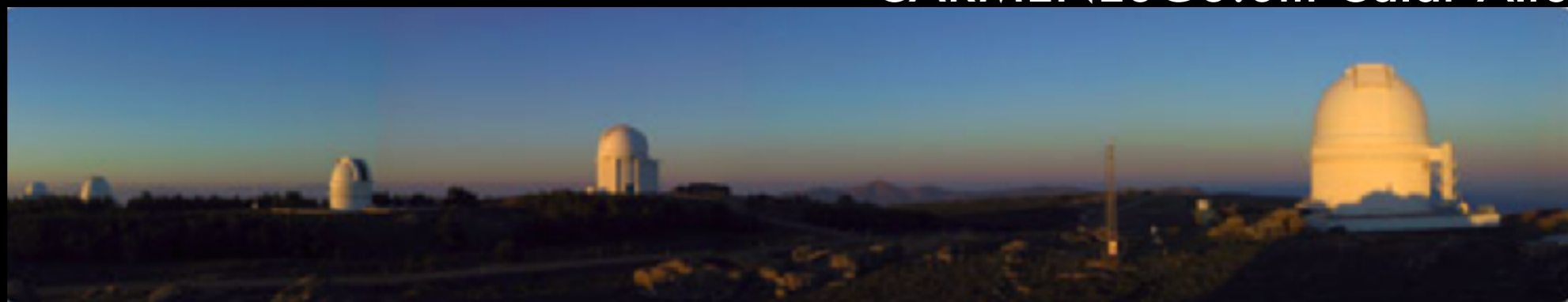
The sub Saturn WASP-107 b with CARMENES

He triplet



Allart et al. 2019

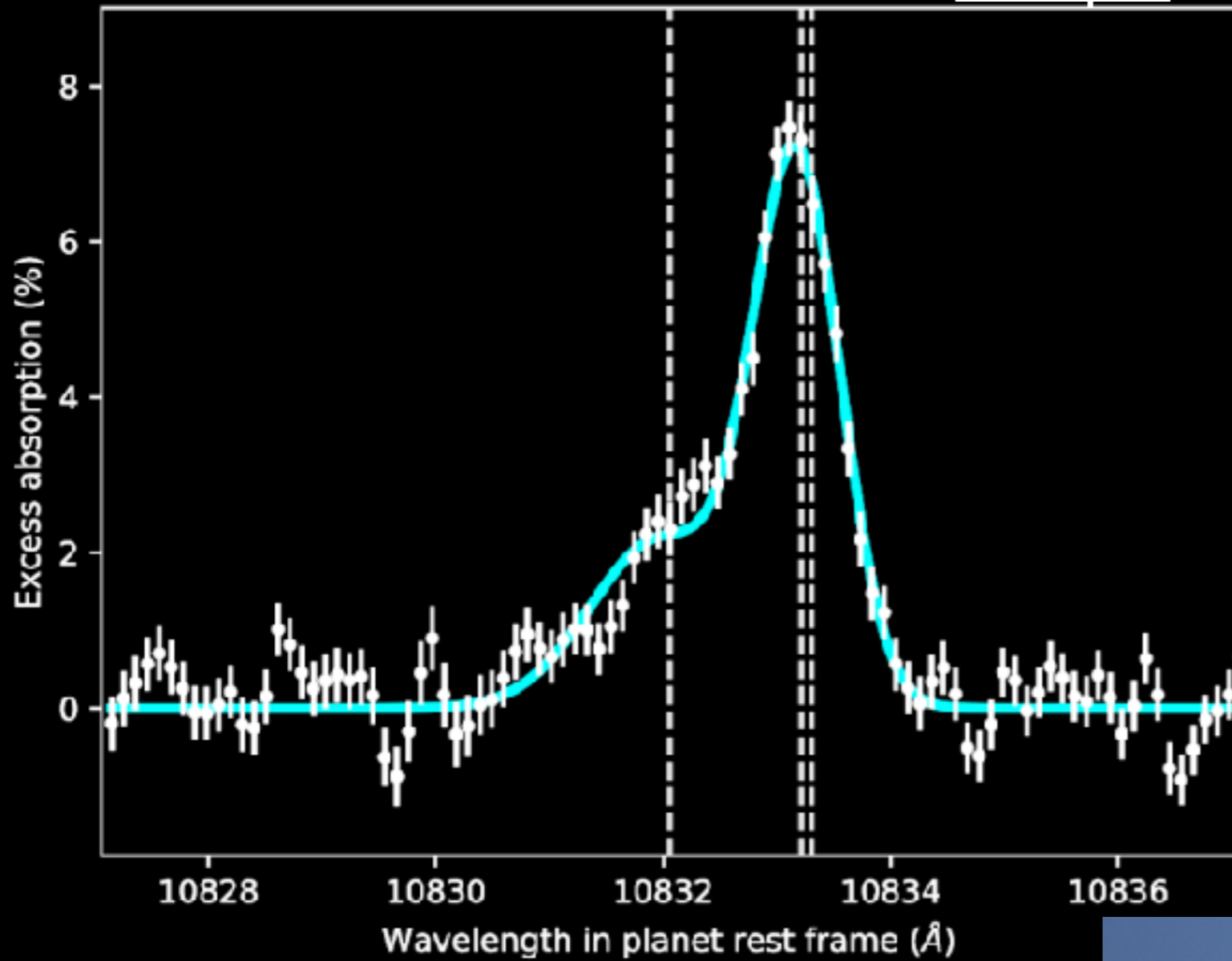
CARMENES@3.6m Calar Alto



@caha.es

The sub Saturn WASP-107 b with NIRSPEC

He triplet

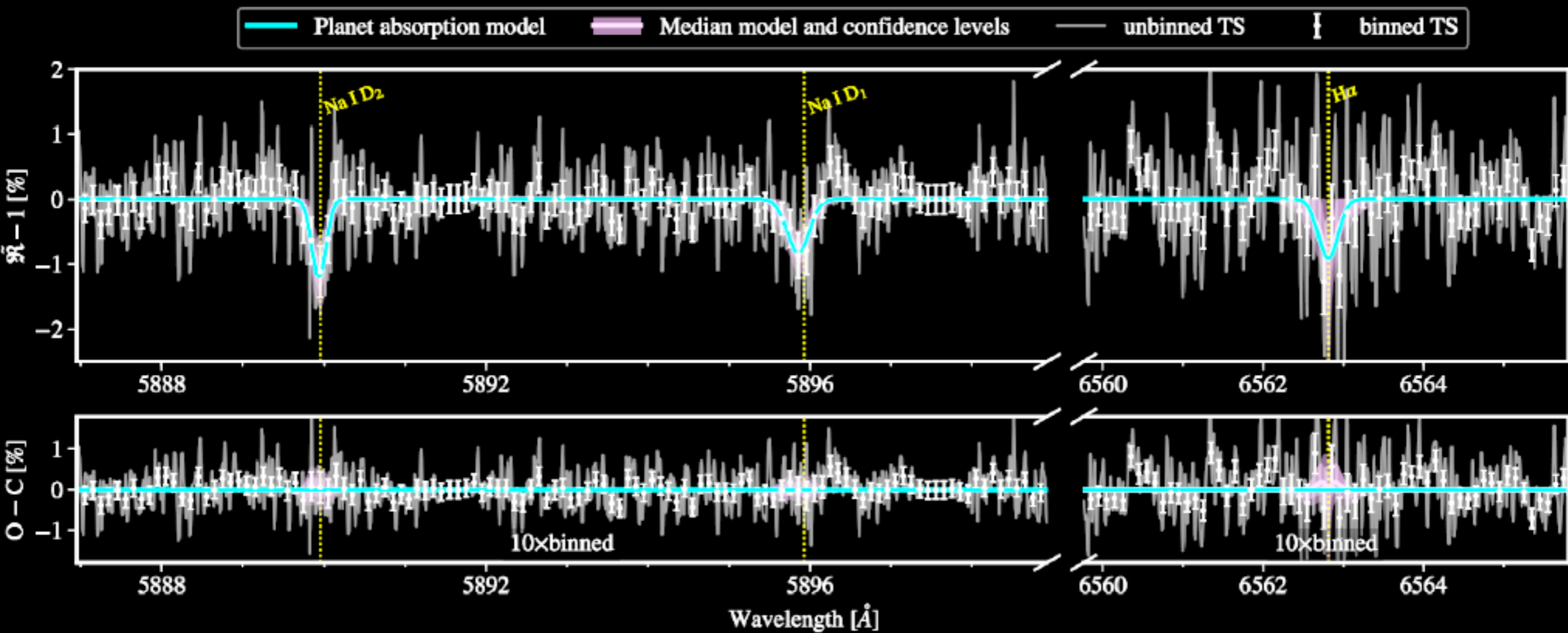


Kirk et al. 2020

