

Residual Stellar Biases in Transmission Spectroscopy:

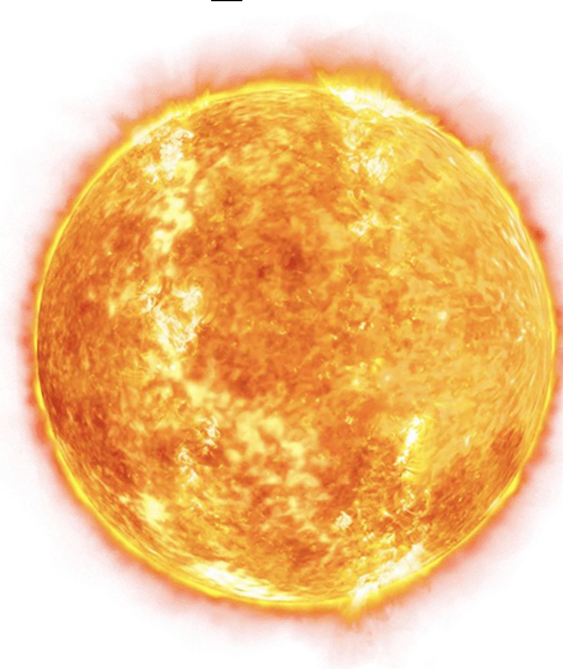
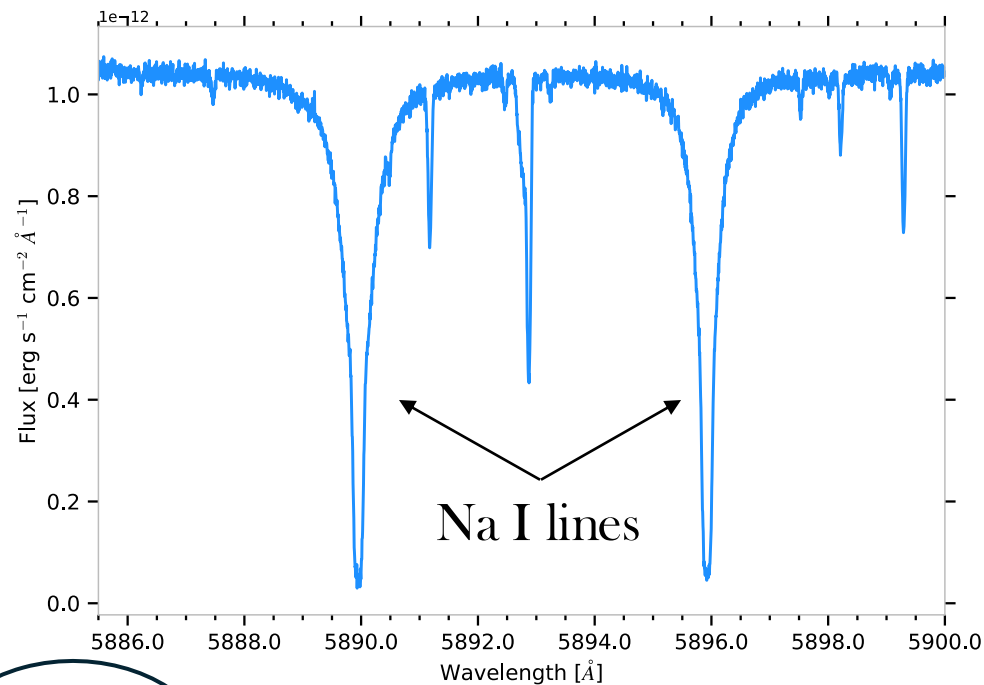
PLATO – ESP2025
Planets throughout the habitable
zone

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Marseille, Monday June 23, 2025

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William Dethier

A Caution for Atmospheric Characterization of Planets in the Habitable Zone

Out-of-transit spectrum



Target star

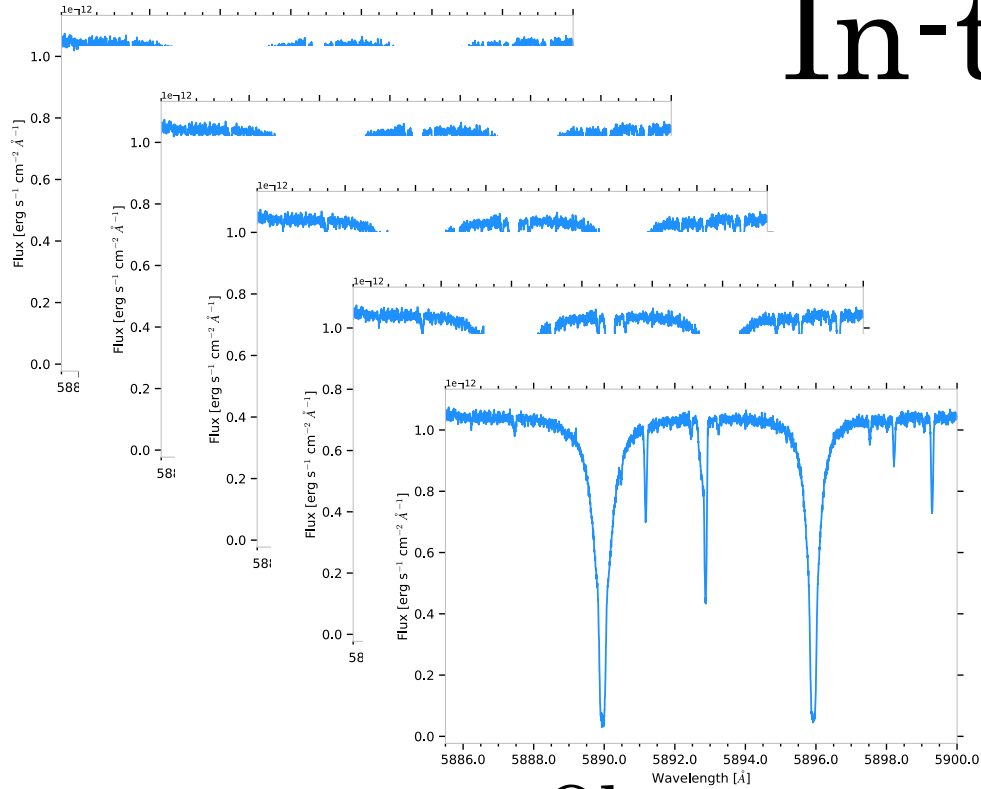
Is there
sodium in the
planet's
atmosphere?



