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HD 115520, A NEW δ SCUTI STAR

J. H. Peña,[1] J. P. Sareyan,[2] B. Cervantes-Sodi,[1] R. Peña,[3] M. Alvarez,[4] M. Cano,[1] and M. A. Sorcia[1]

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RESUMEN

En 2005, durante la observación con fotometría $uvby-\beta$ en el Observatorio Astronómico Nacional de México, de algunas estrellas RR de Lira en la constelación del Boyero, se observaron también algunas estrellas estándares, entre las cuales se encontraba HD 115520. Tras la reducción, esta estrella mostró indicaciones de variabilidad y esta conclusión se vio reforzada tras el análisis de los datos compilados sobre ella. En vista de ello, en 2006, se llevó a cabo una nueva temporada de observación gracias a la cual se demostró su variabilidad. En este trabajo presentamos tanto la fotometría como algunas conclusiones sobre su naturaleza que la establecen como una estrella del tipo δ Scuti.

ABSTRACT

While performing $uvby-\beta$ photoelectric photometry of some RR Lyrae stars in Bootes, acquired in 2005 at the Observatorio Astronómico Nacional, México, we also observed several standard stars, HD115520 among them. After the reduction this star showed indications of variability and a compilation of all the data of this star reinforced this conclusion. In view of this, a new observing run was carried out in 2006 during which we were able to demonstrate its variability. We present here the data we acquired as well as some conclusions on its nature as a δ Scuti star.

Key Words: **STARS: VARIABLES: δ SCUTI — TECHNIQUES: PHOTOMETRIC**

1. INTRODUCTION

Observing δ Scuti stars is most important as their multifrequency spectrum of radial pulsations provides strong constraints on the physics of the star's interior; so any new detection and observation of these stars is a valuable contribution to asteroseismology.

The discovery of new variables, particularly short period variables, occurs in many ways: through studies especially devoted to the detection of new variables, accidentally when taken as reference stars of observations of well-known variables and, as in this case, when the stars are systematically observed. After reducing a 2005 campaign on some RR Lyrae stars and while performing the analysis of the season to determine the goodness of the observations through the behavior of the observed standard stars to transform the data into the standard system, we realized that HD115520 showed a larger scatter than the other standard stars which was, in all cases, merely a few thousands magnitude. That of HD115520 was three times larger in the V filter.

Our goal was, in consequence, the confirmation of the suspected variability of the star; and once this was accomplished, it became the determination of its nature and its physical characteristics. Since we had acquired $uvby-\beta$ photoelectric photometry in 2005, we were able to determine its spectral type, A8V. However, given the scarce data (merely one point per day during 14 days), we were unable to decide on its nature. Nevertheless, the determined spectral type and the small amplitude of variation, suggested that this star might be a δ Scuti, but we were unable to confirm this assumption or to assign to it, even coarsely, a pulsation period. Hence, continuous monitoring of the star was needed and a new run was requested, devoted to the specific aim of determining its variability. The new observations in 2006 served to demonstrate this variability and to establish it as a δ Scuti star.

[1]Instituto de Astronomía, Universidad Nacional Autónoma de México, Mexico.

[2]Observatoire de la Cote d'Azur, France.

[3]Facultad de Ciencias, Universidad Nacional Autónoma de México, Mexico.

[4]Instituto de Astronomía, Universidad Nacional Autónoma de México, Ensenada, B. C., Mexico.

TABLE 1

SUMMARY OF PREVIOUSLY REPORTED OBSERVATIONS OF HD115520

V	$b-y$	m.e.	m_1	m.e.	c_1	m.e.	Nmes	Reference	Hβ	m.e.	Nmes
8.41	.121	~	.182	~	.760	~	4	Hill & Barnes, 1982	2.794		3
8.43	.132	~	.174	~	.741	~	2	Perry & Johnston, 1982	2.790		2
8.424	.125	.006	.181	.007	.762	.008	5	Olsen, 1983	2.790	.001	3
8.42								Oja, 1985			
8.45	.137	~	.175	~	.747	~	5	Crawford & Perry, 1989	2.791		4
	.128	.006	.179	.003	.755	.008	16	Hauck & Mermilliod, 1998	2.791	.00	12

2. BACKGROUND OF HD115520

There are few previous photoelectric measurements of this star (=BD+31 2468, HIP 64827). It is classified in SIMBAD as a normal $F0$ star of magnitude 8.42 mag. Among the photoelectric measurements there are those by Hill & Barnes (1982), Hill, Barnes, & Hilditch (1982), Olsen (1983) and Crawford & Perry (1989). Hipparcos, on the other hand, lists a V of 8.441 mag and a $B-V$ of 0.215, although it presents a possibility of variability given its $V_{\rm max}$ value of 8.44 and $V_{\rm min}$ value of 8.51 mag, with no period assigned. Its parallax is 3.29 mas. The compilation of the reported values for this star in the $uvby-\beta$ system is presented in Table 1, in which we can see that the photometric values are quite consistent with our finding of a relatively large scatter in the V filter beyond the accuracy of the photometry. However, since it was measured only a few times in the past, few points were obtained and its variability remained unexplored.