NIRSPEC@Keck II

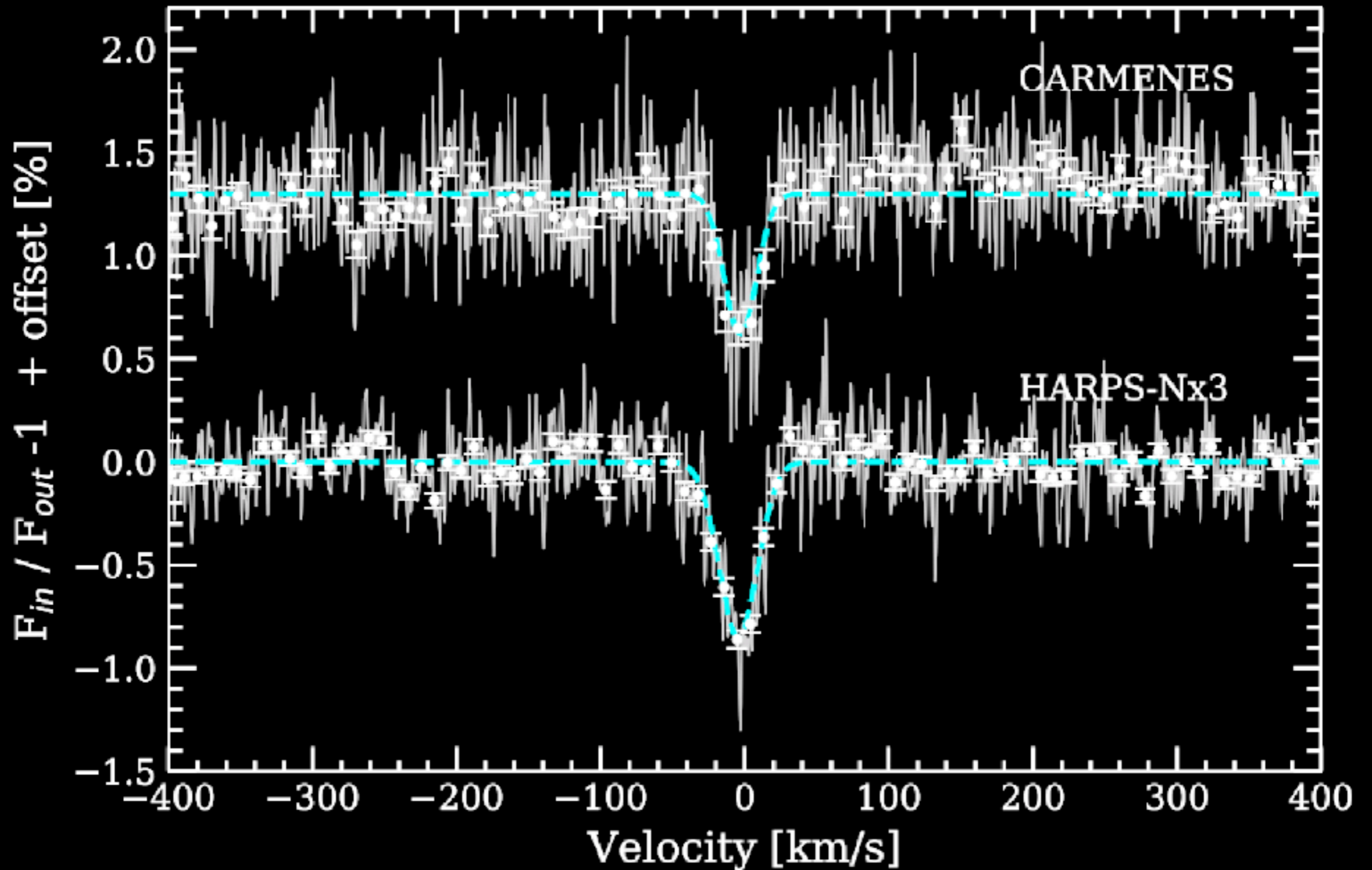


The hot Jupiter WASP-21 b with HARPS and HARPS-N



Chen et al. 2020

Mascara-2b

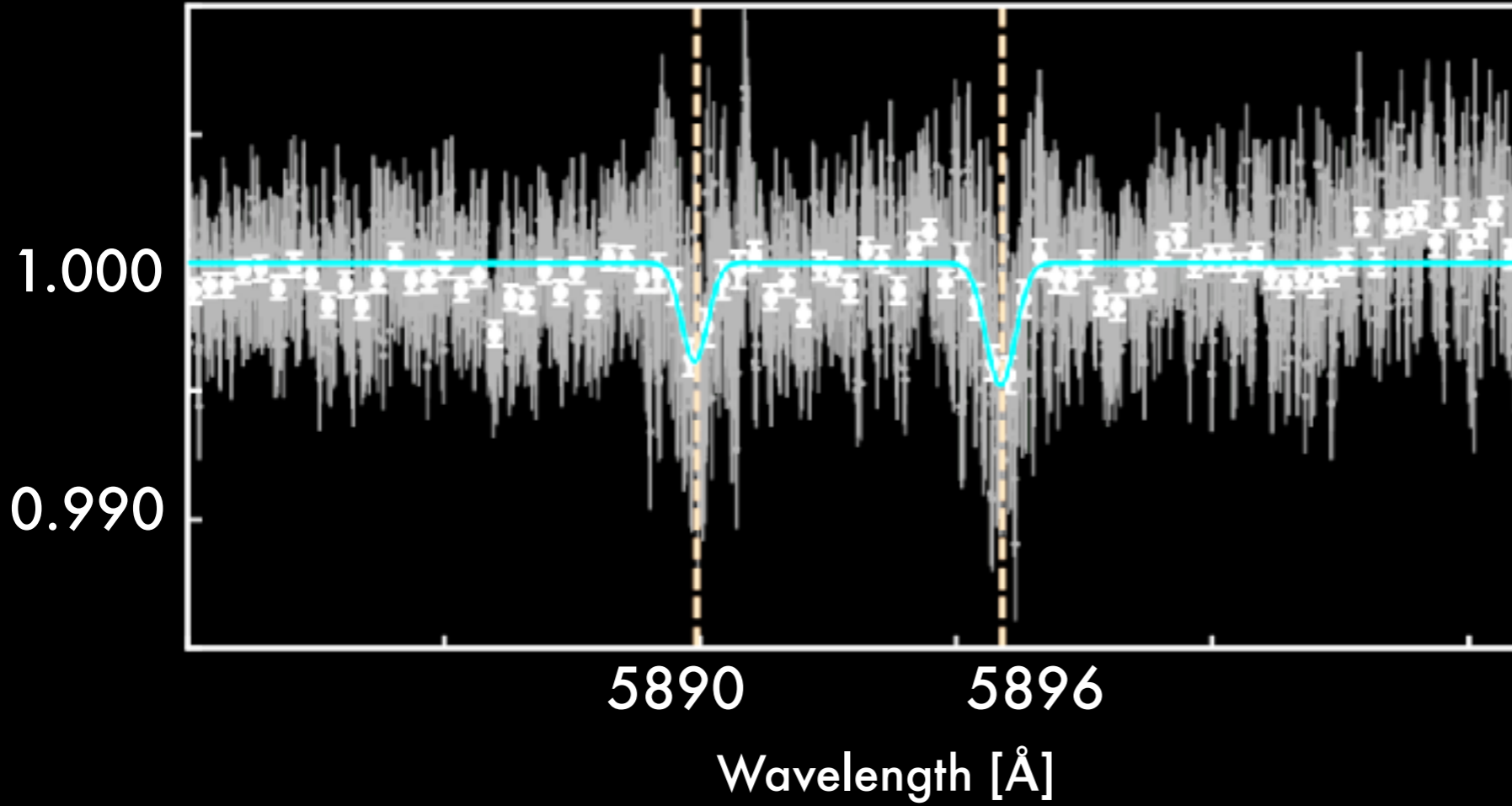


Casasayas-Barris et al. 2019

Ultra Hot Jupiter WASP-76b

Sodium doublet

Relative flux



Seidel et al. 2019

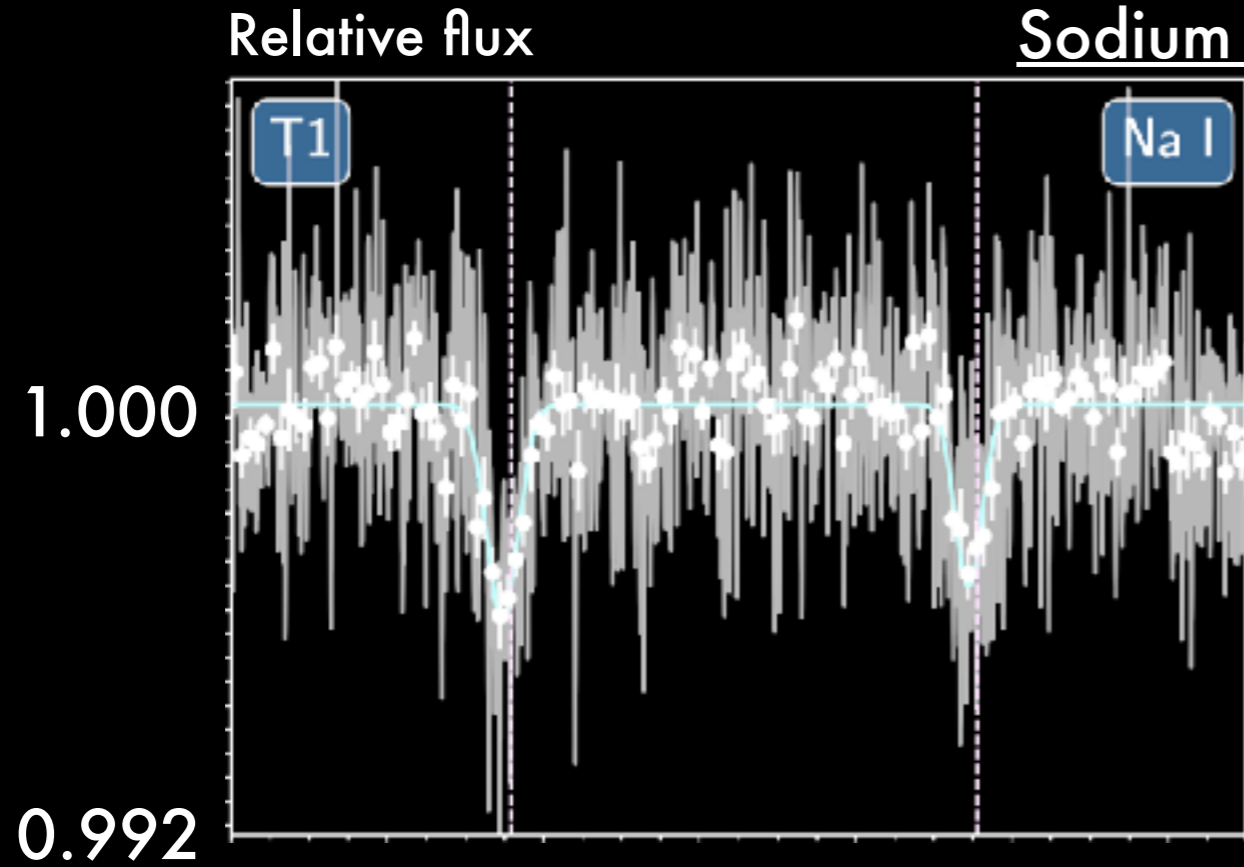
