Methodology for extracting exoplanetary atmospheres using high-resolution transmission spectroscopy

Eva Herrero-Cisneros[1], María Rosa Zapatero Osorio[1]

[1] Centro de Astrobiología (CSIC-INTA)

eherrero@cab.inta-csic.es

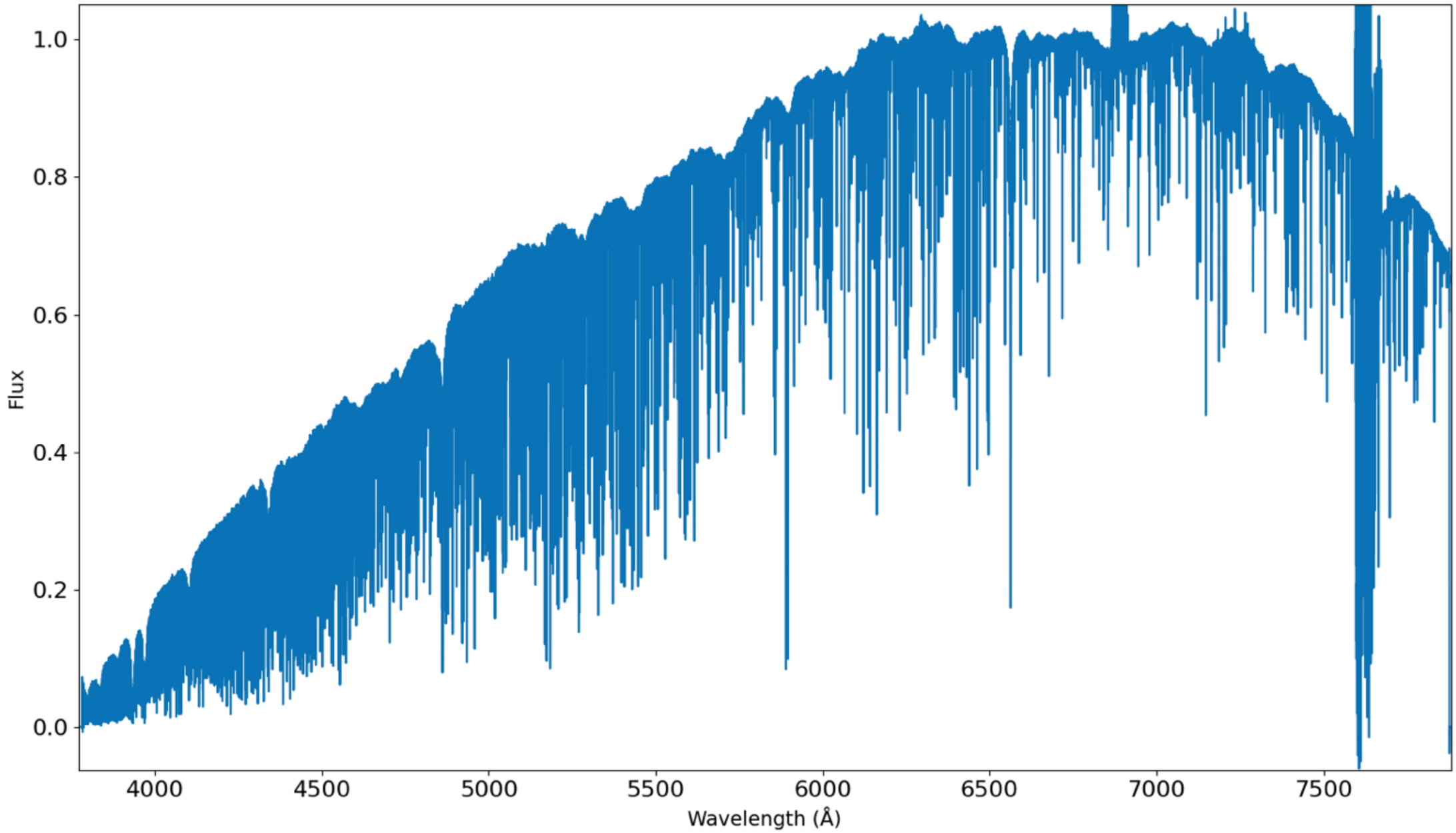
Outline:

- Telluric correction
- Differential extinction correction
- Stellar master spectrum
- Extraction of planetary spectrum
- Search for atomic/molecular features
  - Direct detection method
  - Cross-correlation method

