New spectral windows into the escaping atmospheres of exoplanets

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CONTEXT

Atmospheric escape can significantly influence the evolution of an exoplanet and could be shaping the sub-Jovian desert and the radius valley [1]. Direct observational evidence has thus far mainly come from the Ly-a, H-a and He 10830 Å lines [2] and most modeling efforts have focused on those lines. Observing more spectral tracers would help to better constrain the varying model predictions and get a novel view of escaping atmospheres.

SYNTHETIC TRANSIT SPECTRA

We describe the escaping atmosphere as a solar composition 1D Parker wind [3] and use photoionization code Cloudy [4] to solve the temperature and ionization/ excitation structure [5]. We post-process this with a custom radiative transfer module that includes all spectral lines of the NIST database. We predict the transit spectrum from the FUV to the NIR of a typical hot Jupiter orbiting a solar-type star (Fig. 2 top).

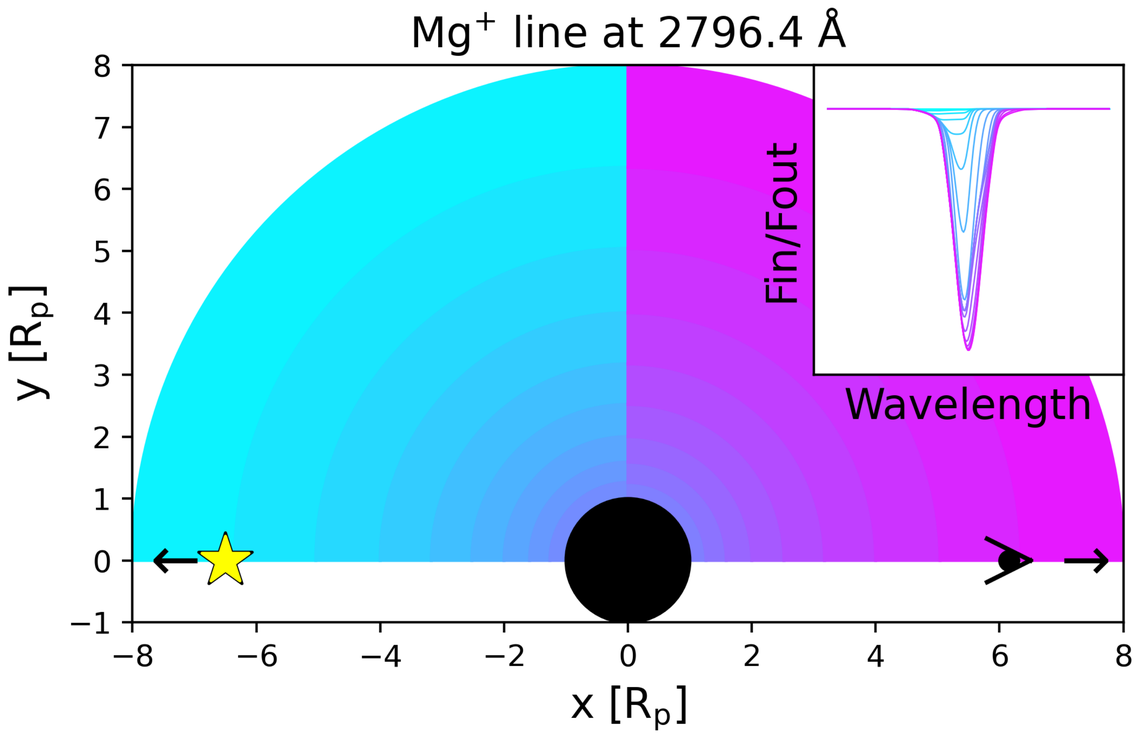

Fig. 1: Spectral line shape when adding consecutive atmospheric layers (top) and line forming altitude definition based on EW contribution (bottom)

