

Detection of the surface magnetic field of the planet-hosting K dwarf WASP-107

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ABSTRACT

I report here the first detection of the large-scale magnetic field of WASP-107, the K6 host star of the low-density exoplanet WASP-107b. I applied Least-Squares Deconvolution to seven archival SPIRou spectropolarimetric observations (2023 May–July) to extract Stokes V and null profiles for each epoch. The two most recent epochs show definite Zeeman detections (false alarm probability $< 10^{-5}$), with $B_\ell = -13.9 \pm 3.1$ G and -15.5 ± 3.5 G, while the null profiles are consistent with noise.

Keywords: Stellar magnetic fields (1610) — Spectropolarimetry (1973) — Planet hosting stars (1242)

1. THE WASP-107 SYSTEM

WASP-107b is a warm super-Neptune transiting the K6 star WASP-107 ($T_{\text{eff}} = 4430 \pm 120$ K, $\log(g) = 4.5 \pm 0.1$, $R_\star = 0.66 \pm 0.02 R_\odot$) every 5.72 d (D. R. Anderson et al. 2017). With a mass of $0.1039^{+0.0039}_{-0.0041} M_{\text{Jup}}$ and a radius of $0.935 \pm 0.023 R_{\text{Jup}}$ (S. W. Yee & S. Vissapragada 2026), it has an exceptionally low bulk density. Its orbit is also strongly misaligned with $\lambda = -158.0^{+15.2}_{-18.5}$ deg (V. Bourrier et al. 2023).

WASP-107b was the first exoplanet with detected helium absorption (J. J. Spake et al. 2018), which traces an escaping atmosphere with a comet-like tail extending $\sim 7 R_p$ (J. J. Spake et al. 2021). This escape is driven by the stellar high-energy radiation, which depends on magnetic activity. However, at this date, no measurement of the large-scale magnetic field of WASP-107, which shapes the stellar wind, has been reported.

2. OBSERVATIONS AND ANALYSIS

I analyzed publicly available archival observations of WASP-107 obtained with SPIRou (J.-F. Donati et al. 2020), the near-infrared spectropolarimeter at Canada-France-Hawaii Telescope, under program 23AO35 (PI: L. Doyle). Seven complete Stokes V sequences were obtained between 2023 May 2 and July 1, each consisting of four 600 s sub-exposures from which Stokes V and a diagnostic null N are derived (J.-F. Donati et al. 1997). The telluric-corrected spectra, reduced with AP-ERO (the standard pipeline of SPIRou) (N. J. Cook

et al. 2022), were retrieved from the Canadian Astronomy Data Centre².

For each epoch, I computed Stokes IV and null N LSD profiles (J.-F. Donati et al. 1997; O. Kochukhov et al. 2010). The line list appropriate for the star was extracted from VALD3 (T. Ryabchikova et al. 2015), using `ExtractStellar` with $T_{\text{eff}} = 4250$ K, $\log g = 4.5$, and solar metallicity, between 1000 and 2500 nm. I kept spectral lines with depth $> 10\%$ and known Landé factors, excluding H, He, Na, K, and Ca. The final line mask has 1262 atomic lines ($\bar{\lambda} = 1682$ nm, $\bar{g}_{\text{eff}} = 1.26$, $\bar{d} = 0.24$). Stokes I was extracted with weights $w_I = d_i/\bar{d}$, and VN with $w_V = d_i \lambda_i g_{\text{eff},i}/(\bar{d} \bar{\lambda} \bar{g}_{\text{eff}})$ following O. Kochukhov et al. (2010), where d_i is the line depth, λ_i its wavelength, and $g_{\text{eff},i}$ its effective Landé factor.

3. MAGNETIC FIELD DETECTION

The LSD profiles for the seven epochs are shown in Figure 1.