CENTRO DE ASTROBIOLOGÍA · CAB
ASOCIADO AL NASA ASTROBIOLOGY PROGRAM
CSIC INTA

espresso

ESPRESSO stellar spectrum



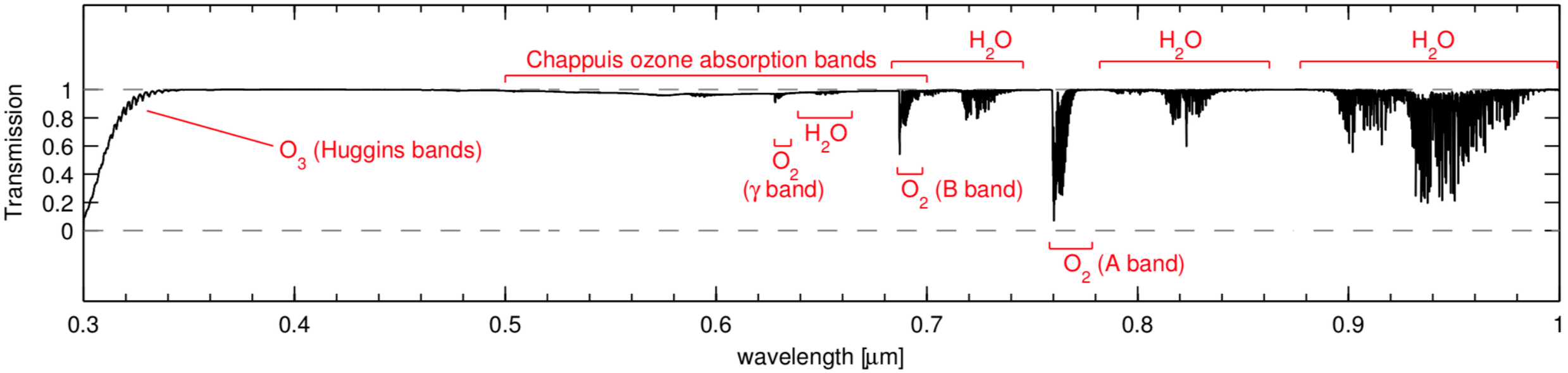
Wavelength range: 3782 Å - 7887 Å

R = 138000

Spectral type: F8

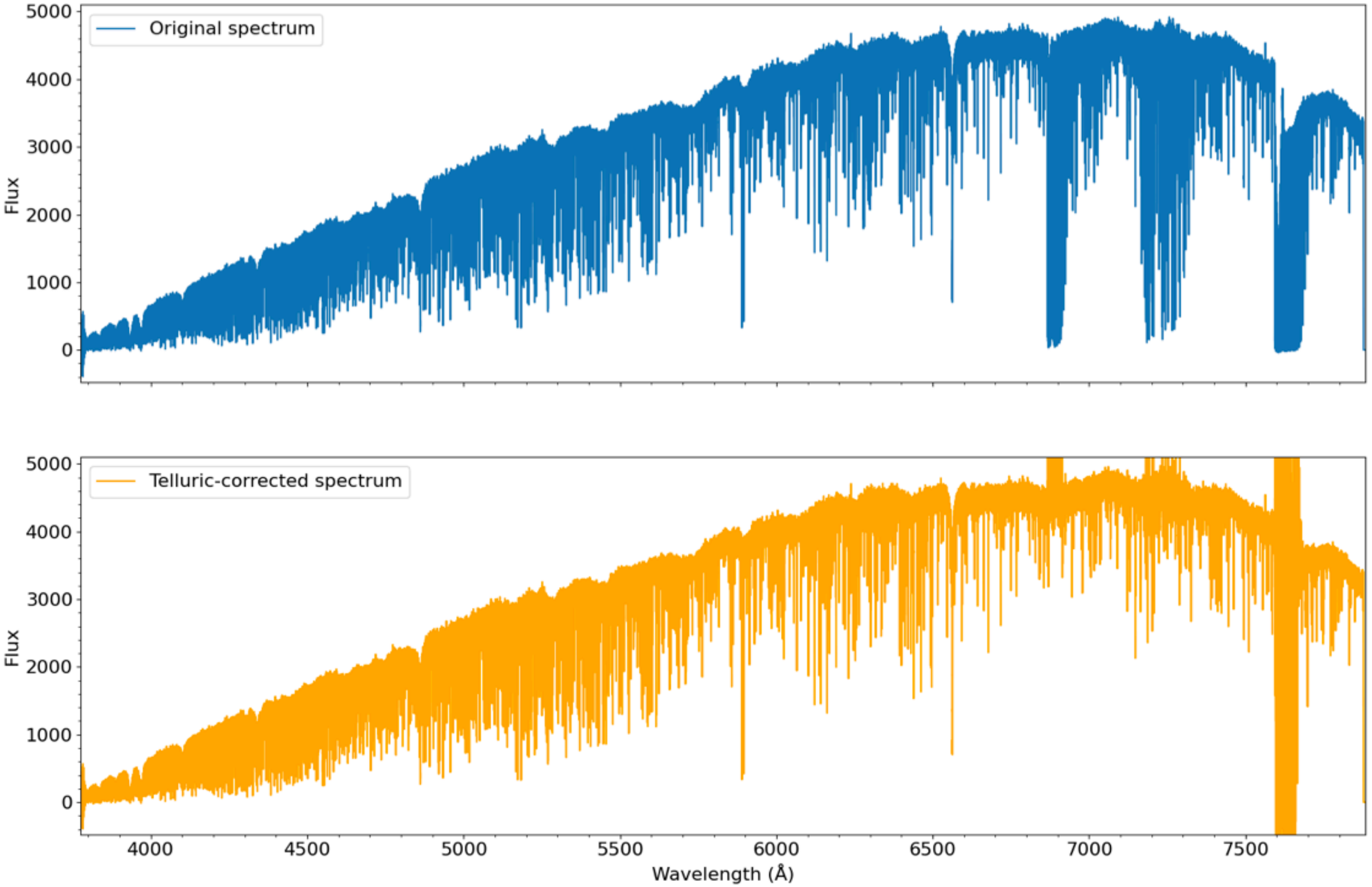
