

# V2109 Cygni, a second overtone field RR Lyrae star

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**Abstract.** We present the first (as of February, 1999) *UBV* and *wby* photometric measurements for the short period variable star V2109 Cyg discovered by the Hipparcos satellite and classified as a field RRc variable. We have obtained new times of maxima and the period change has been studied. We determined the fundamental physical parameters using the geometric distance of the star and the most recent synthetic colour grids. The results are:

$$[\text{Fe}/\text{H}] = -0.9 \pm 0.2, M_{\text{bol}} = 0.73 \pm 0.43 \text{ mag}, \langle T_{\text{eff}} \rangle = 6800 \pm 200 \text{ K}, \log g = 2.7 \pm 0.2, R = 4.6 \pm 0.9 R_{\odot}.$$

Additionally, we took medium resolution ( $\lambda/\Delta\lambda \approx 11000$ ) spectra in the red spectral region centered at 6600 Å. A complete radial velocity curve has been determined from 60 spectra. We found no systematic difference between the velocities from H $\alpha$  and metallic lines indicating a smooth pulsation. The mass of the star is found to be  $M = 0.5 \pm 0.3 M_{\odot}$  using the photometric *logg* value and the acceleration curve calculated from the radial velocity data. The finally adopted set of the physical parameters lies in the typical range of RR Lyrae stars, which implies that V2109 Cyg is the shortest period RR Lyrae-type variable. The visual amplitude vs. period and the Fourier amplitude parameter  $R_{21}$  vs. period diagrams suggest that V2109 Cyg probably pulsates in the second overtone mode.

**Key words:** stars: fundamental parameters – stars: individual: V 2109 Cyg – stars: oscillations – stars: variables: RR Lyr

## 1. Introduction

V2109 Cyg (=HD191635,  $\langle V \rangle = 7.49$ ,  $\Delta V = 0.16$ ,  $P = 0^{\text{d}}18605$ ) was discovered by the Hipparcos satellite (ESA 1997) and was classified as an RRc variable based on the observed properties. Its period is shorter than that of the shortest period RR Lyrae variable in the 4th edition of the General Catalogue of Variable Stars (V1407 Sgr, RRc,  $P = 0^{\text{d}}218689$ ). Furthermore, its brightness places the star among the brightest RR Lyrae-type variables known. In fact, only RR Lyrae itself is brighter around maximum light and S Eri, which classification is quite uncertain (S Eri – RRc:,  $P = 0^{\text{d}}27$ , spectral type F0IV).

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The short period of V2109 Cyg falls far beyond the typical range observed in RRc variables. Several authors claimed for similarly short-period (between  $0^{\text{d}}21$ - $0^{\text{d}}28$ ) RRc stars in globular clusters that they may be second overtone RR Lyrae (RRe) variables (e.g. Clement et al. 1979, Walker 1994, Walker & Nemec 1996). Stothers (1987) concluded, based on his hydrodynamical calculations, that second overtone pulsators probably do not exist among RR Lyrae type stars. Recently, Kovács (1998) argued the second overtone interpretation of the observed short-period RRc stars in globular clusters and in LMC (Alcock et al. 1996) using the Fourier decomposition of the suspected RRe stars. He suggested that the earlier candidate RRe stars are ordinary RRc variables at the short-period end of the instability strip.

We started a long-term observational project of Strömgren photometry of the newly discovered bright Hipparcos variables in 1998. We have chosen V2109 Cyg because of its brightness, period and theoretical importance. Since the period, spectral type and light curve amplitude alone do not exclude the possibility of wrong classification (i.e. there are a few high-amplitude  $\delta$  Scuti stars with similar photometric parameters – see e.g. Kiss et al. 1999, Rodríguez et al. 1998), accurate determination of the fundamental physical parameters is highly desirable.

