

HIPMACHIN I: VLT/CRIRES+ detection of blueshifted helium during a transit of the 17-Myr-old planet HIP 67522b

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ABSTRACT

We report excess absorption in the metastable He I triplet at 1083 nm during a transit of HIP 67522b, a 17-Myr-old, very low-density giant planet. On 2026 Jan 20, we observed the last 1.9 h of a transit and 1.4 h after egress with VLT/CRIRES+ (Y band, $R \approx 10^5$). Relative to the last post-egress spectra, full-transit spectra show excess absorption of $3.2 \pm 0.3\%$ (equivalent width 65 ± 7 mÅ, 10σ), blueshifted by 28 ± 4 km s^{−1} (19 – 33 km s^{−1} across fits) from the planet’s radial velocity. The absorption decreases gradually through the time series and remains detectable 0.5–1 h after egress, suggesting escaping gas trailing the planet over several planetary radii. The reference may still contain planetary helium, so these values are lower limits. A contribution from the flaring star cannot be excluded. If planetary in origin, HIP 67522b is the youngest planet with a secure detection of escaping helium.

Keywords: Exoplanet atmospheres (487) — Exoplanet atmospheric evolution (2308) — Transmission spectroscopy (2133) — High resolution spectroscopy (2096) — Hot Jupiters (753)

1. INTRODUCTION

Atmospheric escape should peak in the first ~ 100 Myr, while planets contract and their stars are most active (J. E. Owen 2019). The metastable He I triplet at 1083 nm in vacuum (A. Oklopčić & C. M. Hirata 2018) traces escaping gas (L. Nortmann et al. 2018). Yet the youngest planets with secure helium detections are ~ 150 – 250 Myr old (M. Zhang et al. 2023; J. Orell-Miquel et al. 2024); claims for younger ones, around very active stars, remain tentative (T. Hirano et al. 2024).

HIP 67522b is a 17-Myr-old, $\approx 10 R_{\oplus}$ planet on a 6.96-day orbit around a G-type star (A. C. Rizzuto et al. 2020). Its poorly constrained mass, only 14 – $28 M_{\oplus}$ (P. C. Thao et al. 2024; A. Lavail et al. 2026; H. R. James et al. 2026), makes it one of the lowest-density planets known. Blueshifted H α absorption (-21 ± 3 km s^{−1} rel-

ative to the star) was reported during a transit (R. P. Milburn et al. 2025), and A. Lavail et al. (2026) found a tentative D/H enrichment requiring intense hydrogen escape.

2. OBSERVATIONS AND DATA REDUCTION

We observed HIP 67522 on 2026 Jan 20 with VLT/CRIRES+ (R. J. Dorn et al. 2023) in circular spectropolarimetry mode (Y1029 setting, $0.2''$ slit, $R \approx 10^5$). We obtained 34 polarimetric sequences of four 75 s sub-exposures (136 in total) between 05:47 and 09:04 UT (airmass 2.05 to 1.10), reduced with the **cr2res** pipeline. The median signal-to-noise ratio is 45 per pixel per spectrum near 1083 nm.

We corrected each sub-exposure for telluric absorption with **molecfit** (A. Smette et al. 2015), shifted it to the stellar rest frame with **barycorrpy** and a systemic velocity of 7.4 km s^{−1} (A. C. Rizzuto et al. 2020), and normalized it. With the ephemeris of H. Chakraborty et al. (2026), our sequence starts 0.57 h after mid-transit

and ends 1.42 h after egress ($T_4 = 07:39$ UT), with 64 sub-exposures in full transit, 13 during egress, and 59 after. The outer planet, HIP 67522c (M. G. Barber et al. 2024), was not transiting. The reduced spectra and the code reproducing Figure 1 are on Zenodo (A. Lavail 2026).

3. RESULTS AND DISCUSSION

Lacking pre-transit spectra, we divided all spectra by a reference, the mean of the last 20 sub-exposures ($T_4 + 0.96$ – 1.42 h; Figure 1a,b). In each ratio, we fitted and subtracted four OH lines (two within the He I absorption; A. Masson et al. 2024) and the terrestrial He I airglow (J. Orell-Miquel et al. 2024), which brightens at dawn, during the reference. We masked the strong airglow components and the strongest OH doublet (stellar frame, relative to 1083.327 nm: $+10$ to $+31$ and $+43$ to $+53$ km s $^{-1}$). The full-transit transmission spectrum (Figure 1c) has an equivalent width (EW, unmasked pixels from -60 to $+12$ km s $^{-1}$) of 65 ± 7 mÅ. A Gaussian fit gives a depth of $3.24 \pm 0.30\%$ and a FWHM of 71 ± 11 km s $^{-1}$. Its centroid, -22.4 ± 4.2 km s $^{-1}$ in the stellar rest frame, is -28 ± 4 km s $^{-1}$ relative to the planet (-19 to -33 km s $^{-1}$ for triplet models, other fit windows or a planet-frame fit).

The signal is present in both nodding positions, while the photospheric Mg I 1081.4 nm control line shows no excess (-1 ± 4 mÅ).

The EW decreases smoothly with time (Figure 1d), without a clear drop at egress. It is still 50 ± 5 mÅ at $T_4 + 0$ – 0.5 h and 26 ± 5 mÅ at $T_4 + 0.5$ – 1 h. As the planet moves $6.5 R_p$ per hour, this requires gas at least $4 R_p$, and possibly $7.5 R_p$, behind its center. The full-transit EW grows from 50 to 70 mÅ as the reference

shrinks from the last 40 to the last 10 sub-exposures, away from egress: the reference probably still contains helium, and our values are likely lower limits.