Teff = 6100 K

Telluric correction



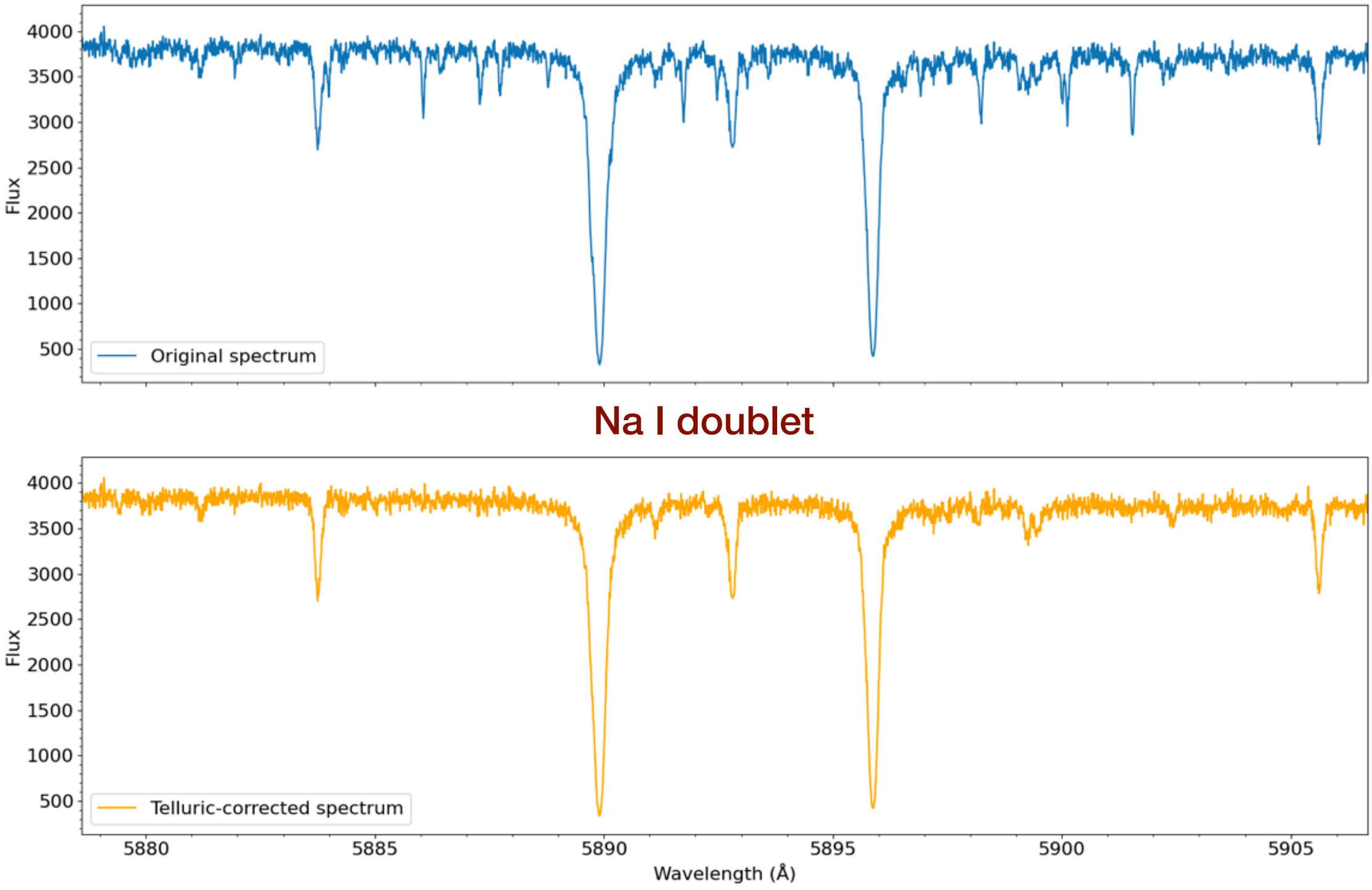
Credit: Smette et al. 2015

Telluric correction



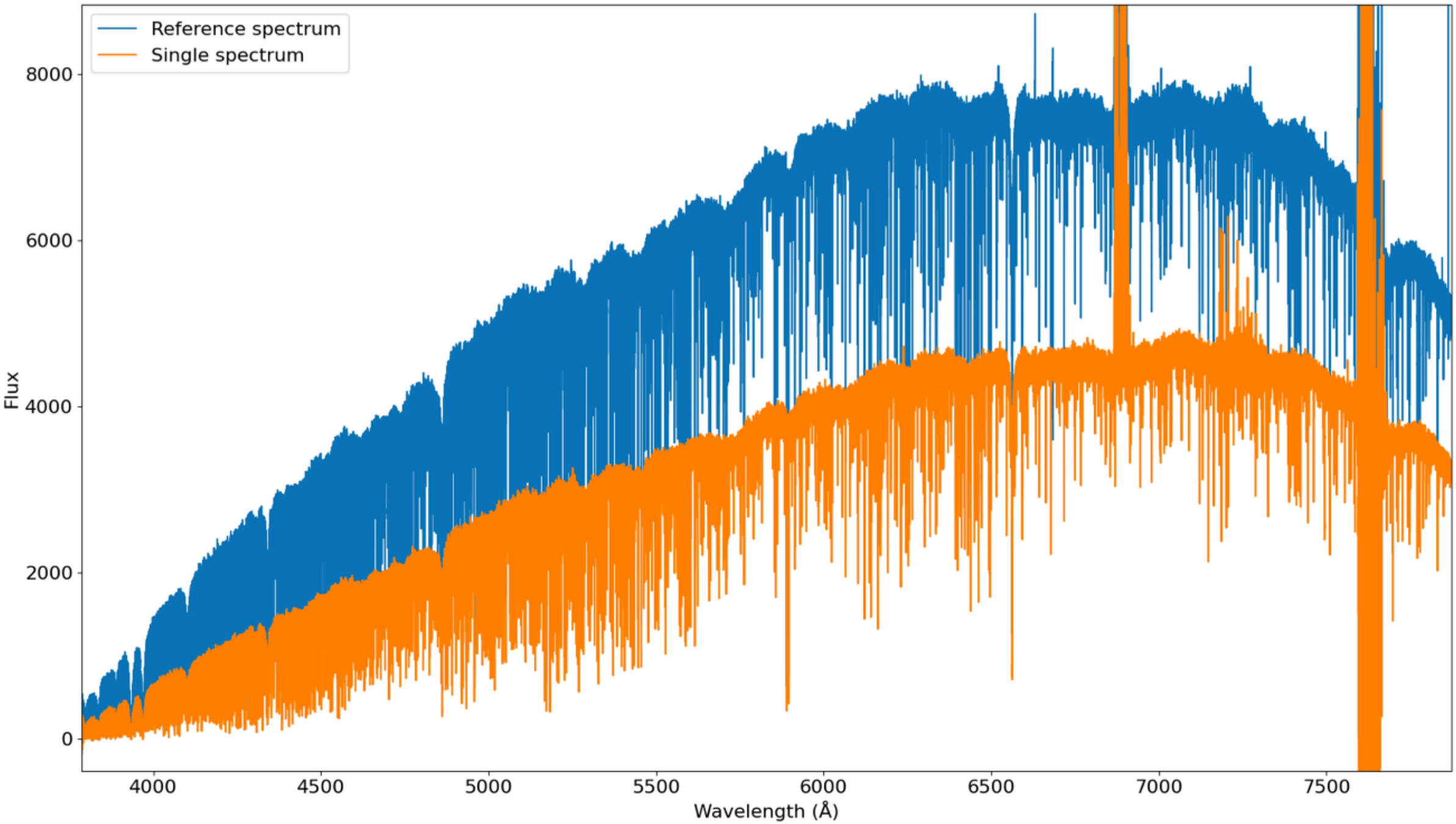
Telluric correction performed with Molecfit (Smette et al. 2015; Kausch et al. 2015)

