

Bayesian Retrieval techniques for high-dimensional spectroscopic observations of exoplanet atmospheres

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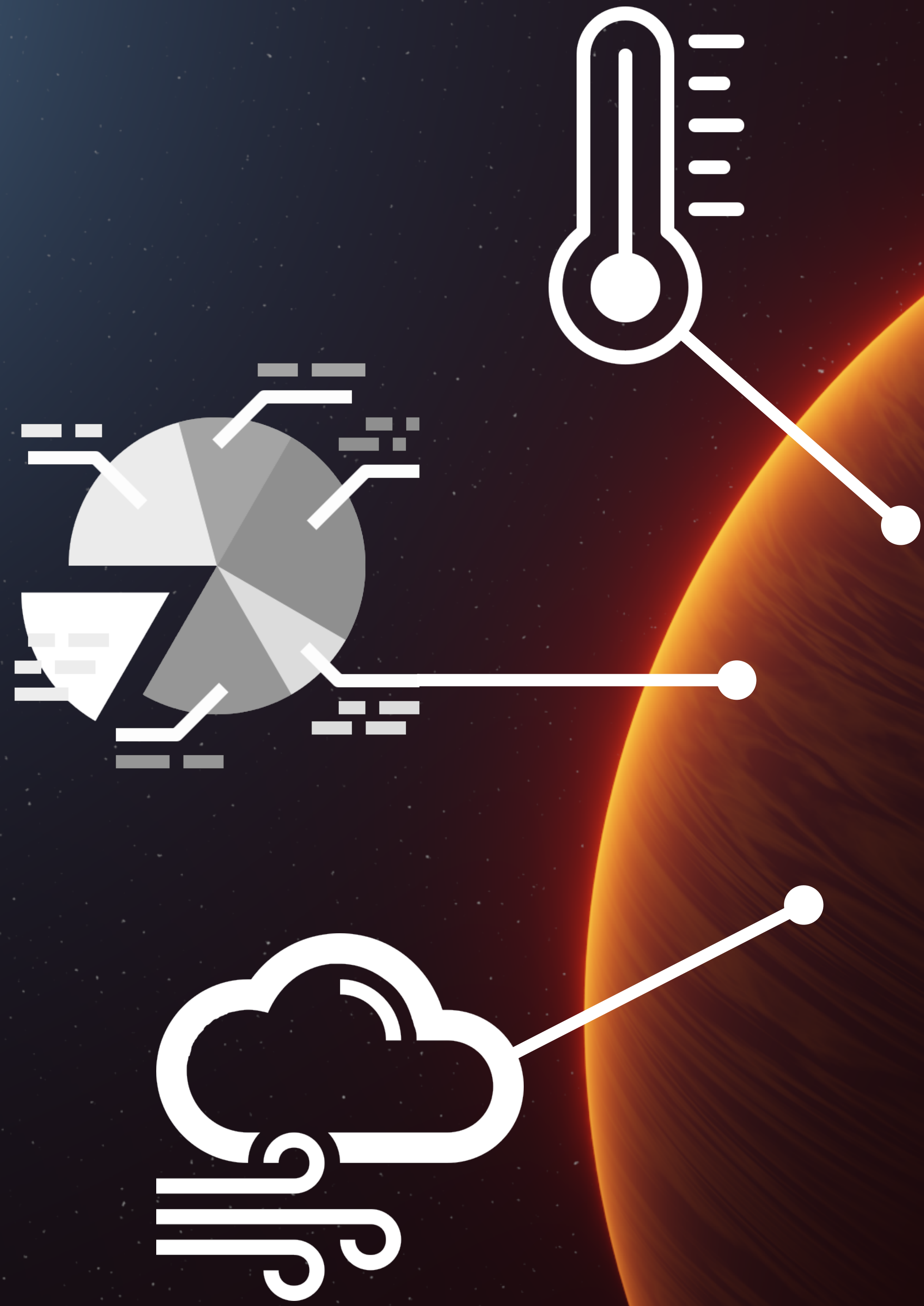
@HoeijmakersJens

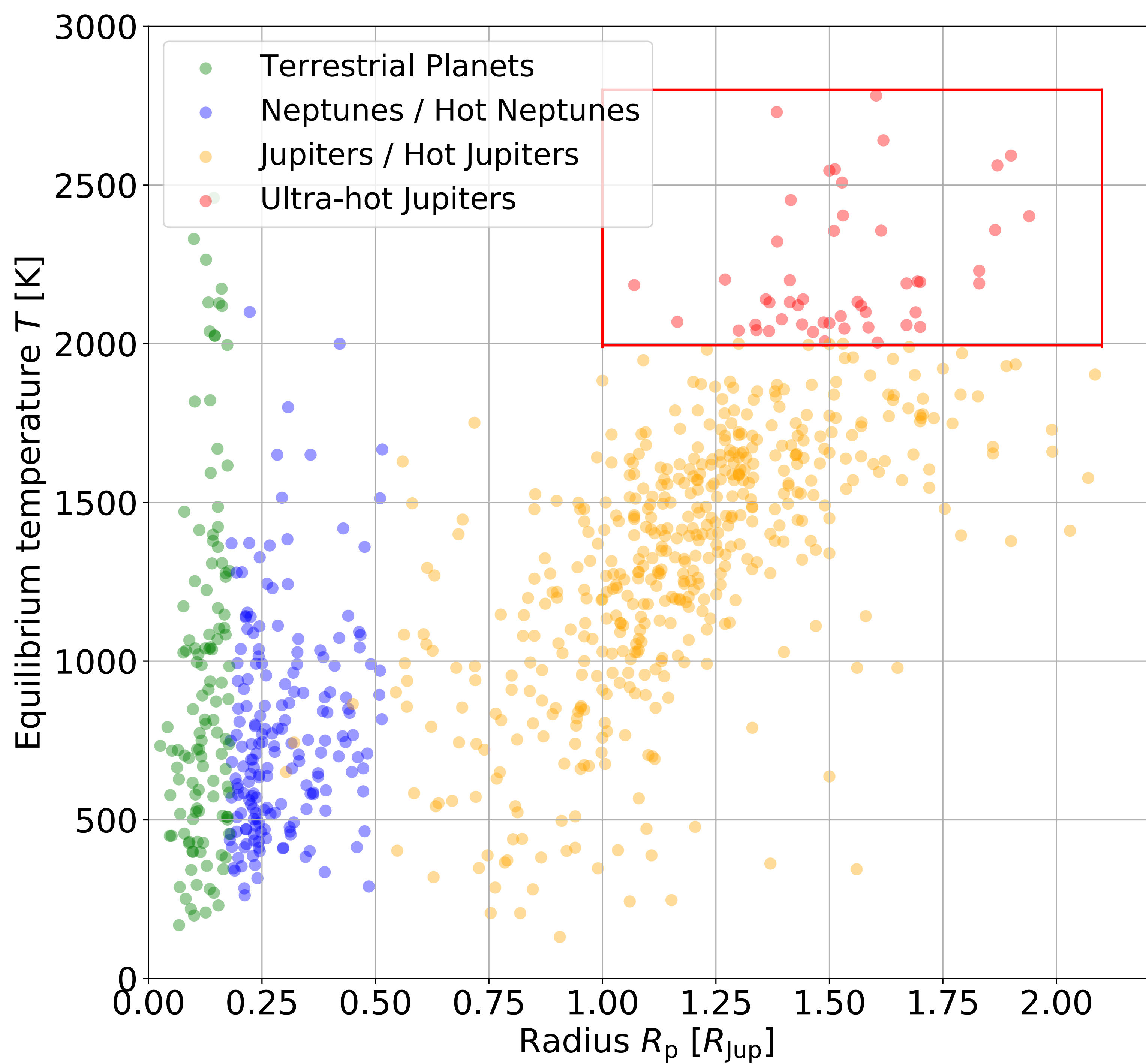
[http://hoeijmakers.github.io/
jens.hoeijmakers@fysik.lu.se](http://hoeijmakers.github.io/jens.hoeijmakers@fysik.lu.se)

