COMMISSIONS G1 AND G4 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS
Volume 63 Number 6260 DOI: 10.22444/IBVS.6260

Konkoly Observatory
Budapest
30 January 2019

HU ISSN 0374 – 0676

HD220735 AND HD30110, NEW SHORT PERIOD VARIABLE STARS

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Abstract

We have obtained $uvby-\beta$ photoelectric photometry with the 0.84 m telescope of the San Pedro Martir Observatory, México, for the stars HD220735 and HD30110 which were found to be new variable stars. For these stars we determined some of their physical characteristics, such as effective temperature and surface gravity.

1 Introduction

Confirming the variability and establishing the nature of suspected variables is an important matter. As a continuation of our search for high-amplitude δ Scuti (HADS) stars, several from a list of suspected variables from the study of Nichols et al. (2010) were tested for variability. Based on this, we carried out a systematic analysis of four of them: HD30110, HD217587, HD221012, and HD220735 and determined variability in the first and last one.

2 Observations

These were all done at the Observatorio Astronómico Nacional de San Pedro Mártir México. The 0.84 m telescope, to which a spectrophotometer was attached, was utilized at all times. The observing season was carried out over several nights in October and November, 2016. Table 1 lists the log of the observations.

2.1 Data acquisition and reduction

The procedure to determine the physical parameters has been reported elsewhere (Peña et al., 2016). If the photometric system is well-defined and calibrated, it provides an efficient way to investigate physical conditions such as effective temperature and surface gravity via a direct comparison of the unreddened indexes with those obtained from the theoretical models. These calibrations have already been described and used in previous analyses (Peña & Peniche; 1994; Peña & Sareyan, 2006).

Table 1: Log of observing seasons.

Date yr/mo/day	Target 1	Target 2	Target 3	HJD 245+(day)
16/10/2526	HD217587	HD30110	Cephs	7687
16/10/2627	HD221012	HD30110	Cephs	7688
16/10/2728	cloudy			7689
16/10/2829	HD30110	HD221012	Cephs	7690
16/10/2930	HD220735			7691
16/10/3031	cloudy			7692
16/11/3101	HD220735	HD30110	Cephs	7693
16/11/0102	HD30110	HD221012		7694
16/11/0203	CC And	V0367 CAM	Cephs	7695

Table 2: Transformation coefficients obtained for the observed season

season	B	D	F	J	H	I	L
Oct 2016	0.031	1.008	1.031	−0.004	1.015	0.159	−1.362
σ	0.028	0.003	0.015	0.017	0.005	0.004	0.060

The reduction was done considering the accuracy of the standard stars. As was stated in Peña et al. (2016) reporting on BO Lyn, the observational pattern, as well as the reduction procedure, have been employed at the SPM Observatory since 1986 and hence, have been described many times. A detailed description of the methodology can be found in Peña et al. (2007). Over the seven nights of observation, the following procedure was used: for each measurement at least five ten-second integrations of each star and one ten-second integration of the sky for the *uvby* filters and the narrow and wide filters that define Hβ were taken. What must be emphasized here are the transformation coefficients for the observed season (Table 2) and the season errors which were evaluated using the ninety-one observed standard stars. These uncertainties were calculated through the differences in magnitude and colors for (V, $b-y$, m_1, c_1 and Hβ) which are (0.054, 0.012, 0.019, 0.025, 0.012), for a total of 94 points in *uvby* and 68 points in Hβ, respectively, which provide a numerical evaluation of our uncertainties. Emphasis must be made on the large range of the standard stars in the magnitude and color indexes values: V:(5.62, 8.00); $(b-y)$:(−0.09, 0.88); m_1:(−0.09, 0.67); c_1:(−0.02, 1.32) and Hβ:(2.50, 2.90).