Telluric correction



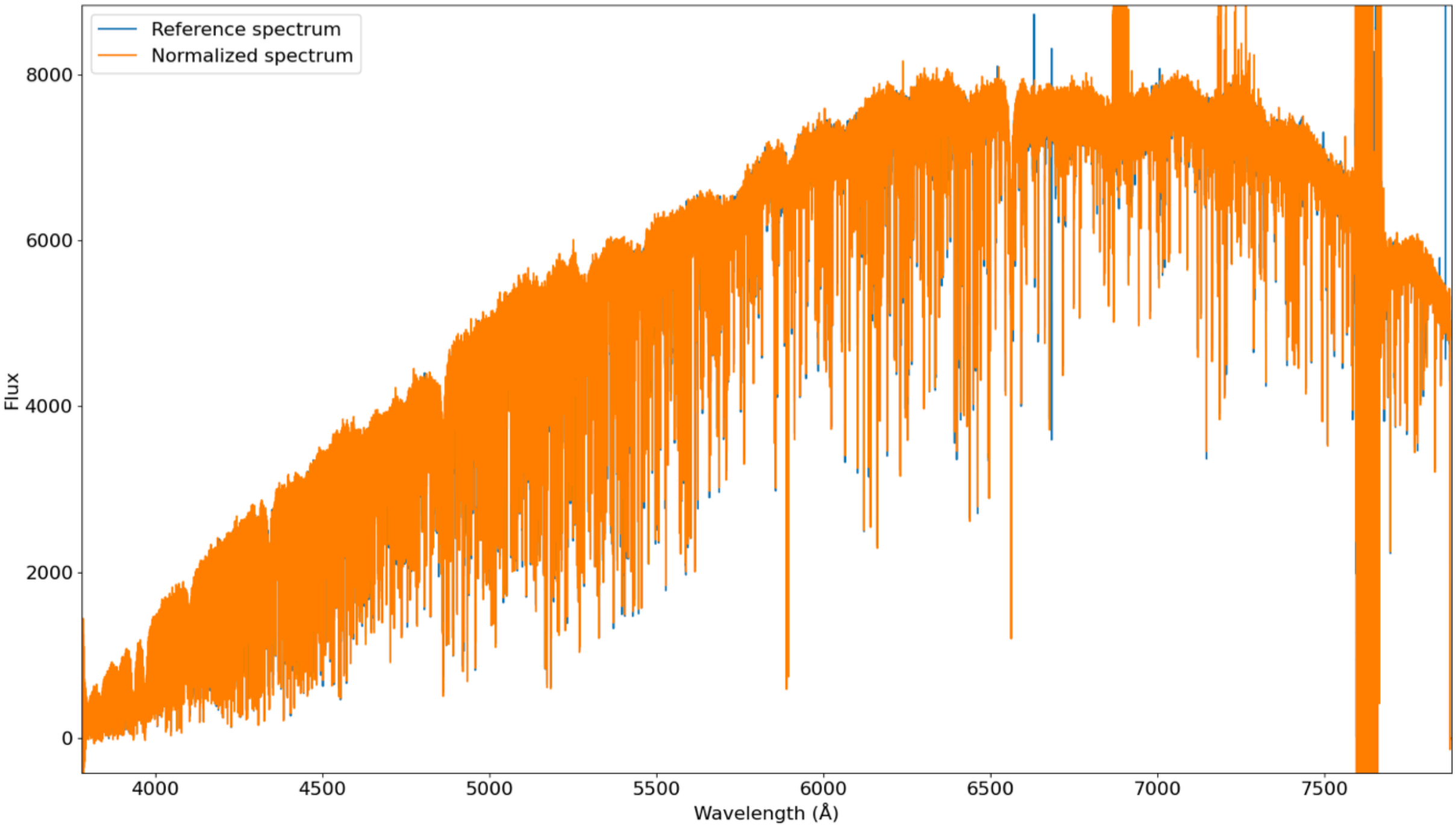
Na I doublet

Differential extinction correction

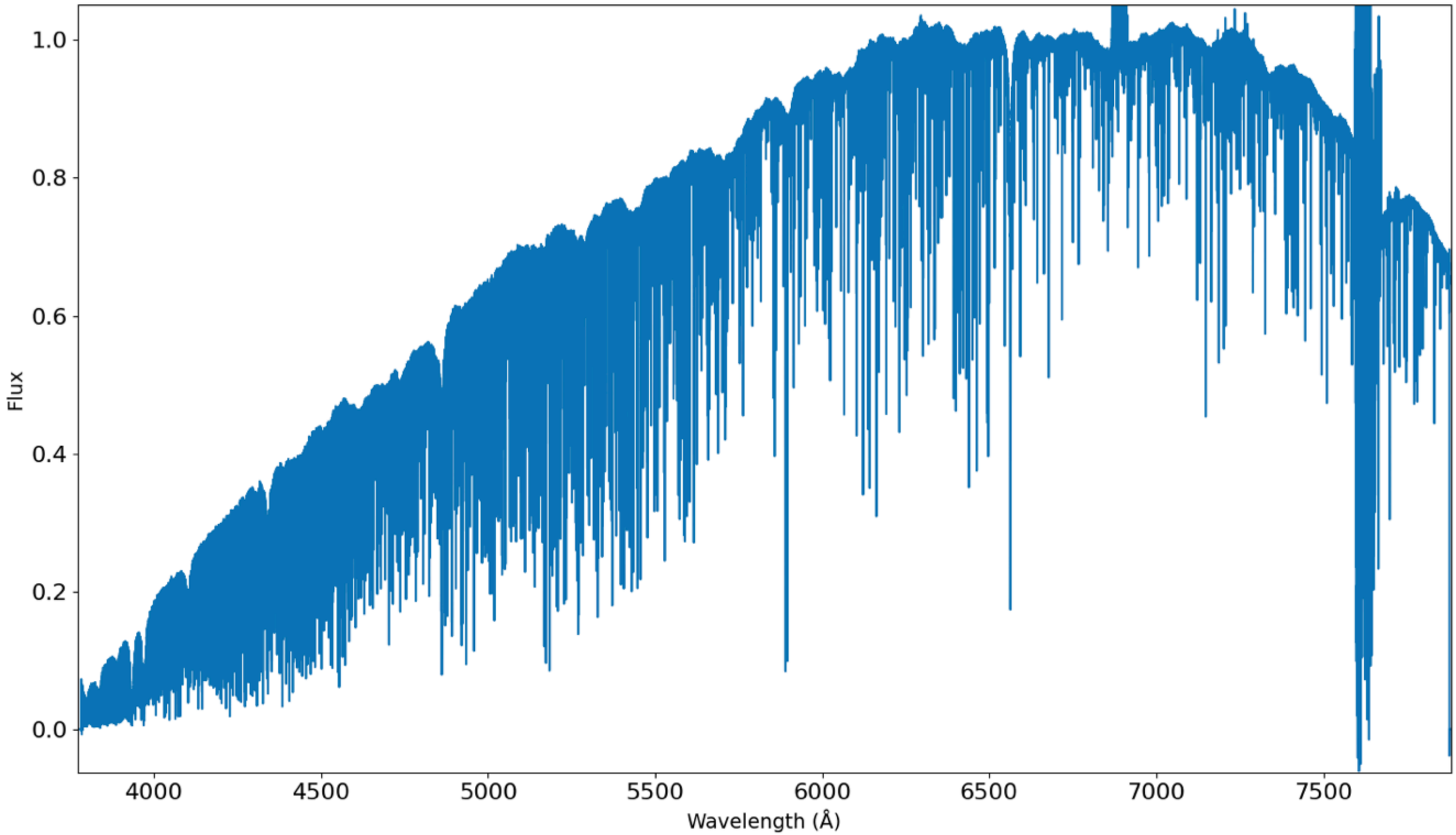


Reference spectrum: exposure with min airmass

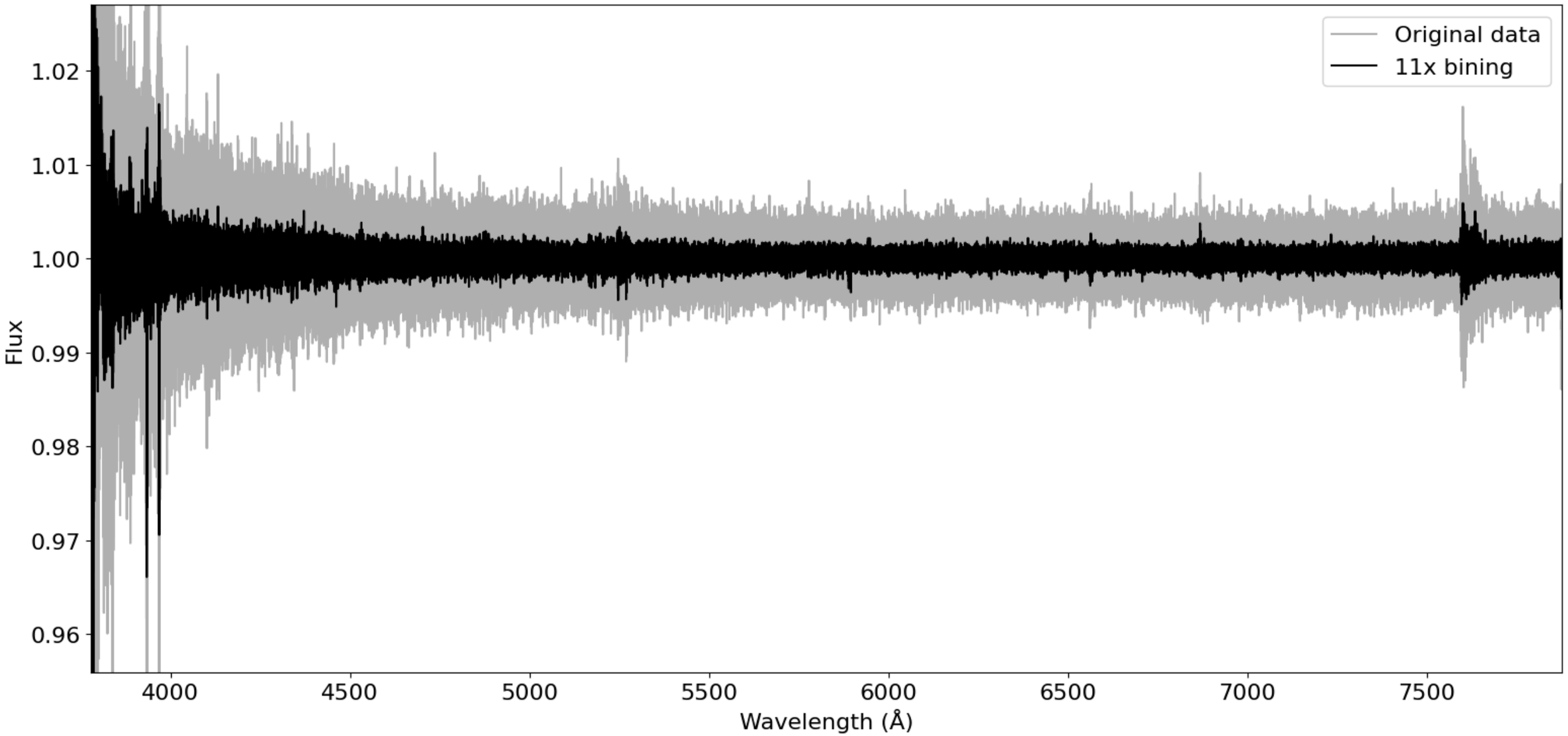
Differential extinction correction