HARPS@3.6m



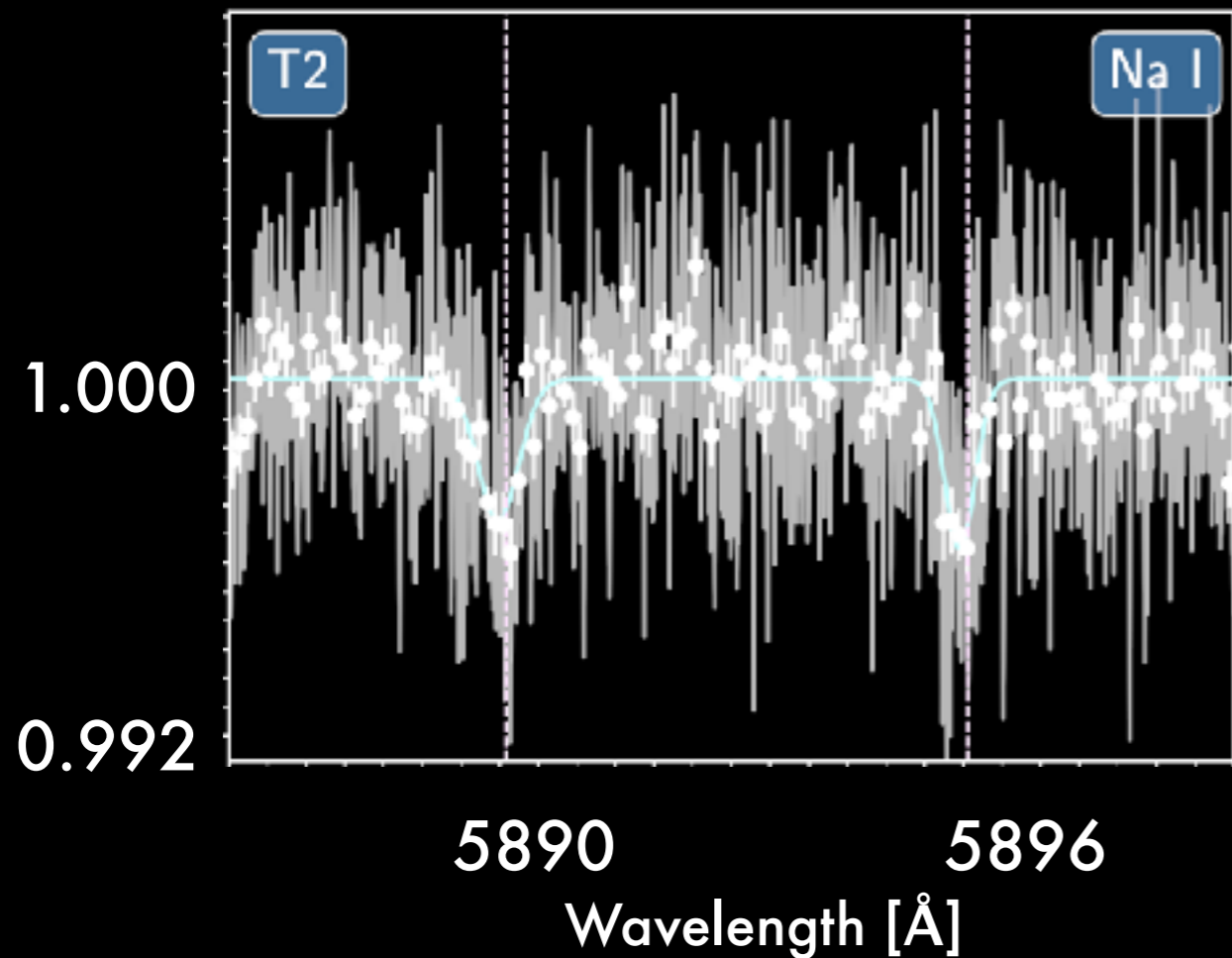
@<https://eso.org/>

Ultra Hot Jupiter WASP-76b

Sodium doublet



Tabernero et al. 2020



ESPRESSO@VLT



Ultra Hot Jupiter WASP-76b

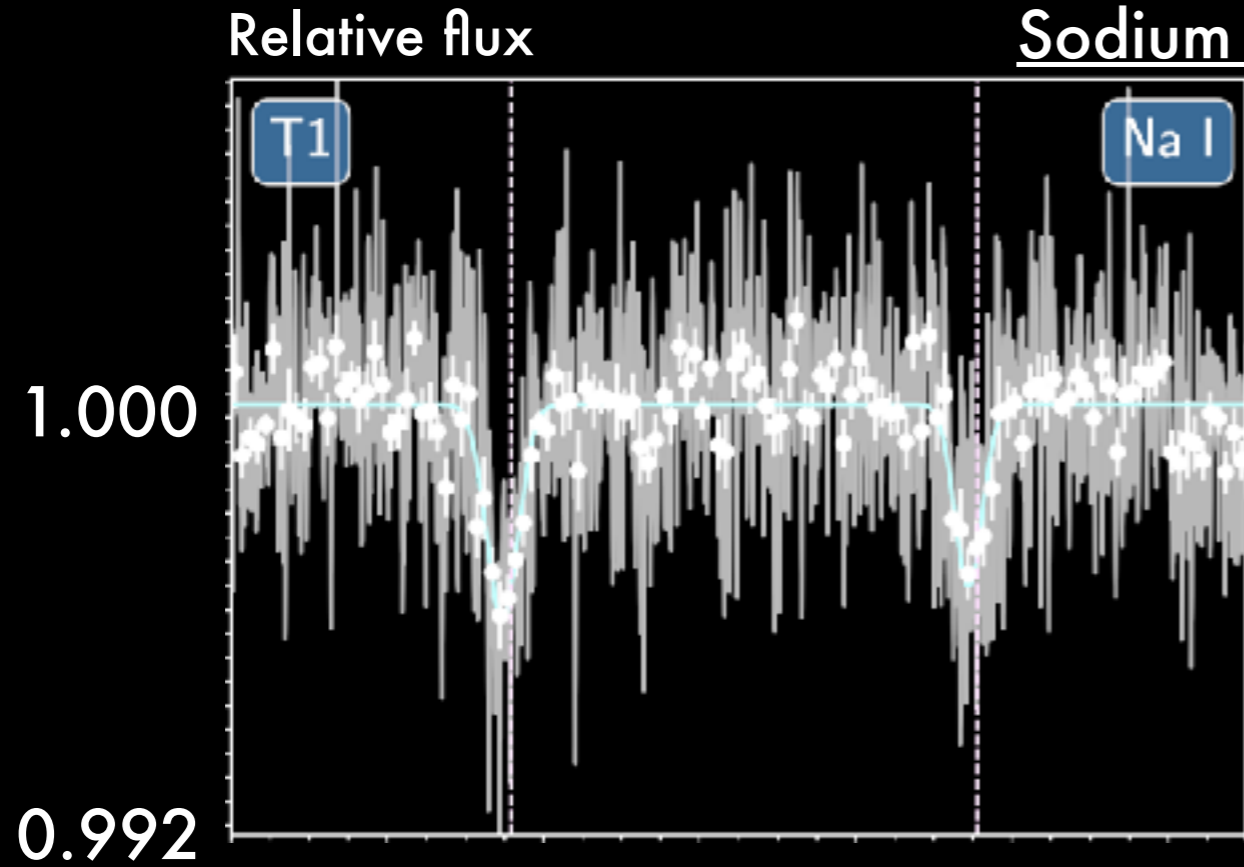
Sodium doublet

Relative flux

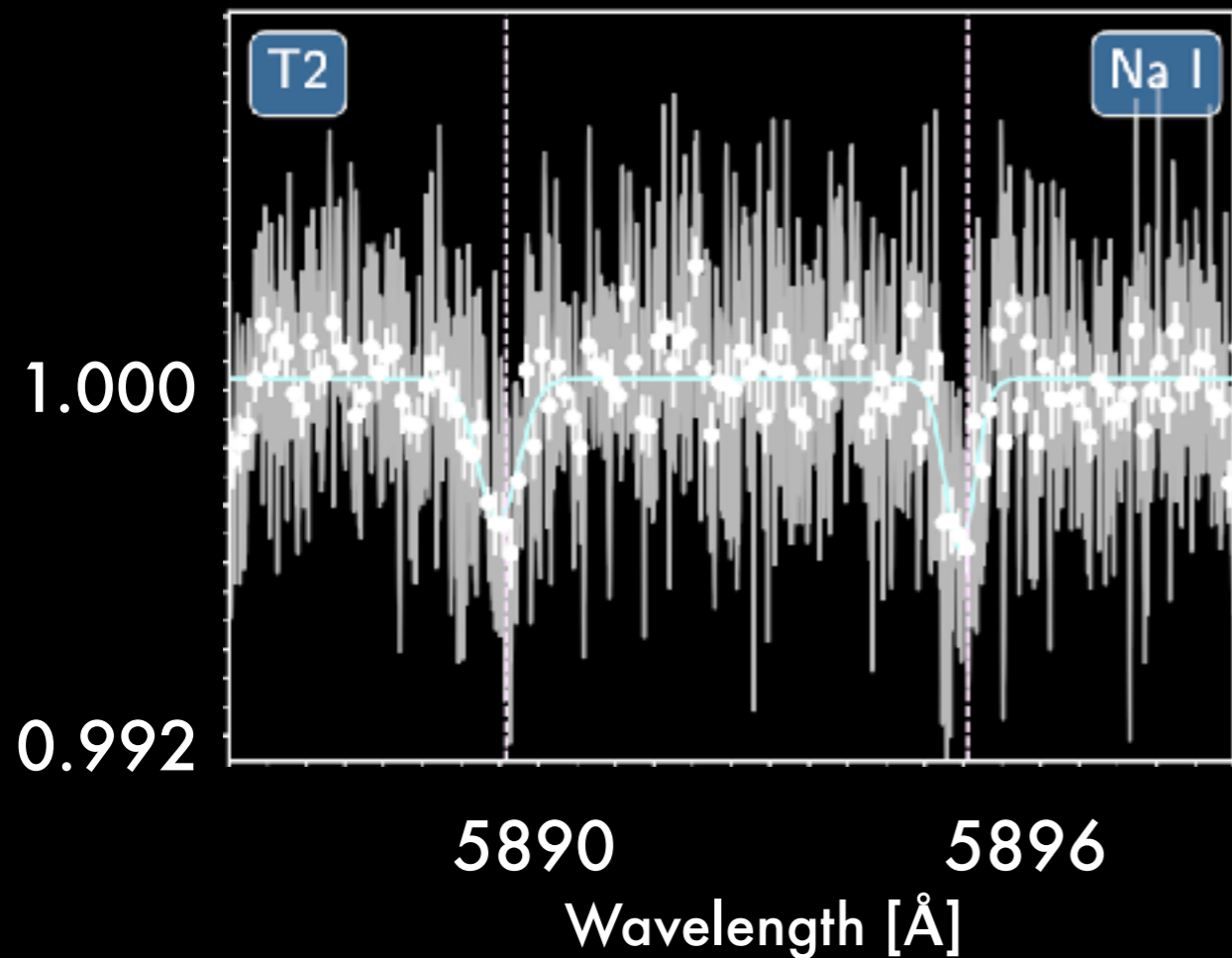