To verify the consistency of the data from our derived standard stars values, mean values for each one were calculated as well as their standard deviations. These are presented in Table 3 in decreasing brightness. The last column of this Table is N, the number of entries. In all but HD190849 the standard deviations are on the order of hundredths of magnitude. The large dispersion of this star could be due to variability, as in the case of HD 115520 (Peña et al., 2007)

The file `6260-t7.txt` lists the photometric values of HD 220735. In this Table column 1 reports the time of the observation in HJD, columns 2 to 5 list the Strömgren values V, $(b-y)$, m_1 and c_1, respectively; column 6, Hβ; the remaining columns list the unreddened indexes [m1], [c1] & [u-b]. The data of HD 30110 is also available online as `6260-t8.txt`. The photometry of the light

Table 3: Mean photometric values and standard deviations of standard stars

ID	V	$(b-y)$	m_1	c_1	β	σV	$\sigma(b-y)$	σm_1	σc_1	$\sigma\beta$	N
BS8085	5.196	0.670	0.657	0.159		0.016	0.003	0.026	0.015		6
HD013871	5.782	0.285	0.158	0.526		0.033	0.001	0.014	0.003		8
HD015335	5.893	0.373	0.157	0.386		0.013	0.002	0.019	0.005		6
HD057006	5.905	0.336	0.151	0.490		0.015	0.003	0.021	0.002		4
HD035520	5.911	0.142	0.062	1.328		0.024	0.003	0.014	0.002		8
HD224165	5.933	0.715	0.543	0.250		0.101	0.002	0.001	0.001		2
HD033203	6.013	0.615	−0.181	0.006		0.012	0.004	0.012	0.006		8
BS8086	6.044	0.814	0.635	0.103		0.025	0.004	0.027	0.014		6
HD202314	6.184	0.691	0.449	0.299		0.031	0.004	0.022	0.010		7
HD056386	6.187	−0.006	0.114	0.990		0.010	0.001	0.021	0.004		4
HD221661	6.202	0.599	0.410	0.374		0.086	0.002	0.004	0.001		2
HD015596	6.225	0.562	0.270	0.386		0.012	0.002	0.020	0.005		6
HD217754	6.426	0.205	0.188	0.783		0.179	0.001	0.001	0.001		2
HD033632	6.477	0.340	0.145	0.351		0.005	0.002	0.014	0.005		8
HD028354	6.536	0.005	0.116	0.785		0.007	0.002	0.015	0.005		8
HD013936	6.573	0.023	0.129	1.123		0.009	0.002	0.018	0.007		6
BS8389	6.582	0.029	0.115	1.104		0.015	0.003	0.016	0.008		7
HD043461	6.621	0.013	0.061	0.580		0.025	0.002	0.015	0.007		6
HD042089	6.644	0.585	0.328	0.532		0.022	0.003	0.021	0.008		6
HD012884	6.754	0.087	0.208	0.898		0.028	0.001	0.017	0.004		7
HD018066	6.967	0.760	0.549	0.337		0.015	0.002	0.025	0.010		6
HD055036	6.996	0.257	0.020	1.358		0.016	0.002	0.016	0.011		3
HD044812	7.002	0.668	0.451	0.302		0.006	0.003	0.024	0.010		6
HD224055	7.141	0.599	−0.144	0.213							1
HD208344	7.226	0.071	0.177	1.094		0.075	0.003	0.017	0.004		7
HD049564	7.391	0.843	0.694	0.362		0.019	0.001	0.028	0.008		4
HD204132	7.541	0.369	0.061	1.328		0.037	0.003	0.019	0.009		7
HD028304	7.721	0.147	0.029	0.612		0.006	0.003	0.015	0.004		7
HD048691	7.820	0.143	−0.039	−0.015		0.007	0.002	0.016	0.011		5
HD013801	7.939	0.213	0.161	0.688		0.012	0.001	0.016	0.006		7
HD031125	7.921	0.027	0.173	0.994		0.010	0.002	0.015	0.005		8
HD047777	7.927	−0.055	0.064	0.116		0.010	0.002	0.024	0.017		5
HD219364	7.952	0.686	0.530	0.382		0.021	0.002	0.004	0.011		2
HD013997	7.990	0.479	0.314	0.360		0.010	0.003	0.020	0.004		7
HD207608	8.054	0.312	0.145	0.528		0.055	0.004	0.017	0.003		7
HD052955	8.329	0.414	0.201	0.359							1

curves of the variables is presented in Figures 1 and 2.