Stellar master spectrum using out-of-transit data



Extraction of planetary spectrum

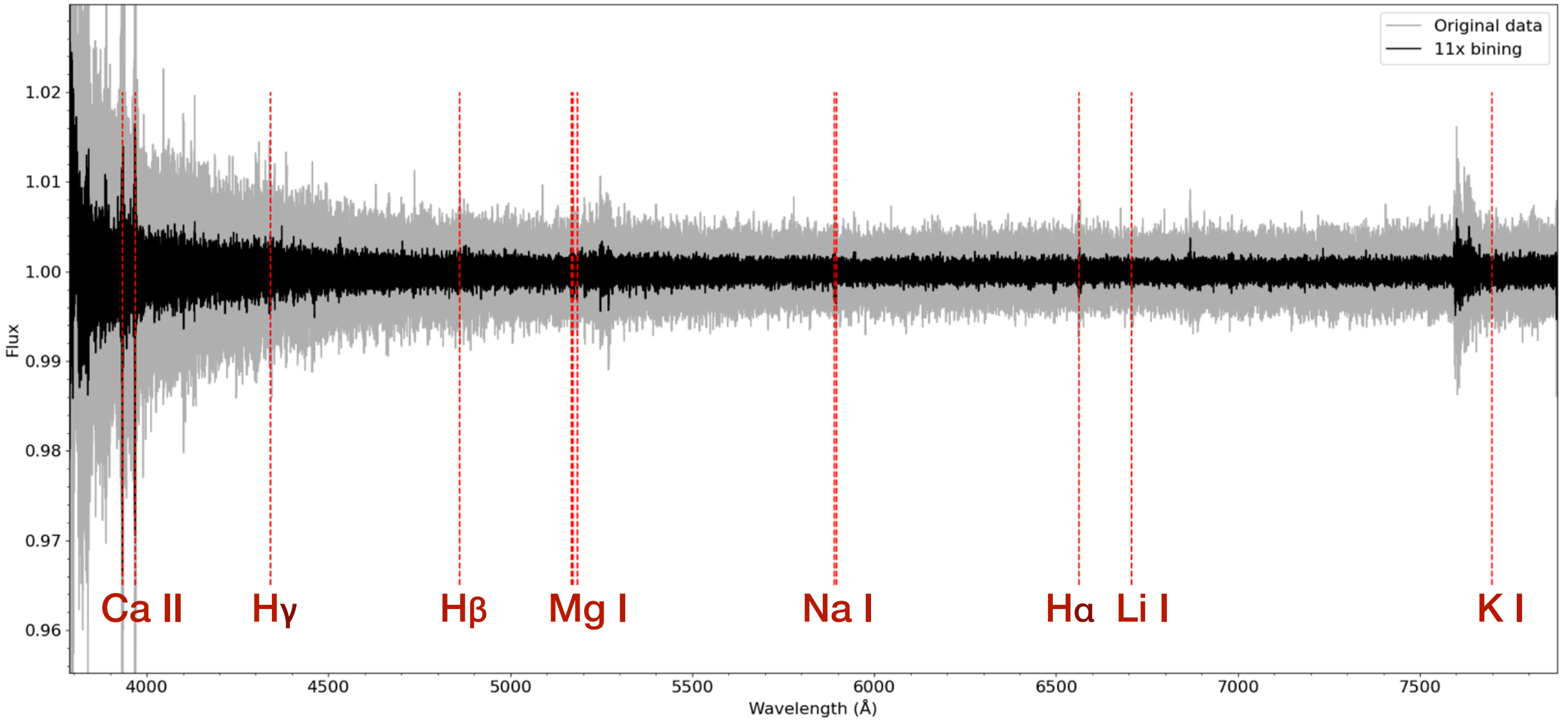


WASP-76 b Teq = 2200 K $M_p = 0.92\ R_{Jup}$

$R_p = 1.83\ R_{Jup}$ $\rho = 0.201$ g/cm3

Tabernero et al. 2021

Identification of individual atomic lines



