Stars and their variability observed from space
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THE STRANGE CASE OF HD 65987, A MAGNETIC BP STAR WITH TWO PERIODS

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Abstract. *TESS* photometry of the magnetic chemically peculiar star HD 65987, a member of the open cluster NGC 2516, shows clear photometric variability with a period of 1.45 d. However, new magnetic and spectroscopic measurements of this star reveal a magnetic field varying with a stellar rotation period of about 7.7 d. The origin of the 1.45 d variations is suggested to be stellar pulsations.

Keywords: Stars: chemically peculiar, magnetic field, individual: HD 65987

1 Introduction

HD 65987 is a member of the open cluster NGC 2516, a cluster with an unusually large number of magnetic stars. Its membership was confirmed by data of the cluster and surroundings in *Gaia* given in DR2. Its parallax and proper motions are in good agreement with mean values for the cluster. The star's position within the main sequence in a *uvby* H–R diagram supports its cluster membership.

A longitudinal magnetic field was detected in HD 65987 with the FORS1 spectropolarimeter at the ESO VLT (Bagnulo et al. 2006). The field was detected twice at about the 6–7σ level. The star is clearly magnetic, and has a longitudinal field that reverses sign.

2 *TESS* photometry

Light variability of this star was observed by *TESS* (Ricker et al. 2015). Several groups have concluded that its light varies with a small amplitude and a period of 1.44 to 1.46 d, and that the variations are what would be expected for rotational variability of a magnetic Bp star (Balona et al. 2019; David-Uraz et al. 2019; Cunha et al. 2019). This range of periods is in good agreement with the photometric observations by North (1984). One 27 d–long *TESS* light-curve (of seven available) is shown in Fig. 1.

3 New magnetic observations

The magnetic field of HD 65987 was measured from seven new polarised spectra obtained during a 10-night run with the HARPSpol spectropolarimeter at ESO's La Silla Observatory during 2016 February. The values of $\langle B_z \rangle$ were measured as described by Landstreet et al. (2015), using only the cores of the Hα, Hβ, and Hγ Balmer lines in order to minimise the effects of abundance patchiness over the surface. The new data confirm that the strength of the $\langle B_z \rangle$ field reaches several hundred G, and that it reverses sign.

However, when the $\langle B_z \rangle$ values are plotted on the photometric period, they form a scatter plot. No smooth regular variation of $\langle B_z \rangle$ with photometric period is observed. The magnetic observations have therefore been searched for periodic variations using a χ^2 minimisation strategy. The data strongly suggest a period of about (7.7 ± 0.6) d, or perhaps the 1/day alias of this period at 1.15 d, but are *completely inconsistent* with variations in the 1.45 d photometric period.

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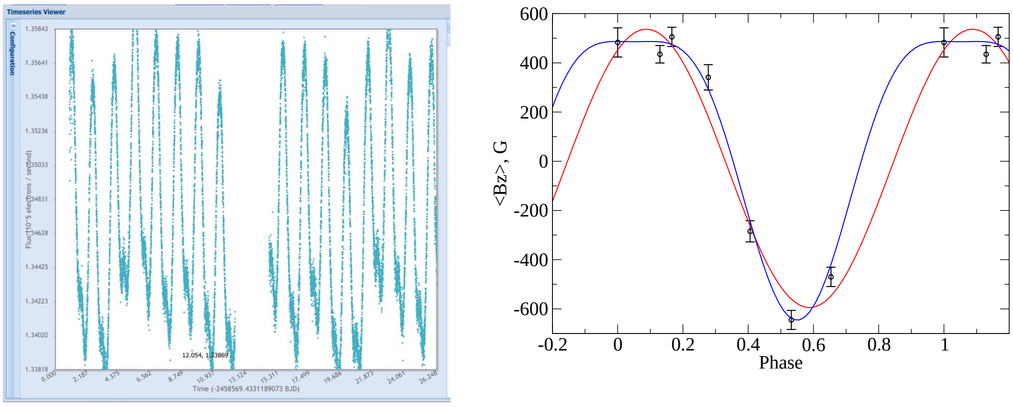

Fig. 1. Left: *TESS* light-curve from a single 27-day observation block with 120 s cadence starting, on 2019 March 26. The separation between successive peaks in the obvious light variations implies a period of about 1.45 d. **Right**: New magnetic field ($\langle B_z \rangle$) measurements, phased with period $P = 7.73$ d. The smooth curves are a sine wave fit (red), and a higher-order fit (blue).

4 Discussion

It is clear from the above descriptions that the $P = 1.45$d light variations do not represent the rotation period of HD 65987. There is no obvious signature of any $P \approx 7.7$ d magnetic field variations as in the observed light variations. This is probably consistent with the low amplitude of line-strength variations observed in the spectra.

So – what is causing the light variations?

Light variablity of HD 65987 with $P = 1.456$ d was observed in *seven* different 27 d series of observations obtained with *TESS*. It seems extremely unlikely that the variations are the result of an instrumental artefact.

There is no hint of a second star in the modern data. No eclipse-like light variations are seen. No radial-velocity variations larger than about 1 km/s are observed on time-scales of days, months, or years (González & Lapasset 2000). Although the spectrum of HD 65987 is quite complex, all the apparently unblended or weakly blended lines in the optical spectrum have widths consistent with the rotational velocity (v sin $i = 21$ km/s) of a single star. There are no hints of a secondary spectrum.

The most probable explanation for this period discrepancy is that HD 65987 is a *Slowly Pulsating B Star* or SPB star. Such stars show low-amplitude light variations of 0.1 mag or less, and periods typically of one to a few days (Lata et al. 2016, and references therein). HD 65987 lies in the instability region for such pulsations (Miglio et al. 2007), and its light variability has the appropriate amplitude and frequency. The light-curve appears to vary somewhat in amplitude, and could conceal multiple frequencies. In other words, HD 65987 shows *rotational* variability via the magnetic data, and *pulsational* variability via photometry.

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References

Bagnulo, S., Landstreet, J. D., Mason, E., et al. 2006, A&A, 450, 777
Balona, L. A., Handler, G., Chowdhury, S., et al. 2019, MNRAS, 485, 3457
Cunha, M. S., Antoci, V., Holdsworth, D. L., et al. 2019, MNRAS, 487, 3523
David-Uraz, A., Neiner, C., Sikora, J., et al. 2019, MNRAS, 487, 304
González, J. F. & Lapasset, E. 2000, AJ, 119, 2296
Landstreet, J. D., Bagnulo, S., Valyavin, G. G., et al. 2015, A&A, 580, A120
Lata, S., Pandey, A. K., Panwar, N., et al. 2016, MNRAS, 456, 2505
Miglio, A., Montalbán, J., & Dupret, M.-A. 2007, MNRAS, 375, L21
Ricker, G. R., Winn, J. N., Vanderspek, R., et al. 2015, JATIS, 1, 014003