3 Newly found delta Scuti stars

Since there were two newly found variables, HD 30110 and HD 220735, among the several observed stars, the analysis of each one of them is presented separately. These stars, according to Simbad have no previous reports on their variability.

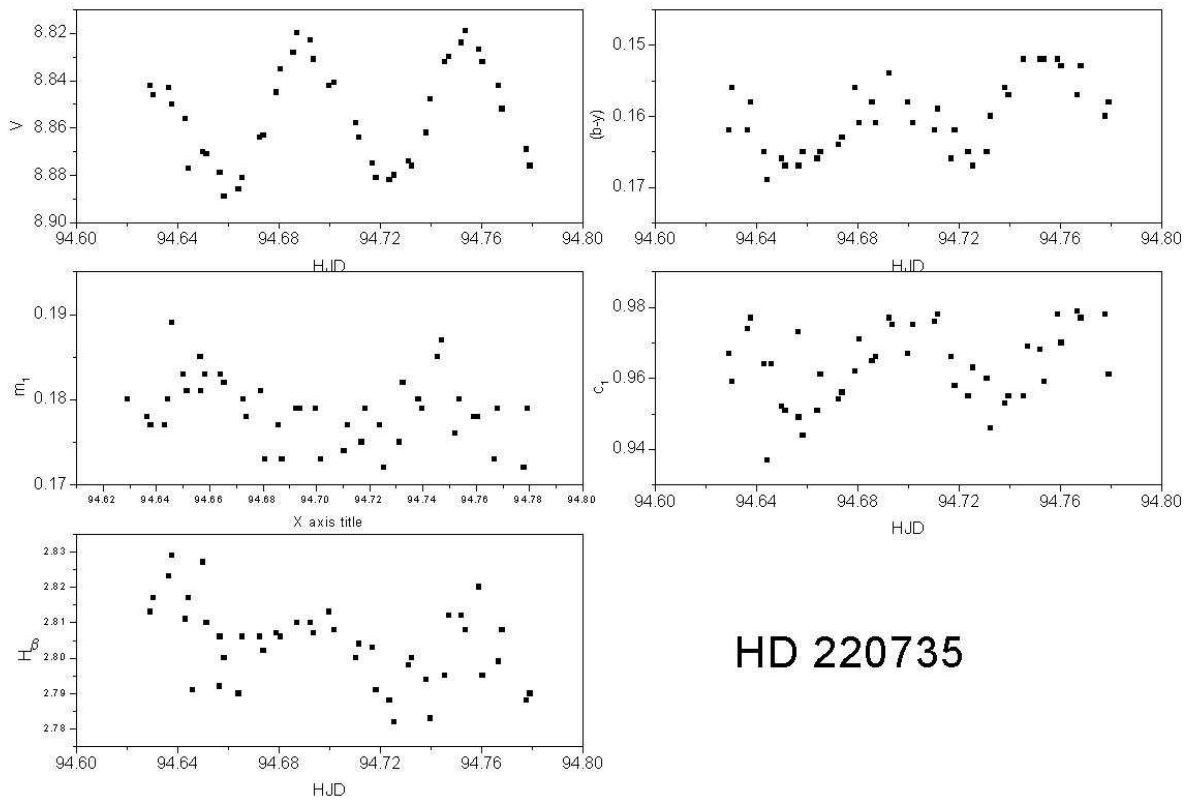

Figure 1. Light curve of HD 220735 in $uvby-\beta$ photoelectric photometry. Top, left, V magnitude, top right, $(b-y)$; middle left, m_1, middle right, c_1 and bottom left, Hβ.