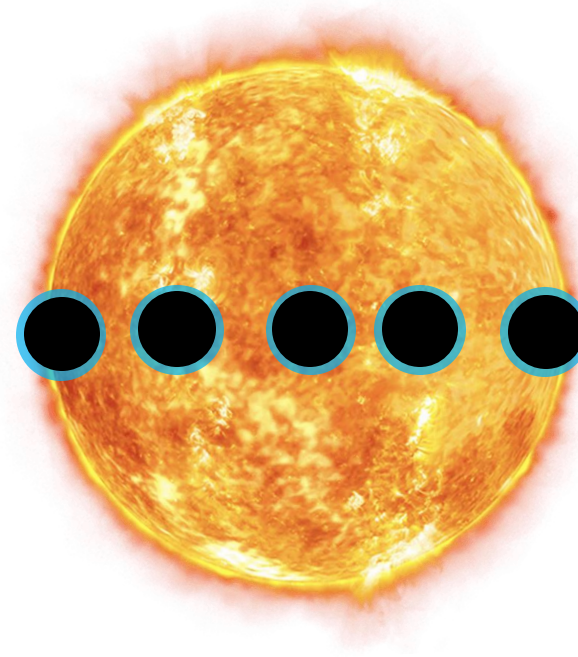
Observer

Observed before/after the transit

In-transit spectra



Target star



Observer

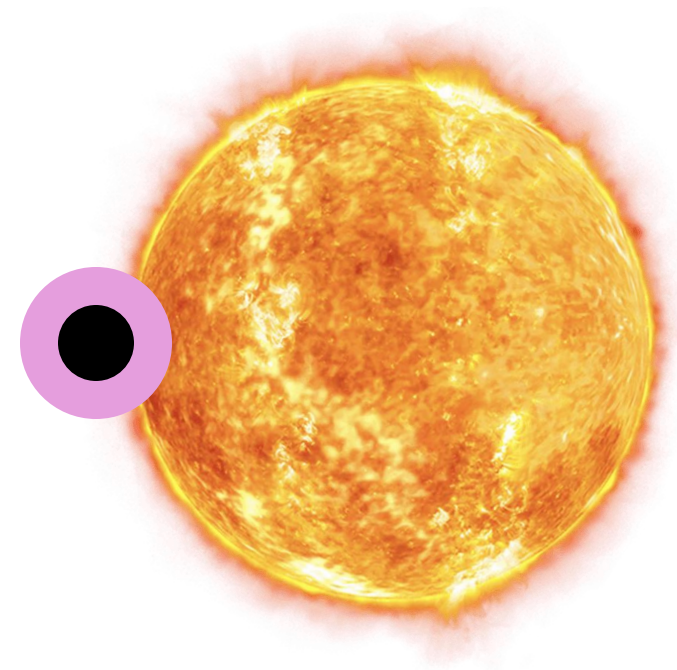
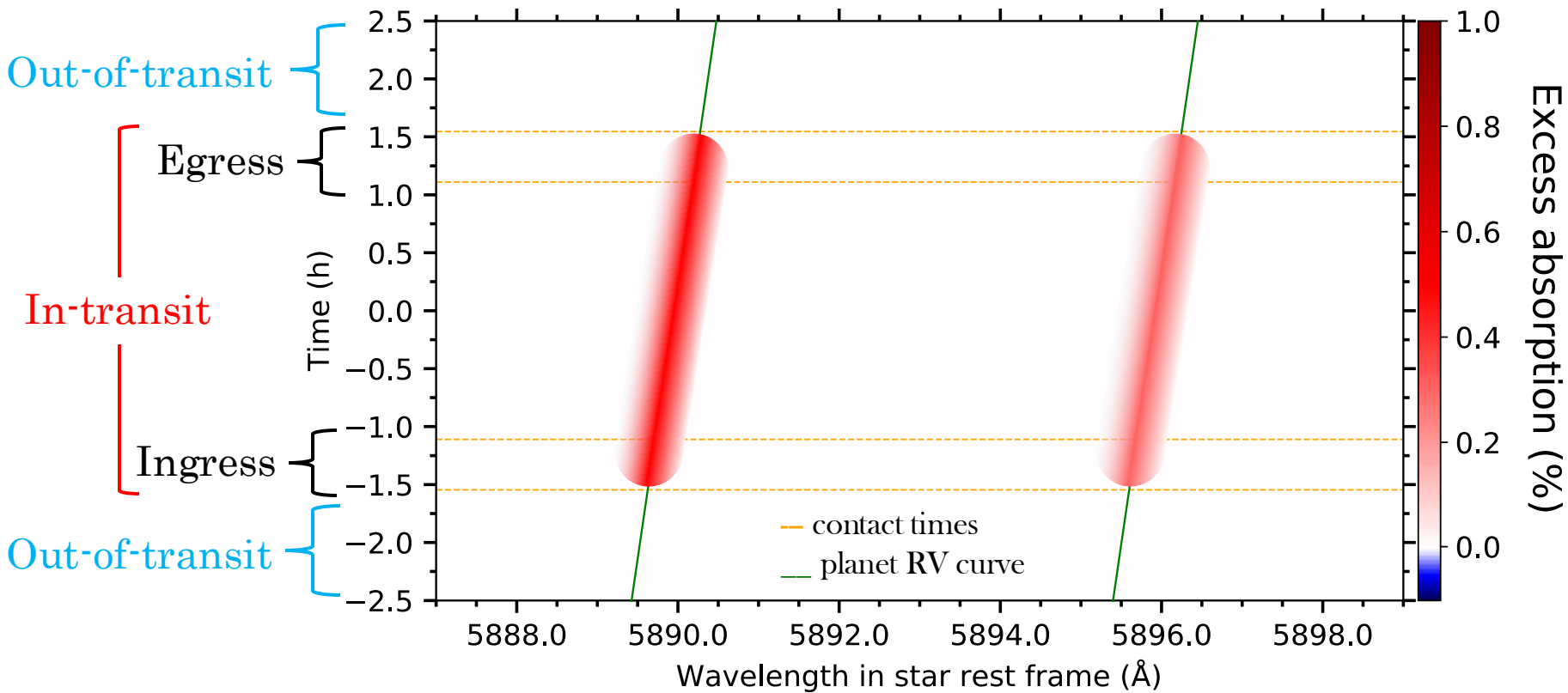
Observed during the transit

Absorption spectrum

$$A = \frac{F_{out} - F_{in}(t)}{F_{out}}$$

What we expect to see...

Temporal evolution

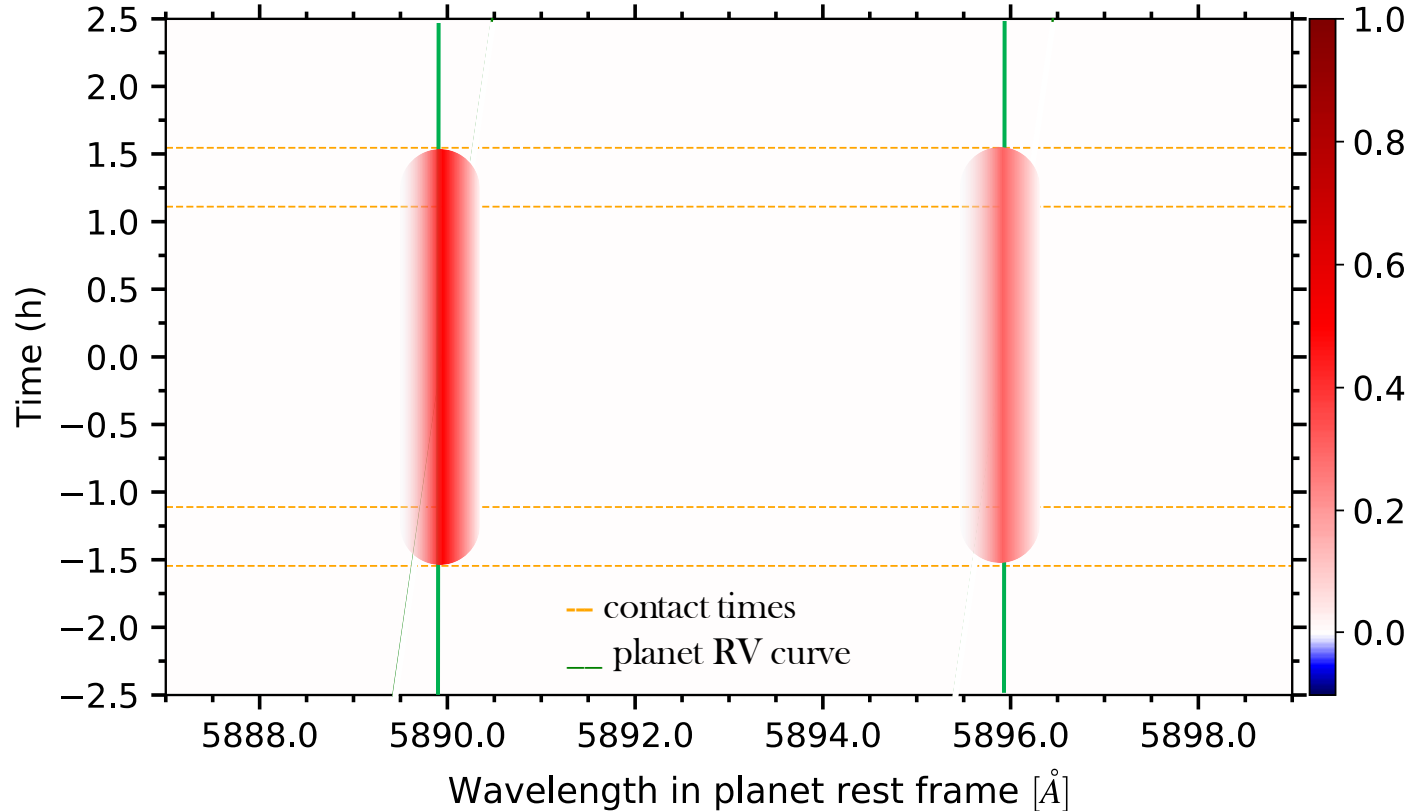


Absorption spectrum

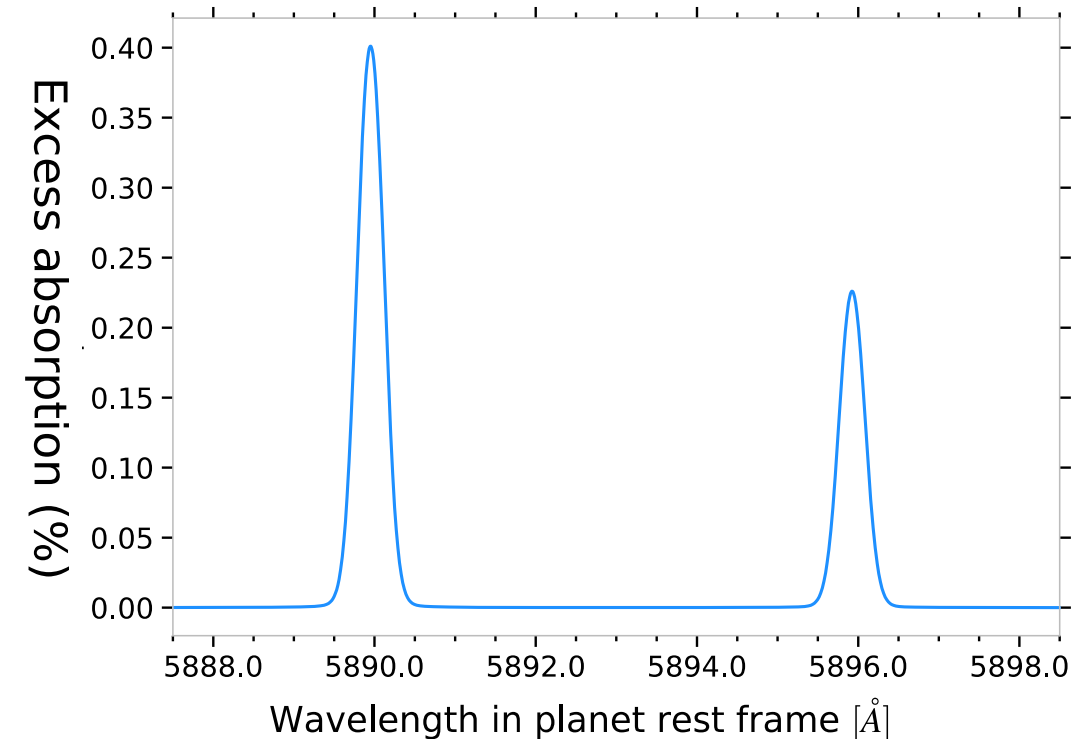
$$A = \frac{F_{out} - F_{in}(t)}{F_{out}}$$

What we expect to see...