3. OBSERVATIONS

3.1. *Data Acquisition*

These were all taken at the Observatorio Astronómico Nacional, México. The 1.5-m telescope, to which a spectrophotometer was attached, was utilized in all seasons. The observations were carried out from June 2 to June 16, 2005 and from May 14 to May 16, 2006. But after the possible variability was established, we reviewed our observed material to find out in which other seasons it was observed. We discovered that it was used as a standard star on two other occasions, on March 31, 1999, and on March 2, 1997.

3.2. *Data reduction*

In each season the following observing routine was employed: a multiple series of integrations was carried out, consisting of five 10 s integrations of the star from which five 10 s integrations of the sky were subtracted. To transform the data into the standard system a series of standard stars was also observed on each night with the same procedure. The reduction of the season was canonical. Calculation of the values into the standard system was done in the following fashion: The standard photometric values utilized for the transformation were those listed by the Astronomical Almanac and from a list by Olsen (1983) to include fainter stars.

The coefficients defined by the following equations which adjusted the data to the standard system are:

$$
\begin{aligned}
V_{\rm std} &= A + B(b-y)_{\rm inst} + y_{\rm inst} \\
(b-y)_{\rm std} &= C + D(b-y)_{\rm inst} \\
m_{1_{\rm std}} &= E + F(m_1)_{\rm inst} + J(b-y)_{\rm inst} \\
c_{1_{\rm std}} &= G + H(c_1)_{\rm inst} + I(b-y)_{\rm inst} \\
H\beta_{\rm std} &= K + L(H\beta)_{\rm inst}
\end{aligned}
$$

In the above transformation equations the coefficients D, F, H and L are the slope coefficients for $(b-y)$, m_1, c_1 and β, respectively. B, J and I are the color term coefficients of V, m_1, and c_1. Table 2 presents the transformation coefficients. An estimation of the accuracy was done comparing the $uvby-\beta$ obtained data with those of the standard stars considered. The uncertainties were evaluated in the following manner: the average differences (present data minus standard data) were evaluated and provide an uncertainty for the transformation of the season; the standard deviations of these differences are presented in Table 3. The detailed description of obtaining the transformation coefficients of the 2005 season are presented elsewhere (Peña et al. 2007).

Table 3 lists all the observed standard stars in the 2005 season in all filters. Column 1 reports

TABLE 2

COEFFICIENTS OF THE TRANSFORMATION OF THE DATA INTO THE STANDARD SYSTEM

Season	B	D	F	J	H	I	L
1997	0.0087	1.0151	0.8880	0.0358	1.0853	0.3018	
1999	0.0698	1.0183	1.0594	0.0005	1.0509	0.2739	
2005	0.0209	0.9900	1.0740	0.0172	1.0353	0.1252	−1.3350
2006	−0.022	0.9597	1.0480	0.0055	1.0337	0.0383	

TABLE 3

MEAN VALUES AND STANDARD DEVIATIONS FOR ALL THE OBSERVED STANDARD STARS DURING THE 2005 SEASON

ID	V	$b-y$	m_1	c_1	σV	σby	σm_1	σc_1	N	Type
HD125607	8.097	0.563	0.384	0.346	0.009	0.012	0.013	0.011	15	constant
BS5270	6.177	0.627	0.097	0.455	0.009	0.005	0.002	0.006	2	constant
BS5717	6.276	0.000	0.143	1.045	0.009	0.004	0.005	0.016	12	constant
HD128165	7.211	0.574	0.558	0.254	0.007	0.005	0.006	0.025	15	constant
HD100600	5.935	−.073	0.109	0.303	0.007	0.009	0.012	0.021	9	constant
HD135662	8.724	0.337	0.153	0.472	0.005	0.004	0.006	0.010	14	constant
HD134169	7.680	0.362	0.115	0.303	0.005	0.024	0.025	0.016	14	constant
HD122563	6.170	0.621	0.091	0.436	0.003	0.007	0.010	0.042	11	constant
HD117243	8.338	0.397	0.200	0.389	0.003	0.007	0.002	0.007	2	constant
HD115520	8.413	0.127	0.168	0.751	0.015	0.006	0.004	0.011	15	New var

