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Research Note

HD 24733 is an eclipsing spectroscopic binary

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Abstract. The known spectroscopic binary HD 24 733 is shown to be an eclipsing variable. The accurate value of the orbital period (1.762 838 days) has been determined. According to the photometric data, the system is a β Lyrae type interacting binary.

Key words: binaries: eclipsing – binaries: spectroscopic – stars: individual: HD 24 733

1. Introduction

The star HD 24 733 = SAO 24 324 is a known spectroscopic binary (Acker, 1971 and references therein) but lacks detailed photometric study. On the basis of occasional measurements (Bouigue, 1959) its V brightness ($7^{\rm m}_{.}02$) and B−V colour index ($+0^{\rm m}_{.}25$) are included in the UBV photometric catalog (Blanco et al., 1970).

This star served as the comparison star for HD 25 056, a supergiant within the instability strip. The supergiant star was included in a project aimed at detecting low amplitude Cepheid variables.

In this case, however, it was obvious from the second night of observation that it is the comparison star that varies and the candidate-pulsator is stable because the magnitude difference between HD 25 056 and the check star HD 24 723 has been constant.

2. Observations

When HD 24 733 turned out to be photometrically variable, its brightness was measured as frequently as possible and the former programme star, HD 25 056 became the comparison star. Although the spectral type (and the corresponding B−V colour index) of HD 25 056 is quite different from that of HD 24 733, its angular proximity to the new variable and the very similar V brightness preferred this choice to using HD 24 723 which is much fainter. This latter star was kept for checking constancy of the comparison star. The magnitudes of the comparison star HD 25 056 are as follows:

$$V = 7^{\rm m}_{.}03 \ , \ B-V = 1^{\rm m}_{.}20 \ , \ U-B = 0^{\rm m}_{.}92 \ .$$

The observations were performed with an unrefrigerated UBV photometer attached to the 50 cm Cassegrain telescope at Piszkéstető Mountain Station of Konkoly Observatory. This integrating photometer houses an EMI 9502 QB type photomultiplier tube and the following filters:

V: GG 11 (2mm)
B: BG 12 (1mm) + GG 13 (2mm)
U: UG 2 (2mm)

The aperture of the diaphragm was 25”.

33 observations (distributed on 18 nights) have been collected. Each observation is an average of 3–4 data points, while a data point is the average of four 5-second integration in each colour. No allowance was made for differential extinction because of the angular proximity of the variable and the comparison stars. The instrumental magnitudes were converted into the ‘standard’ UBV system using seasonal transformation coefficients. During the interval of the present observations the average values of the coefficients used in the equations of transformation are as follows:

$$V = v - 0.189 \times (B - V)$$
$$B - V = 1.233 \times (b - v)$$
$$U - B = 1.002 \times (u - b)$$

The observational data are listed in Table 1. The mean error of the individual observations is $0^{\rm m}_{.}005$ in V, $0^{\rm m}_{.}008$ in B and $0^{\rm m}_{.}012$ in U. The transformation of the data from the instrumental into the ‘standard’ UBV system does not introduce any significant error as was pointed out by Moffett and Barnes (1985) when comparing the author’s previous extensive Cepheid photometry with the observations collected in the catalogue compiled by Mitchell et al. (1964), at least for the V and B−V data. The ultraviolet data are somewhat less reliable because of the inadequate altitude of the Piszkéstető observatory’s site. The V, B−V and U−B curves are shown plotted in Fig. 1. When plotting the data, the zero phase was arbitrarily chosen at J.D. 2 400 000.