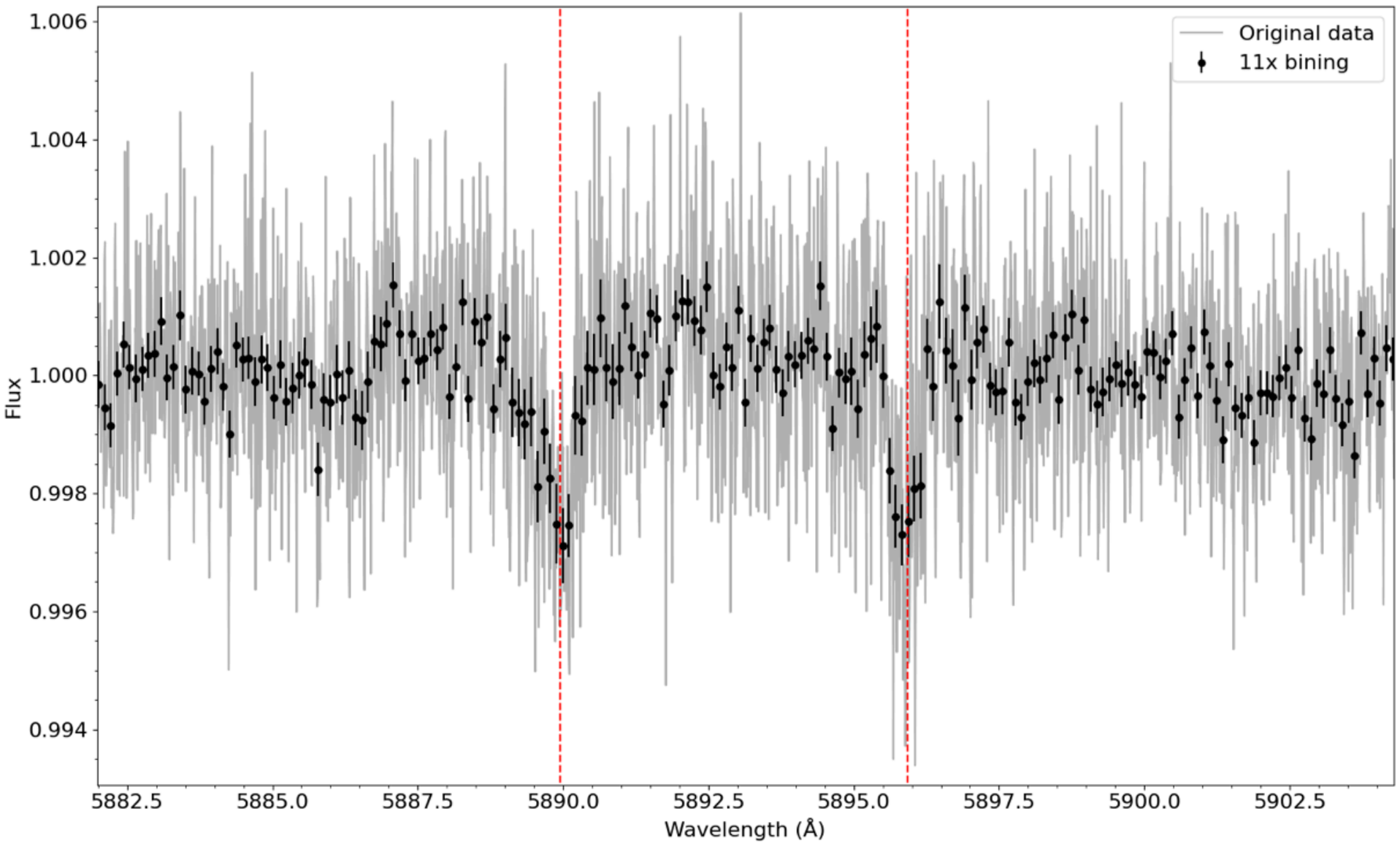
WASP-76 b Teq = 2200 K $M_p = 0.92\ R_{Jup}$

$R_p = 1.83\ R_{Jup}$ $\rho = 0.201$ g/cm3

Tabernero et al. 2021

Identification of individual atomic lines

Na I doublet



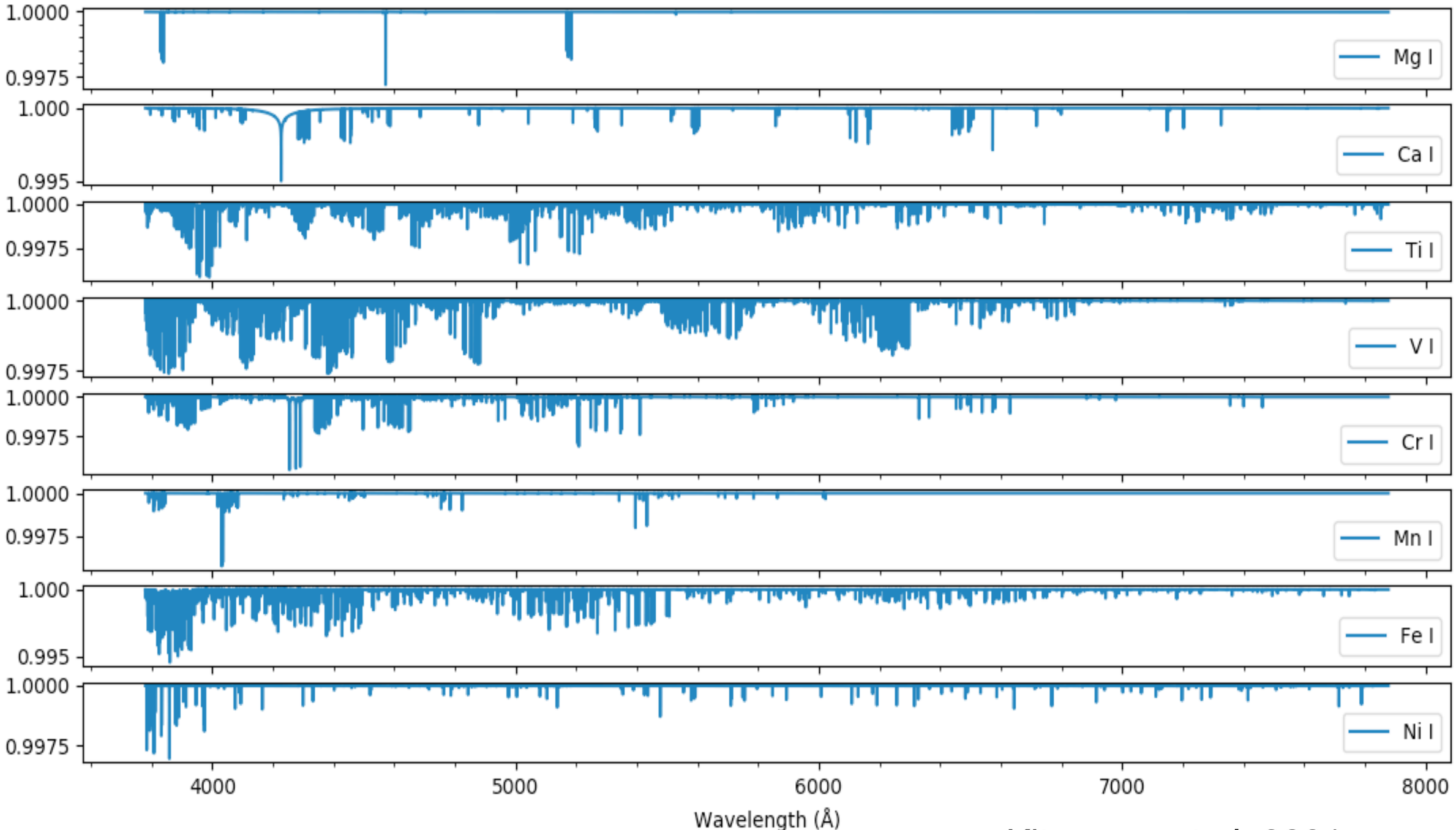
WASP-76 b Teq = 2200 K $M_p = 0.92\ R_{Jup}$