The main aim of this paper is to present the first *UBV* and *wby* photometry for V2109 Cyg. Also, our radial velocity measurements are the first time-resolved spectroscopic observations of this star to date. The paper is organised as follows: the photometric and spectroscopic observations are described in Sect. 2. Sect. 3 deals with the detailed multicolour photometric analysis and the determination of fundamental physical parameters, while the mode of pulsation is discussed in Sect. 4.

## 2. Observations

### 2.1. Photometry

The photometric observations were carried out on 5 nights during August–November, 1998 using the 0,4 m Cassegrain-type telescope of Szeged Observatory. The detector was a single-channel Optec SSP-5A photoelectric photometer equipped with *UBV* and *wby* filters supplied by the manufacturer. We made differential photometry in respect to HD191022 ( $V=7.44$ ,  $B - V=0.66$ ,  $b - y=0.41$ ,  $m_1=0.20$ ,  $c_1=0.38$ ). The resulting

**Table 1.** The journal of observations

Julian Date	type
2451032	<i>uvby</i>
2451037	<i>uvby</i>
2451080	<i>uvby</i>
2451087	<i>UBV</i>
2451106	spectr.
2451108	spectr.
2451110	<i>UBV</i>

overall accuracy is about  $\pm 0.01$  for  $V$  and  $B - V$ ,  $\pm 0.015$  for  $U - B$  and  $b - y$ ,  $\pm 0.025$  for  $m_1$  and  $c_1$ . This considerably large scatter is due to the frequent atmospheric instabilities caused by the nearby city of Szeged. Fortunately the large number of individual points (468 in *uvby*, 178 in *UBV* colours) allowed the calculation of accurate normal curves<sup>1</sup>. The light, colour and radial velocity curves (Sect. 2.2.) were phased using the finally adopted period  $P = 0^d 186049$  and epoch  $\text{Hel.JD}(\text{max.}) = 2451032.3936$  and can be seen in Fig. 1 (see Sect. 3.1. for the period analysis).