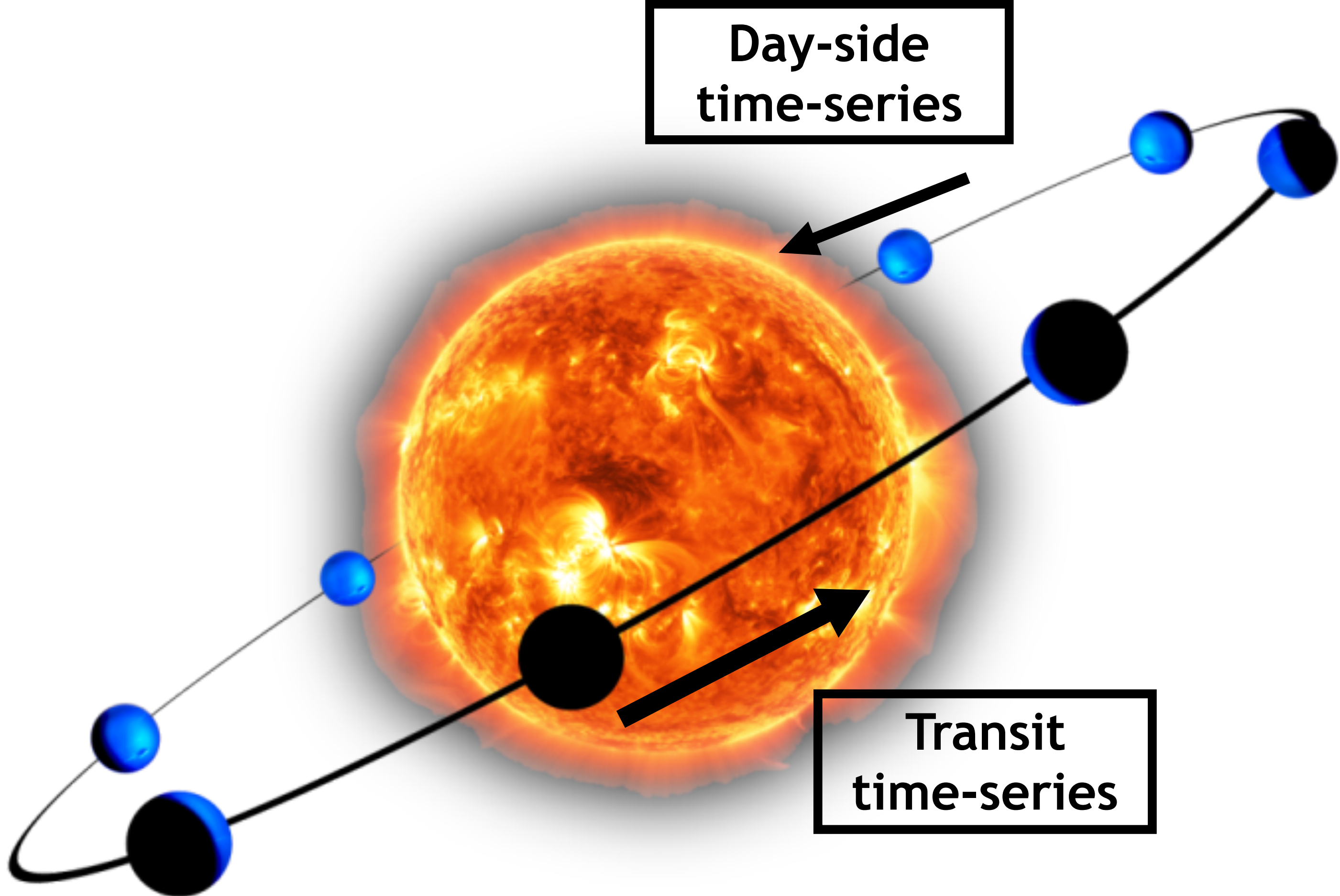
eSSENCE Seminar
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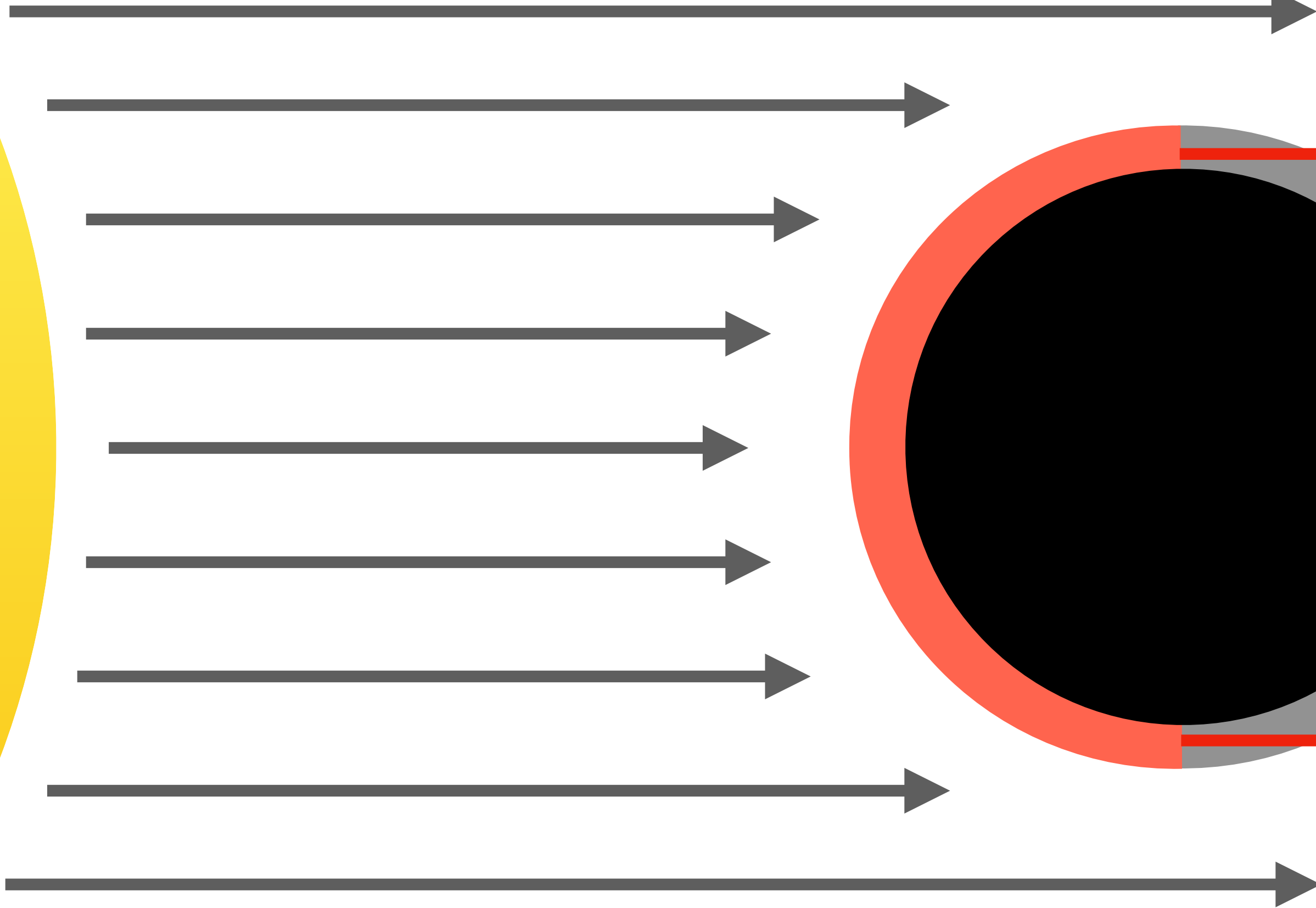


Day-side
time-series

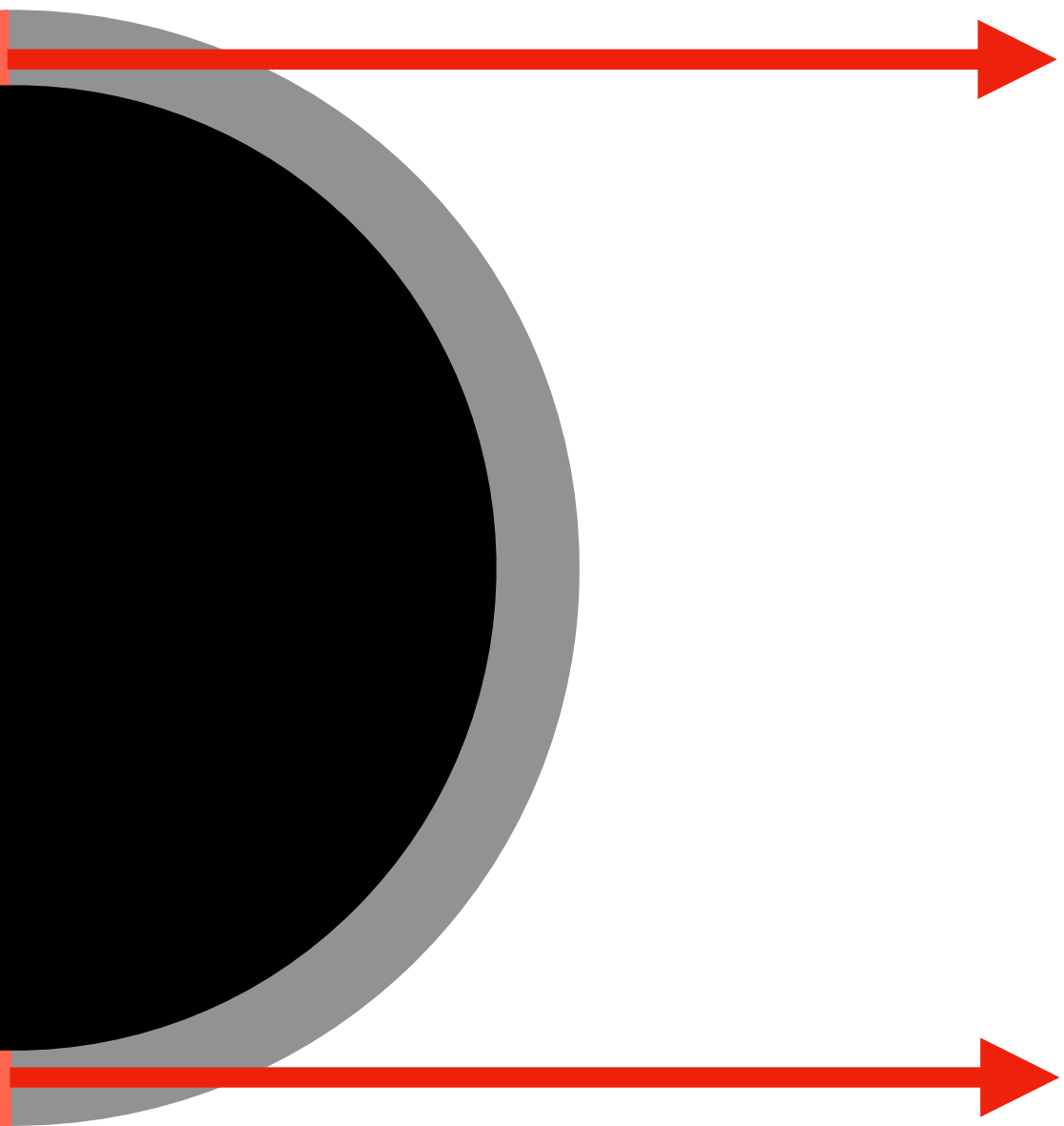
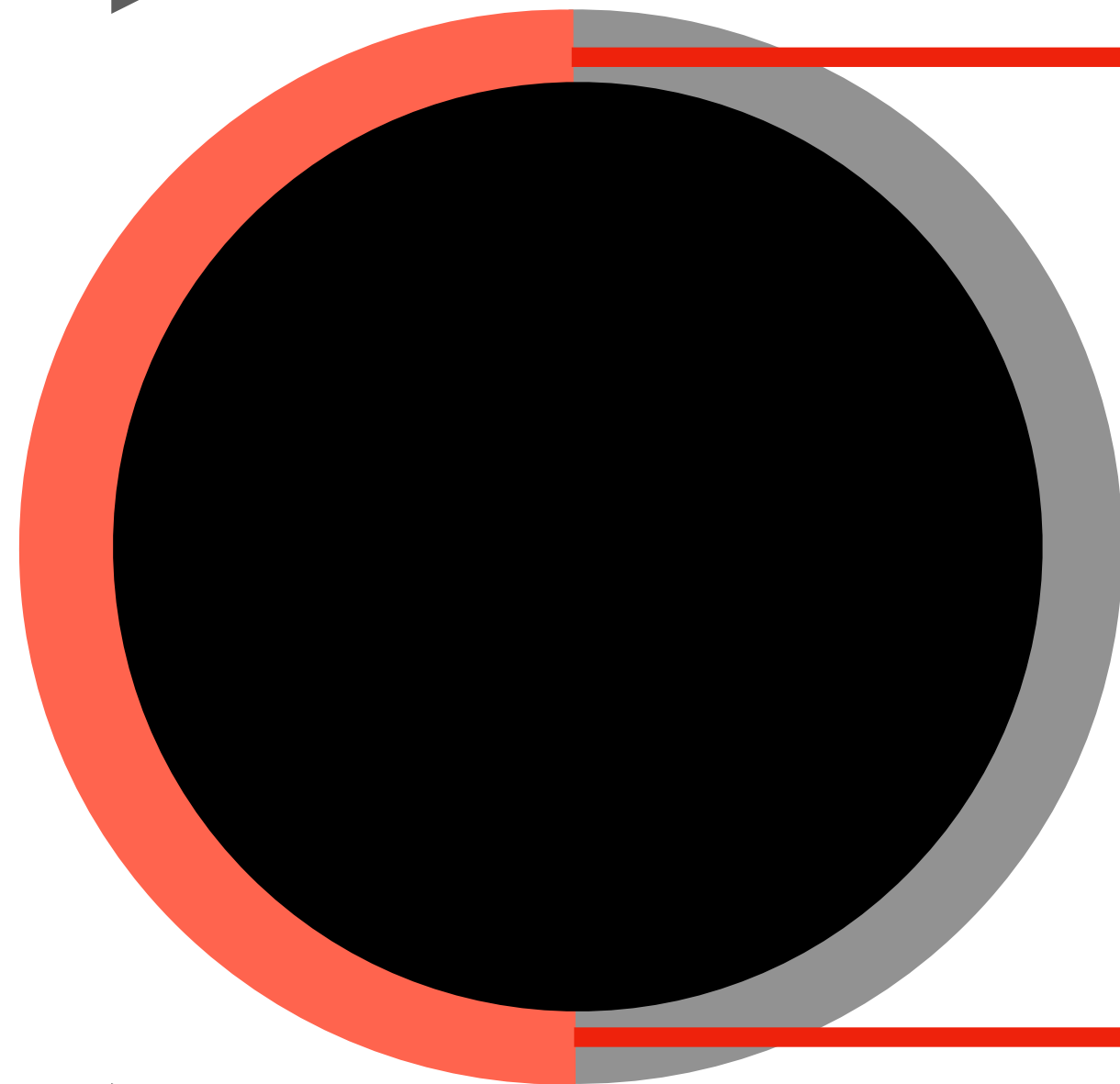
Transit
time-series



