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The First Determination of the Rotation Period for DH Car

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In January 1924, Ejnar Hertzsprung discovered a new variable star, DH Car. As it later turned out, this was the first discovery of a flaring red dwarf, type UV Cet in current classification. I present the first determination of the rotation period of DH Car from data acquired with TESS orbital observatory. The period is 0.89 days.

1 Introduction

Ejnar Hertsprung (1924) gave his paper on the discovery of the variable star, later designated DH Car in the standard variable-star manner, the name "Note on a peculiar variable star or Nova of short duration". In the beginning of the paper, he writes: "On the night of 1924 January 29 I took 5 plates in succession each with 30 minutes, followed by 4 plates each with $9\frac{1}{2}$ minutes exposure time...". The plates showed a brief brightening of the star by $1\overset{\mathrm{m}}{.}1$ (pg). Historically, it was the first observation of a flare on a star of the faint part of the main sequence; such stars are now called UV Ceti variables (cf. Samus et al. 2017). Hertzsprung (1924) suggested an interesting, now completely obsolete, explanation of the event: "A rough estimate indicates that a fall into the star of a body like a small planet would yield sufficient energy for an outburst as observed, but there may of course be other causes for the phenomenon".

Regardless the importance of the star DH Car, the literature on it is very limited. As of November 2024, the Simbad database lists only 11 publications, most of which not directly related to the object itself. Remarkably there is no reference to Hertzsprung (1924) in the list.

The coordinates of DH Car are: RA = $11^{\mathrm{h}}14^{\mathrm{m}}51\overset{\mathrm{s}}{.}752$, Dec = $-61^\circ 45' 37\overset{''}{.}11$ (equinox and epoch 2000.0). The star has a companion in $4\overset{''}{.}5$ to the east. Using the G, BP, and RP magnitudes from the Gaia DR3 catalogue (Gaia Collaboration et al. 2023) and interpolating in the table provided by E. Mamajek[1] (cf. Pecaut et al. 2012), we find the star's visual magnitude $V = 16.0$ and spectral type M4V. The Gaia DR3 catalogue gives $T_{\mathrm{eff}} = 3320.2$ K, $\log g = 4.42$ cm s^{-2}, [Fe/H] = –0.47, distance 84 pc.

Today, 100 years after its discovery, we revisit the star DH Car, based on data from the TESS[2] (Transiting Exoplanet Survey Satellite) space telescope. This telescope provides a unique opportunity to observe variable stars, through long data series with high time resolution. Using these possibilities, the present paper focuses on the determination of the rotation period of DH Car.

[1] https://www.pas.rochester.edu/~emamajek/EEM_dwarf_UBVIJHK_colors_Teff.txt
[2] https://exoplanets.nasa.gov/tess/

2 Observations and analysis

The space mission TESS was launched on April 18, 2018. The main purpose of the mission is to detect and study exoplanets around bright stars using the transit method. The main instrument of the TESS mission is a package of four wide-field CCD cameras.

In addition to its primary missions, TESS provides unique data for a wide range of astrophysical research. TESS continuously observes, for $\sim$ 27 days, one of 26 equal-size $24^\circ \times 96^\circ$ sectors, into which the northern and southern hemispheres of the celestial sphere are divided. The sectors overlap near the poles of the ecliptic, forming regions of continuous observations for more than 300 days. More details on the TESS project are provided in Ricker et al. (2015).

Our study of DH Car is based on TESS data with a 2-minute time resolution published in the public domain at the MAST[3] portal. According to information from the portal, DH Car light curves are available for the 37th (April 2, 2021–April 28, 2021) and 38th (April 29, 2021–May 26, 2021) sectors. Thus, we have 55 days of virtually uninterrupted observations available to us. The data were obtained using the lightkurve[4] package, written in Python and designed to analyze the light curves of the Kepler/K2 and TESS projects. Loaded data contains two types of instrument fluxes with different degrees of pre-processing (Ricker et al. 2015). This work uses PDCSAP FLUX (Presearch Data Conditioning Simple Aperture Photometry Flux) values, which are the result of simple aperture photometry (SAP_FLUX) of objects after accounting for long-term and instrumental trends. It is also worth noting that each photometric point on the light curve is assigned a QUALITY parameter characterizing the degree of influence of instrumental effects. Data with QUALITY $\neq 0$ were excluded from our consideration.