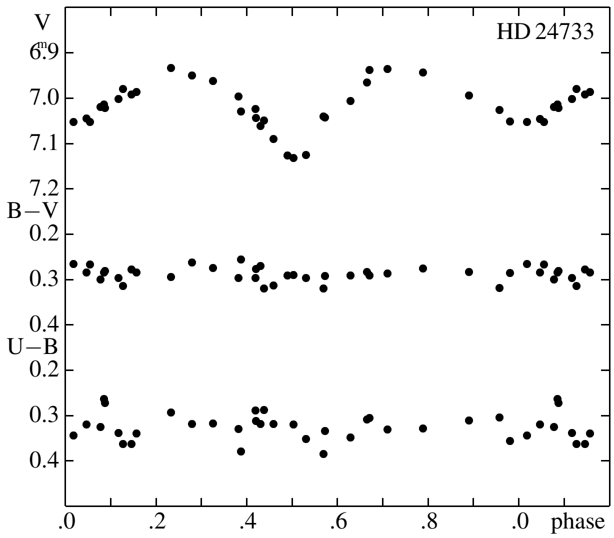

Fig. 1. The V, B−V and U−B phase curves of HD 24 733. The accurate period of $1\overset{\mathrm{d}}{.}762\,838$ was used and zero phase was arbitrarily chosen at J.D. 2 400 000

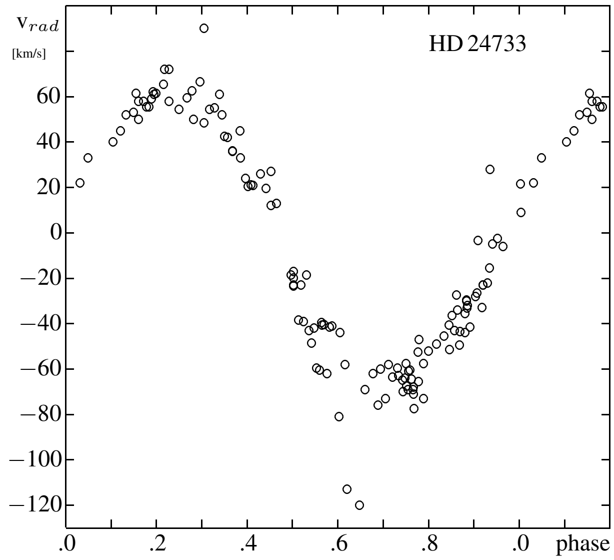

Fig. 2. Acker's (1971) radial velocity data phased with the same ephemeris as given for Fig. 1. The original data have been corrected for the systematic errors mentioned in her Table 5

Table 1. Photometric observational data

J.D. Hel. 2 400 000+	V [mag]	B−V [mag]	U−B [mag]
48593.4936	7.126	0.291	-
48594.4888	7.052	0.267	-
48646.2735	7.062	0.270	0.318
48646.4024	7.132	0.290	0.319
48647.2437	7.051	0.285	0.356
48647.3099	7.053	0.266	0.344
48647.3593	7.045	0.284	0.319
48647.4138	7.019	0.300	0.325
48973.3271	7.026	0.318	0.304
49002.3808	7.048	0.320	0.287
49032.2487	6.996	0.296	0.329
49032.3849	7.090	0.312	0.318
49034.2754	7.125	0.296	0.351
49034.3435	7.040	0.320	0.384
49035.2525	7.013	0.284	0.263
49035.3271	6.980	0.313	0.362
49360.2046	7.044	0.276	0.312
49365.3248	6.962	0.274	0.317
49365.4345	7.029	0.256	0.379
49389.2370	6.993	0.283	0.310
49603.4739	7.024	0.296	0.288
49606.4670	7.001	0.296	0.338
49606.5364	6.986	0.284	0.339
49666.3505	7.021	0.280	0.272
49666.4542	6.991	0.278	0.362
49688.3593	7.042	0.291	0.334
49688.4590	7.006	0.291	0.348
49688.5234	6.965	0.283	0.308
49690.2965	6.937	0.290	0.305
49690.3656	6.935	0.286	0.330
49690.5044	6.943	0.275	0.328
49721.2563	6.933	0.294	0.293
49721.3376	6.949	0.262	0.318

3. Discussion

The spectroscopic-binary nature of HD 24 733 was discovered by Acker (1971). She determined an orbital period of 1.7629 days for this system whose primary is an A7V star. The phase curve of Acker's radial velocity data is plotted in Fig. 2.