Starlight

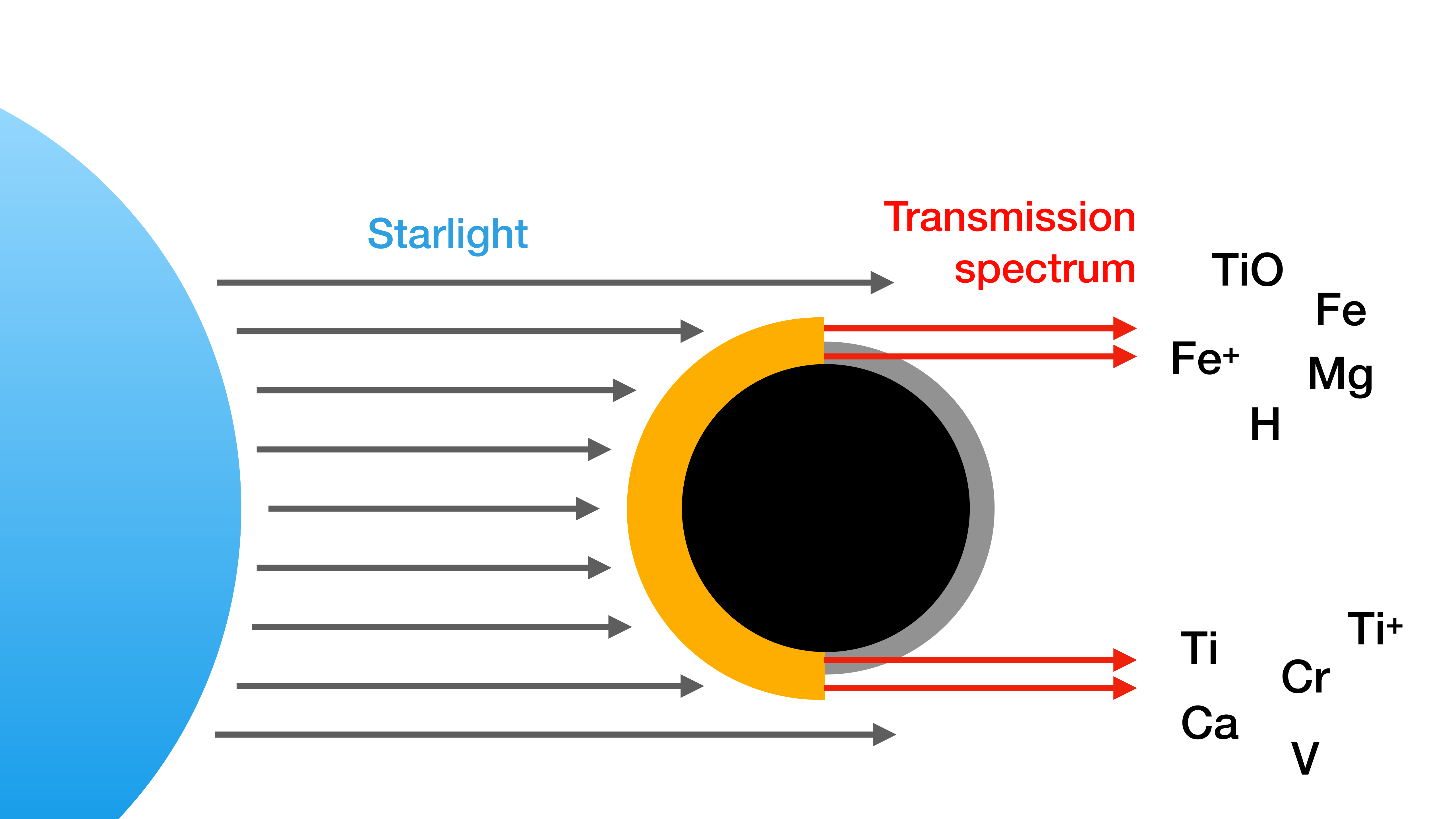


Transmission spectrum



H₂O
CO
CO₂

CH₄
Na
HCN
K



Starlight

Transmission spectrum

TiO

Fe

Fe⁺

Mg

H

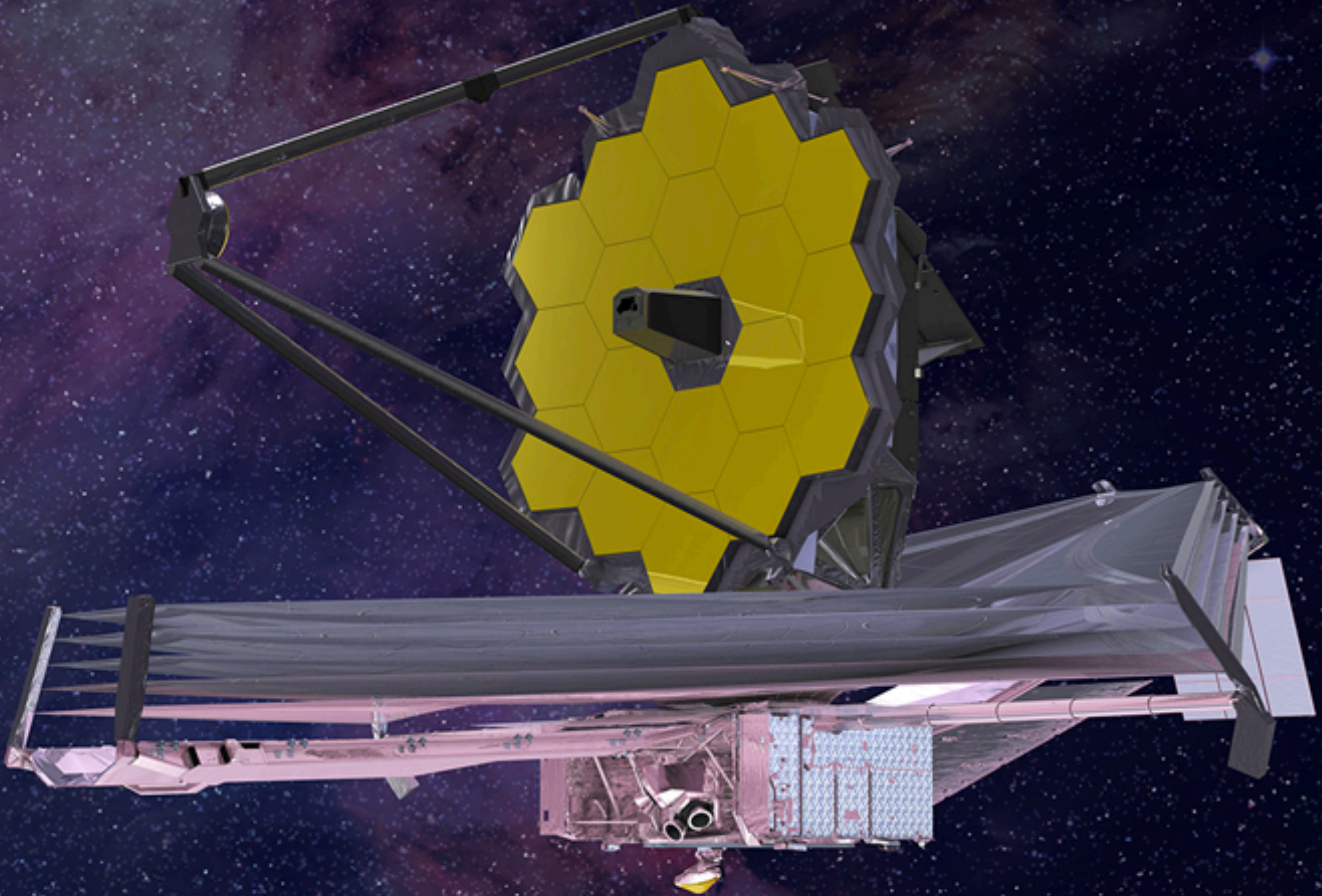