Temporal evolution



Mean signature

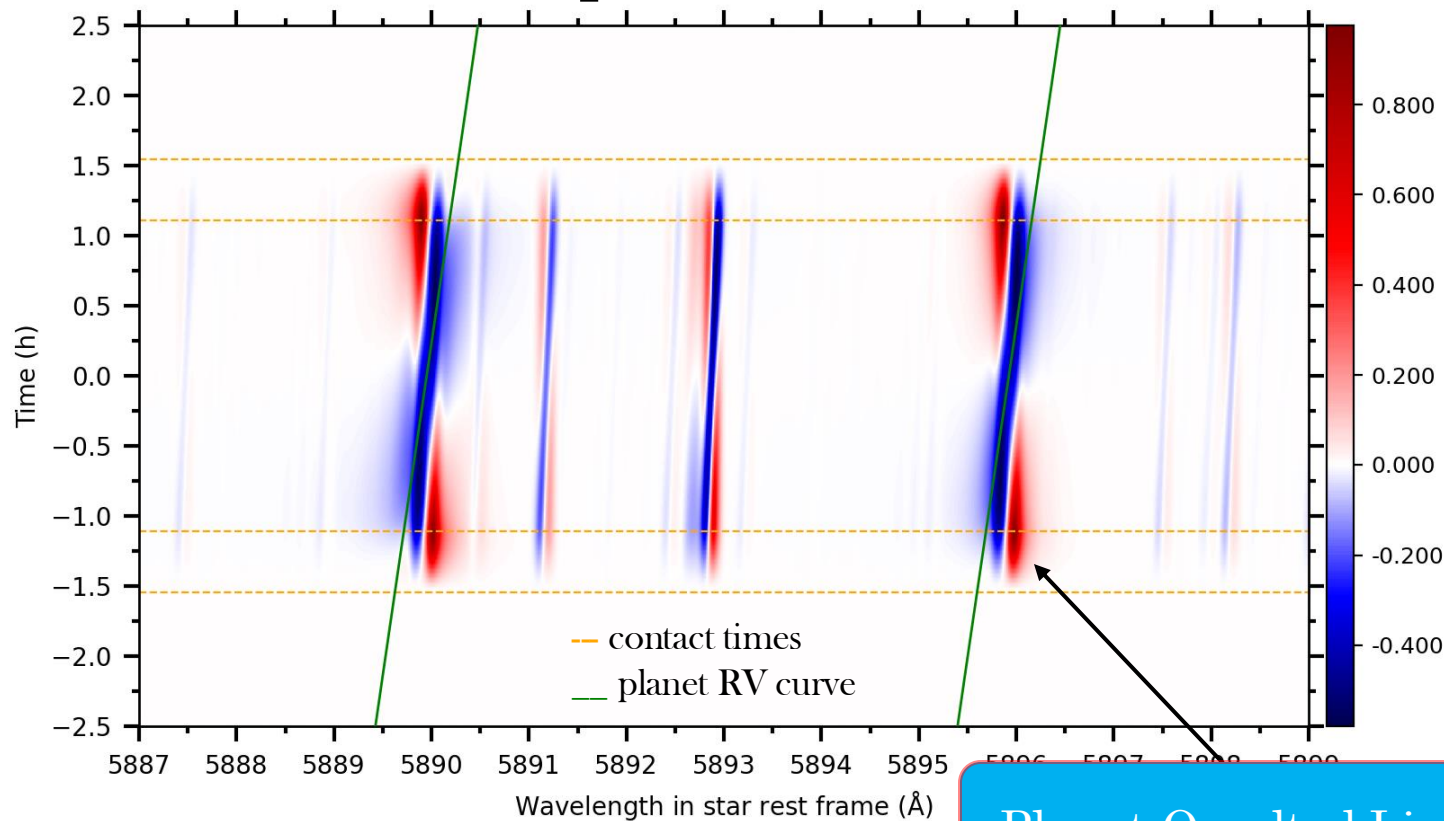


Absorption spectrum

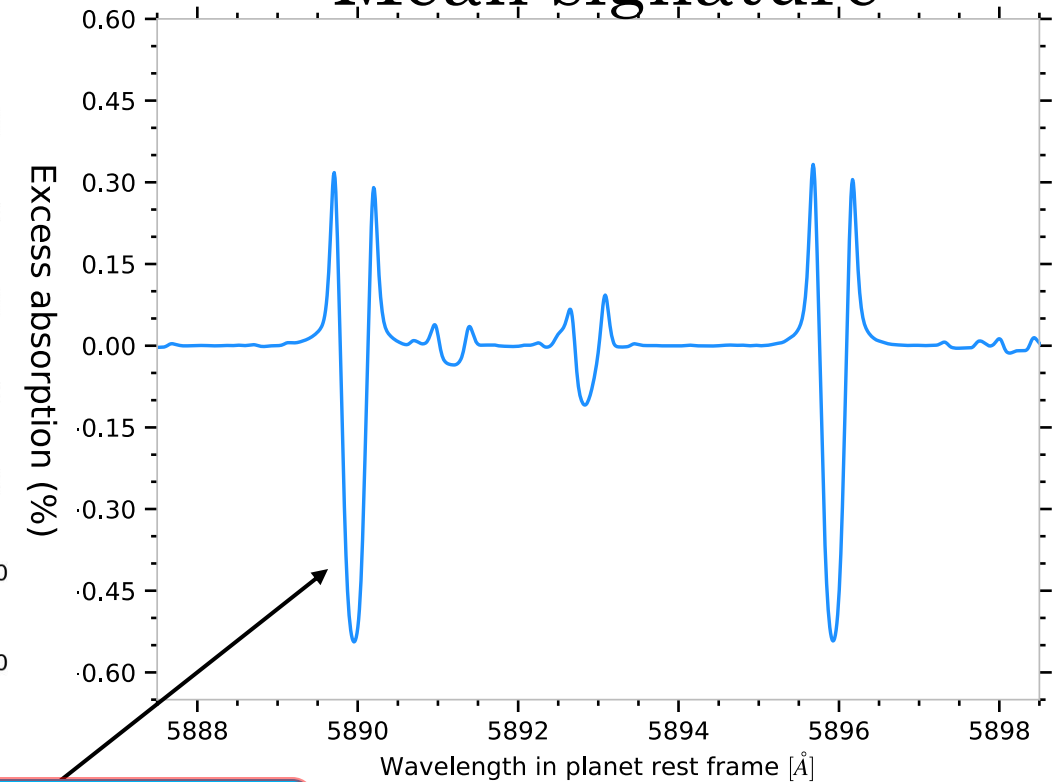
$$A = \frac{F_{out} - F_{in}(t)}{F_{out}}$$

What we actually see

Temporal evolution



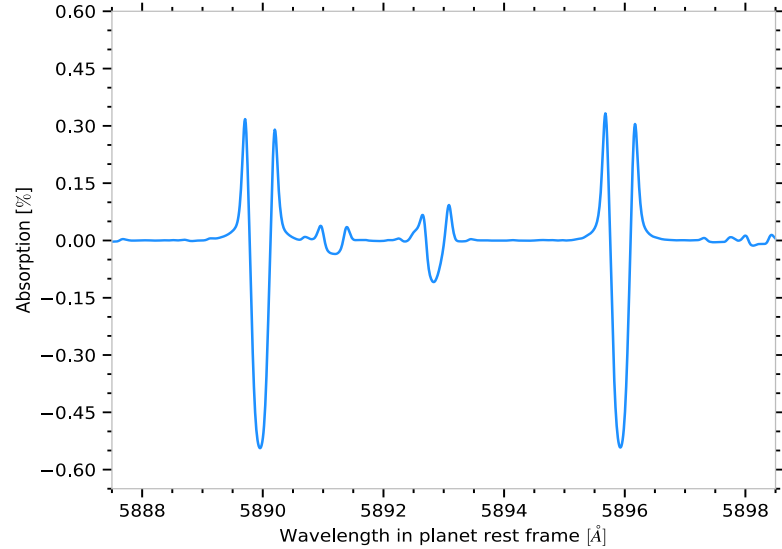
Mean signature



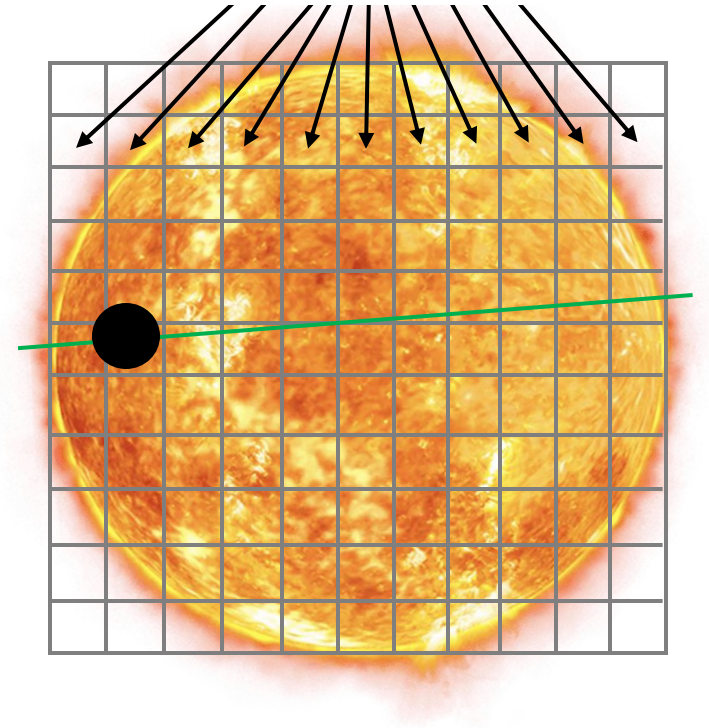
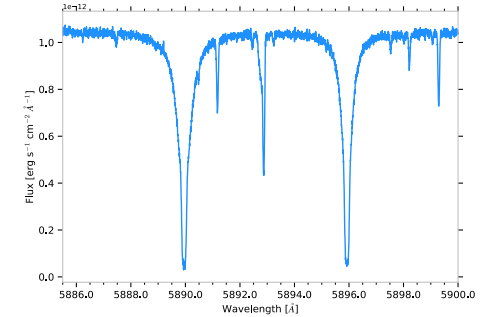
Planet-Occulted Line Distortion

How to deal with these?