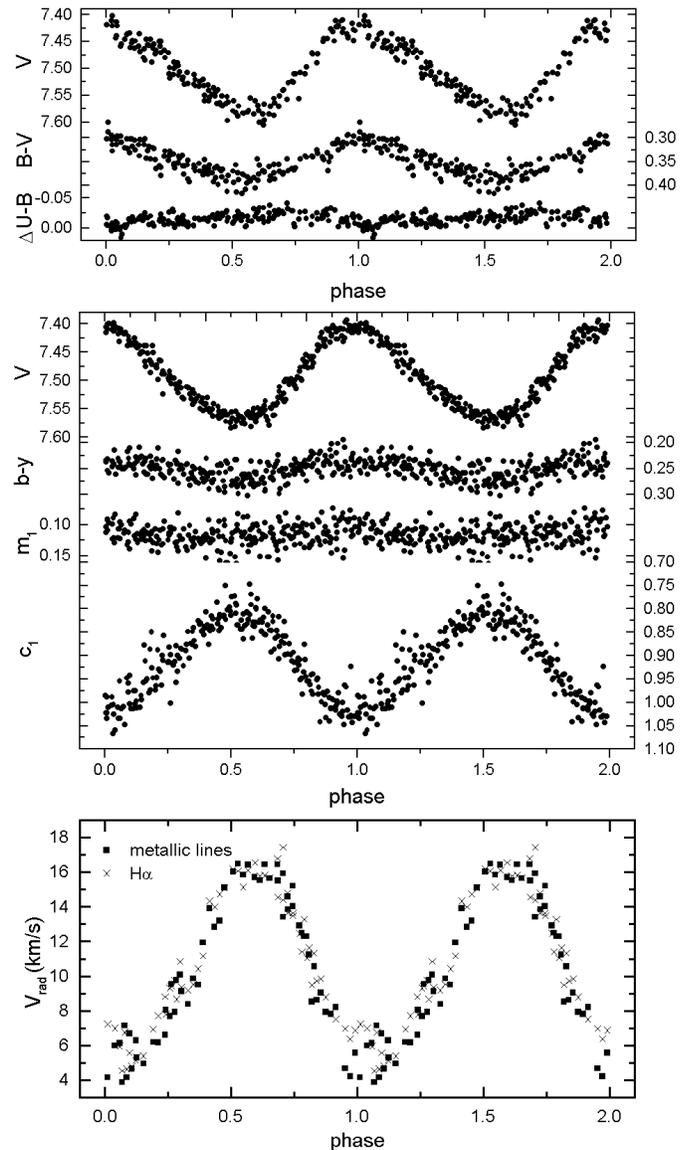
## 2.2. Spectroscopy

The spectroscopic observations were carried out at David Dunlap Observatory with the Cassegrain spectrograph attached to the 74'' telescope. The detector and the spectrograph setup was the same as used by Vinkó et al. (1998). The resolving power ( $\lambda/\Delta\lambda$ ) was 11,000 and the signal-to-noise ratio reached about 60.

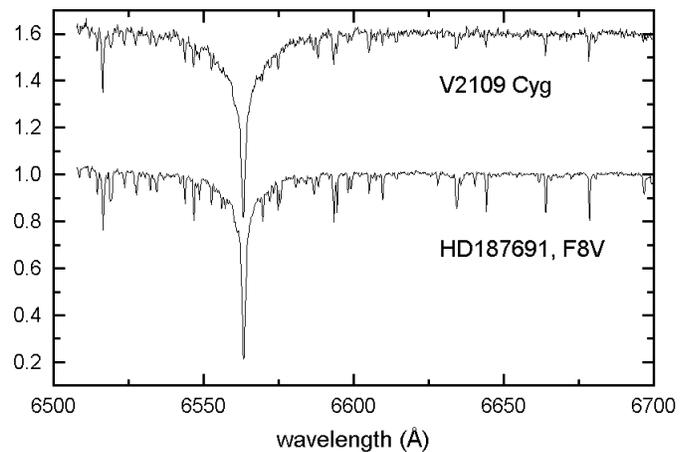
The spectra were reduced with standard IRAF tasks, including bias removal, flat-fielding, cosmic ray elimination, order extraction (with the task *doslit*) and wavelength calibration. For the latter, two FeAr spectral lamp exposures were used, which were obtained immediately before and after every four stellar exposures. The sequence of observations FeAr-var-var-var-var-FeAr was chosen because of the short period of V2109 Cyg. Careful linear interpolation between the two comparison spectra has been applied in order to take into account the sub-pixel shifts of the four stellar spectra caused by the movement of the telescope. The exposure time was fixed as 5 minutes, which corresponds to 0.02 in phase, avoiding phase smearing of the radial velocity curve. The spectra were normalized to the continuum by fitting cubic spline, omitting the region of  $\text{H}\alpha$ .

Radial velocities were determined by cross-correlating parts of the spectra of V2109 Cyg with the spectrum of the IAU standard velocity star HD187691, using the IRAF task *fxcor*. The spectral type and radial velocity of HD187691 are F8V and  $+0.1 \pm 0.3 \text{ km s}^{-1}$ . The cross-correlated regions were [6550–6580] ( $\text{H}\alpha$ ) and [6580–6700] Å (photospheric metal lines). Typical spectra of V2109 Cyg and HD187691 are presented in Fig. 2.

<sup>1</sup> Individual photometric data are available upon request from the first author (l.kiss@physx.u-szeged.hu).