I computed the longitudinal field following G. A. Wade et al. (2000) with the equation:

$$B_\ell = \frac{-2.14 \times 10^{11}}{\bar{\lambda} \bar{g}_{\text{eff}} c} \frac{\int (v - v_0) V(v) dv}{\int [I_c - I(v)] dv}, \quad (1)$$

with $\bar{\lambda}$ in nm, v and c in km s^{-1} , and v_0 the centroid of Stokes I at each epoch. The detections give $B_\ell = -13.9 \pm 3.1$ G (June 28) and -15.5 ± 3.5 G (July 1). For the earlier epochs, in chronological order, -6.6 ± 3.2 , -3.3 ± 3.5 , -0.9 ± 3.3 , -1.8 ± 4.9 , and -5.3 ± 3.5 G. All null values are within 1σ of zero signal. Detection significances were assessed with the false alarm proba-

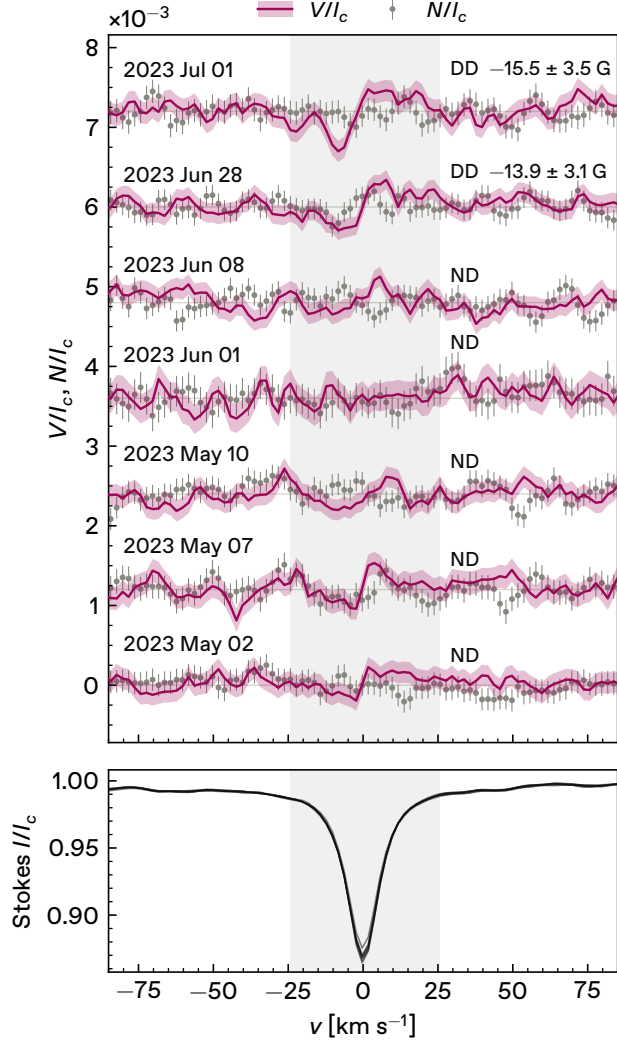


Figure 1. LSD profiles of the seven 2023 epochs in the stellar rest frame. Top: V/I_c (purple line, the shaded band shows 1σ error bars) and N/I_c (gray points with 1σ error bars) with a vertical offset per epoch. The labels indicate the date, the detection status (DD: definite detection; ND: no detection) and, for definite detections, the mean longitudinal magnetic field B_ℓ in Gauss. Bottom: Stokes I for all epochs. The shaded vertical window indicates the range used for computing B_ℓ .

bility (FAP) (J.-F. Donati et al. 1997). The two most recent epochs (June 28 and July 1) are definite detections (FAP = 1.9×10^{-6} and 5.0×10^{-6}). The other five are non-detections (FAP $> 4 \times 10^{-3}$), and all null profiles are consistent with noise.

A close analog is the young planet host DS Tuc A, whose longitudinal field ranges from -36 to -4 G and whose planet, at $20.35 R_\star$, has a trans-Alfvénic orbit in stellar-wind models driven by its Zeeman Doppler map (S. Bellotti et al. 2026). WASP-107b orbits slightly closer in ($a \approx 16.5\text{--}18 R_\star$; D. R. Anderson et al. 2017; V. Bourrier et al. 2023; M. M. Murphy et al. 2024; Y. Wu et al. 2026) around a star with a weaker field ($|B_\ell| \leq 15.5$ G), so, depending on the still unconstrained stellar wind, it may also lie near the Alfvén surface, where a magnetic star–planet connection can occur over part of the orbit. Zeeman Doppler Imaging with denser phase coverage would map the field topology needed to model this interaction.

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