Ti

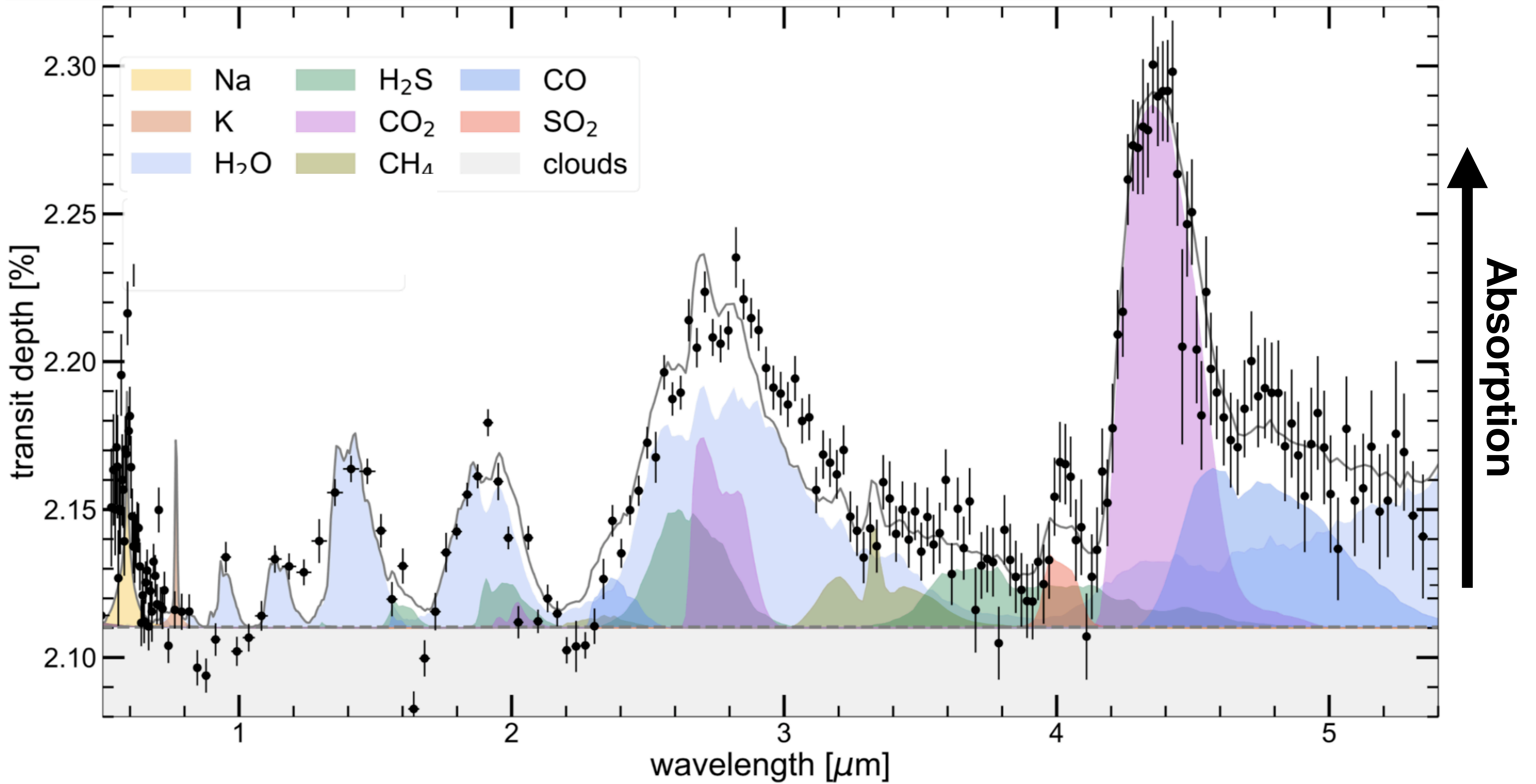
Ti⁺

Cr

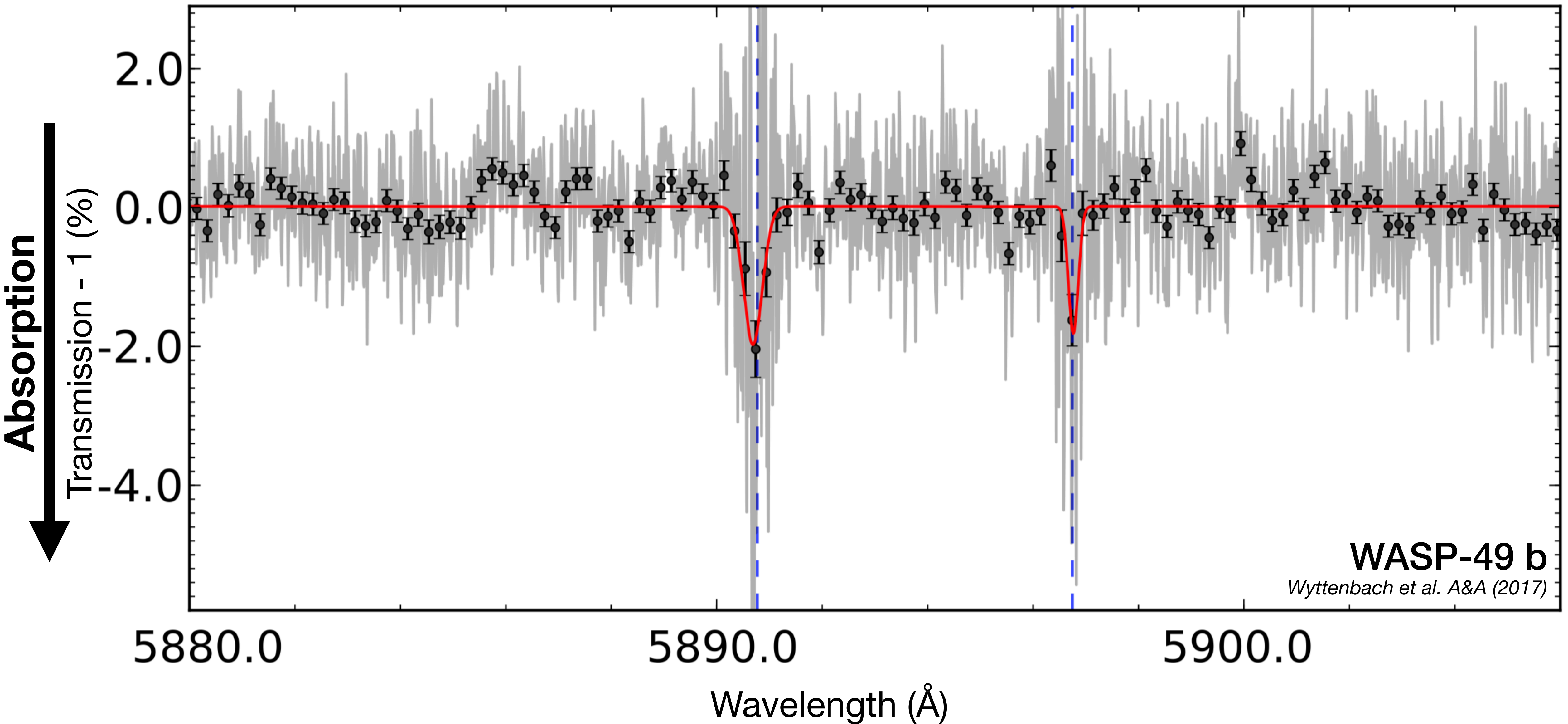
Ca

v

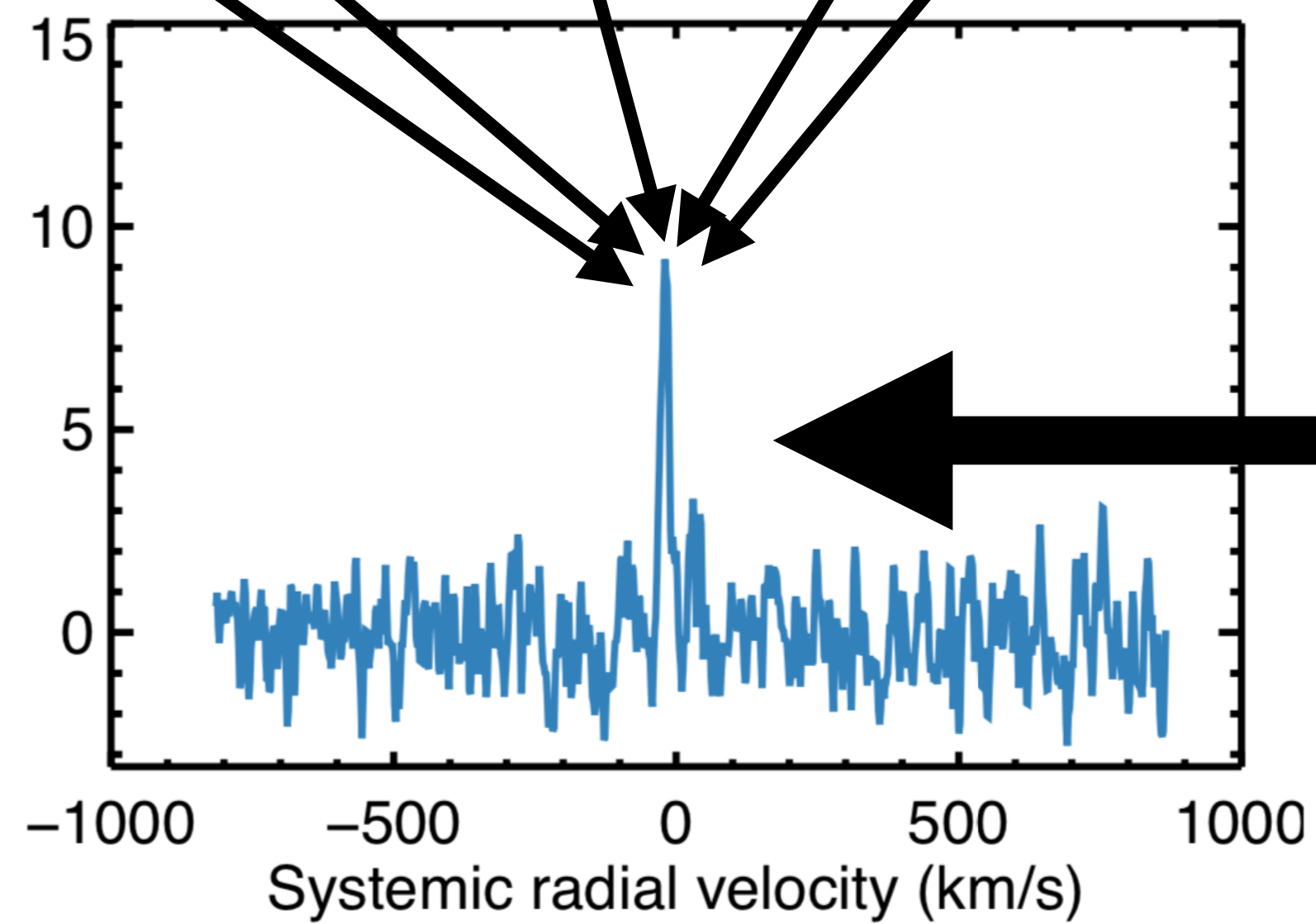
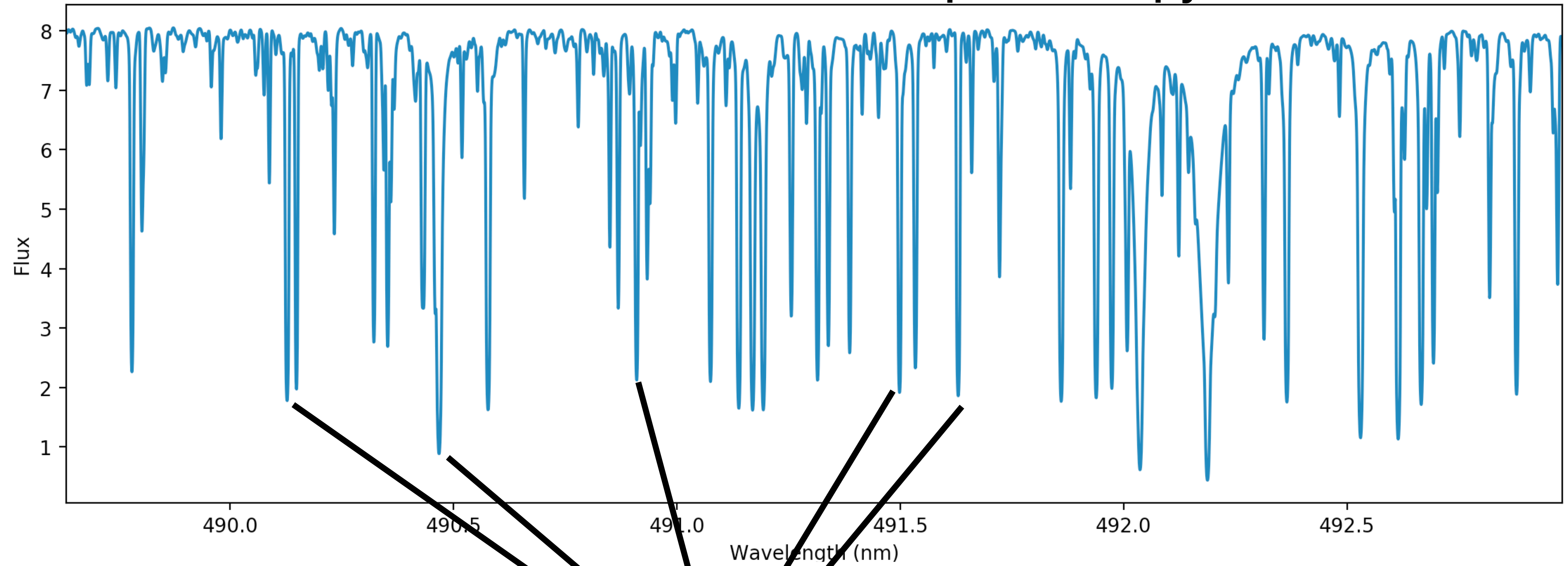