1. Distribute local spectra on grid
2. Simulate a transiting bare planet
3. Compute synthetic absorption spectrum

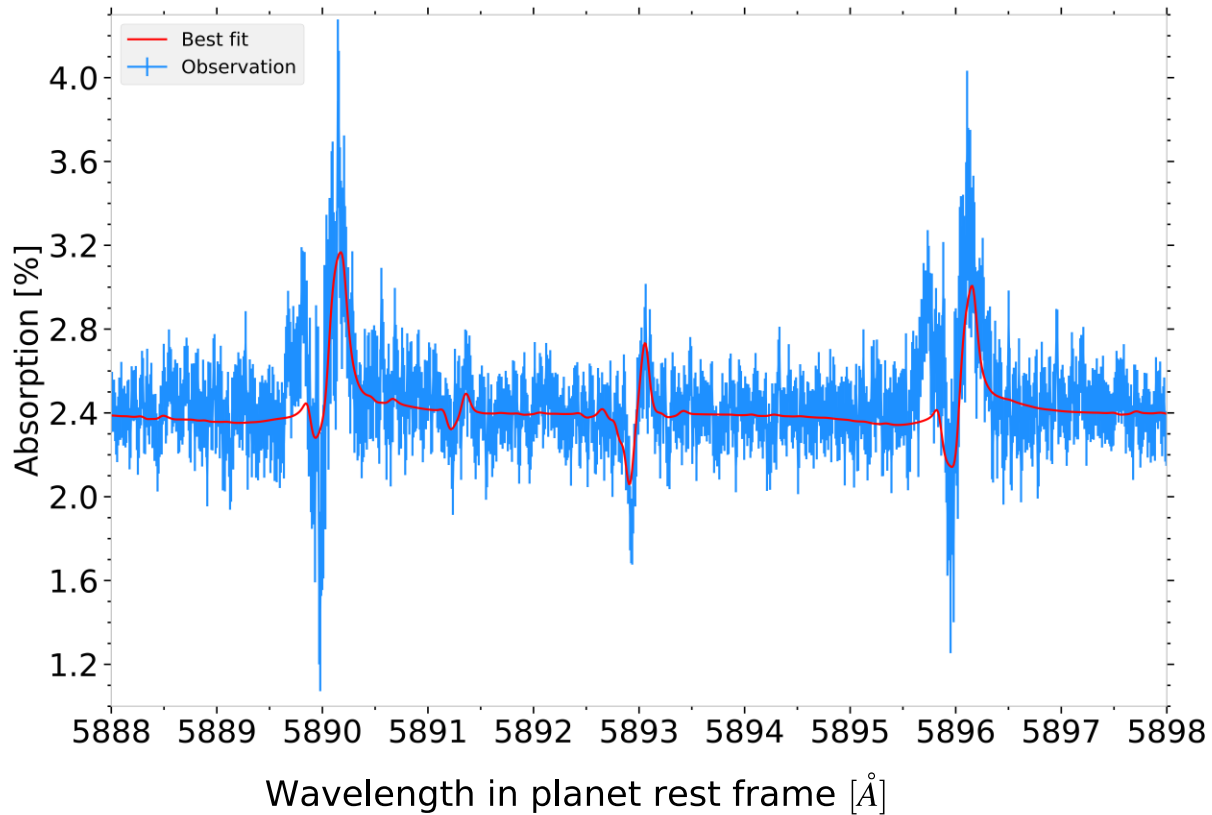


4. Use simulated spectrum to correct observations
 - Analyse residual atmospheric signal

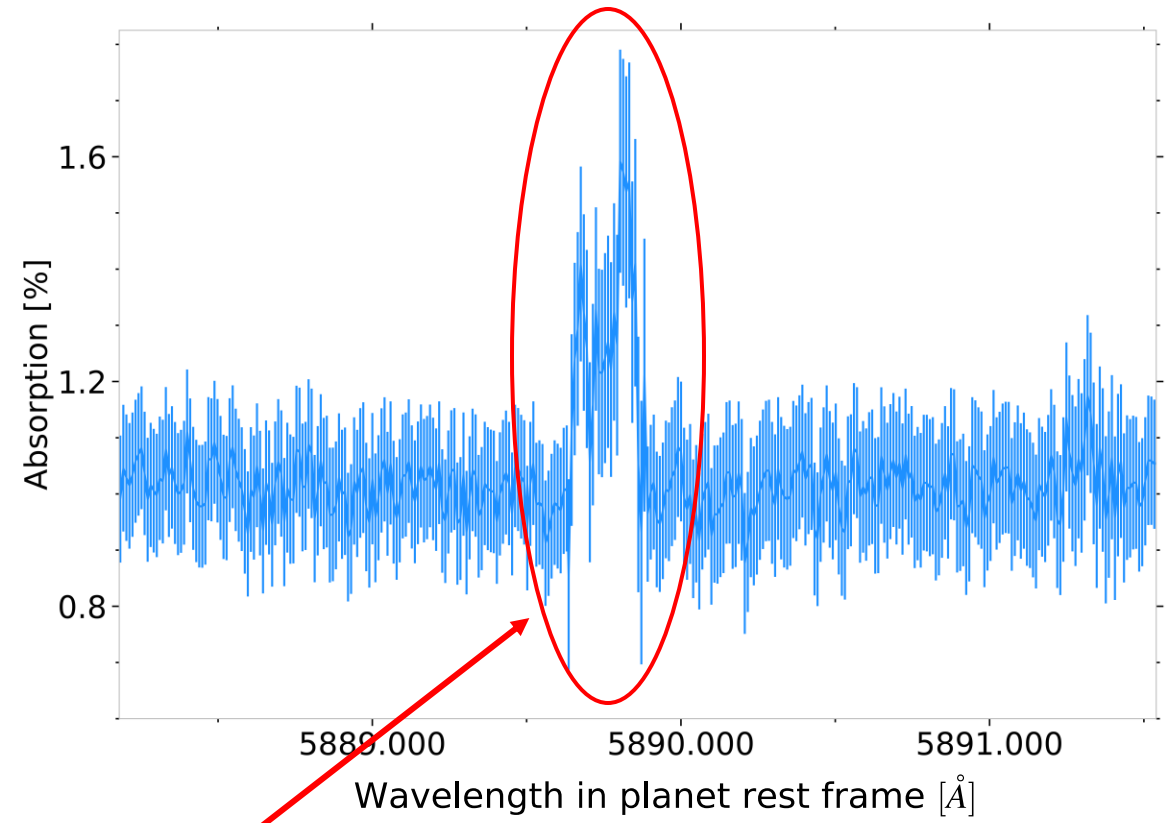


Correcting absorption spectra

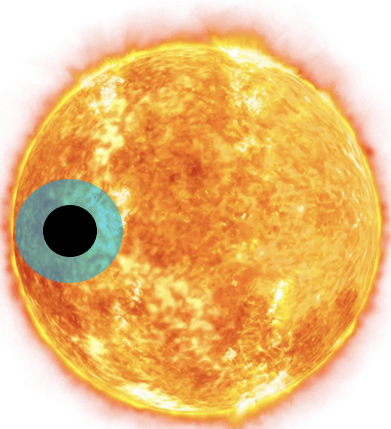
Observation and best fit



Observation
best fit



Pure atmospheric signature?