Ultra Hot Jupiter WASP-76b

Sodium doublet



Tabernero et al. 2020



ESPRESSO@VLT

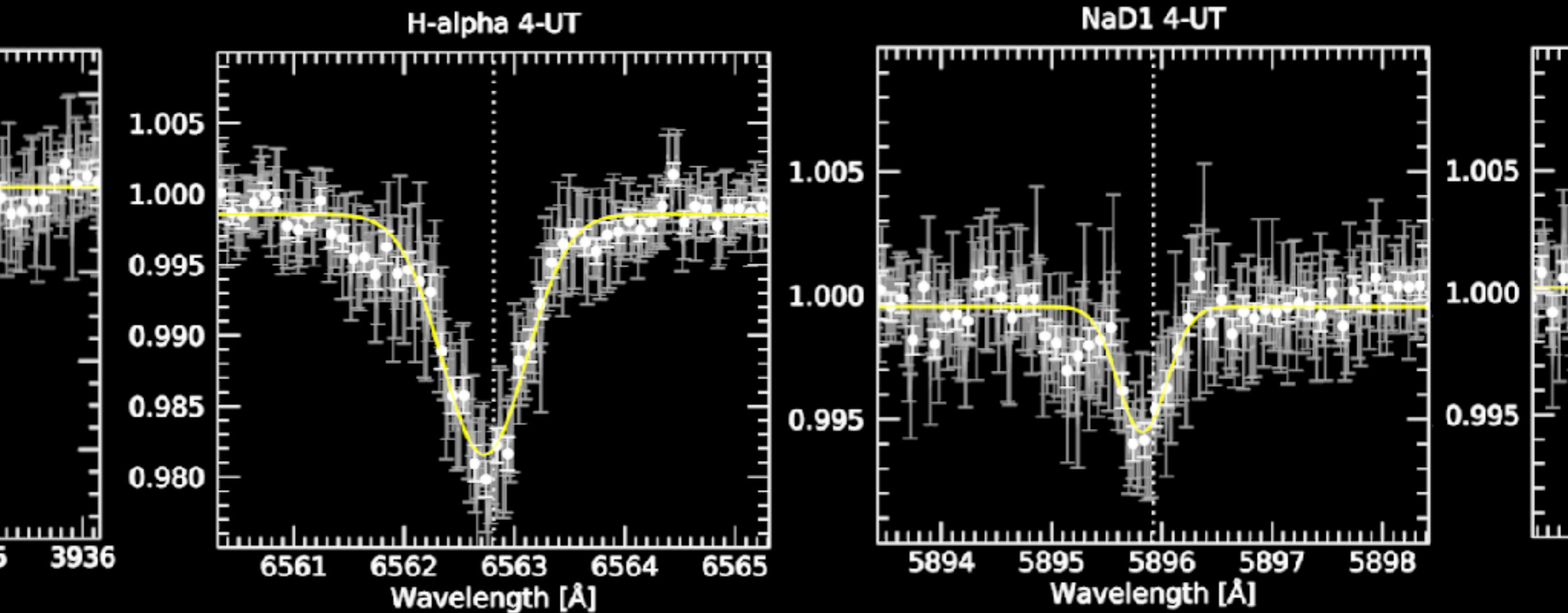


A decorative border of yellow and grey circles surrounds the text. The circles vary in size and are scattered around the central text.

Detected
resolved lines
(to date)