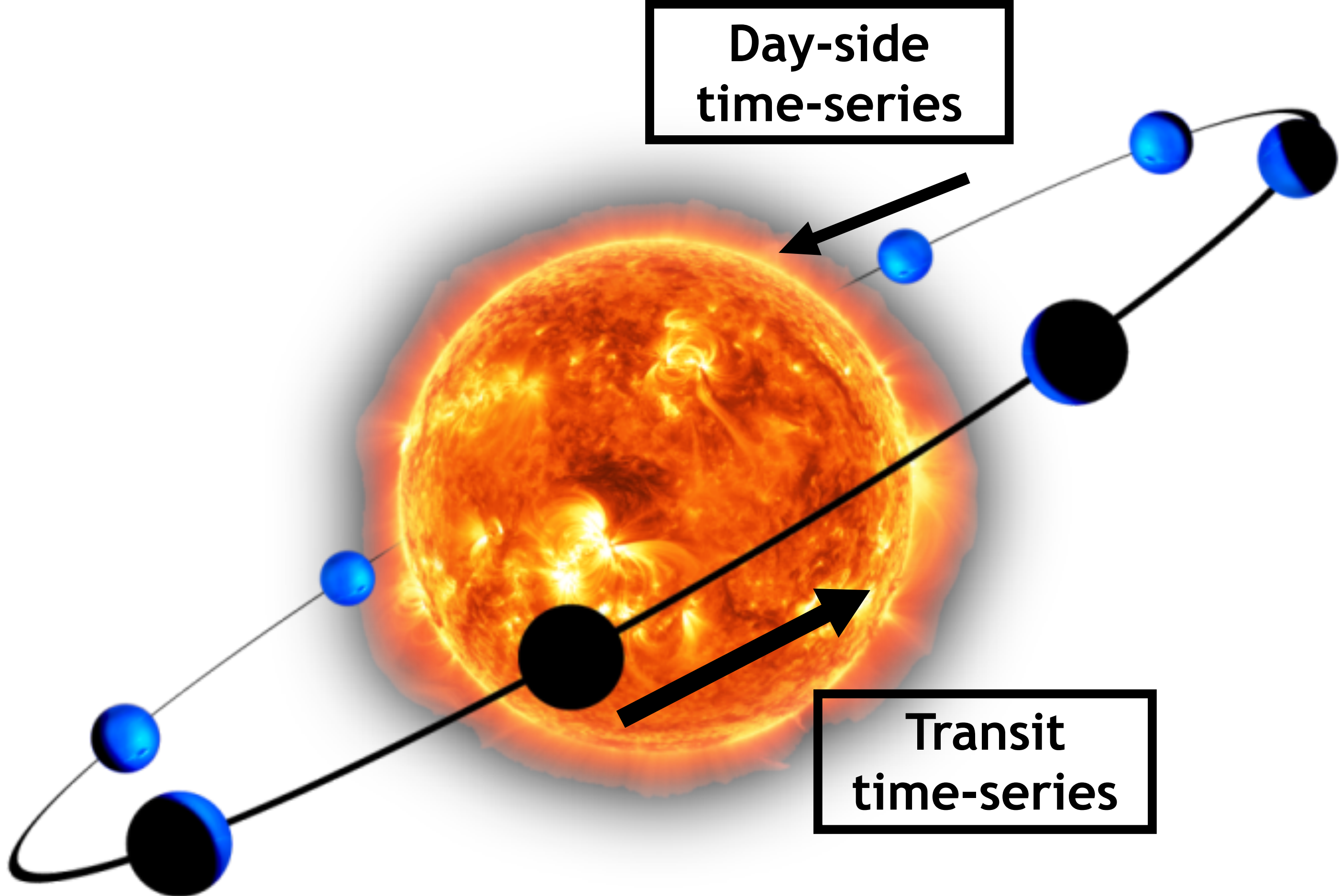
High-resolution spectroscopy



Iron: Cross-correlation spectroscopy



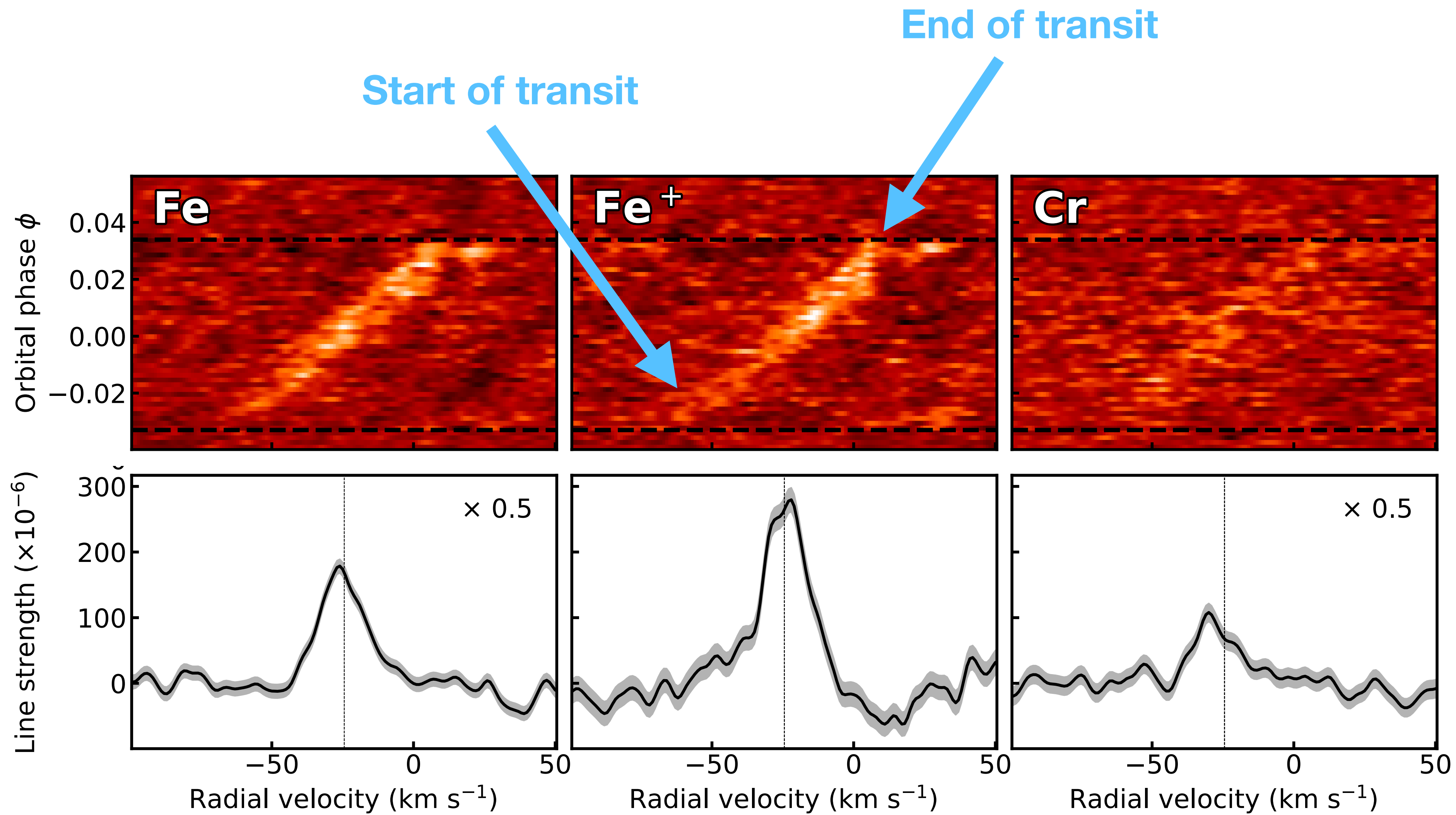
Measure velocity!



Day-side
time-series

Transit
time-series

Spectral traces: WASP-189 b



WASP-121 b (~2400 K)