**Fig. 1.** The light, colour and radial velocity curves phased according to the adopted ephemeris.



**Fig. 2.** Sample spectra of V2109 Cyg and HD187691.

**Table 2.** The observed heliocentric radial velocities from the two cross-correlated spectral region.

Hel. J.D.	$V_{\text{rad}}(\text{H}\alpha)$	$V_{\text{rad}}(\text{m.})$	Hel. J.D.	$V_{\text{rad}}(\text{H}\alpha)$	$V_{\text{rad}}(\text{m.})$	Hel. J.D.	$V_{\text{rad}}(\text{H}\alpha)$	$V_{\text{rad}}(\text{m.})$
2451106.4859	7.8	8.1	2451106.5687	14.6	15.5	2451106.8044	7.0	4.7
2451106.4902	9.4	9.6	2451106.5723	14.4	13.4	2451106.8081	6.4	4.2
2451106.4938	8.7	9.8	2451106.5760	13.7	13.8	2451106.8117	6.9	5.6
2451106.4975	9.4	9.1	2451106.5796	13.7	14.0	2451106.8153	7.2	4.1
2451106.5025	9.2	8.4	2451106.5863	11.4	12.5	2451106.8203	7.0	6.0
2451106.5062	9.5	9.9	2451106.5899	11.1	12.3	2451106.8240	6.0	6.1
2451106.5098	10.4	9.5	2451106.5936	9.5	8.5	2451106.8276	6.7	7.1
2451106.5135	11.2	11.9	2451106.5972	9.7	8.6	2451106.8313	5.6	6.7
2451106.5183	14.3	13.9	2451106.7543	16.8	16.4	2451106.8360	5.1	6.3
2451106.5220	14.0	12.8	2451106.7584	17.4	15.9	2451108.5002	4.5	3.9
2451106.5256	14.7	13.1	2451106.7620	14.8	14.5	2451108.5038	4.6	4.2
2451106.5293	15.1	15.1	2451106.7657	13.5	15.2	2451108.5074	4.8	4.7
2451106.5356	16.2	16.0	2451106.7705	12.5	12.9	2451108.5111	5.3	5.3
2451106.5393	16.1	16.4	2451106.7741	13.3	12.2	2451108.5160	5.4	5.0
2451106.5429	15.1	15.8	2451106.7778	11.7	11.2	2451108.5233	6.9	6.2
2451106.5466	16.1	16.4	2451106.7814	11.3	10.5	2451108.5269	7.7	6.2
2451106.5516	16.6	15.7	2451106.7864	9.8	9.0	2451108.5320	8.8	6.6
2451106.5552	15.8	15.5	2451106.7901	8.8	7.9	2451108.5356	9.3	7.7
2451106.5589	15.8	16.4	2451106.7937	7.9	7.8	2451108.5393	9.8	7.9
2451106.5625	15.7	15.6	2451106.7974	7.5	8.2	2451108.5429	10.8	10.0

The observed heliocentric radial velocities are presented in Table 2. The velocimetric accuracy is about  $\pm 1\text{--}1.5 \text{ km s}^{-1}$ , which was estimated by the residual scatter of the measurements around a fitted low-order Fourier polynomial. This equals 0.1 pixel uncertainty which could be associated with the limited accuracy of the wavelength calibration, as well as the slightly different spectral types of V2109 Cyg and HD187691. Fortunately, the latter affects the resulting radial velocities less significantly, as almost all of the metallic lines in the spectrum of HD187691 can also be identified in V2109 Cyg.

We have found no significant systematic difference between the velocities of the two cross-correlated regions, which means that the velocity gradient between the atmospheric regions of H $\alpha$  and metallic lines does not exceed our accuracy (see Vinkó et al. 1998 concerning this comparison for Type II Cepheid variables).

### 3. Photometric analysis

#### 3.1. Period

The photometric period was studied by means of standard Fourier analysis and the classical O–C diagram. We have calculated the Discrete Fourier Transform for all measurements made through V filter. The DFT spectrum showed a principal peak at  $f_0 = 5.37488 \text{ c/d}$  ( $P=0^{\text{d}}18605$ ), in good agreement with the Hipparcos-period ( $0^{\text{d}}1860656$ ). After prewhitening with this frequency and its harmonics, the resulting periodogram did not contain any significant peak (Fig. 3). This suggest the mono-periodic nature of V2109 Cyg.