Ultra Hot Jupiter WASP-121 b

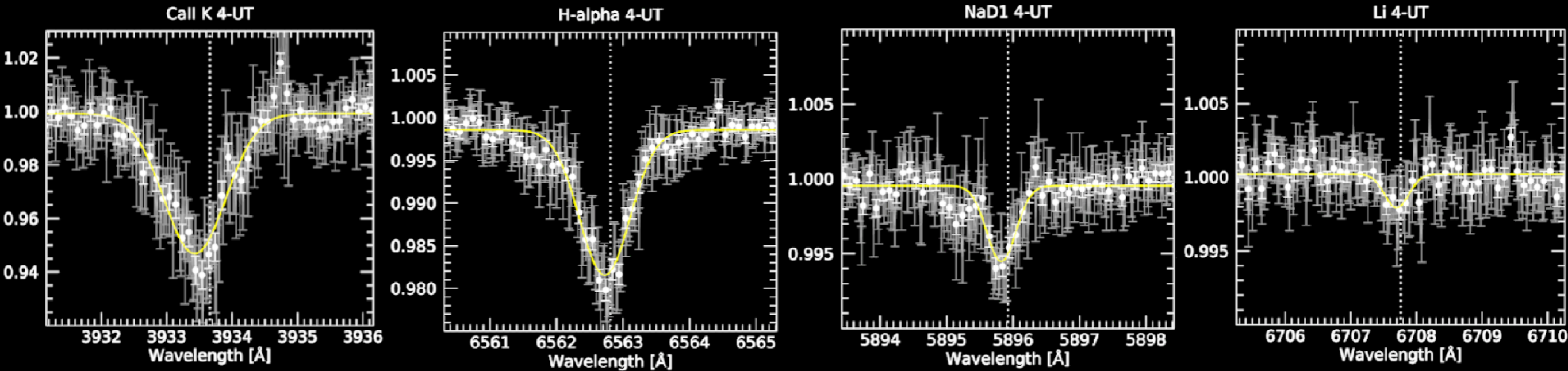
ESPRESSO 4UT data



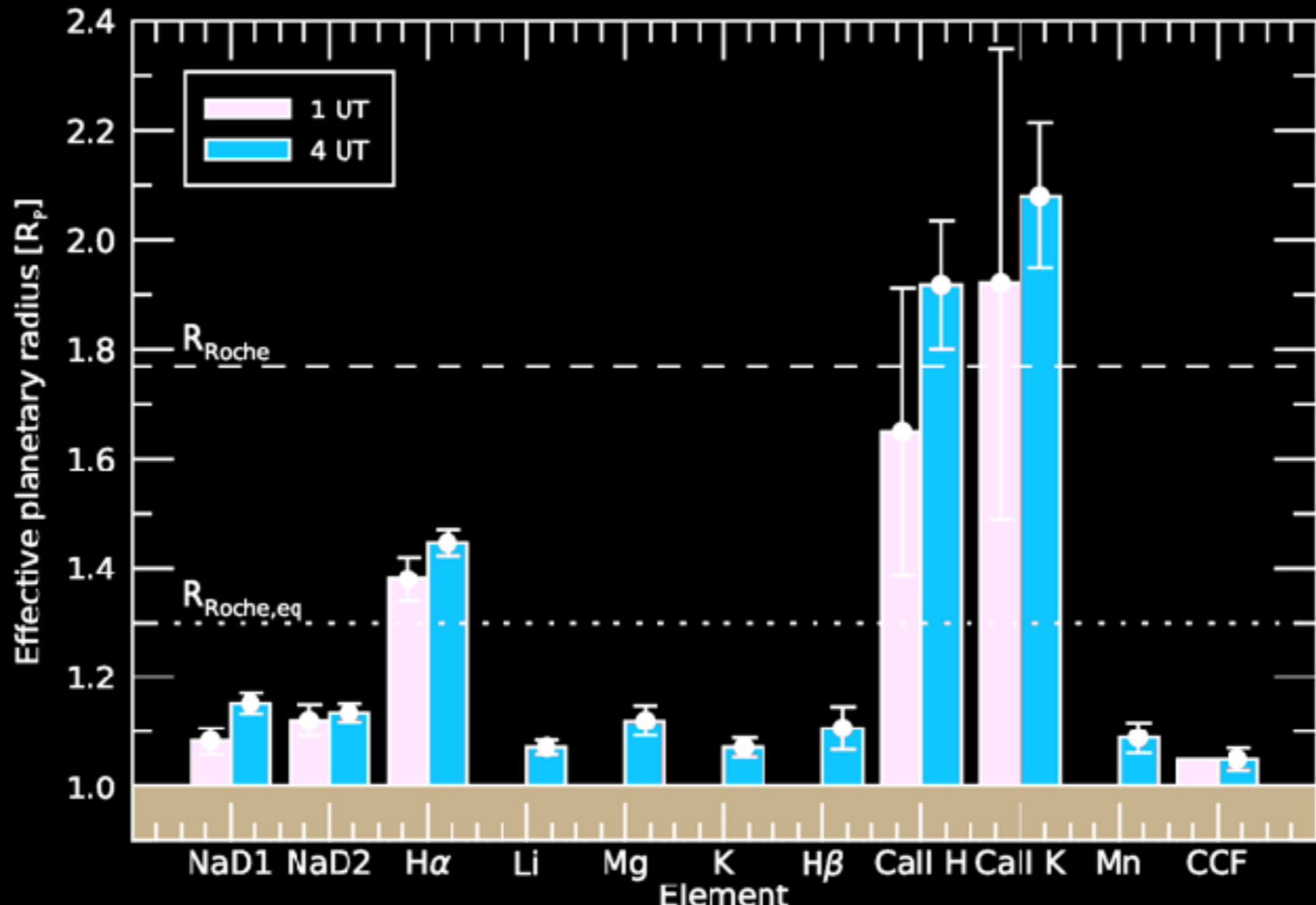
Borsa et al. 2021

ESPRESSO 4UT data

Ultra Hot Jupiter WASP-121 b

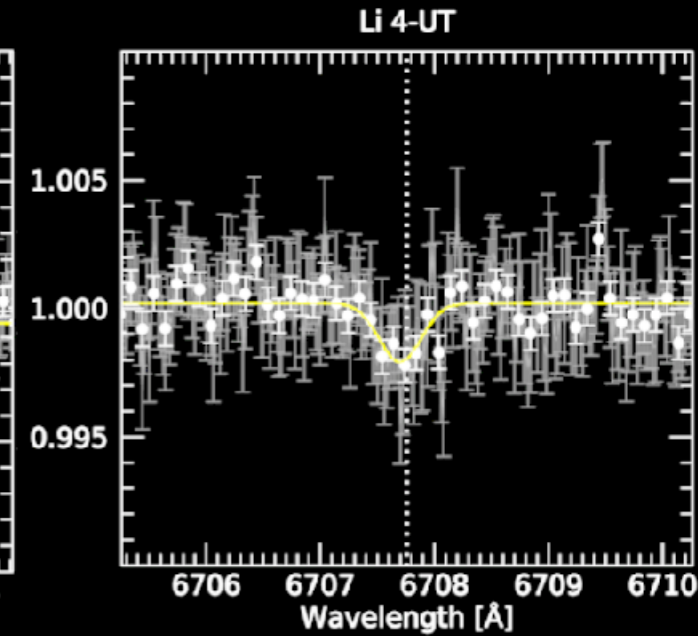
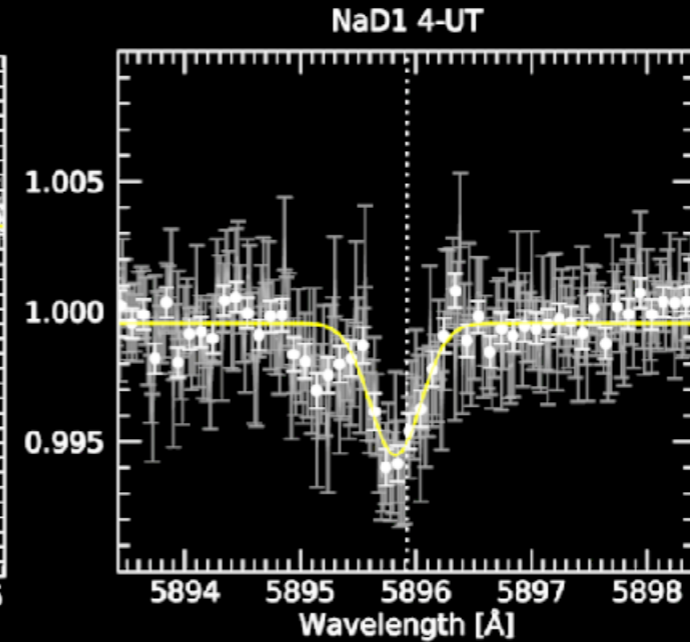
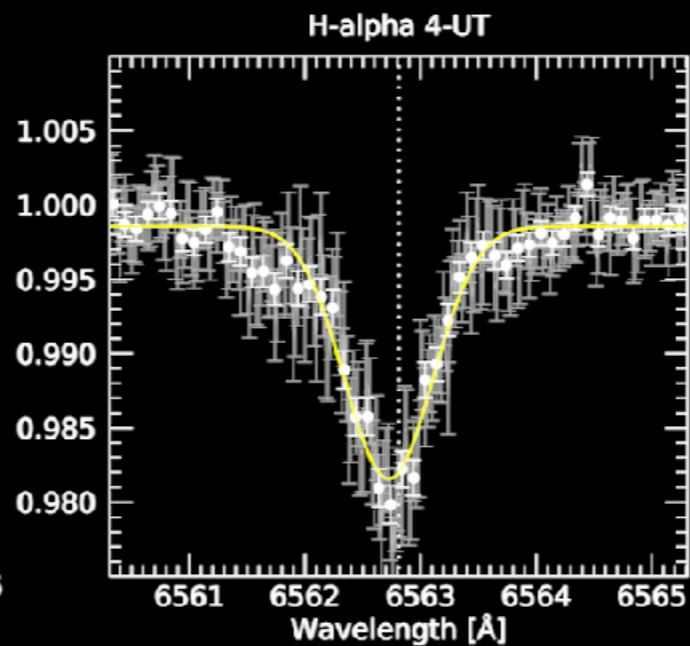
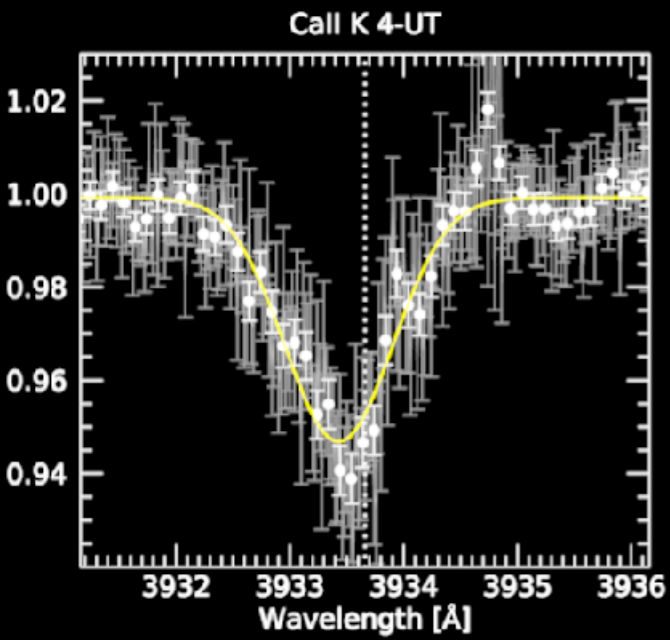