Mg I

Ca I

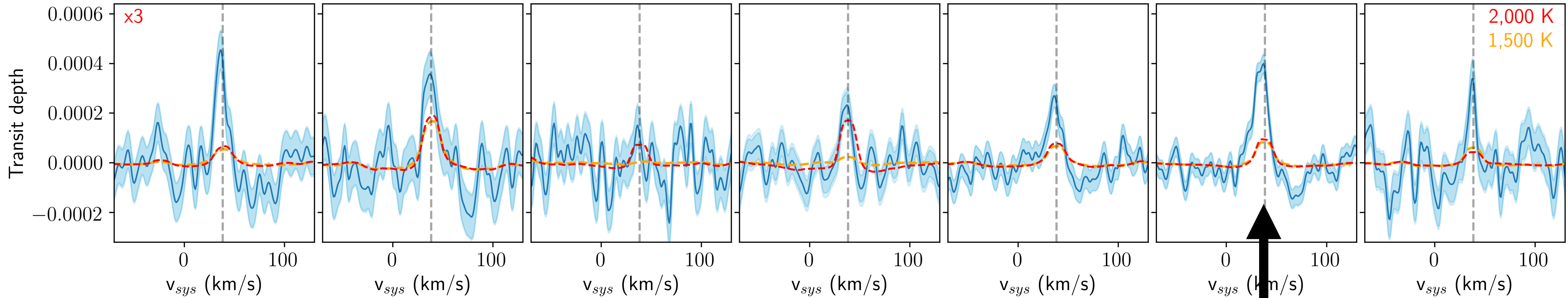
Ti I

VI

Cr I

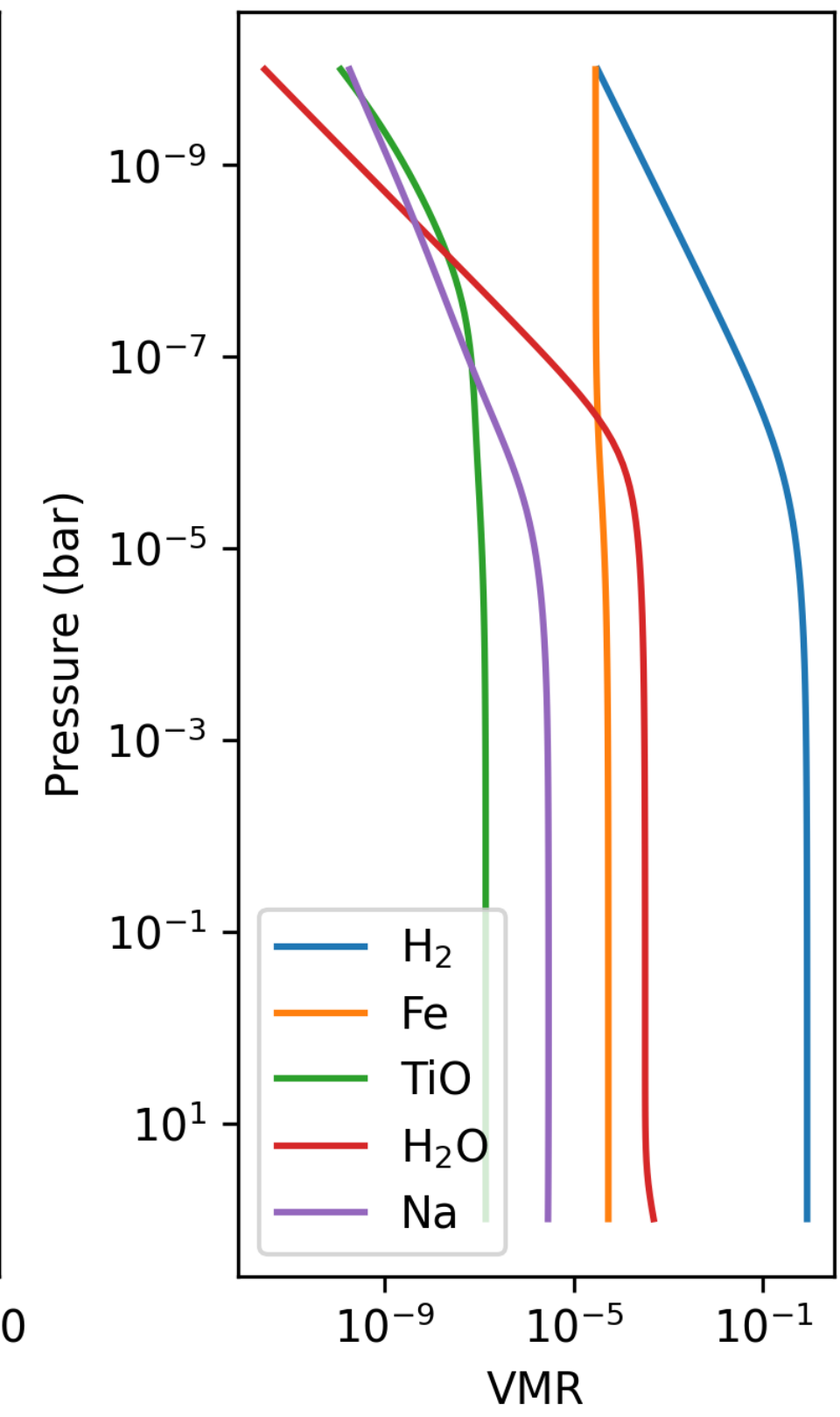
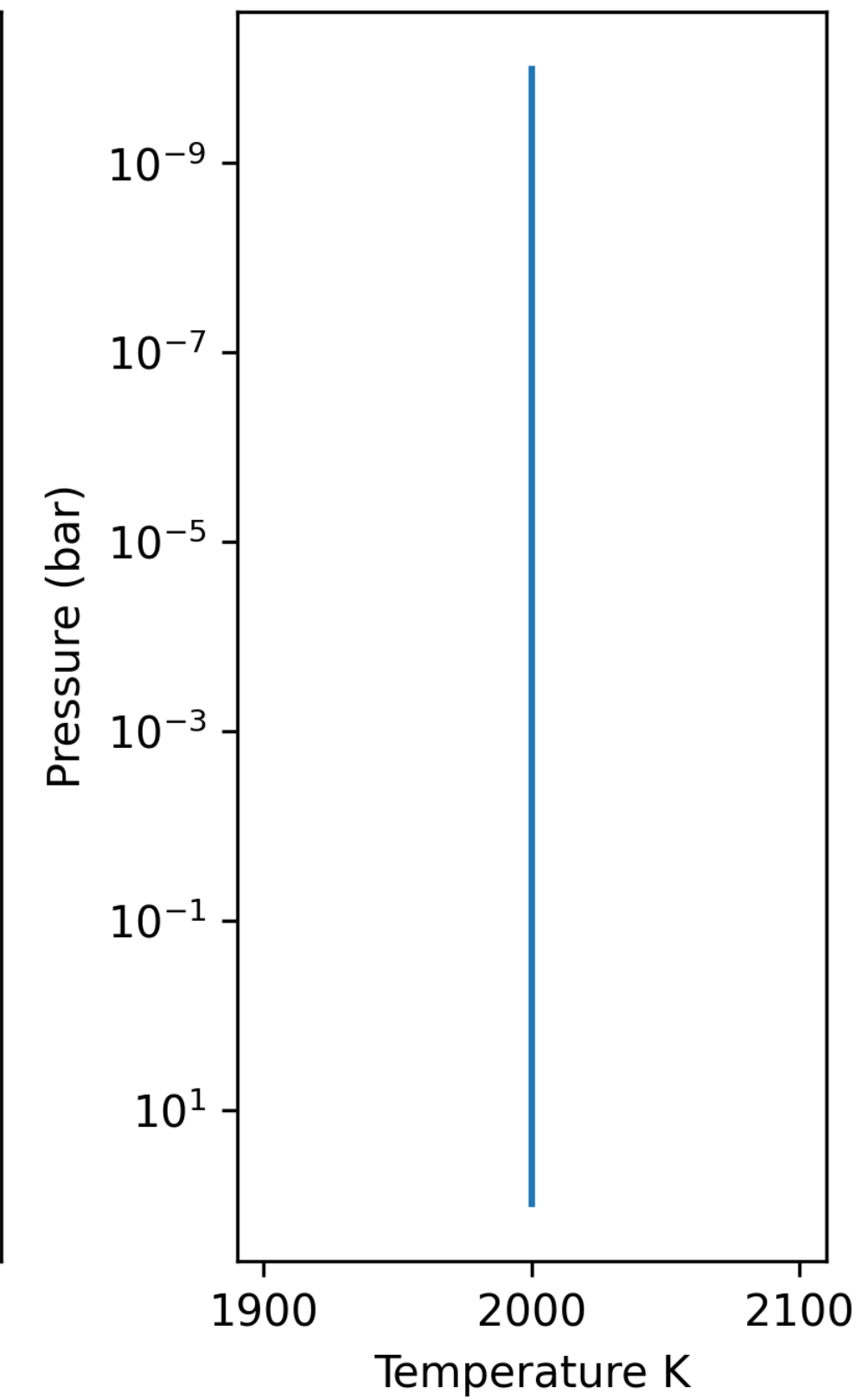
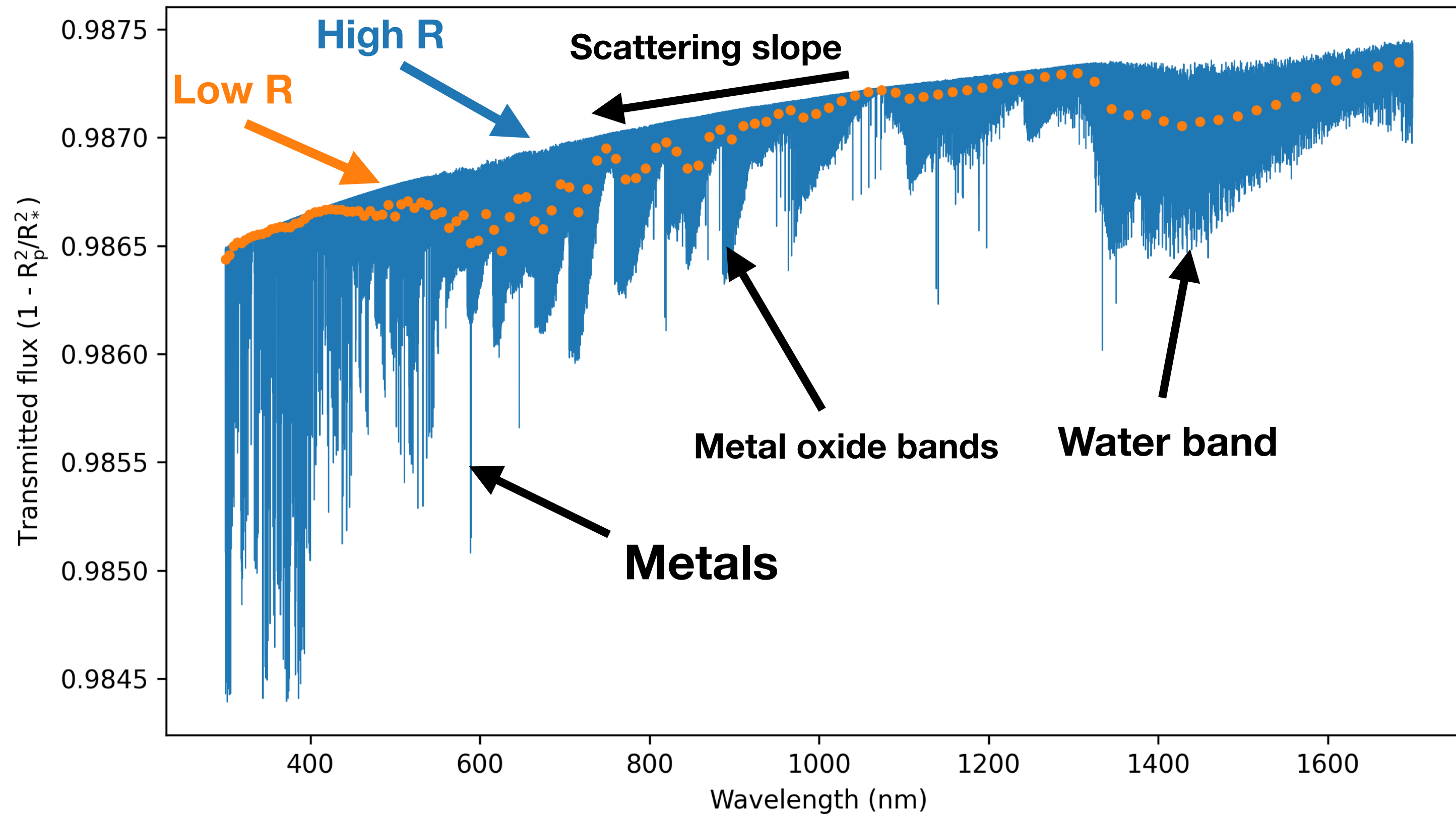
Fe I