3 Rotation period

Although TESS provides continuous data, there are still some gaps associated with the transfer of information to the Earth. In addition, some data are excluded from consideration due to bad quality (QUALITY $\neq 0$). Therefore, we apply the Lomb–Scargle periodogram analysis method (Lomb 1976, Scargle 1982), which is effective for dealing with heterogeneous time series, to estimate the rotation period ($P_{\rm rot}$).

The light curve for DH Car is shown in Fig. 1 (sector 37) and Fig. 2 (sector 38). The power spectrum and the phased light curve plotted with the derived period are presented. The period obtained is $0^{\rm d}.89$, or $21^{\rm h}.4$. Combining the data from two sectors into one observation series shows the same result.

4 Conclusions

Based on TESS space telescope observations of DH Car obtained from sectors 37 and 38, a rotation period of 0.89 days has been determined for the first time.

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[3]https://mast.stsci.edu/
[4]https://docs.lightkurve.org/

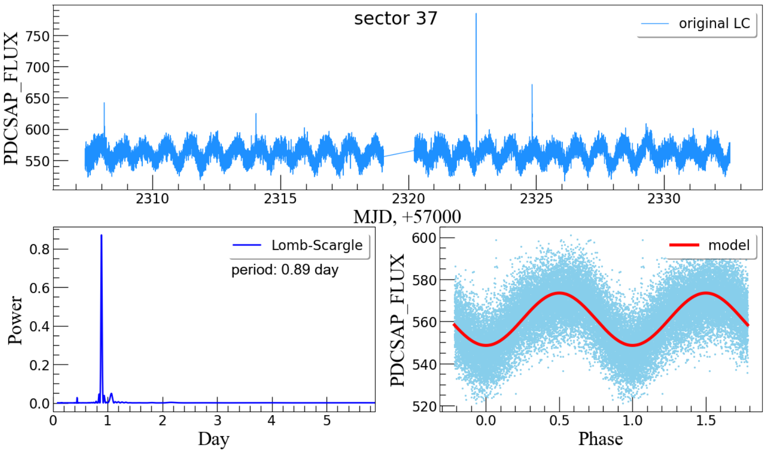

Figure 1.
Top panel: the light curve of DH Car from sector 37 data. Bottom panel: periodogram and phased light curve. The red color shows the Lomb–Scargle model corresponding to the period of 0.89 days.

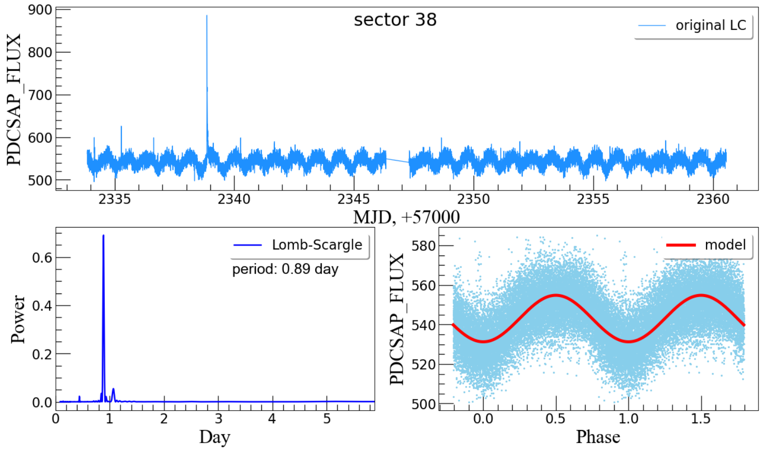

Figure 2.
Top panel: the light curve of DH Car from sector 38 data. Bottom panel: periodogram and phased light curve. The red color shows the Lomb–Scargle model corresponding to the period of 0.89 days.

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