Borsa et al. 2021



ESPRESSO 4UT data

Ultra Hot Jupiter WASP-121 b



Borsa et al. 2021

Additional spectral lines
CRIRES+@VLT
NIRPS@3.6m

Instruments suitable
for this work, e.g.
HDS@Subaru



@<https://eso.org/>



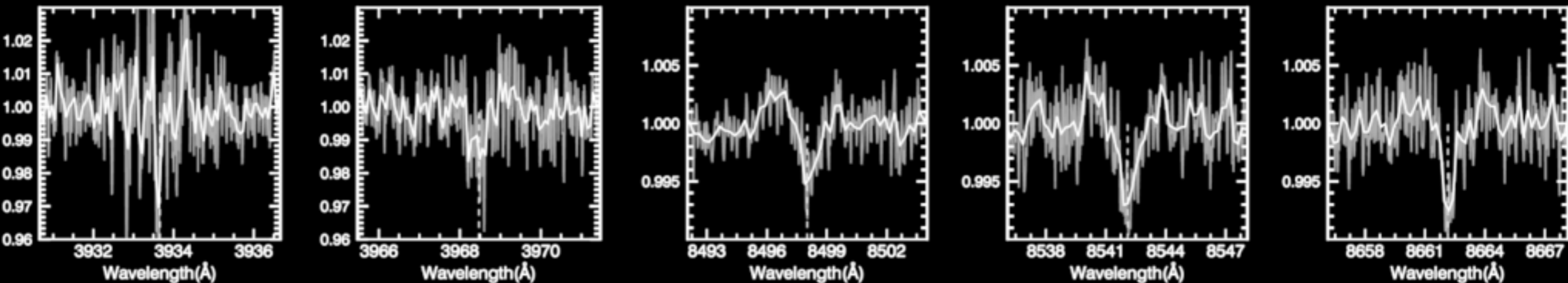
@NAOJ



And what to do
with them?

Studies of line shapes

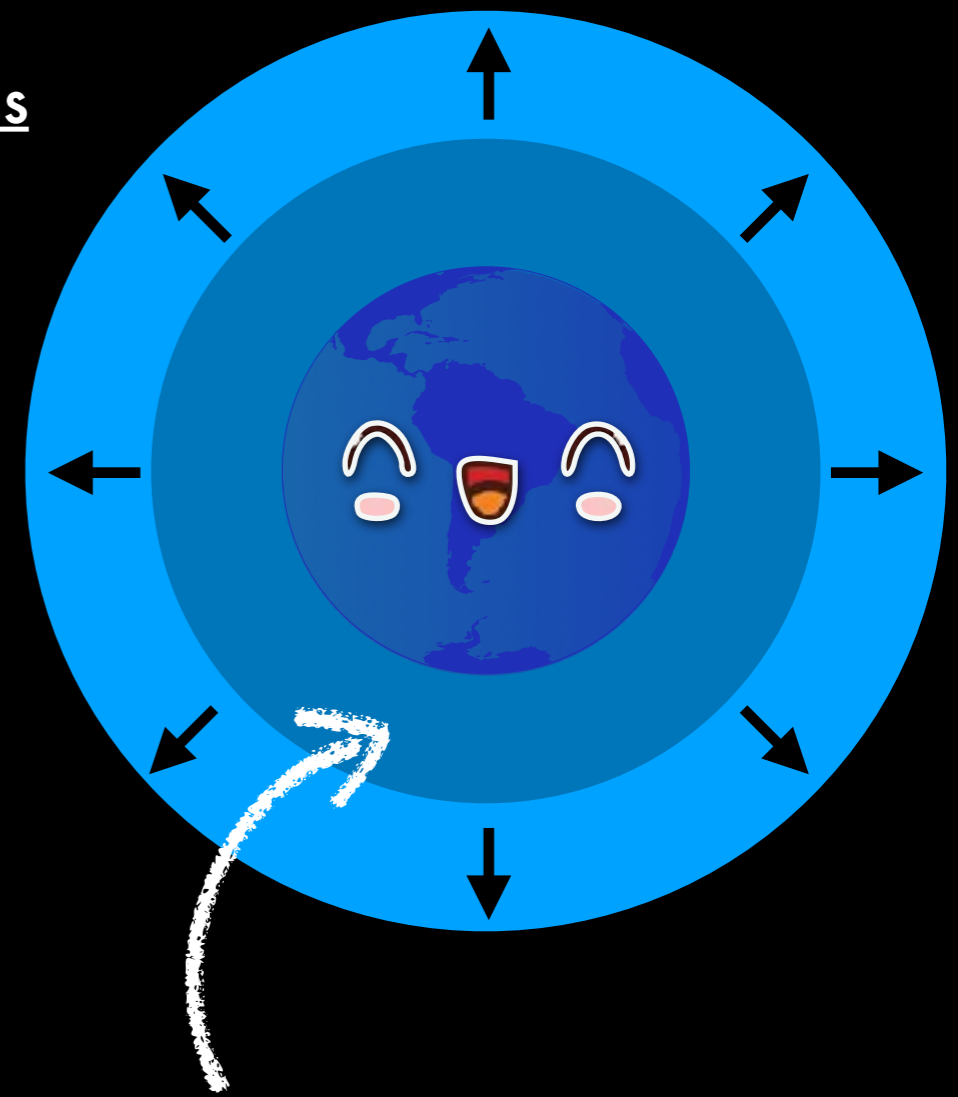
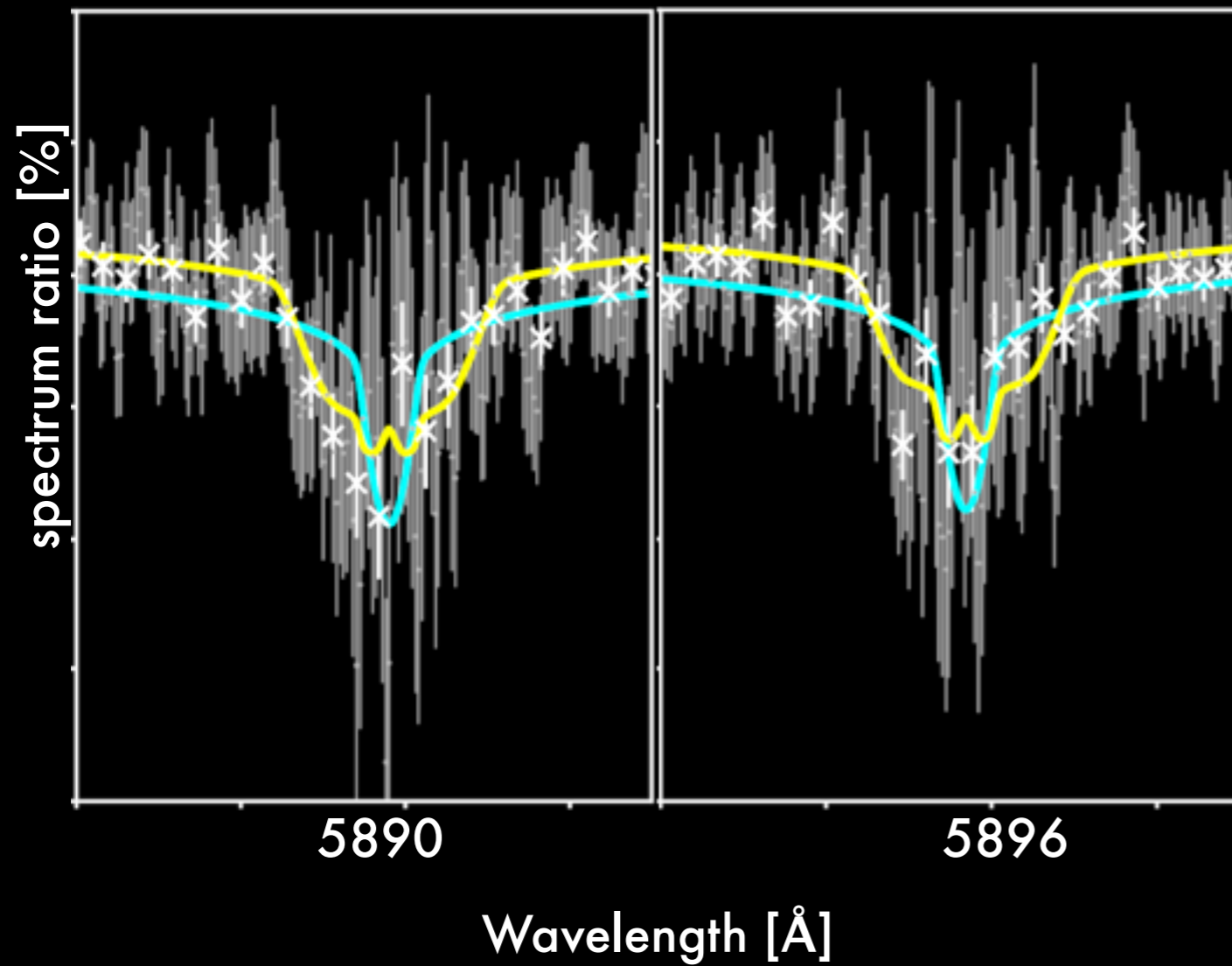
Calcium