Ni I

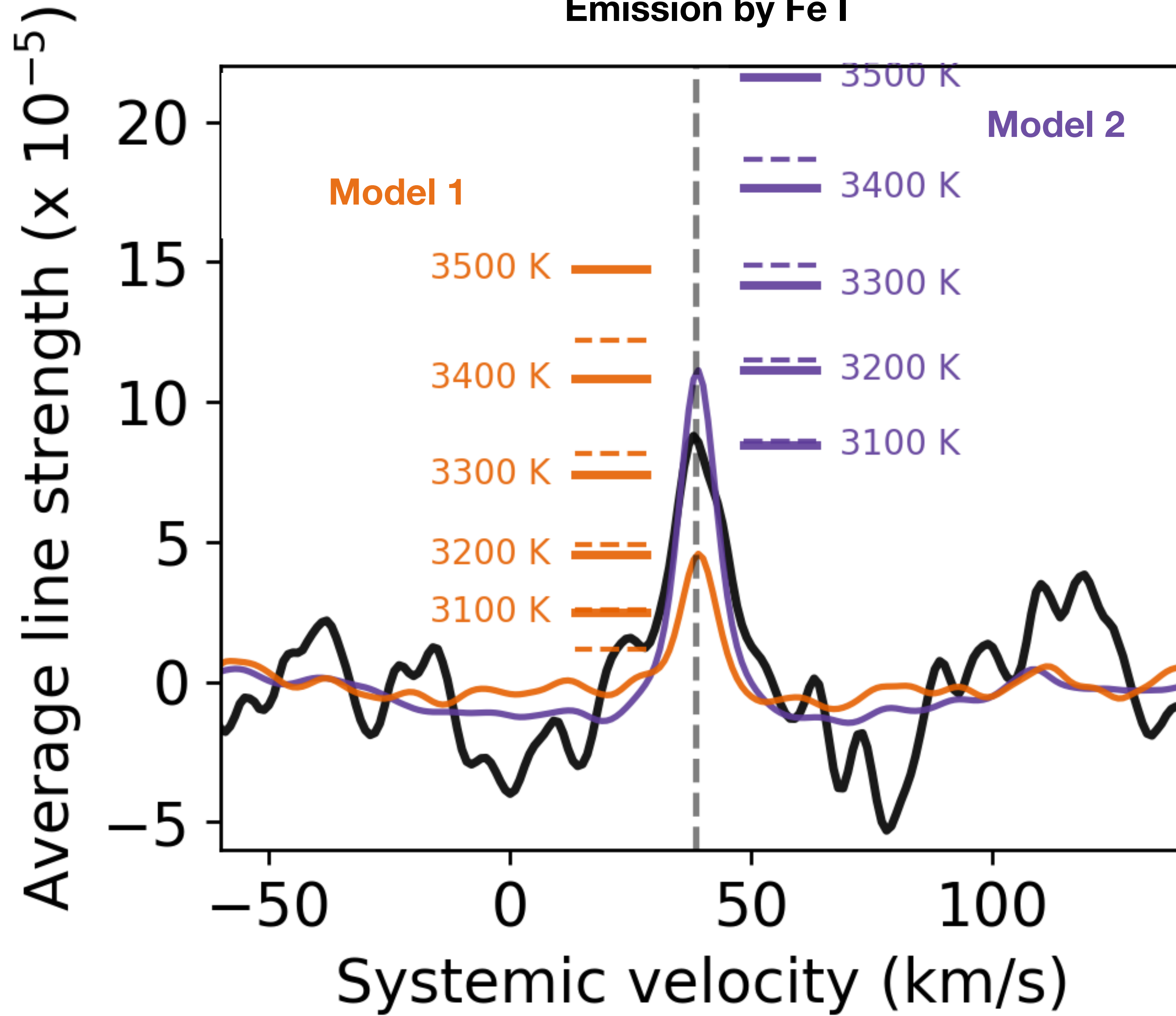


Model comparison

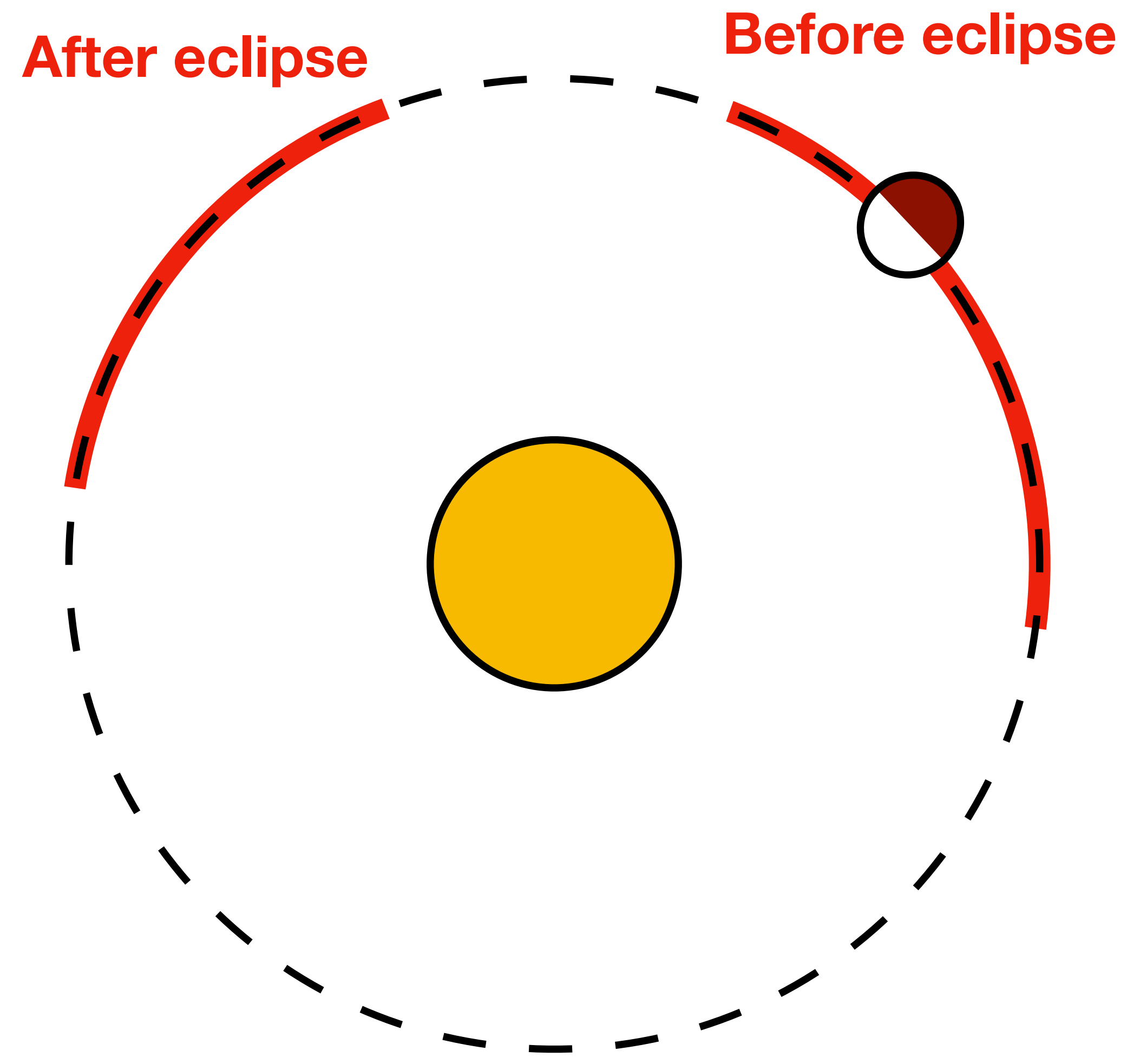
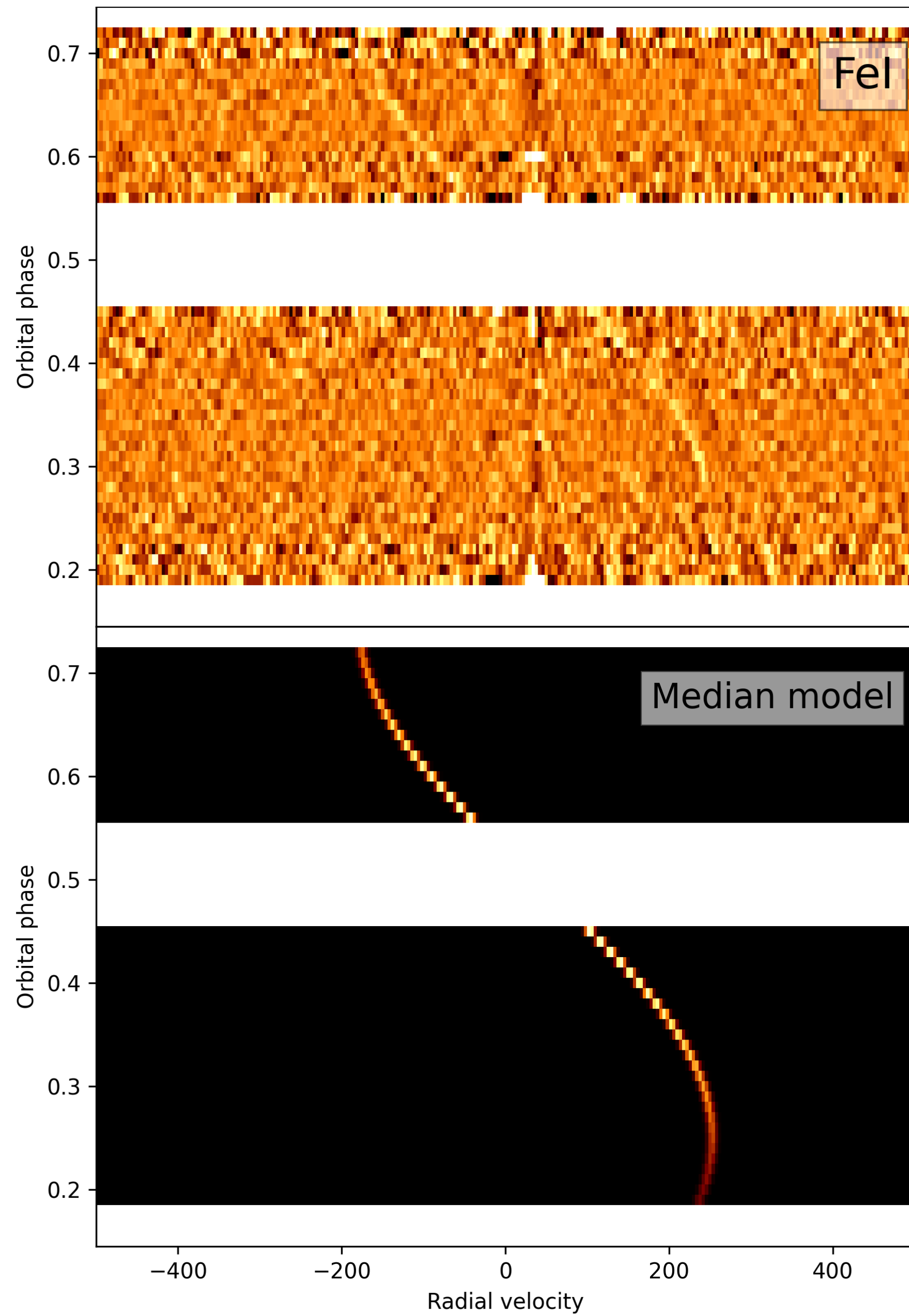
1D Model comparison – transmission