We have obtained four times of maxima using V light curves (Table 3). An O–C analysis was performed in order to refine the period value (see a recent application of this technique in Kaszás

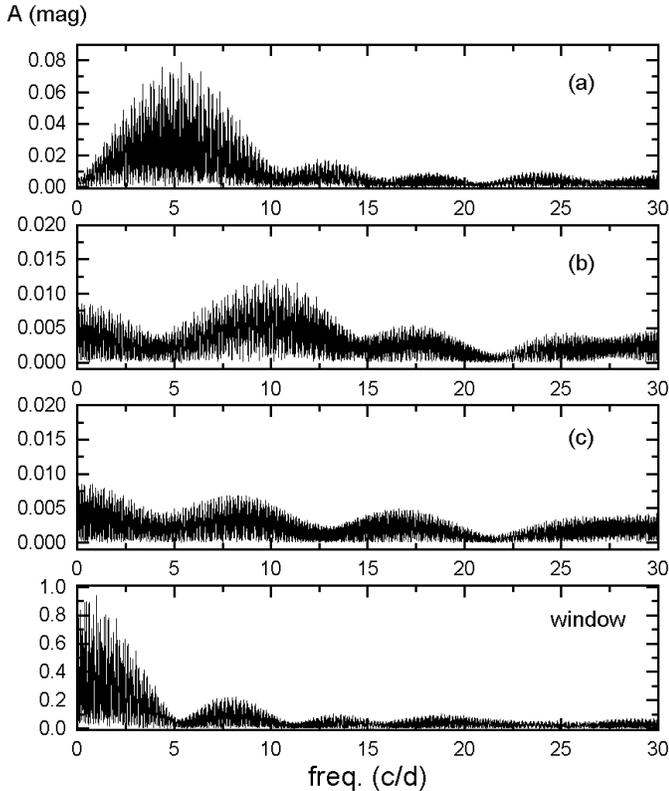
**Table 3.** New times of maxima of V2109 Cyg.

i	$T_i(\text{HJD})$
1	2451032.3936
2	2451037.4134
3	2451080.3928
4	2451110.3465

et al. 1998). The original ephemeris from Hipparcos photometry ( $E_0=2448500.0280$ ,  $P=0^{\text{d}}1860656$ ) was used to construct the top panel in Fig. 4 (the error bars associated to our data points correspond to a  $\pm 0^{\text{d}}002$  uncertainty, this relatively high value is due to the flat top of the light curve). The positive shift in this diagram suggest a somewhat *longer* period than that published by ESA (1997). The middle panel shows the recalculated O–C values using a period corrected with the slope of the top diagram ( $P=0^{\text{d}}1860662(3)$ ). However, there can be seen some hints of systematic decreasing trend in our new O–C points, suggesting a *shorter* period. The corrected O–C diagram is presented in the bottom panel of Fig. 4 ( $P=0^{\text{d}}186049(5)$ ). The last period is in better agreement with the result of the Fourier analysis, therefore we conclude that the recent period is  $0^{\text{d}}186049 \pm 0^{\text{d}}000005$ , and, assuming that the Hipparcos data were phased properly, a sudden period decrease happened between 1991 and 1998. Follow-up observations are needed to clarify the present state of period change.

#### 3.2. Strömgren calibrations – physical parameters

In order to minimize the effect of the observational scatter, we used the normal curves (Table 4) of the light and colour variations to infer physical parameters of V2109 Cyg.