Yan et al. 2019

- Same species, different lines
- Different lines probe different altitudes
- Possible to trace ionisation rates(?)
- Possible winds carrying calcium upwards

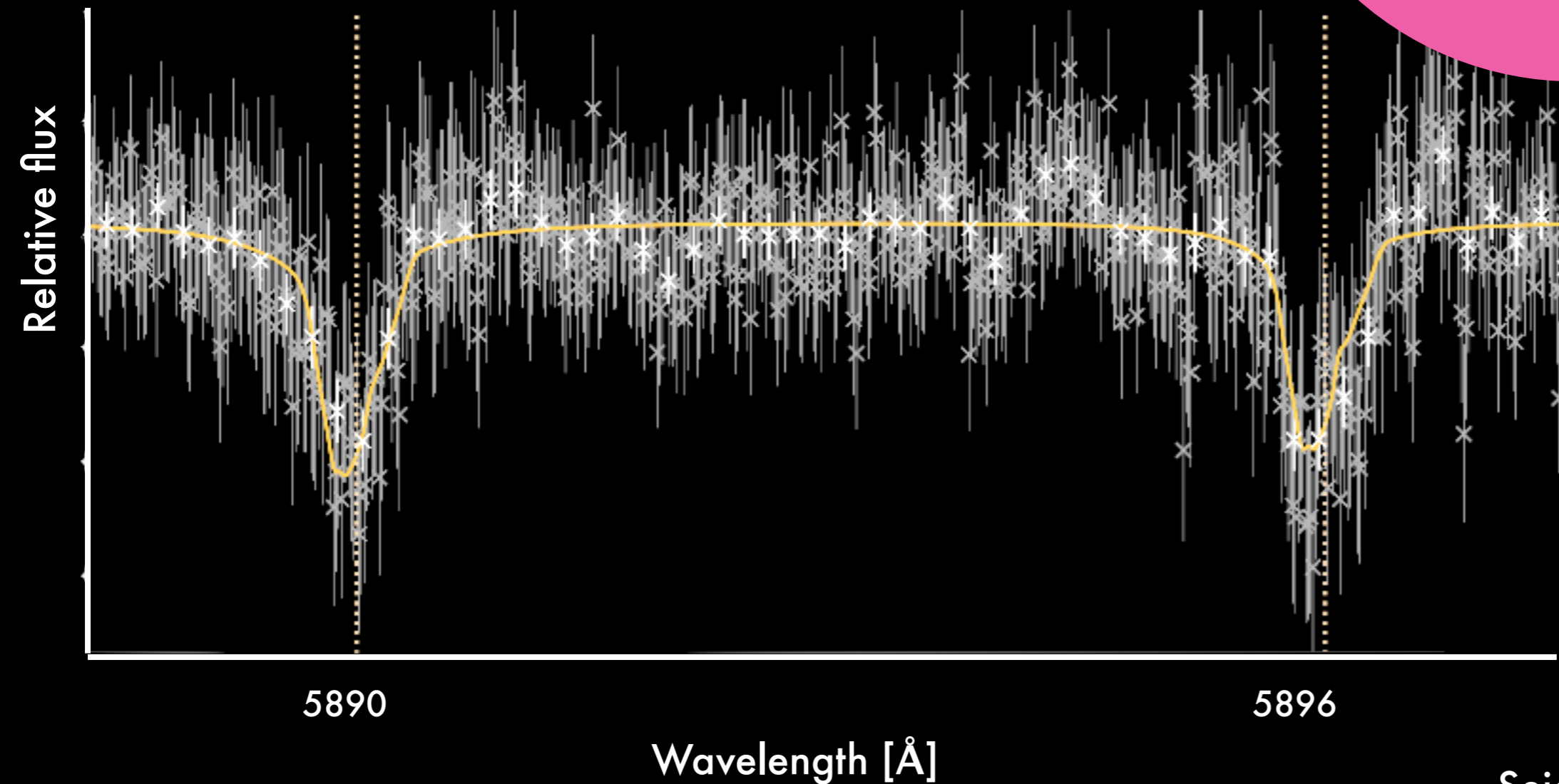
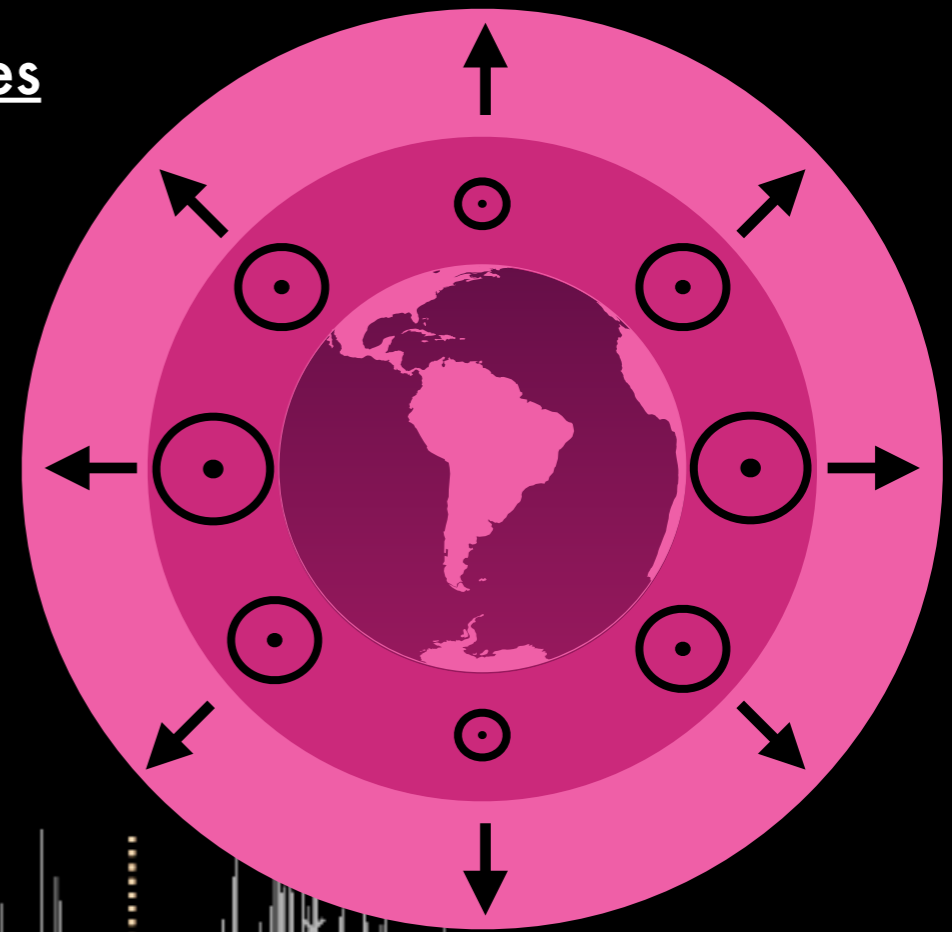
Studies of line shapes



Why won't you tell me what happens down here?