the ID of the stars, Columns 2 to 5 the average Strömgren values V, $b-y$, m_1 and c_1 respectively, whereas Columns 6 to 9 list the standard deviations obtained from the nightly observations. Column 10 lists the number of times the star was observed and Column 11 reports if the star is constant or variable. As can be seen from the standard deviations of the constant stars, regardless of their brightness and color, all are on the order of thousands of magnitude. On the other hand, those of HD115520 are a factor of three higher in V but of the same order in the indexes. To test this assertion we plotted the light curves of all the observed standard stars (Figure 1) and made a linear fit of all the data in the whole sample. Table 4 lists the coefficients of this fit, along with the correlation coefficient and the standard deviation of such fit. The last column lists the number of data points. As can be seen, HD115520 has discernible variability around the line of the fit. The star HD125607 also shows a standard deviation of such a magnitude that may be due to intrinsic variability. No further test for this star was carried out.

The only value of the 1999 season gives very consistent figures with respect to both the literature values and those obtained in the 2005 season.

In the 2006 season, besides the observation of HD115520, three more stars were observed to verify the variability of the star. They were C1, HD116879, an F5 star of magnitude 9.63; C2 was HD114311, of spectral type F6V and magnitude 9.03 and finally, C3, HD115045, B9 and 9.52, respectively. Just to remember, HD 115520 has a magnitude 8.42, hence the constancy found in the reference stars reinforces the suspition of variability of HD115520 since they are fainter. Its spectral type, although not unquestionably assigned (A by Perry & Johnston 1982; F0 by Hill 1982) is bracketed by those of the reference stars. The results of the two nights in 2006 on HD115520 are presented in Table 5, as in Table 3, with the average magnitudes and colors for HD115520 and the three reference stars, whereas Table 6 presents the averaged values of all seasons. As can be seen the standard deviation of $C2$ is as large as that of HD115520 which might suggest the possibility of a new variable. However, since we are analyzing only

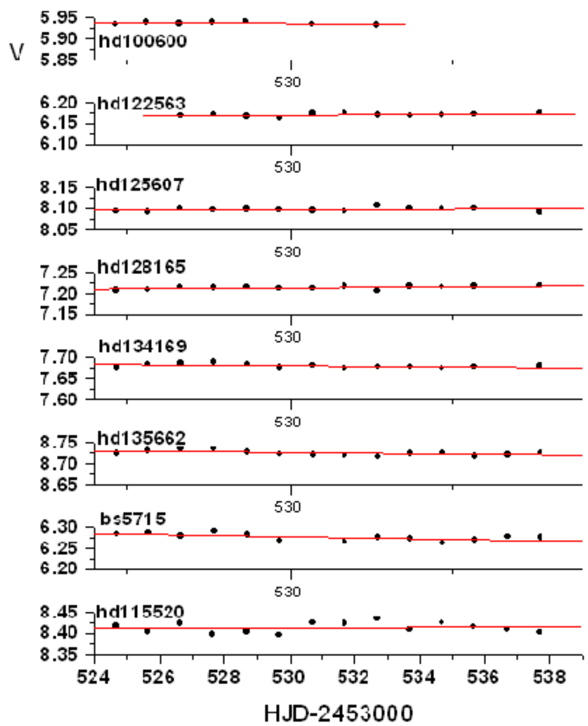

Fig. 1. Observed standard stars in the 2005 season. The continuous line represents a linear fit. As can be seen, the observations of HD115520 lie scattered around the straight line.

TABLE 4

LINEAR FIT COEFFICIENTS FOR STANDARD STARS OBSERVED IN 2005

Star	A	B	R	SD	N
HD100600	6.1584	$-4.19706E-4$	-0.3667	0.0033	7
HD122563	5.9660	$3.84285E-4$	0.3921	0.0033	11
HD125607	7.9580	$2.6206\ E-4$	0.2456	0.0044	13
HD128165	6.9552	$4.86855E-4$	0.4981	0.0036	13
HD134169	7.9784	$-5.61522E-4$	-0.4960	0.0042	13
HD135662	9.0917	$-6.91458E-4$	-0.5326	0.0048	14
BS5717	6.9085	-0.00119	-0.5970	0.0073	13
HD115520	8.2799	$2.50989E-4$	0.0932	0.0117	14

the absolute photometry of HD115520 the results are valid. The final $uvby-\beta$ photometry is reported in Table 9; the light curves are shown in Figure 2.