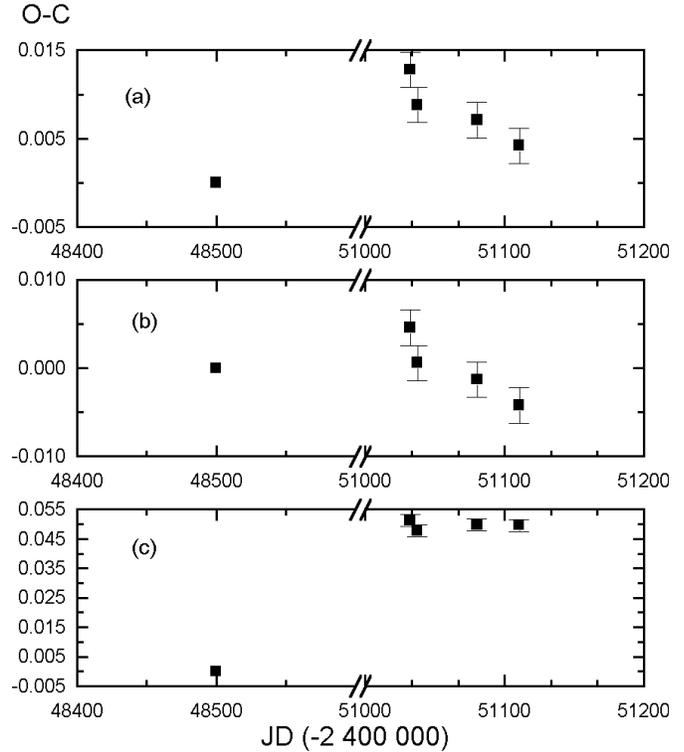
**Fig. 3a–c.** The DFT amplitude spectrum with a principal peak  $f_0$  **a**, the prewhitened spectrum with  $f_1 = 2f_0$  **b** and the remaining periodogram with no significant peak **c**. The window function is shown separately (*bottom panel*).

The geometric distance of V2109 Cyg, as measured by the Hipparcos satellite, is  $205 \pm 40$  pc. To convert the distance and the apparent magnitude to absolute magnitude, one has to include the effect of interstellar reddening.

The colour excess was estimated: *i*) using a spectral type–colour relation for an F0 star; *ii*) using intrinsic colour calibrations based on the Strömgren indices.

The dereddened  $B - V$  colour of an F0-type star is  $(B - V)_0 = 0.30$  (Carroll & Ostlie 1996). The mean  $B - V$  colour of V2109 Cyg is  $0.35 \pm 0.01$  mag, thus, a resulting colour excess is  $E(B - V) = 0.05$ . This value has quite large uncertainty (at least  $\pm 0.03$  mag), since the spectral type cannot be determined as precise as  $\pm 2$  subclass and consequently, the  $(B - V)_0$  might differ  $\pm 0.03$ – $0.05$  mag.

Two Strömgren calibrations were applied to obtain the intrinsic  $(b - y)_0$  colour. Crawford (1975) and Olsen (1988) presented  $uvby - \beta$  calibrations for F-type stars. Since we have no  $\beta$ -measurements, we have to estimate the actual value of  $\beta$  index using the different relations of Strömgren indices vs.  $\beta$  (see Figs. 1, 3 and 6 in Crawford 1975). All of them suggest  $\beta \approx 2.70$  with  $\pm 0.02$  uncertainty. Adopting this value, final calibration equations of Crawford (1975) and Olsen (1988) give  $E(B - V) = 0.00$  and  $E(B - V) = -0.02$ , respectively (a ratio of  $E(b - y)/E(B - V) \approx 0.7$  was used). The simple average of these reddenings is  $E(b - y) = 0.006$ , while a weighted mean



**Fig. 4a–c.** The O–C diagram of V2109 Cyg with three ephemerides. **a** original ephemeris; **b** assuming constant period over the time base; **c** assuming sudden period jump between the older and recent observations (note the break in the horizontal axis and large positive O–C values).

assigning a larger weight to the spectral-type–colour relation (3-1-1 – because of the very uncertain determination of the  $\beta$  index) is  $E(B - V) = 0.03 \pm 0.02$ . Fortunately, the star lies in a considerably close vicinity and, consequently, its reddening is not expected to have a large value. The total visual absorption,  $A_V$ , due to this reddening probably does not exceed 0.10 mag.