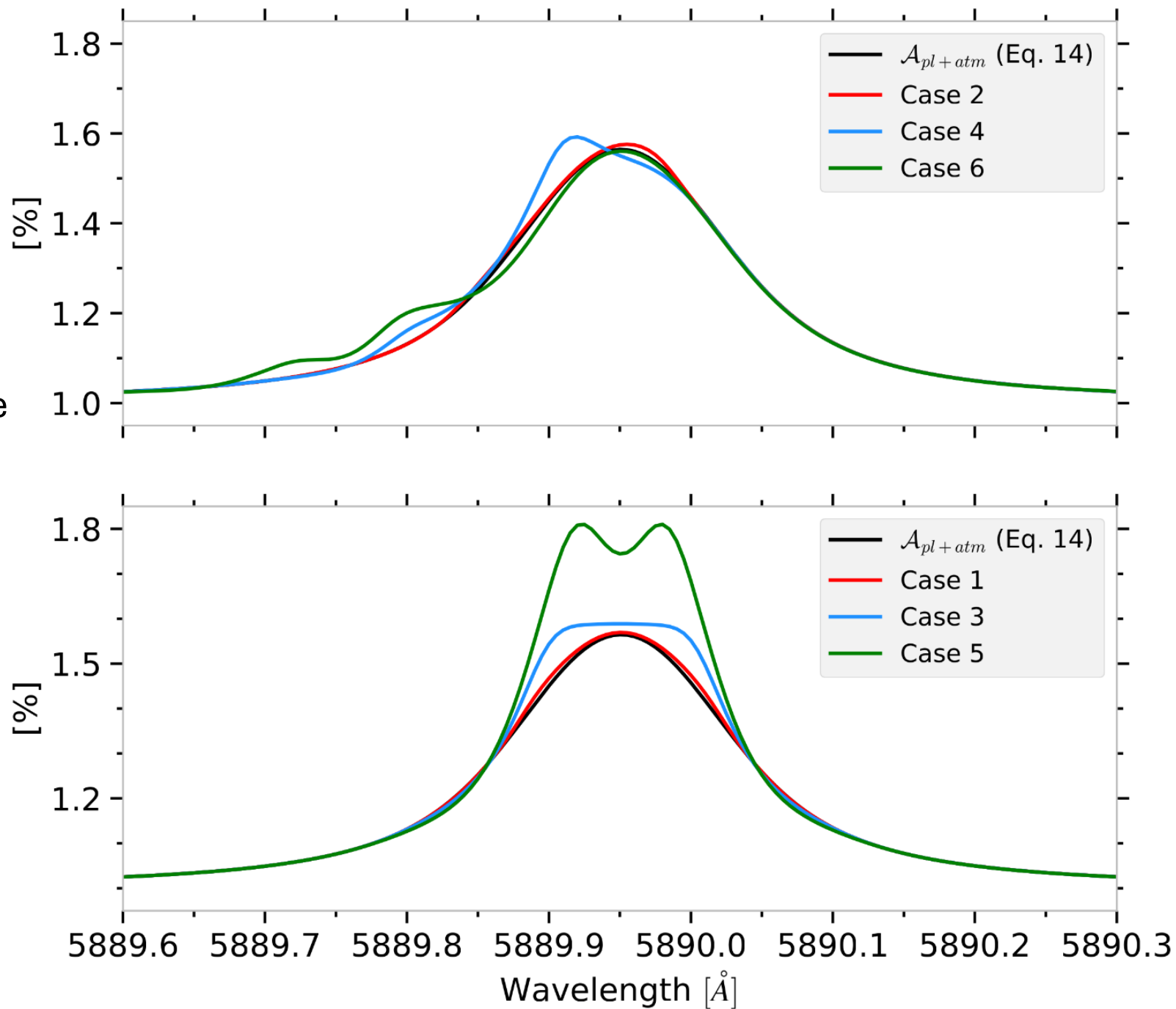
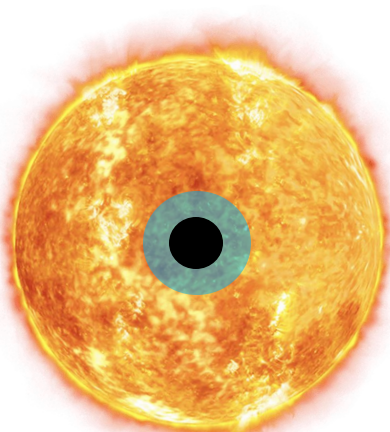


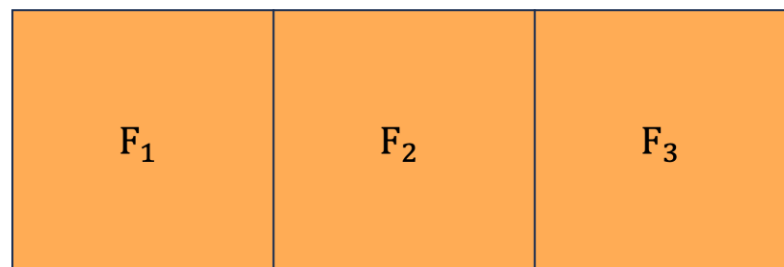
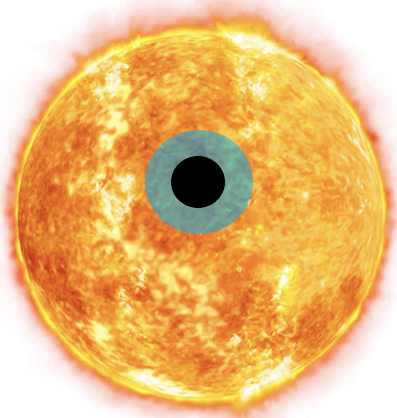
Black : Pure atm signature

$V \sin(i) = 4 \text{ km/s}$

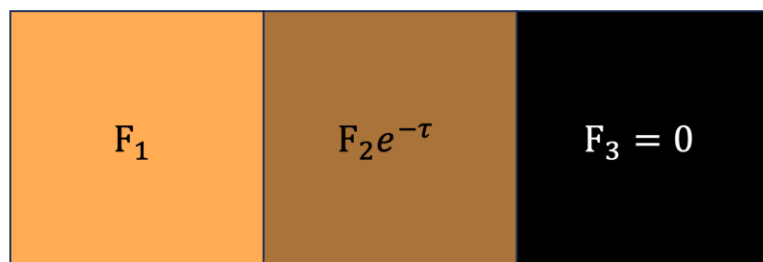
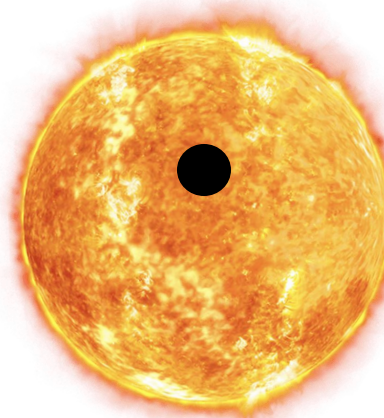
$V \sin(i) = 10 \text{ km/s}$