Seidel et al. 2020a

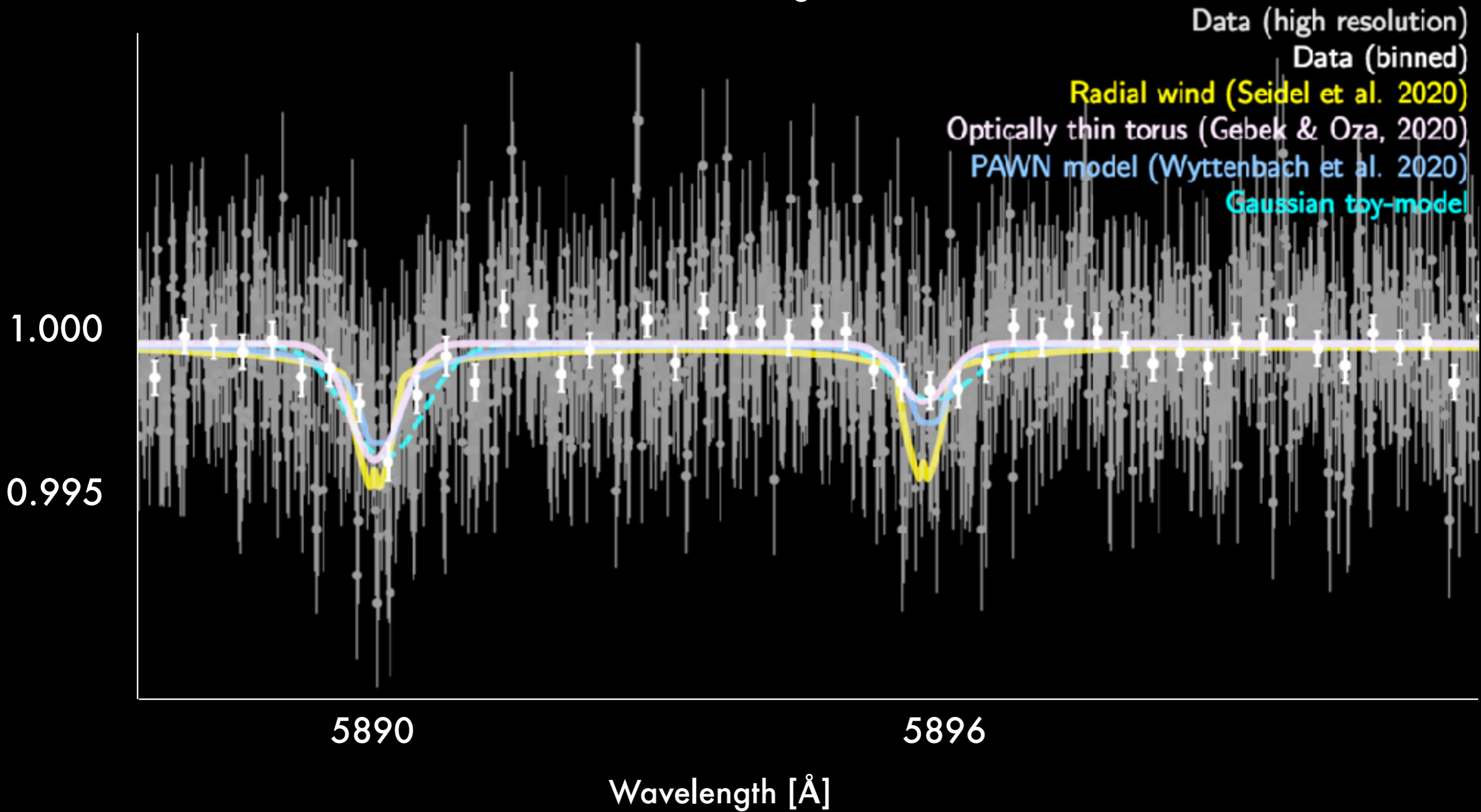
Studies of line shapes
WASP-76b



Seidel et al. 2021

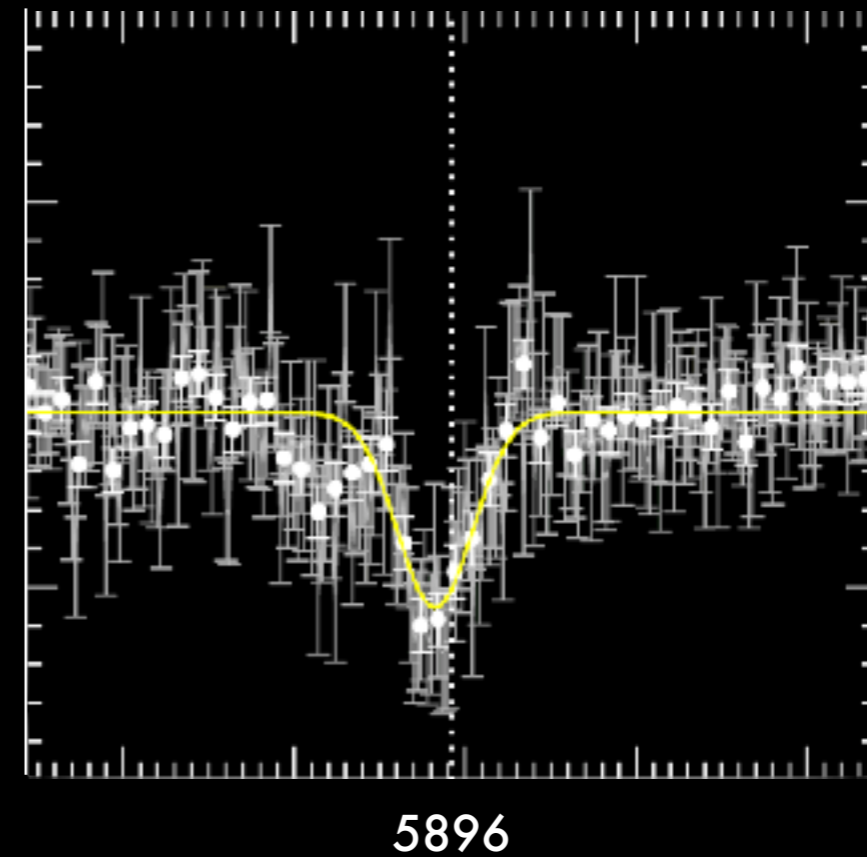
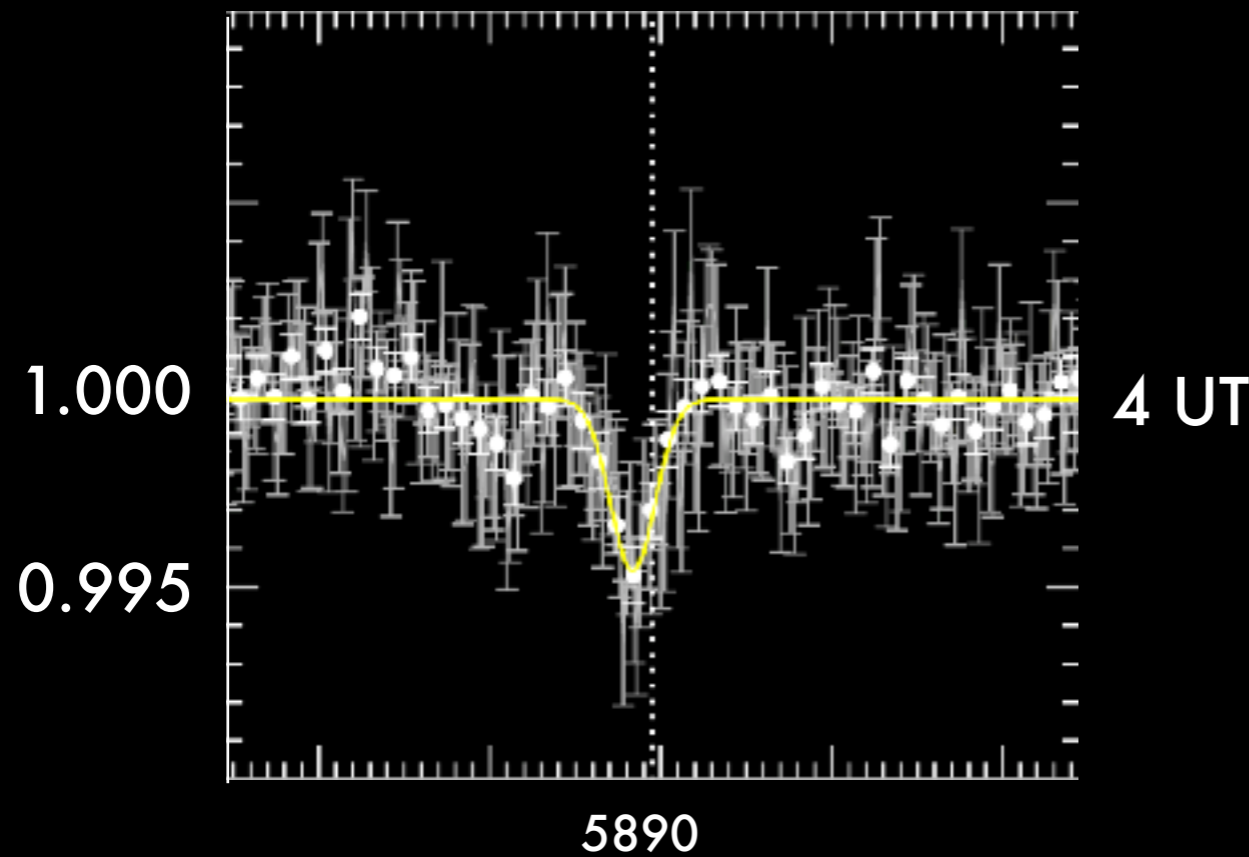
Ultra Hot Jupiter WASP-121 b

HARPS, 3 nights combined



Hoeijmakers et al. 2020

Ultra Hot Jupiter WASP-121 b ESPRESSO, 1 night partial transit



Wavelength [Å]

Borsa et al. 2021

From ESPRESSO to HIRES@ELT:

- From 4x8m to 39m mirror size
- Higher precision from ESPRESSO to HIRES
- Partial transits for smaller signals become accessible