4. FREQUENCY DETERMINATION

Given the way the data were acquired in 2005, it was not possible to determine its true variability. We observed this star only once each night during the entire 2005 season; hence no short period variation of less than one day could be detected. With the relatively few data points acquired in the 2006 season, only two short nights, we were able to demonstrate its variability as seen in Figure 2. It is evident that the light curve beating behavior is the result of at least two close frequencies. Below we describe our attempt to determine them.

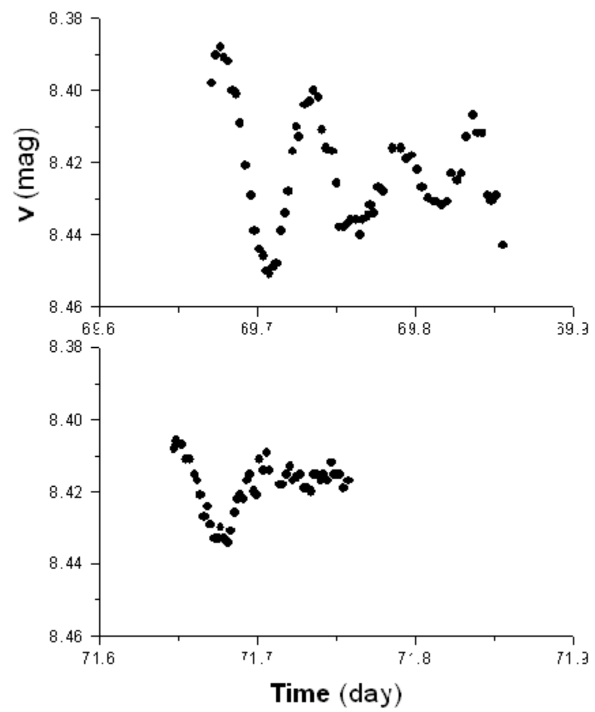

Fig. 2. V variation of the HD115520 star in 2006. Y axis is V in magnitudes, X axis is time (time shown=HJD-2453800.0).

4.1. *Cycle Counting*

From the light curves we determined times of maximum light at 69.678, 69.734, 69.791 and 69.838 on the first night, whereas on the second night we determined a clear maximum at 71.651 and possibly another one at 71.706 d. Differences between consecutive maxima yield a mean value around 0.0538 d, with a standard deviation of 0.0045. O-C diagrams were evaluated testing this period, which converged to a value of 0.0535 d. This figure corresponds to a frequency of 18.6915 c/d. An error of 0.0002 is determined considering the 38 cycles in an elapsed time span of 2.028 d.

4.2. *Fourier Analysis*

A more detailed evaluation of the period was done through the numerical package of PERIOD04 (Lenz & Breger 2005). The first night gave a dominant peak at 18.75 c/d later improved to 19.01 c/d,

TABLE 5

MEAN VALUES AND STANDARD DEVIATIONS FOR HD115520 AND REFERENCE STARS IN 2006

ID	V	σV	by	$\sigma(b-y)$	m_1	σm_1	c_1	σc_1	N
HD115520	8.421	0.013	0.140	0.003	0.168	0.003	0.808	0.012	117
C1	7.941	0.004	0.274	0.002	0.138	0.003	0.618	0.009	40
C2	9.032	0.012	0.341	0.003	0.145	0.004	0.437	0.008	37
C3	9.556	0.006	0.063	0.003	0.178	0.004	1.084	0.012	39

TABLE 6

COMPILATION OF THE SPM PHOTOMETRIC MEASUREMENTS OF HD115520

date	V	σV	by	$\sigma(b-y)$	m_1	σm_1	c_1	σc_1	β	N	observer
March, 1997	8.467		0.110		0.209		0.704		–	1	jhp,vc[1]
March, 1999	8.432		0.154		0.160		0.801		2.863	1	jhp
June, 2005	8.415	0.013	0.127	0.006	0.167	0.004	0.751	0.011	2.800	14	jhp,jps,ma,rpm,ms
May14, 2006	8.423	0.016	0.139	0.003	0.169	0.003	0.812	0.012	–	65	jhp,mc,bcs,mas
May16, 06	8.419	0.008	0.141	0.002	0.167	0.003	0.804	0.012	–	52	jhp