The new photometric data have been analysed for obtaining an independent value of the orbital period. Application of a Lafler–Kinman (1965) type algorithm resulted in the orbital period of $1\overset{\mathrm{d}}{.}762838$, the last digit being uncertain. The same method was applied to Acker's (1971) radial velocity data corrected for the systematic errors (referred to in her Table 5). Application of this algorithm resulted in $1\overset{\mathrm{d}}{.}76284$, in excellent agreement with the photometric orbital period.

Based on the new photometric data, the following current elements are determined for the system:

$$\text{Min. I} = \text{J.D.Hel.}\ 2\,448\,646.404 \;+\; 1\overset{\mathrm{d}}{.}762\,838 \times E$$
$$\pm.007 \qquad \pm.000\,005$$

This ephemeris can be used as a starting formula for later studies aimed at revealing period changes. It is worth mentioning, however, that the phase relation of the radial velocity and the photometric phase curves does not imply a strong period change.

The brightness of the system varies between $6\overset{\mathrm{m}}{.}96$ and $7\overset{\mathrm{m}}{.}13$ in V, the depth of the primary minimum being $0\overset{\mathrm{m}}{.}17$ while that of the secondary minimum is $0\overset{\mathrm{m}}{.}11$. The increased scatter of the B−V and U−B colour curves near both minima is a manifestation of instability of the light curve which hints at interaction between the components.

In order to extract some information about the physical parameters of the system including the secondary star itself, the light curve has been analysed with the help of Budding's (1973) program package. Because the light curve is represented by small number of data points, the results can be considered as

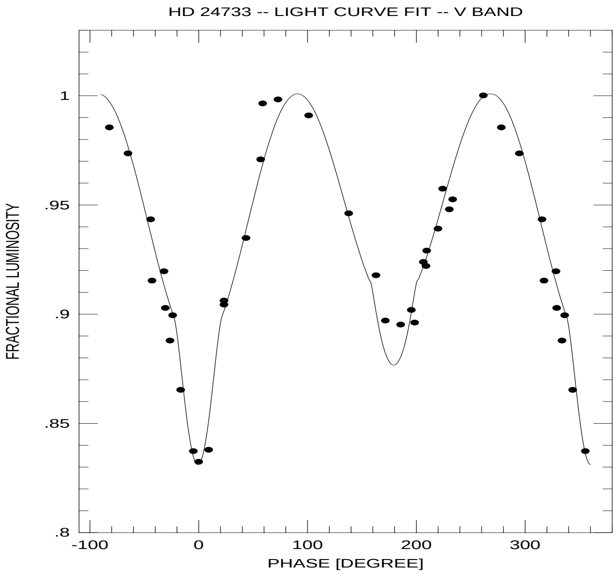

Fig. 3. Light curve fit to the V-data. The physical parameters corresponding to the best fit are described in the text

preliminary ones. The best fit is shown in Fig. 3. The corresponding physical parameters are as follows: the system consists of an A7V primary star and a G0V secondary component, the inclination being 67 degrees, the radius of the primary star is equal to one third of the semi-major axis of the orbital separation. The stellar parameters were taken from Lang's (1991) handbook. Appearance of the light curve (β Lyrae type) indicates that the components are elliptical.

Starting from Acker's (1971) spectroscopic data, the semi-major axis a=1.634×10^6 km and a mass function of $0.045\,\mathscr{M}_\odot$, however, a secondary star of 0.75 solar mass can be deduced, that corresponds to an early K star on the main sequence. The observed light curve (depth of minima) does not support such a large difference between the luminosity of the components. The system cannot be treated as consisting of two mass points: the components are distorted and circumstellar matter may be present.

Further study of this interesting binary system in different wavelength regions including both photometric and spectroscopic investigations is recommended. Because HD 24 733 is rather bright, its high resolution spectroscopic observation in ultraviolet would be especially important.

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