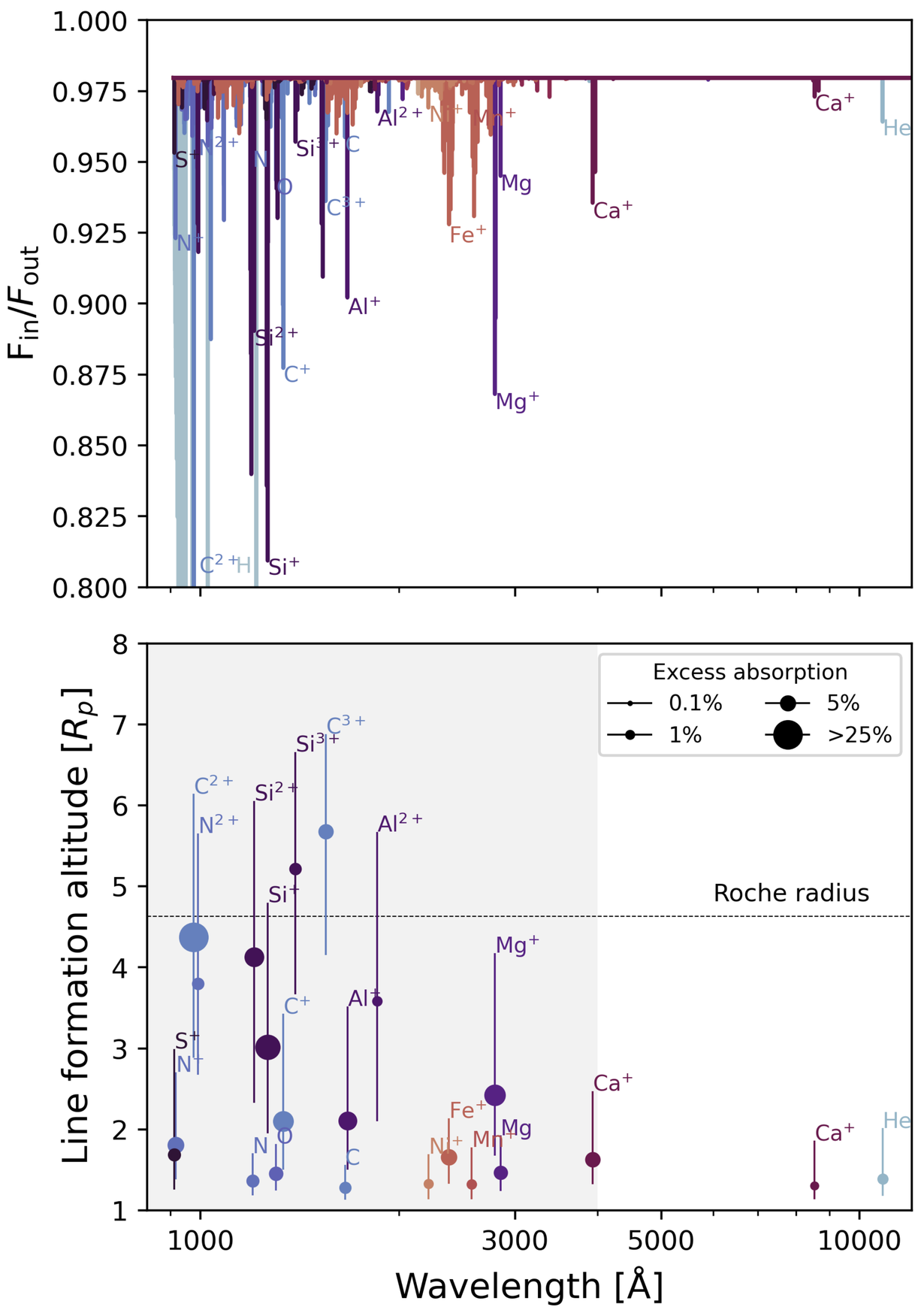

Fig. 2: Transit spectrum (top) and line forming altitudes of the strongest lines (bottom)

LINE FORMING ALTITUDES

Knowing which atmospheric altitudes are probed by a spectral line can help to get a more complete picture of the planetary outflow and to inform which models are appropriate for interpreting observations. We define a measure of the line forming altitude based on the contribution of each atmospheric layer to the total equivalent width (EW) of the line (Fig. 1). We present the formation altitudes of the strongest lines in the spectrum in Fig. 2 bottom. Note that the formation altitude does not always correlate with the transit depth!

CONCLUSIONS

Especially the UV window is promising for observing atmospheric escape. Targeting a complementary set of lines for the same planet will help in constraining atmospheric escape rates [5], upper atmospheric compositions, and may shed light on processes such as stratification and rain-out.

REFERENCES
[1] Owen 2019, AREPS
[2] dos Santos 2022, IAU
[3] Parker 1958, ApJ
[4] Ferland et al. 2017, RMAA
[5] Linssen et al. 2022, A&A