[1]vc: Víctor Costa, IAA, Spain.

whereas the second night gave 19.84 c/d, and the two nights together gave a frequency of 18.79 c/d, which was later prewhitened. This yielded a second and a third frequencies, F2 and F3, whose amplitudes and phases are listed in Table 7 and shown in Figure 3. Of course, we are aware that the scarce number of data points on only two relatively short nights implies aliasing problems. In Table 7, we list the goodness of the adjustment through the residuals. Furthermore, the frequency resolution taking the two nights is 0.3 c/d (Loumous & Deeming, 1978). To minimize the aliasing problem in the first frequency, we have tested the frequency obtained from the O-C results, 18.605 c/d. The improvement and prewhitening of this frequency yielded a better O-C value of 18.692 c/d, which gave frequencies F4 and F5 using PERIOD04. There is no way to discriminate between the two sets with such scarce data. However, the conclusion that can be drawn is that the light curve behavior can be explained with two relatively close frequencies, a fact which is common among δ Scuti stars.

5. PHYSICAL PARAMETERS

We carried out a well-known procedure to determine the reddening as well as the unreddened colors of our star. This analysis follows the method commonly utilized (see for example Peña, González, & Peniche 1999) and which is based on Nissen (1988). We used the photometric $uvby-\beta$ values reported in Table 9. The package gives the reddening, the unreddended indexes, the absolute magnitude, and the distance. Table 8 lists those values. They can be compared, for example, with those reported by Crawford & Perry (1989), which are listed in the last row of Table 8. Both results are consistent if we do not consider, being unphysical, the negative value for $E(b-y)$ that they report. Its position in the $[m_1]-[c_1]$ diagram establishes it as an A8V star. Its temperature and log of surface gravity can be determined by locating HD115520 in the $(b-y)_0$ vs. c_0 grids of Lester, Gray, & Kurucz (1986) (Figure 4); the values we determine are 7700 K and 4, respectively. The distance of 130 pc is of the same order of magnitude as that given by Hipparcos (300 pc).

A recent study on the rotation velocities of red and blue horizontal branch stars through spectroscopy and photometry by Behr (2003) included, deliberately, several stars that had previously been ruled out as true HB stars or were likely to be main-sequence A-stars "contaminants", in order to test their discrimination protocols and to confirm prior identifications. HD115520 was considered in this sample. They found for this star: an effective temperature T_{eff} of 8199 K (+449,−317); log g=4.63 (+0.34,−0.23); [Fe/H]=0.62 (±0.13) and a stellar type belonging to the main-sequence. These results

TABLE 7

OBTAINED FREQUENCIES WITH PERIOD04

	Frequency (c/d)	Amplitude (mag)	phase	residuals	HJD
F0	18.82	0.0130	0.2789		2453869
F1	14.63	0.01155	0.6438	0.0048	2453871
F2	18.00	0.01831	0.8100		whole set
F3	16.16	0.01442	0.6888	0.0044	whole set

TABLE 8

REDDENING, UNREDDENED VALUES, AND DISTANCE FOR HD115520

ID	$E(b-y)$	$(b-y)_0$	m_0	c_0	β	V_0	M_v	Distance modulus	Distance pc
Present Paper	0.000	0.156	0.168	0.751	2.791	8.41	2.89	5.53	127
Olsen 1983	0.000	0.156	0.181	0.762	2.790	8.42	2.77	5.65	135
Mean	0.000	0.156	0.175	0.753	2.791	8.43	2.87	5.56	129
Crawford & Perry 1989	−0.020	0.137	0.175	0.747	2.791	8.45	2.92	5.53	