The blueshift and post-egress absorption suggest gas pushed away from the star into a trailing tail, as in WASP-69b and WASP-107b (L. Nortmann et al. 2018; J. J. Spake et al. 2021; R. Allart et al. 2025). The blueshift exceeds the escape velocity (13 – 19 km s $^{-1}$ at $1 R_p$), so the gas is unbound, and the line width far exceeds thermal broadening (≈ 11 km s $^{-1}$ at 10^4 K), implying bulk velocities of tens of km s $^{-1}$. The H α absorption (R. P. Milburn et al. 2025) had the same blueshift but lasted less than the transit. Alternatively, stellar He I variability, largest at young ages (D. M. Krolikowski et al. 2024), could mimic a planetary signal. A uniform deepening of the stellar line, centered at $+6$ km s $^{-1}$, is disfavored ($\Delta\text{BIC} \approx 110$). A localized chromospheric feature cannot be excluded: flares of HIP 67522 cluster after transit (E. Ilin et al. 2025). A full transit with pre-transit spectra and simultaneous photometry will settle this. If planetary, this detection supports an escape origin for the D/H enrichment of HIP 67522b (A. Lavail et al. 2026), and opens a path toward the spectroscopic characterization of other young planets.

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Software: cr2res, molecfit, barycorrpy, NumPy, Matplotlib, astropy, SciPy

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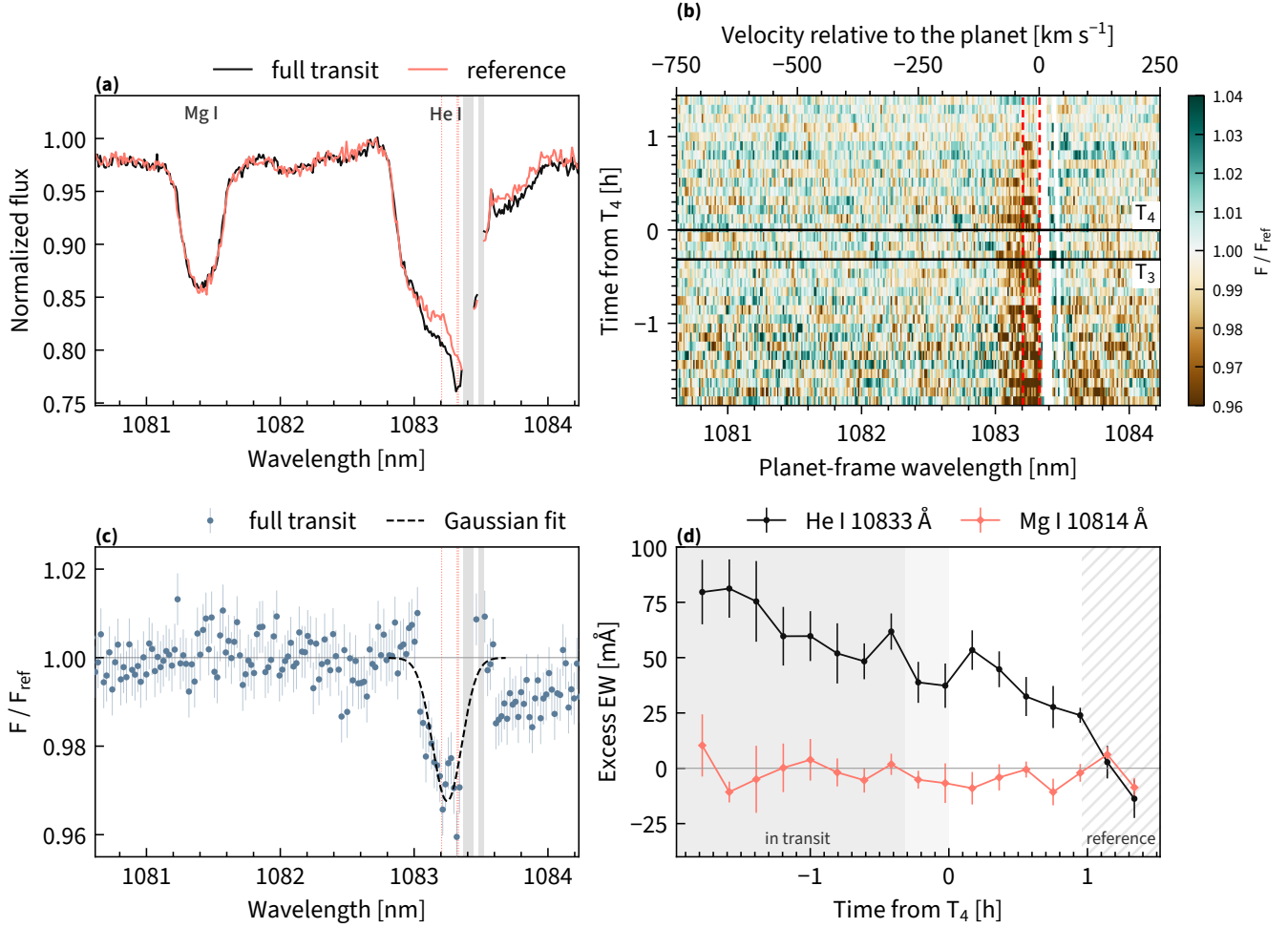


Figure 1. He I absorption of HIP 67522b. (a) Mean full-transit and reference spectra, in 3 km s^{-1} bins, versus vacuum wavelength in the stellar rest frame; gray: masked sky lines; dotted lines: He I wavelengths. (b) Spectra divided by the reference, in the planet rest frame, versus time from fourth contact; dashed lines: He I components; horizontal lines: third and fourth contacts; white: masked. (c) Ratio of the two spectra in (a), in 6 km s^{-1} bins, with a Gaussian fit. (d) Excess EW of He I and of the Mg I control line (excluding a telluric H_2O line), per nodding pair.

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