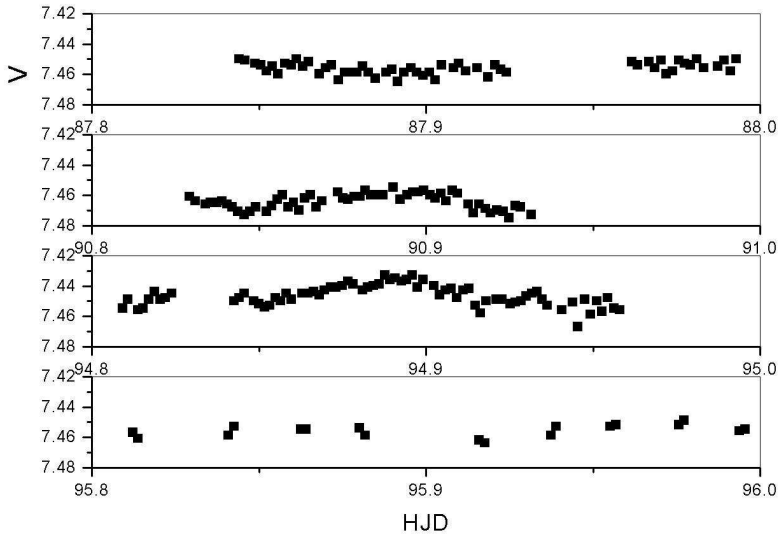

Figure 2. Light curve of HD 30110 in the V filter. We present the light curve for the four nights the star was observed.

3.1 HD 220735

This star was observed on only one night for a sufficient time span to cover two cycles. To determine the periodic behavior of HD220735 the following methods were employed. In the first method differences of the two consecutive times of maximum light were evaluated to determine a coarse period since it was observed for a time span long enough to reach two times of maximum light. The times of maximum light were found at HJD94.68757 and HJD94.7534. The difference of these maxima gave 0.0658 d, which gives a coarse period of pulsation of this star.

As a second method, we used a time series method amply utilized by the δ Scuti star community: Period04 (Lenz & Breger, 2005). The V magnitude of the $uvby - \beta$ set was analyzed with this code.

The analysis of these data gave the results listed in Table 4 with a zero point of 8.854 mag, residuals of 0.0078 mag and 13 iterations. This frequency coarsely agrees with that determined by the difference of the two maximae: 0.0638 d. The analysis of Period04 is presented in Figure 3. Beginning at the top is the periodogram of the original data; next are the consecutive sets of residuals. The scale of the Y axis shows the relative importance of the residuals. However, it is obvious that the data of only one night cannot provide an accurate period determination. To complicate things more, this preliminary analysis suggests the presence of a second frequency, a common phenomena with δ Scuti stars.

3.2 HD 30110

This star was observed on the nights of JD2457687, JD2457690, JD2457694 and a few points on JD2457695. Although it is clearly variable, especially on nights

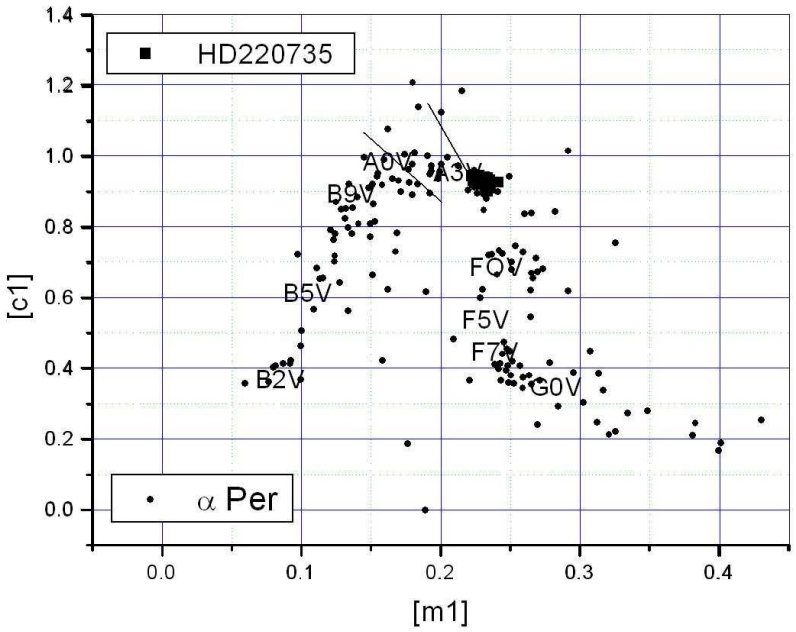

Figure 3. Position of the HD220735 star in the $[m_1] - [c_1]$ diagram of alpha Per (Peña & Sareyan, 2006)