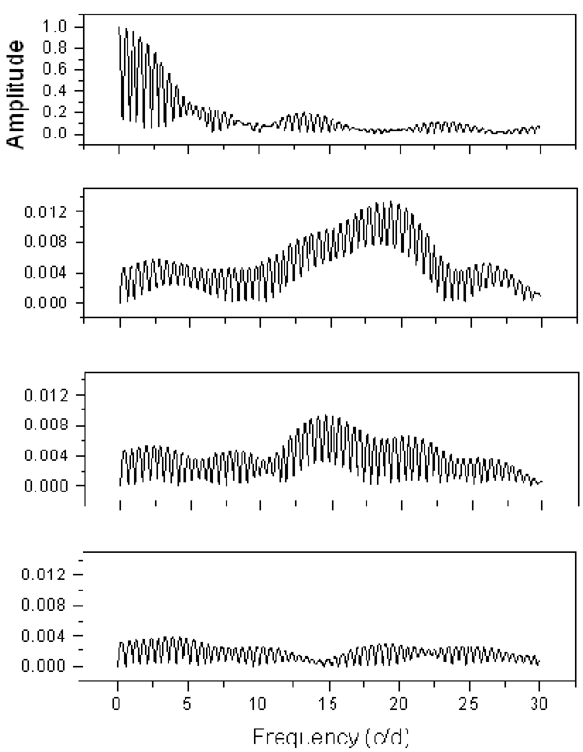

Fig. 3. Periodograms of the two consecutive nights. From top to bottom, window, first frequency obtained at 18.8217c/d, periodogram after prewhitening the 18.8217 with a peak at 14.6266c/d, and finally the prewhitened histogram of the two previously determined frequencies.

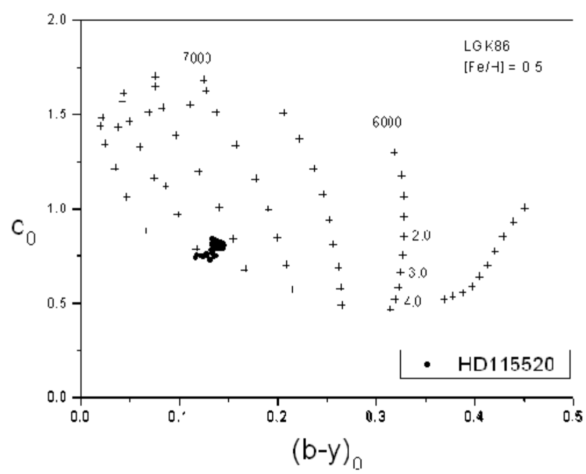

Fig. 4. Location of the photometric data of HD 115520 in the grids of LGK86.

are consistent with those obtained in the present Paper and have been employed to choose the metallicity used to discriminate between the models.

6. ON THE NATURE OF HD115520

What kind of object might HD115520 be? Rodriguez & Breger (2001) state that "δ Scuti stars are pulsating stars of short periods located in the lower part of the Cepheid instability strip, with luminosities ranging from the zero-age main sequence