$R_p = 1.83\ R_{Jup}$ $\rho = 0.201$ g/cm3

Tabernero et al. 2021

Cross-correlation method

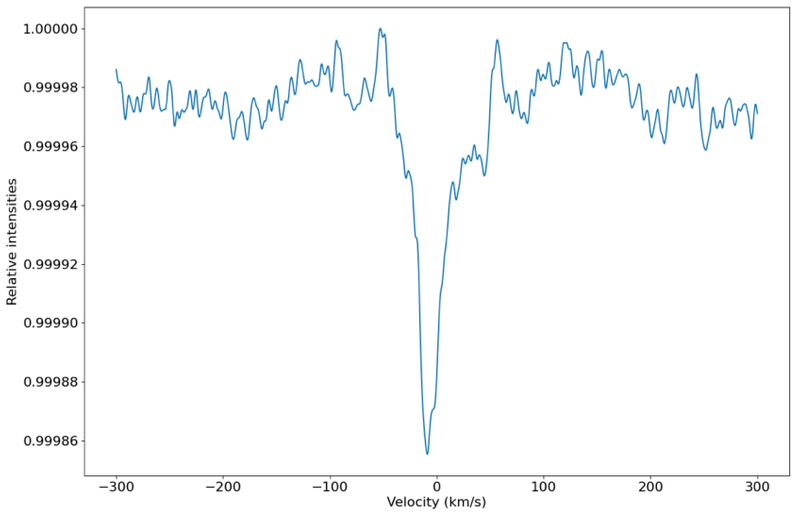
- Planetary spectrum
- Reference spectrum: - Combs / masks
  - Synthetic spectra