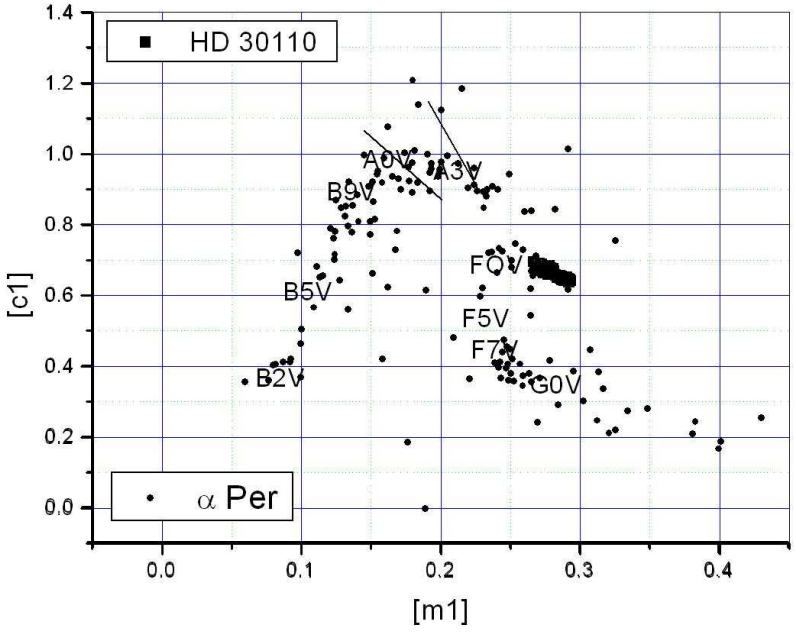

Figure 4. Position of the HD30110 star in the $[m_1] - [c_1]$ diagram of alpha Per (Peña & Sareyan, 2006)

Table 4: Output of PERIOD04 with the V magnitude of HD 220735 of the present paper's $uvby - \beta$ data

Nr.	Frequency	Amplitude	Phase
F1	15.666	0.026	0.8586
F2	29.6147	0.0056	0.6816

Table 5: Output of PERIOD04 with the V magnitude of HD 30110 of the present paper's $uvby - \beta$ data

Nr.	Frequency	Amplitude	Phase
F1	0.6223	0.0105	0.7757
F2	9.2300	0.0049	0.9286

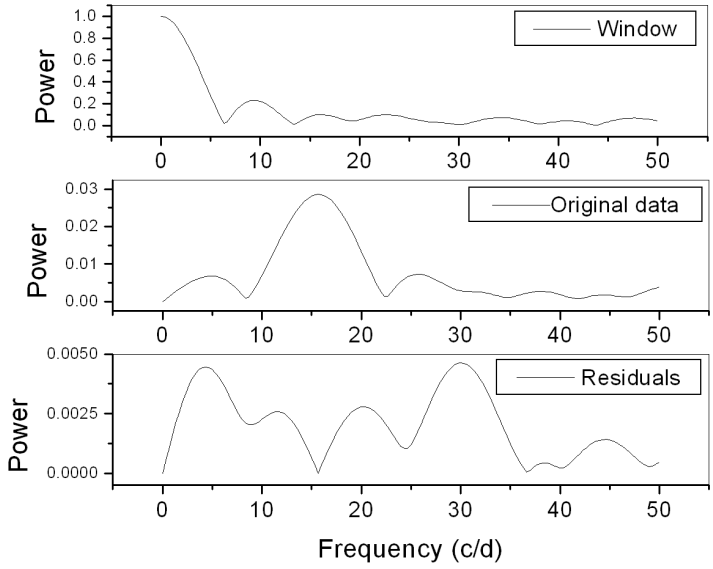

Figure 5. Frequency spectrum of HD 220735 with the SPM V data. Top to bottom: first is the frequency spectrum of the window, and middle, that of the original data and bottom, the set of residuals. We call attention to the scale of the Y axis to show the relative importance of each frequency.