TABLE 9

$uvby-\beta$ PHOTOELECTRIC PHOTOMETRY OF HD115520

V	$b-y$	m_1	c_1	time	β	time	V	$b-y$	m_1	c_1	time	β	time
8.423	0.134	0.163	0.764	524.6508	2.795	524.6503	8.431	0.138	0.169	0.802	869.8201		
8.410	0.118	0.163	0.756	525.6479	2.797	525.6473	8.423	0.138	0.169	0.802	869.8230		
8.423	0.117	0.165	0.739	526.6242	2.798	526.6235	8.425	0.137	0.170	0.818	869.8264		
8.398	0.121	0.169	0.748	527.6193	2.801	527.6187	8.423	0.135	0.170	0.817	869.8296		
8.405	0.128	0.166	0.768	528.6858	2.805	528.6840	8.413	0.134	0.169	0.808	869.8326		
8.410	0.127	0.174	0.760	529.6779	2.799	529.6757	8.407	0.137	0.166	0.811	869.8368		
8.428	0.129	0.174	0.758	530.6866	2.804	530.6859	8.412	0.134	0.171	0.815	869.8395		
8.429	0.138	0.160	0.750	531.6847	2.803	531.6843	8.412	0.138	0.167	0.811	869.8422		
8.433	0.134	0.168	0.761	532.6998	2.795	532.6978	8.429	0.141	0.165	0.820	869.8460		
8.408	0.133	0.162	0.780	533.6755	2.797	533.6736	8.431	0.138	0.170	0.813	869.8486		
8.430	0.132	0.167	0.728	534.6715	2.798	534.6709	8.431	0.138	0.170	0.813	869.8486		
8.419	0.129	0.165	0.752	535.6668			8.429	0.145	0.162	0.815	869.8515		
8.440	0.136	0.168	0.745	536.6884	2.792	536.6874	8.443	0.138	0.171	0.806	869.8553		
8.397	0.124	0.172	0.747	537.6760	2.816	537.6750	8.408	0.138	0.173	0.812	871.6470		
8.398	0.135	0.172	0.836	869.6713			8.406	0.139	0.170	0.831	871.6492		
8.390	0.137	0.171	0.836	869.6736			8.407	0.142	0.164	0.825	871.6523		
8.388	0.135	0.174	0.829	869.6764			8.411	0.139	0.167	0.827	871.6545		
8.391	0.134	0.173	0.836	869.6788			8.411	0.138	0.172	0.819	871.6572		
8.392	0.137	0.169	0.836	869.6817			8.415	0.141	0.169	0.826	871.6603		
8.400	0.134	0.172	0.839	869.6844			8.417	0.140	0.169	0.823	871.6623		
8.401	0.138	0.172	0.832	869.6867			8.421	0.138	0.172	0.817	871.6642		
8.409	0.137	0.169	0.837	869.6890			8.427	0.139	0.171	0.810	871.6665		
8.421	0.136	0.171	0.829	869.6926			8.424	0.143	0.167	0.815	871.6685		
8.429	0.141	0.170	0.818	869.6961			8.429	0.145	0.166	0.814	871.6703		
8.439	0.142	0.166	0.824	869.6982			8.433	0.144	0.165	0.808	871.6729		
8.444	0.142	0.169	0.806	869.7013			8.433	0.144	0.167	0.791	871.6750		
8.446	0.144	0.168	0.806	869.7033			8.430	0.147	0.161	0.806	871.6768		
8.450	0.145	0.167	0.810	869.7053			8.433	0.143	0.168	0.801	871.6793		
8.451	0.144	0.170	0.803	869.7079			8.434	0.143	0.169	0.803	871.6814		
8.449	0.144	0.170	0.802	869.7102			8.431	0.143	0.167	0.805	871.6832		
8.448	0.144	0.169	0.802	869.7122			8.426	0.146	0.160	0.812	871.6856		
8.439	0.145	0.166	0.796	869.7150			8.422	0.144	0.167	0.796	871.6875		
8.434	0.142	0.169	0.797	869.7174			8.421	0.143	0.166	0.804	871.6892		
8.428	0.144	0.166	0.811	869.7196			8.422	0.141	0.171	0.794	871.6915		
8.417	0.141	0.170	0.791	869.7222			8.417	0.143	0.167	0.803	871.6934		
8.410	0.140	0.170	0.795	869.7246			8.415	0.141	0.168	0.793	871.6952		
8.413	0.141	0.167	0.815	869.7267			8.420	0.137	0.173	0.796	871.6977		
8.404	0.136	0.172	0.810	869.7301			8.421	0.141	0.166	0.823	871.6994		
8.403	0.138	0.169	0.811	869.7329			8.411	0.140	0.169	0.786	871.7013		
8.400	0.140	0.167	0.821	869.7354			8.414	0.140	0.166	0.811	871.7038		
8.402	0.137	0.169	0.810	869.7389			8.409	0.140	0.170	0.798	871.7057		
8.411	0.135	0.172	0.809	869.7414			8.414	0.143	0.161	0.817	871.7076		
8.416	0.139	0.167	0.827	869.7436			8.418	0.137	0.170	0.803	871.7159		
8.417	0.137	0.171	0.811	869.7473			8.415	0.143	0.161	0.811	871.7183		
8.426	0.137	0.168	0.811	869.7499			8.413	0.144	0.162	0.798	871.7209		
8.438	0.139	0.168	0.822	869.7520			8.417	0.140	0.169	0.795	871.7226		
8.438	0.139	0.169	0.800	869.7552			8.416	0.143	0.165	0.799	871.7250		
8.437	0.141	0.166	0.815	869.7575			8.415	0.141	0.168	0.792	871.7273		
8.436	0.140	0.167	0.807	869.7595			8.419	0.139	0.168	0.800	871.7294		
8.436	0.142	0.166	0.803	869.7624			8.419	0.140	0.167	0.798	871.7317		
8.440	0.140	0.169	0.806	869.7647			8.420	0.139	0.168	0.802	871.7340		
8.436	0.144	0.164	0.799	869.7668			8.415	0.140	0.168	0.786	871.7357		
8.435	0.141	0.166	0.805	869.7696			8.415	0.142	0.162	0.801	871.7381		
8.432	0.138	0.169	0.802	869.7718			8.417	0.139	0.169	0.789	871.7402		
8.434	0.142	0.166	0.814	869.7739			8.415	0.140	0.166	0.800	871.7419		
8.427	0.141	0.166	0.815	869.7766			8.417	0.137	0.170	0.786	871.7442		
8.428	0.139	0.169	0.807	869.7794			8.412	0.137	0.171	0.790	871.7468		
8.416	0.139	0.168	0.806	869.7856			8.415	0.139	0.167	0.801	871.7486		
8.416	0.138	0.170	0.802	869.7911			8.415	0.139	0.164	0.803	871.7508		
8.419	0.135	0.174	0.795	869.7942			8.415	0.138	0.167	0.803	871.7527		
8.418	0.143	0.164	0.814	869.7978			8.419	0.140	0.163	0.806	871.7547		
8.422	0.141	0.164	0.809	869.8017			8.417	0.139	0.169	0.784	871.7579		
8.427	0.143	0.165	0.812	869.8043			8.426	0.140	0.166	0.803	871.7651		
8.430	0.140	0.168	0.796	869.8079			8.436	0.139	0.167	0.785	871.7670		
8.431	0.141	0.165	0.807	869.8112									
8.431	0.139	0.170	0.792	869.8136			8.421	0.139	0.168	0.802	mean	2.800	
8.432	0.139	0.170	0.802	869.8170			0.013	0.005	0.003	0.021	std dev	0.006	