$V \sin(i) = 20 \text{ km/s}$

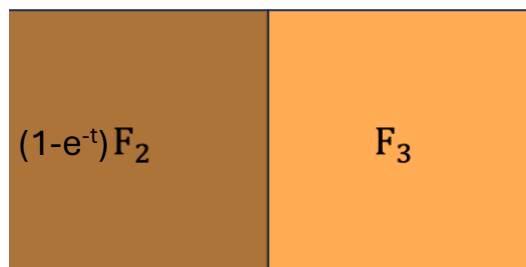




F_{out}

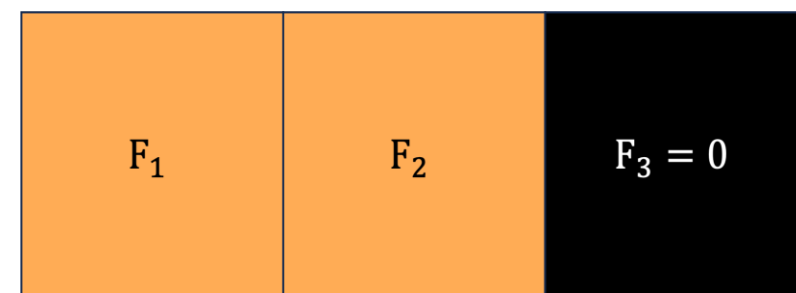


F_{in}^{pl+atm}

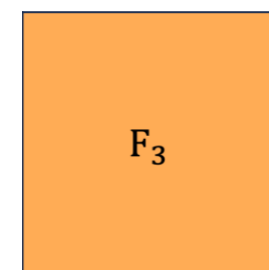


$F_{out} - F_{in}^{pl+atm}$

What we receive

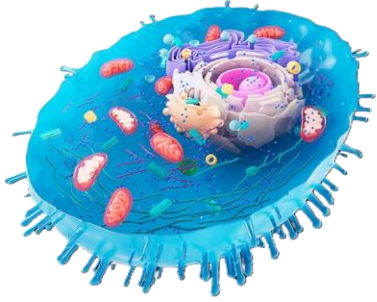


F_{in}^{pl}

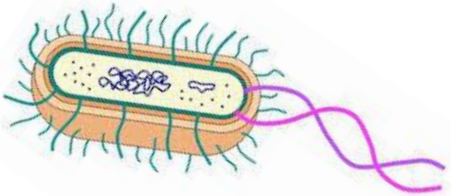


$F_{out} - F_{in}^{pl}$

$$\frac{A_{pl+atm}}{A_{pl}} = \frac{(1-e^{-\tau})F_2 + F_3}{F_3}$$

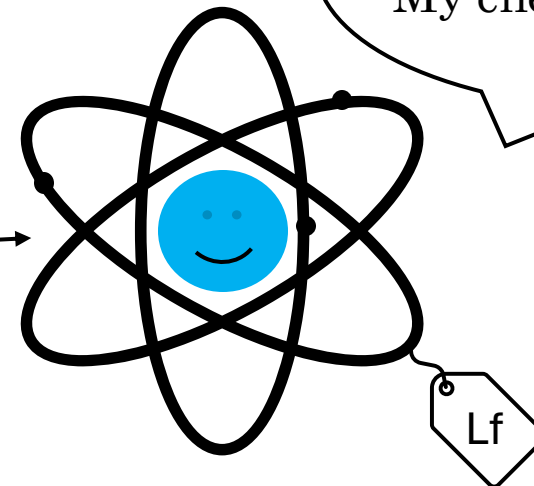
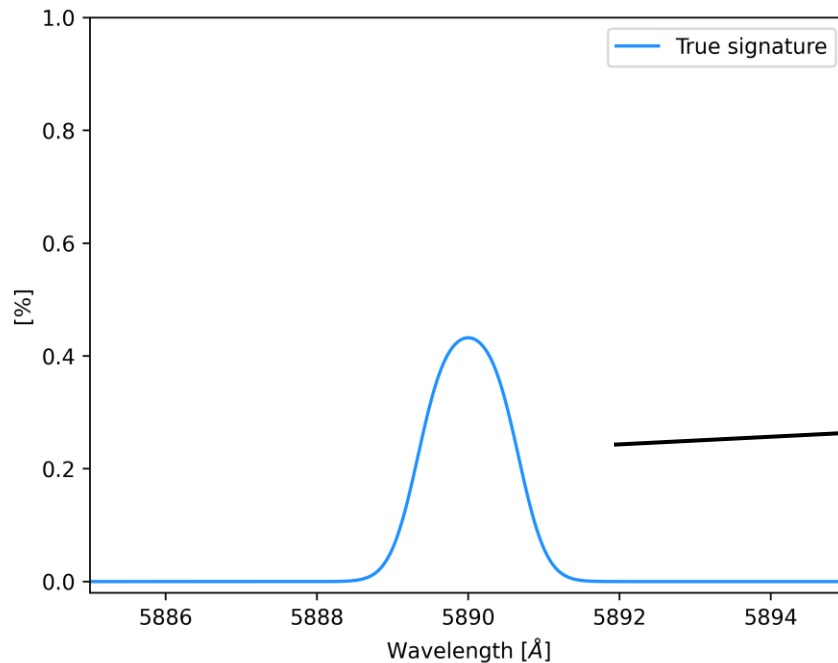
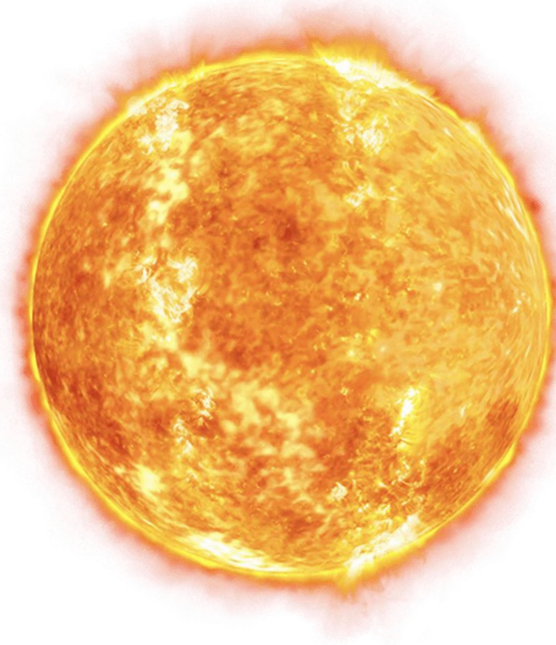
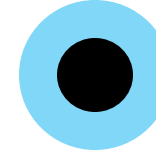
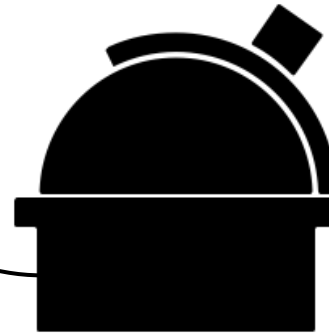
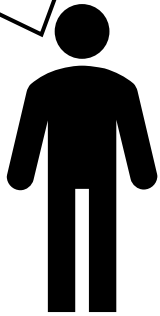


Fine, but what
is the link with
PLATO?



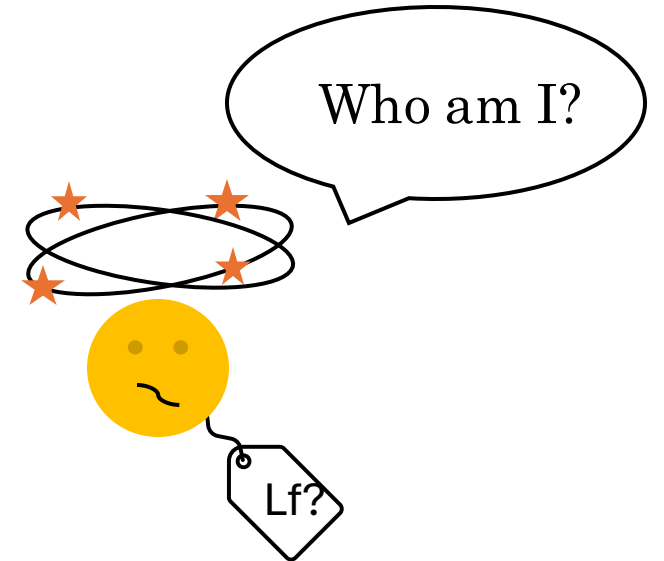
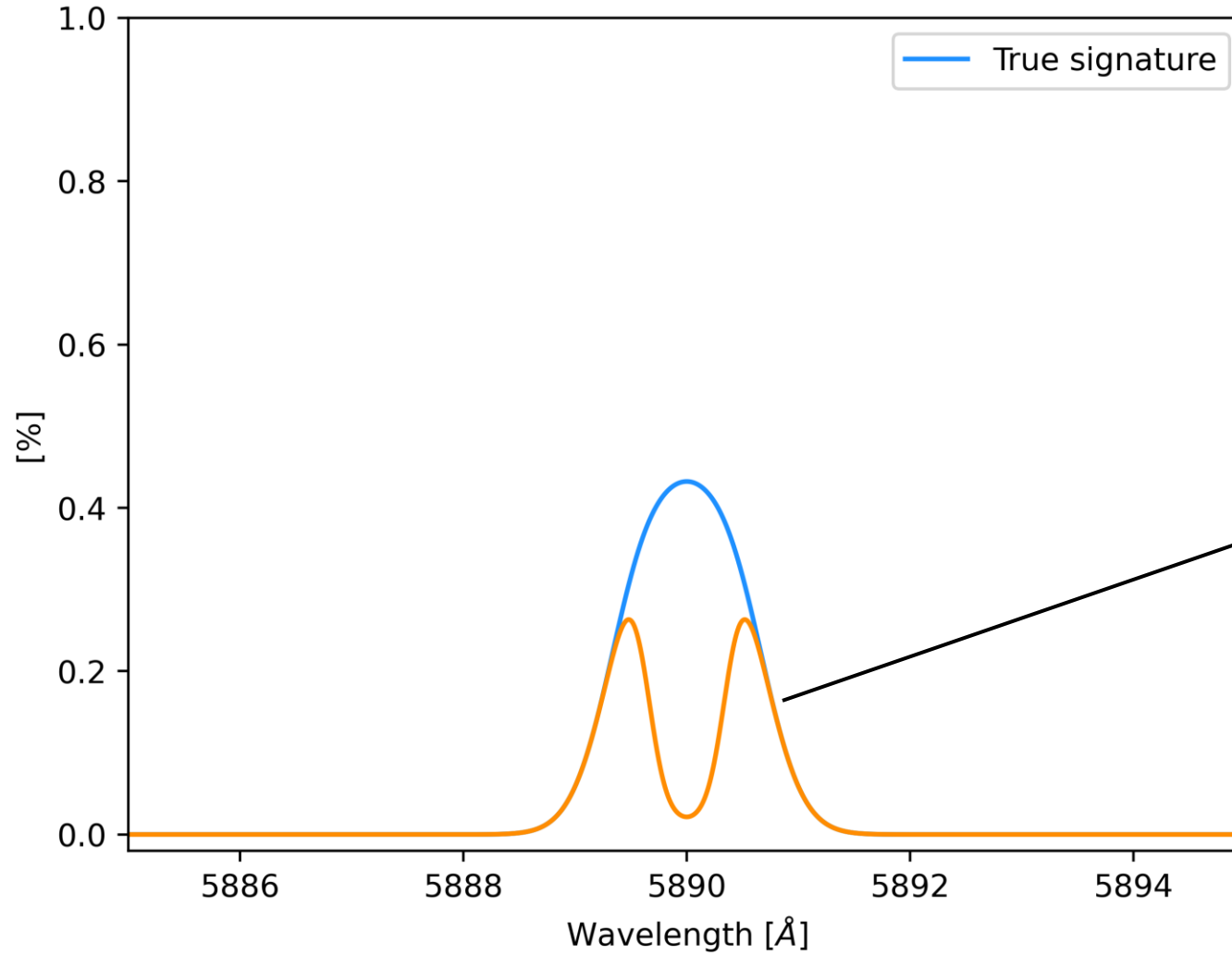
PLATO follow up: The search on habitable planets

I will find life on
another planet!