Table 6: Reddening and parameters of HD 30110 and HD220735

HD	$E(b-y)$	Distance PP	Tycho	Gaia DR2	Gaia DR2*
HD30110	0.016 ± 0.015	82 ± 18	96.3	98.9	98.7
HD220735	0.035 ± 0.011	322 ± 33	—	427	422

JD2457690, JD2457694, due to the fact that it shows a broad maximum, no determination of the peak could be done. A time series analysis was done with PERIOD04. The analysis gave the results listed in Table 5 with a zero point of 7.455 mag, residuals of 0.0040 mag and 10 iterations. We do not need to emphasize that more data are needed before the true behaviour of this star can be determined.

4 Physical Parameters

To determine physical parameters, unreddened photometric values have to be determined through appropriate calibrations. These calibrations were proposed by Nissen (1988) for A and F type stars. Therefore, it is necessary to first determine the range of variation in spectral class of HD 30110 and HD220735. The spectral types can be determined very accurately with the $uvby-\beta$ photometric data. We determined their unreddened photometric indexes $[m_1]$ and $[c_1]$ and positioned them in the plot determined for alpha Per, whose stars have well-determined spectral types. This has been done and is presented in Figures 4 and 5 where we can see that the spectral type is A3-A4 for HD 220735 (Figure 4) and F type for HD 30110 (Figure 5). Hence, in both cases the prescription of Nissen (1988) is applicable.

The application of the above mentioned numerical unreddening package of Nissen's (1988) provided the results for HD30110 and HD220735.

Since a period was determined for HD220735, mean values were calculated for $E(b-y)$ for two cases: i) the whole data sample and ii) in phase limits between 0.3 and 0.8, which is customary for pulsating stars to avoid the maximum. Unfortunately no metal content [Fe/H] was determined for either star. The uncertainty is merely the standard deviation.

The results are summarized in Table 6 which lists the reddening $E(b-y)$, and distance (in pc). Furthermore, our distance values were compared with the available data of Tycho and Gaia DR2. In the case of Gaia, we are using the distance obtained directly inverting the parallax and the distances obtained by the correction perform by Bailer-Jones et al. (2018). Here we can see, as expected, that the discrepancies between Gaia DR2 and the Bailer-Jones corrections are larger at greater distances.

Table 6 presents also the summary of the distances values for both stars: HD 30110 (= Tycho 3745-489-1 = Gaia DR2 2789148712618099 20) and HD 220735 (= Tycho 2237-986-1 = Gaia DR2 2839969578847249280). The first two columns show the ID and reddening $E(b-y)$; the third, fourth, fifth and sixth present the distance values from present paper, Tycho, Gaia DR2 and Distance corrected Gaia DR2, respectively.

To determine the range of the effective temperature and surface gravity in which the stars vary we must locate the determined unrreddened points in some theoretical grids such as those of Lester, Gray and Kurucz (1986, hereinafter LGK86) developed for $uvby$–β photometric data for several metallicities. Hence, in order to locate our unreddened points in the theoretical grids of LGK86, a metallicity has to be assumed. Due to their proximity to the Sun, the model we considered was, therefore, that of solar composition [Fe/H]= 0.0.