(ZAMS) to about 2 mag above the main sequence, with spectral types ranging from about A2 to F2”.

All our findings support the idea that HD115520 fulfills these criteria. Its location on the period vs. color magnitude $M_v - 8.46(b-y)$ diagram (Breger 1979) with values (1.55, 0.054) is consistent with Breger (1979).

If we assume it to be a δ Scuti star, it is possible to establish the pulsational characteristics. Its pulsational constant Q is given by

$$\log Q = -6.454 + \log P + 0.5 \log g + 0.1 M_{\rm bol} + \log T_eff\,. \quad (1)$$

Of course, without a mode identification of this frequency its radial order cannot be determined (m=0 is required to apply Equation 1). Moreover, the absolute value of the period cannot give any information about its radial order without a comparison with seismic models. Considering a bolometric correction of 0.11 mag for a main sequence star of 7700 K and the previously reported values for P, $\log g$, M_v and T_{eff}, a Q of 0.029 is determined. This value, and the period of 0.0535 d, establish HD115520 as a δ Scuti star pulsating in the first overtone (Breger 1979); the period ratio suggests that it might also be a non-radial pulsator, but more information on the periods would be needed before this conclusion can be confirmed.

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REFERENCES

Behr, B. B. 2003, ApJS, 149, 101
Breger, M. 1979, PASP, 91, 5
Crawford, D. L., & Perry, C. L. 1989, PASP, 101, 601
Hauck, B., & Mermilliod, M. 1998, A&AS, 129, 431
Hill, G. 1982, Publ. Dominion Astroph. Obs., 16, No. 9, 87
Hill, G., & Barnes, J. V. 1982, Publ. Dominion Astroph. Obs., 16, No. 7, 71
Hill, G., Barnes, J. V., & Hilditch, R. W. 1982, Publ. Dominion Astroph. Obs., 16, No. 10, 111
Lenz, P., & Breger, M. 2005, Comm. Asteroseismology, 146, 53
Lester, J. B., Gray, R. O., & Kurucz, R. I. 1986, ApJ, 61, 509
Loumos, G. L., & Deeming, T. J. 1978, Ap&SS, 256, 285
Oja, T. 1985, A&AS, 61, 331
Olsen, E. H. 1983, A&AS, 54, 55
Nissen, P. 1988, A&A, 199, 146
Peña, J. H., Arellano Ferro, A., Peña, R., & Sareyan, J. P. 2007, in preparation
Peña, J. H., González, D., & Peniche, R. 1999, A&AS, 138, 11
Perry, C. L., & Johnston, L. 1982, ApJS, 50, 451
Rodríguez, E., & Breger, M. 2001, A&A, 366, 178

M. Alvarez: Instituto de Astronomía, Universidad Nacional Autónoma de México, Apdo. Postal 877, 22830 Ensenada, B. C., Mexico (alvarez@astrosen.unam.mx).
M. Cano, B. Cervantes-Sodi, J. H. Peña, and M. A. Sorcia: Instituto de Astronomía, Universidad Nacional Autónoma de México, Apdo. Postal 70-264, 04510 México, D. F., Mexico (mcano, bcervant, jhpena, msorcia@astroscu.unam.mx).
R. Peña: Laboratorio de Cibernética, Facultad de Ciencias, Universidad Nacional Autónoma de México, 04510 México, D. F., Mexico (rafael@ciencias.unam.mx)
J. P. Sareyan: Observatoire de la Cote d'Azur, Dpt. Gemini, Route de L'Observatoire, UMR 6203, BP 4229, 06304 Nice Cedex 04, France (Jean-Pierre.Sareyan@obspm.fr).