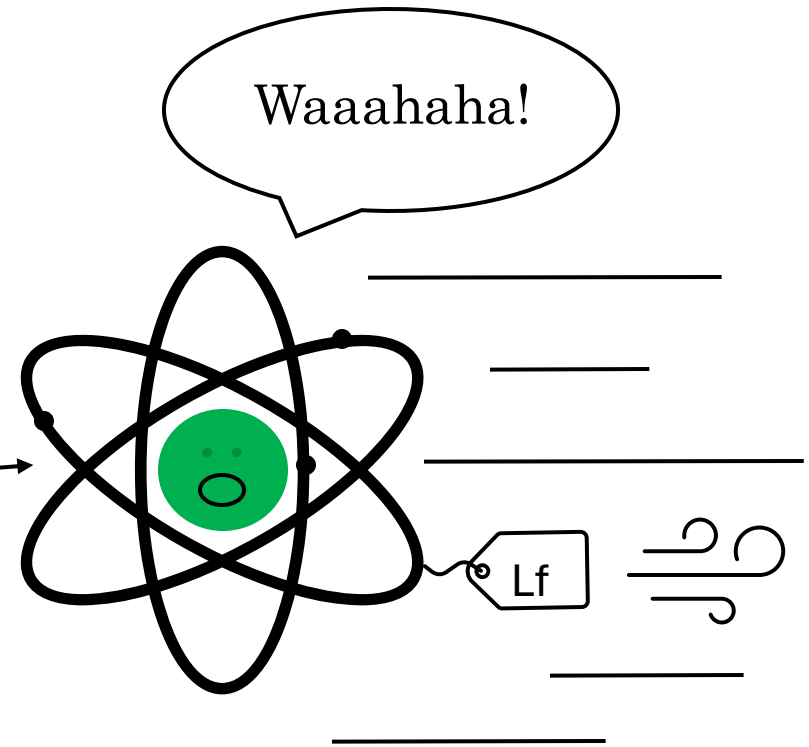
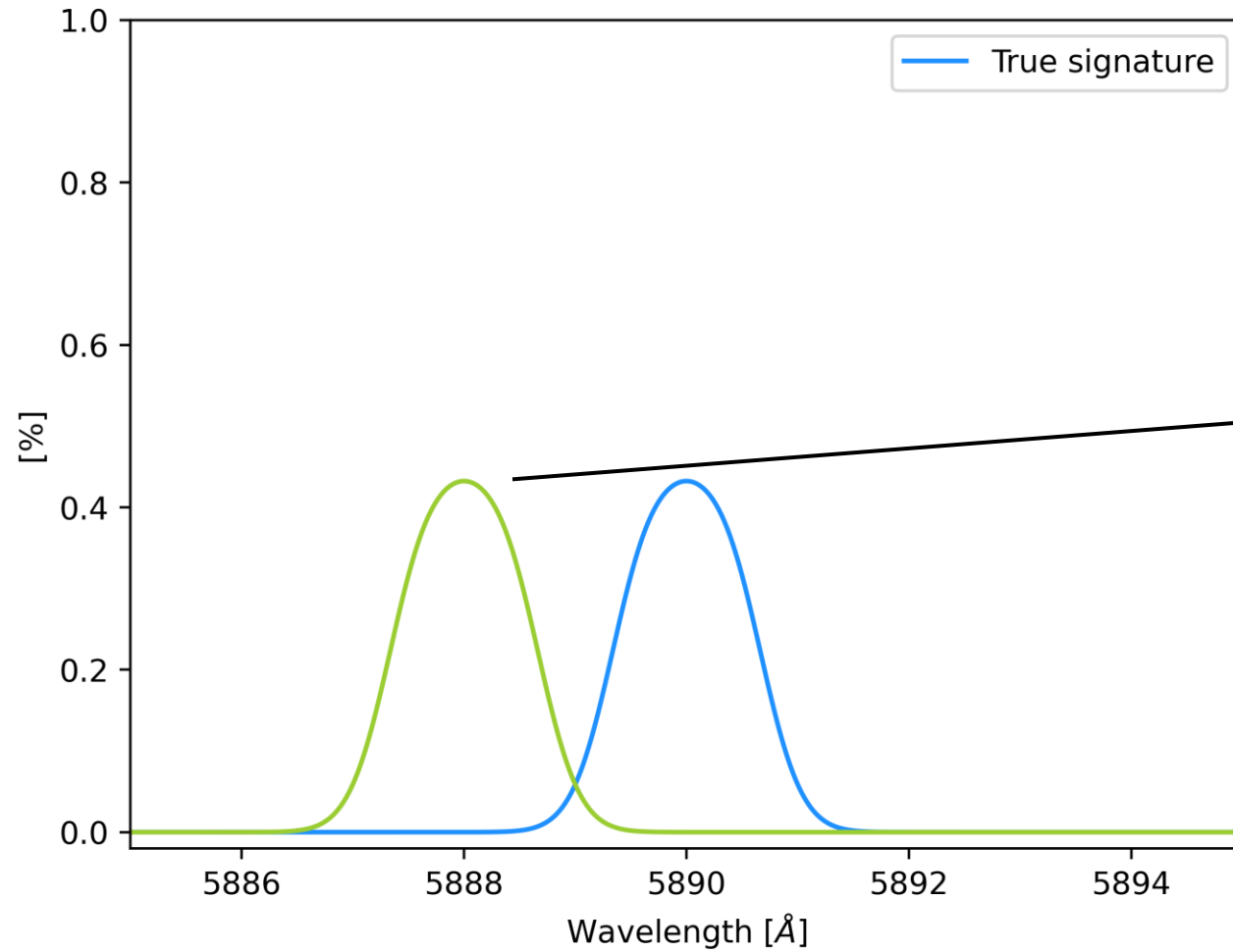


Hi, I am element of life.
My chemical symbol is
Lf

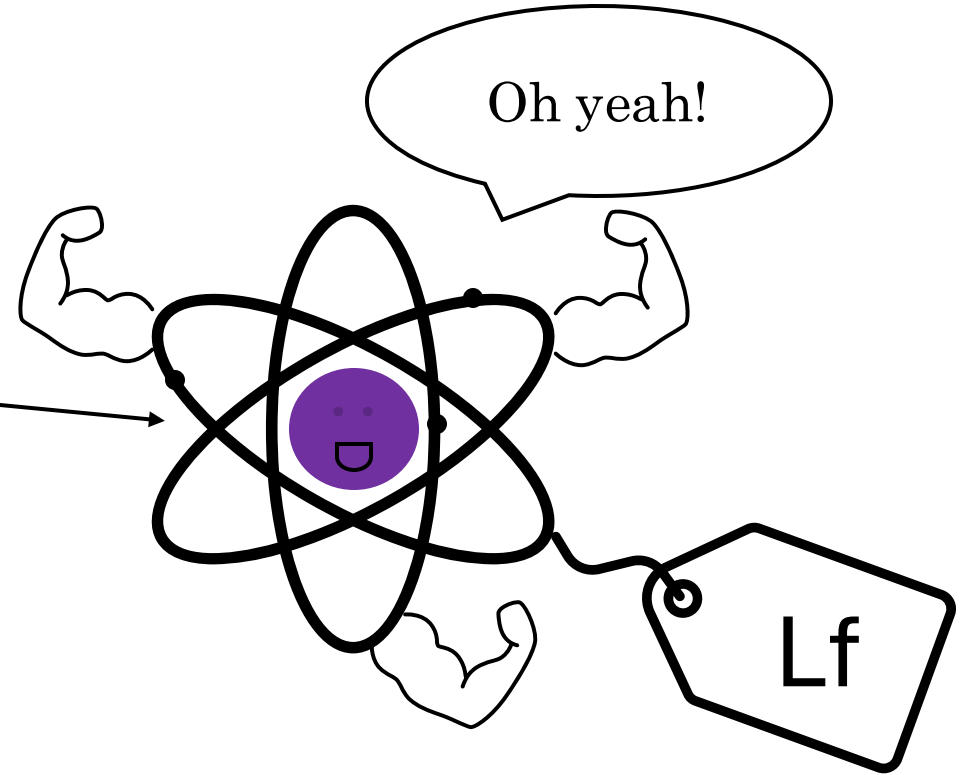
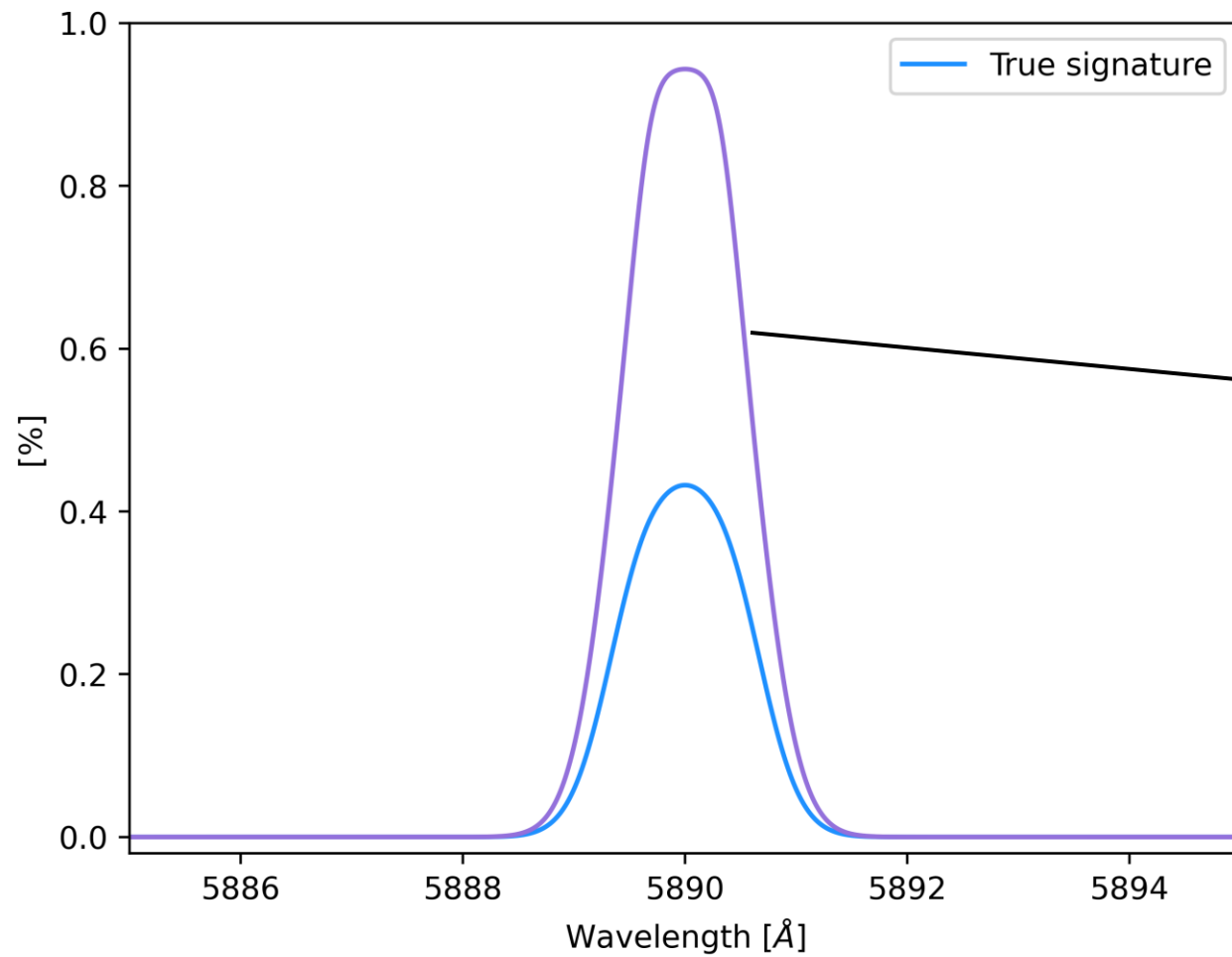
Deformation