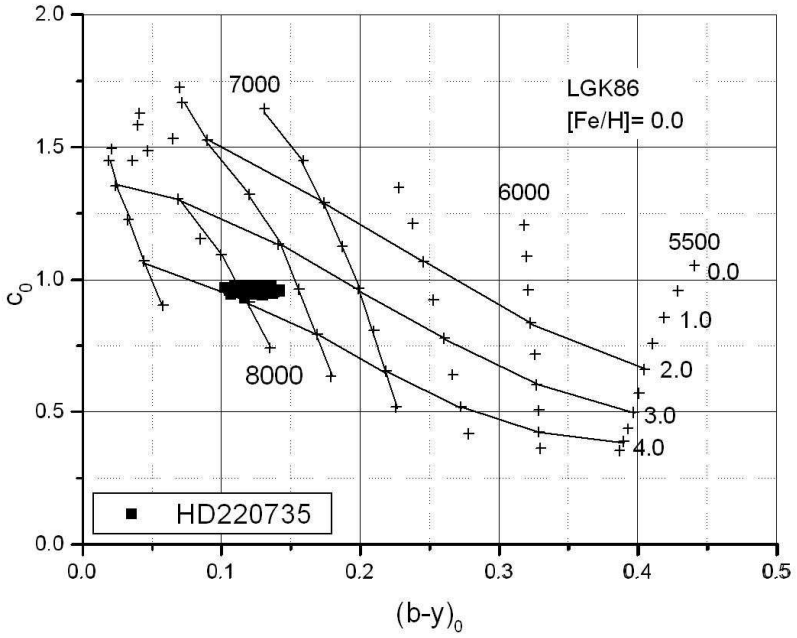

Figure 6. Position of the HD220735 star in the grids of LGK86.

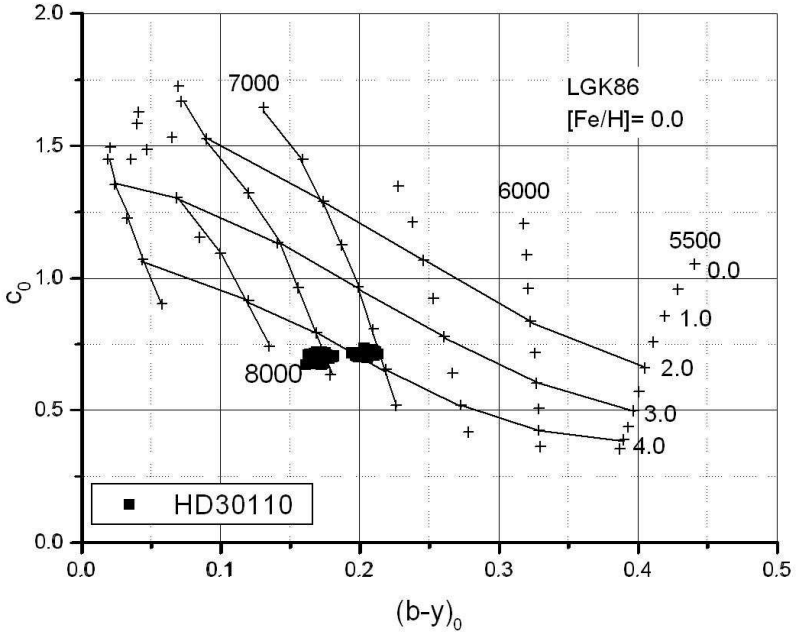

Figure 7. Position of the HD30110 star in the grids of LGK86.

As can be seen in Figures 6 and 7, in the case of [Fe/H] = 0.0 the HD 220735 star varies between an effective temperature of 7600 K and 8100 K; the surface gravity $\log g$ varies between 3.5 and 4.0. The other star, HD30110 has a temperature range that varies between 7000 and 7700 K and its surface gravity range is between 4 and 4.5

Table 7 lists these values. Column 1 shows the phase, column 2 lists the temperature obtained from the plot for each [Fe/H] value; column 3, the effective temperature obtained from the theoretical relation reported by Rodriguez (1989) based on a relation of Petersen & Jorgensen (1972, hereinafter P&J72) $T_e = 6850 + 1250 \times (\beta - 2.684)/0.144$ for each value and averaged in the corresponding phase bin and column 4, the mean value. Column 5 shows the surface gravity $\log g$ from the plot.

5 Conclusions

In the present study we have determined HD30110 and HD220375 to be not previously reported variable stars. Physical characteristics determined are consistent with the determined spectral type.

Acknowledgements. We would like to thank the staff of the OAN at SPM for their assistance in securing the observations and to the GAOOT group for fruitful discussions. This work was partially supported by PAPIIT IN104917 and PAPIME PE113016. Proofreading and typing were done by J. Miller and J. Orta, respectively. C. Villarreal, C. Guzmán, F. Ruiz, A. Díaz B. Juárez and G. Pérez assisted us at different stages. AAS thanks the IA for allotting the telescope time. The comments and suggestions of an anonymous referee improved this paper. We have made use of the SIMBAD databases operated at CDS, Strasbourg, France and NASA ADS Astronomy Query Form.

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