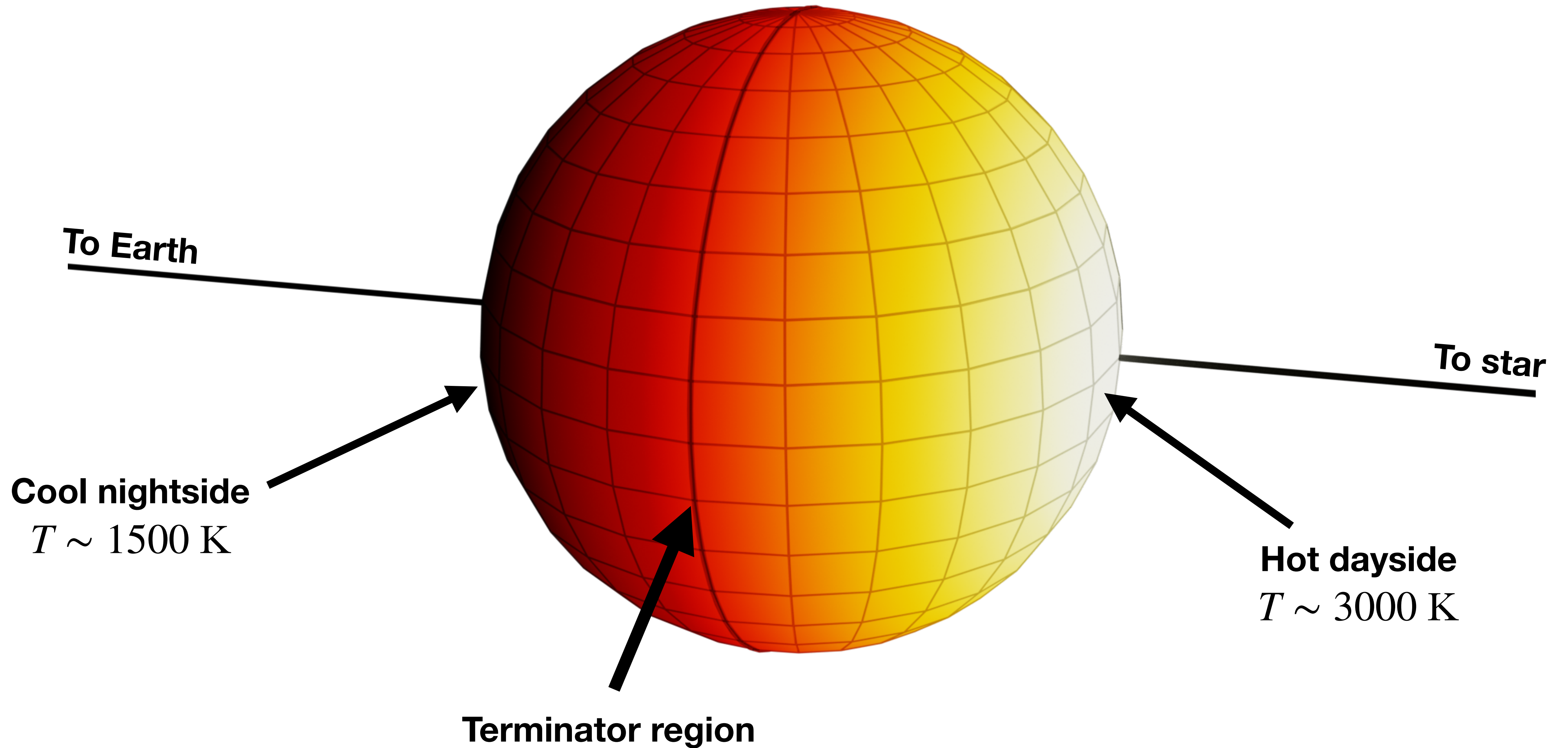
Emission by Fe I



Dayside observations of WASP-121 b



Planets are 3D



eSSENCE Science question:

Create a retrieval framework that

- 1) Models a planet atmosphere in 3D with few free parameters**
- 2) Handles multi-dimensional data from various sources**
- 3) Provides Bayesian posterior probability distributions**
- 4) Runs on the equivalent of a desktop machine**

eSSSENCE Science question:

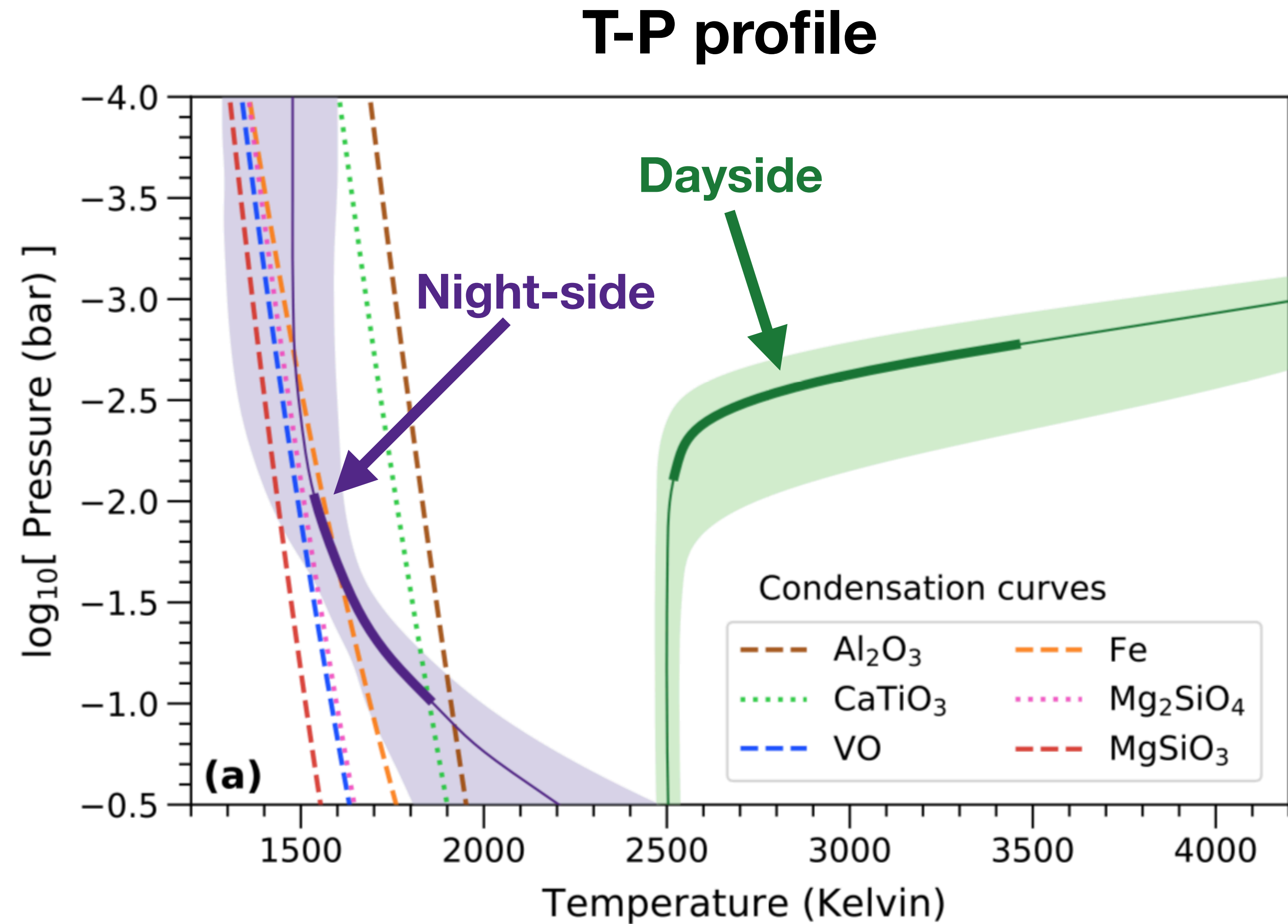
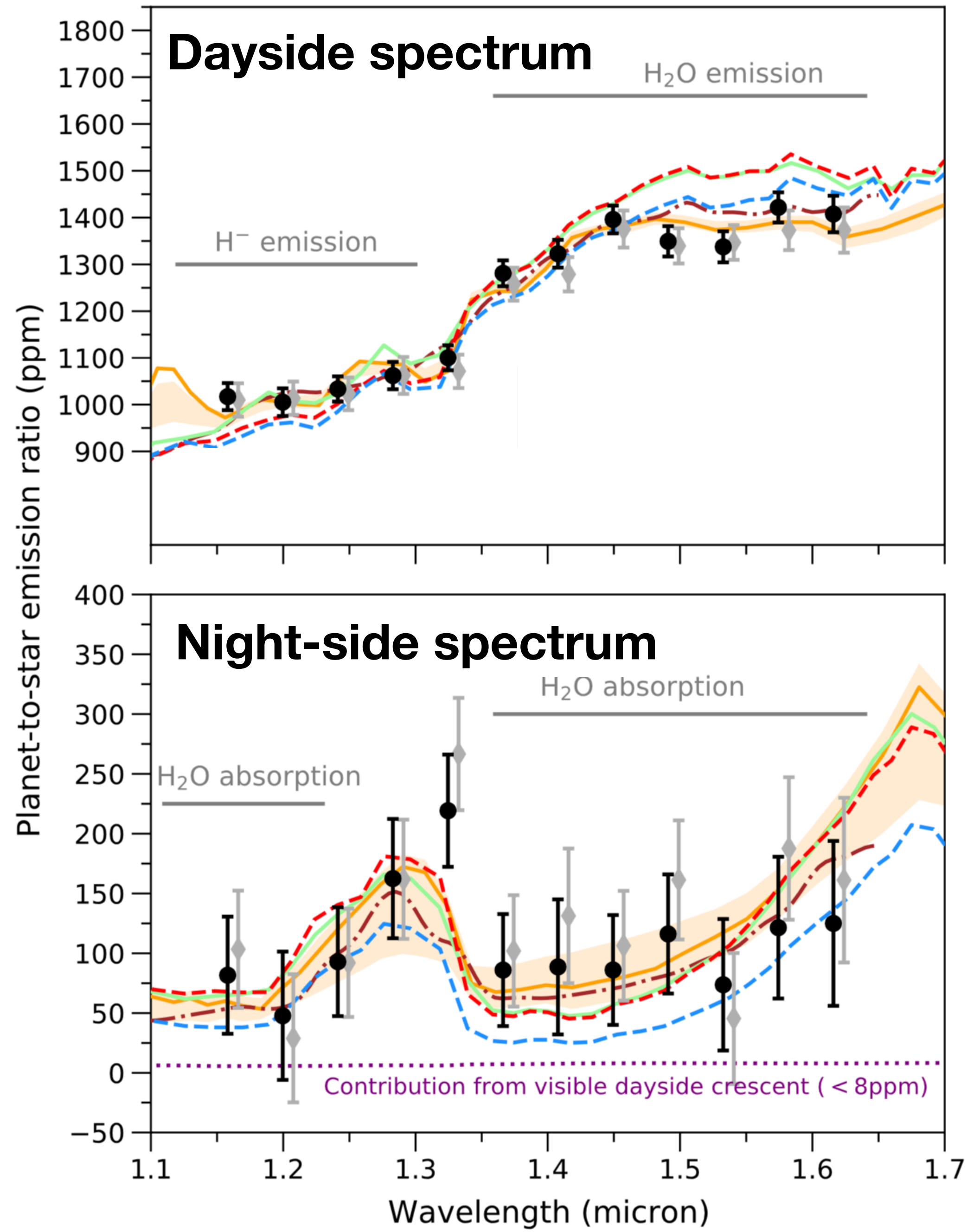
Create a retrieval framework that

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Solution pathway:

Auto-differentiable atmosphere model
in combination with Hamiltonian Monte Carlo

Existing retrieval methods: Low resolution



Mikal-Evans et al. (2022)

Existing retrieval methods: High resolution