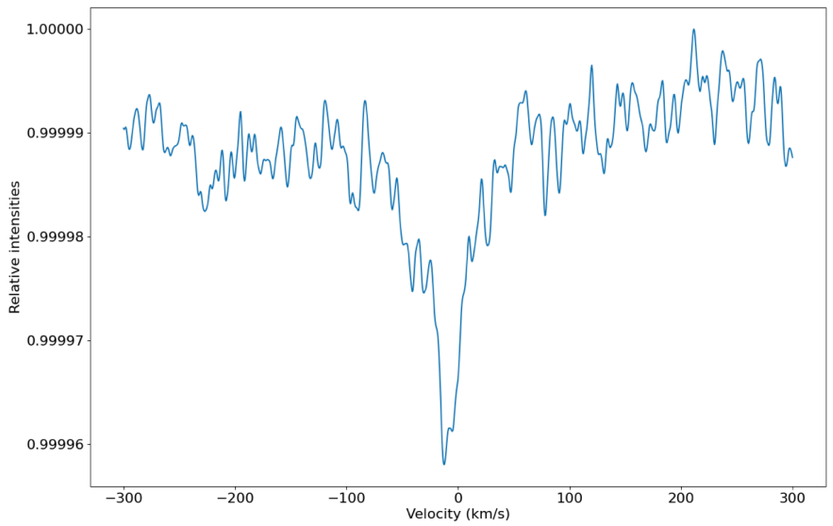
Kitzmann et al. 2021

Cross-correlation method

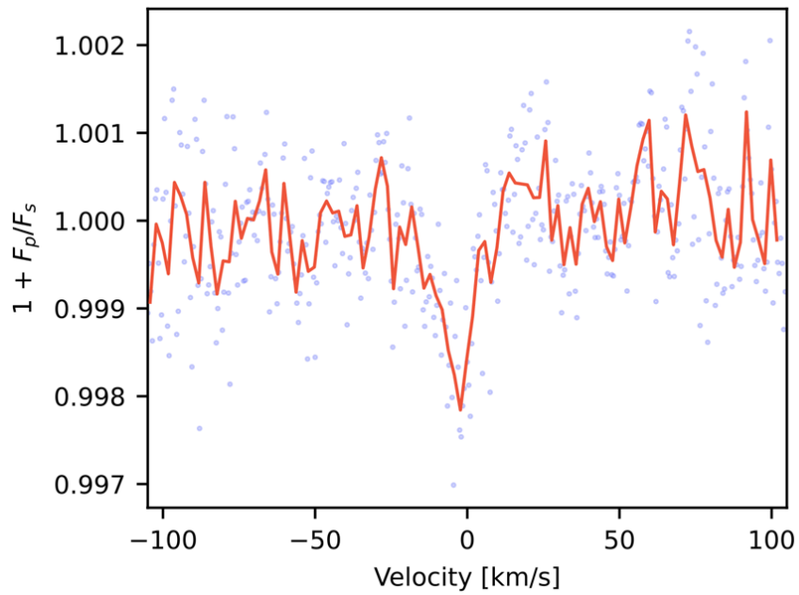
Fe I



Cr I



Ba I



CCFs computed with iSpec (Blanco-Cuaresma et al. 2014) Azevedo Silva et al. 2022

petitRADTRANS (Mollière et al. 2019) synthetic spectra are used as templates

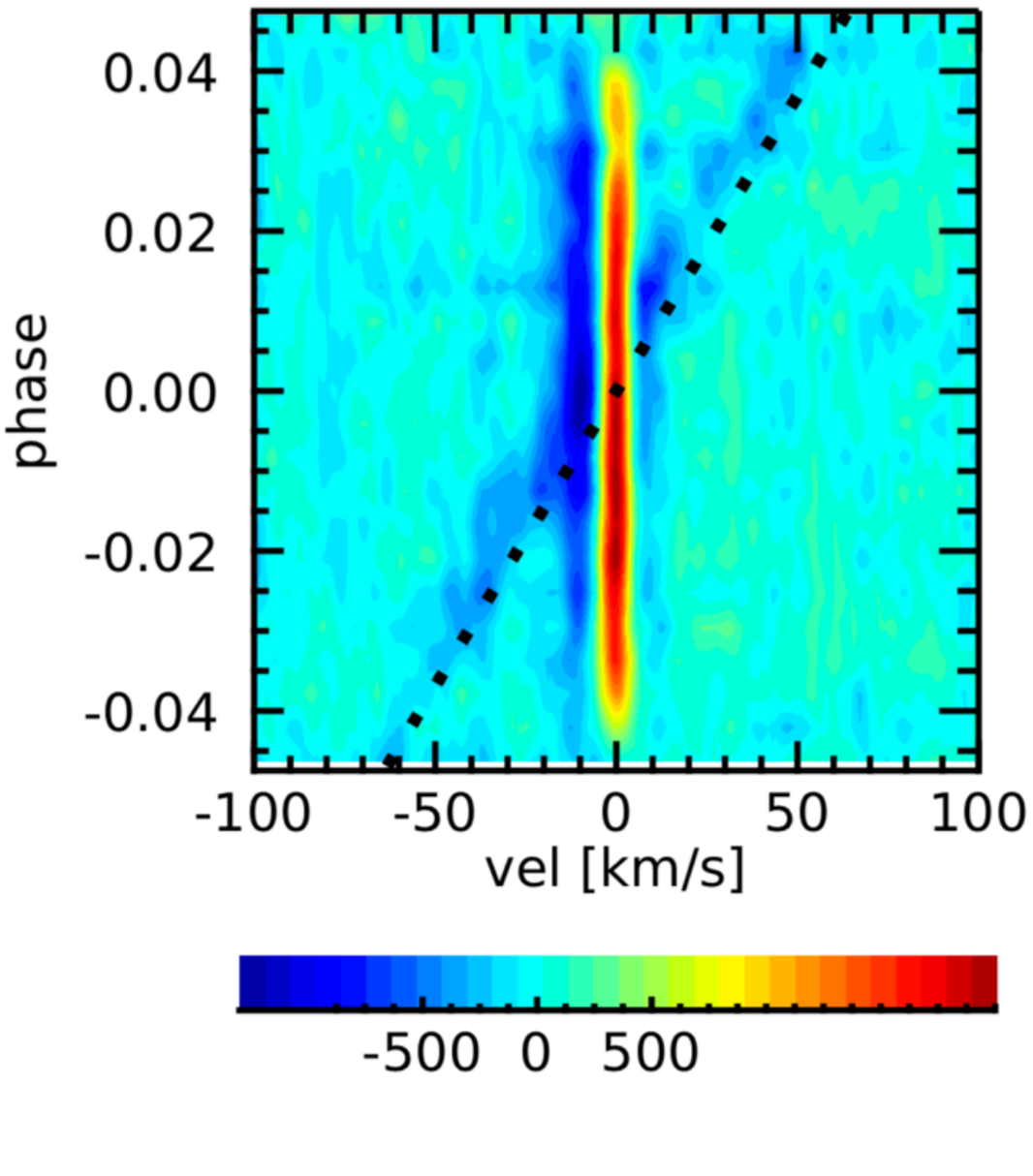
WASP-76 b Teq = 2200 K $M_p = 0.92\ R_{Jup}$

$R_p = 1.83\ R_{Jup}$ $\rho = 0.201$ g/cm3

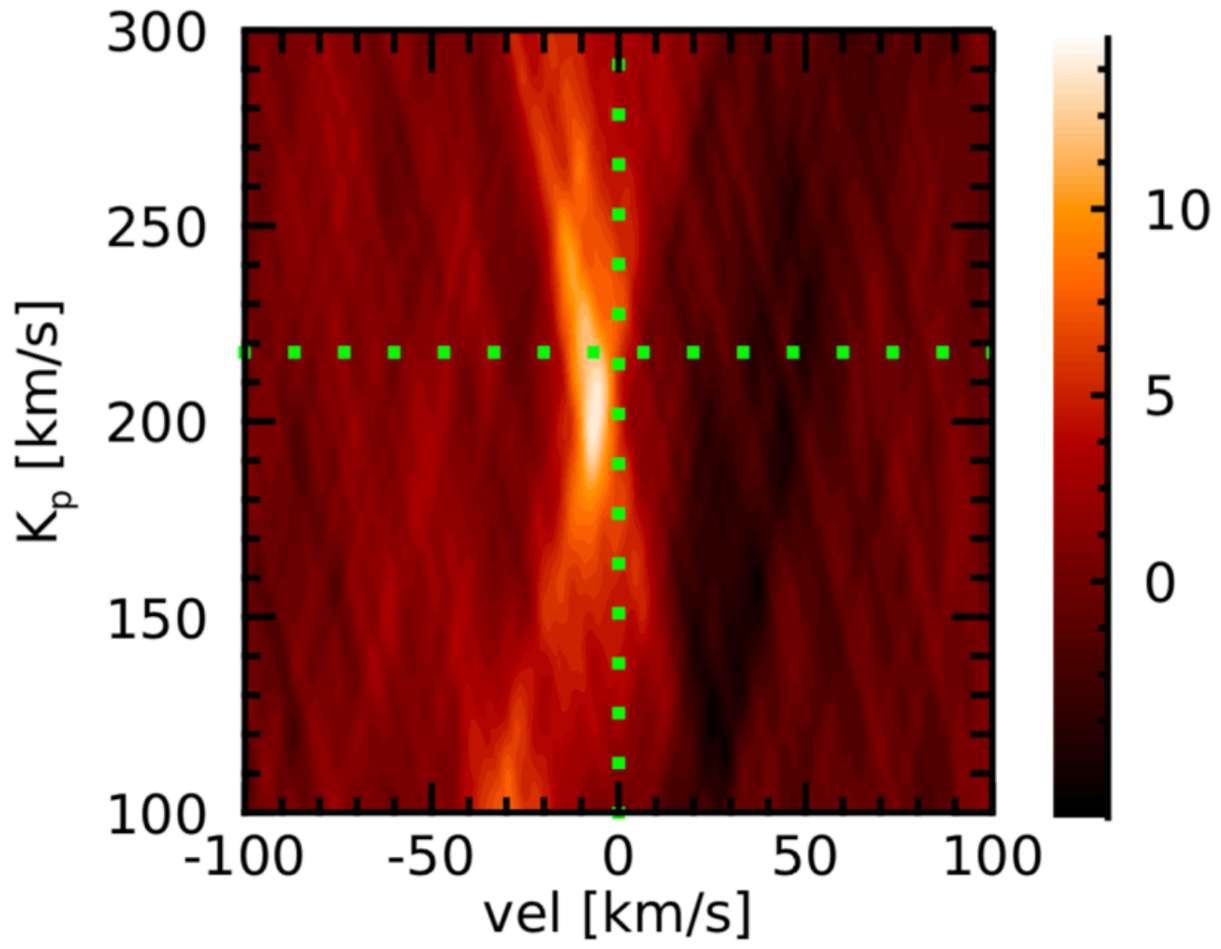
Cross-correlation method

Fe I

2D maps



Kp maps



Borsa et al. 2021

Methodology for extracting exoplanetary atmospheres using high-resolution transmission spectroscopy

Eva Herrero-Cisneros[1], María Rosa Zapatero Osorio[1]

[1] Centro de Astrobiología (CSIC-INTA)

eherrero@cab.inta-csic.es

Outline:

- Telluric correction
- Differential extinction correction
- Stellar master spectrum
- Extraction of planetary spectrum
- Search for atomic/molecular features
  - Direct detection method
  - Cross-correlation method

CENTRO DE ASTROBIOLOGÍA · CAB
ASOCIADO AL NASA ASTROBIOLOGY PROGRAM
CSIC INTA

espresso