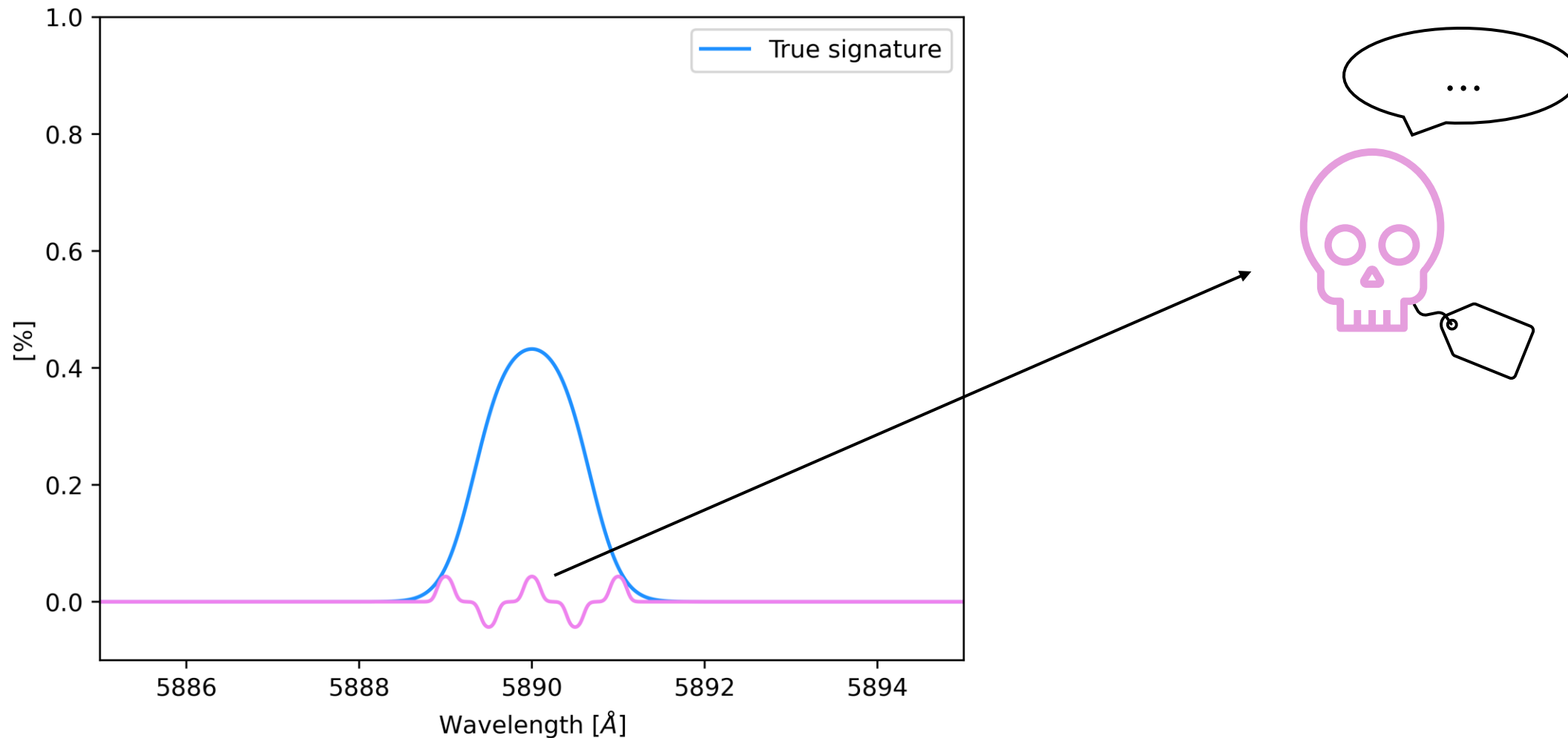
Dynamics



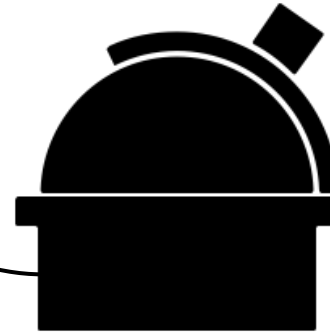
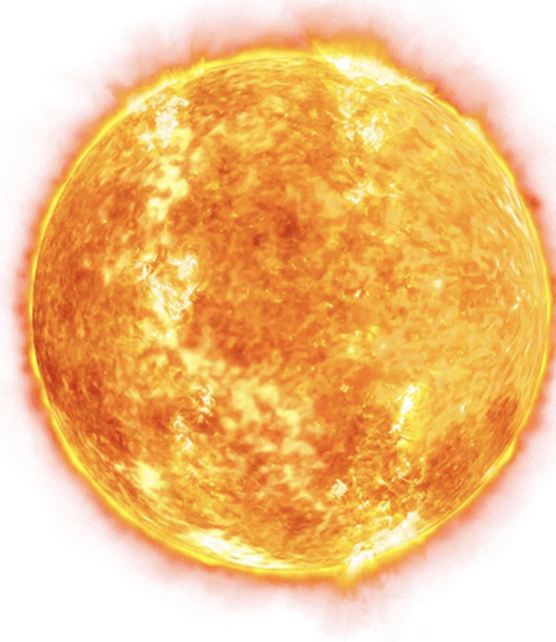
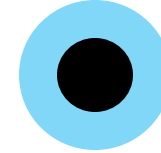
Overestimation



False non detection



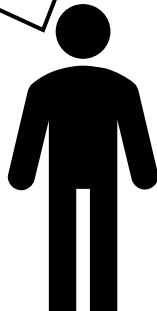
Conclusions



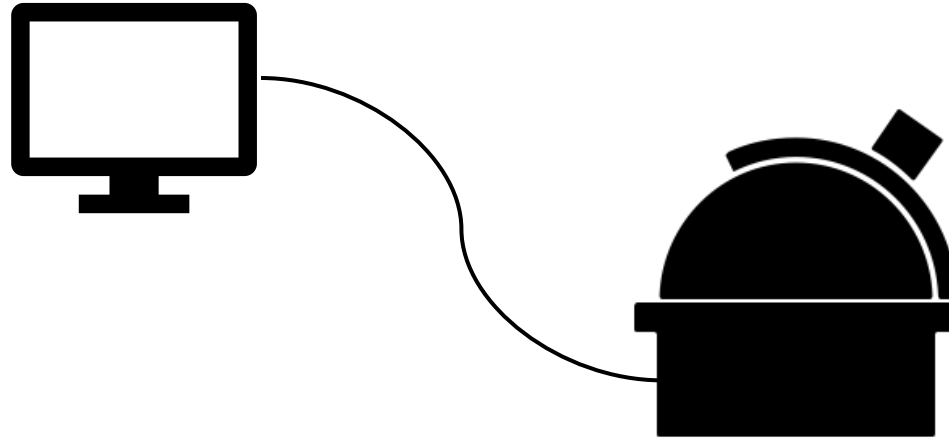
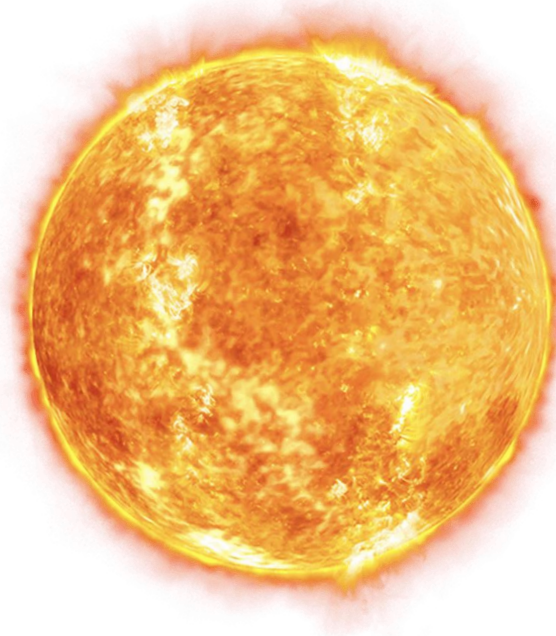
I have the best
telescopes in the
world, but still cannot
detect Lf

Mmm...

I better start working
on my post processing
techniques



Conclusions



***M**eanwhile on Lf0001b...*

Oh-oh...
oops

Did you forget the
address on the invitation?
The Earthians cannot
find us