The calculated visual absolute magnitude corrected for interstellar absorption is  $0.83 \pm 0.43$  mag, while the bolometric absolute magnitude ( $BC(F0) = -0.10$ , Carroll & Ostlie 1996) is  $0.73 \pm 0.43$  (the uncertainty is mainly due to the error of the distance). This gives  $41 \pm 15 L_\odot$  for the luminosity of the star.

The metallicity, expressed with the  $[\text{Fe}/\text{H}]$  value, was determined by Eq. (2) of Malyuto (1994), which involves  $b - y$  and  $m_1$  indices. The mean  $b - y$  ( $=0.255$ ) and  $m_1$  ( $=0.112$ ) values give  $[\text{Fe}/\text{H}] = -0.9 \pm 0.2$  for V2109 Cyg, which suggests a relatively metal rich field RR Lyrae star. The high luminosity also strengthens the classification (see below for further discussion).

The atmospheric parameters  $T_{\text{eff}}$  and  $\log g$  were obtained using the most recent synthetic colour grids of Kurucz (1993). The use of  $(b - y)_0 - (c_1)_0$  colour–colour diagram is shown in Fig. 5, where the normal points presented in Table 4 are plotted. The corresponding  $T_{\text{eff}} - \log g$  pairs were determined by a two-dimensional linear interpolation, resulting in  $\langle T_{\text{eff}} \rangle = 6800 \pm 200$  K and  $\langle \log g \rangle = 2.7 \pm 0.2$  dex. It can be seen in Fig. 5 that the points run almost parallel with the lines of con-

**Table 4.** Strömrgren photometry (normal points) of V2109 Cyg.

phase	V	b - y	m <sub>1</sub>	c <sub>1</sub>
0.00	7.407	0.242	0.104	1.017
0.05	7.414	0.240	0.109	1.007
0.10	7.430	0.237	0.113	0.998
0.15	7.450	0.242	0.115	0.962
0.20	7.468	0.246	0.119	0.927
0.25	7.493	0.247	0.118	0.919
0.30	7.512	0.252	0.120	0.901
0.35	7.530	0.260	0.124	0.864
0.40	7.544	0.265	0.122	0.838
0.45	7.557	0.263	0.125	0.821
0.50	7.565	0.265	0.123	0.814
0.55	7.565	0.270	0.118	0.815
0.60	7.560	0.270	0.119	0.819
0.65	7.549	0.264	0.119	0.840
0.70	7.529	0.260	0.116	0.867
0.75	7.497	0.254	0.112	0.906
0.80	7.473	0.243	0.114	0.941
0.85	7.439	0.236	0.117	0.983
0.90	7.419	0.242	0.111	1.007
0.95	7.411	0.245	0.104	1.008

stant temperature, indicating that the colour variation is mainly caused by the changing gravity, not the variation of the temperature.

Combining the mean temperature, luminosity and solar values  $T_{\text{eff}} = 5770$  K and  $M_{\text{bol}} = 4.75$  (Allen 1976), we calculated the mean stellar radius  $R_* = 4.6 \pm 0.9 R_{\odot}$ . By means of effective gravity

$$g_{\text{eff}} = G \frac{M_*}{R_*^2} + p \frac{dV_r}{dt}$$

where  $p=1.36$  is the geometric projection factor (e.g. Burki & Meylan 1986), we obtain a stellar mass of  $M_* = 0.5 \pm 0.3 M_{\odot}$ . In summary, therefore, we adopt

$$M_V = 0.83 \pm 0.43 \text{ mag}$$

$$M_{\text{bol}} = 0.73 \pm 0.43 \text{ mag}$$

$$L = 41 \pm 15 L_{\odot}$$

$$[\text{Fe}/\text{H}] = -0.9 \pm 0.2$$

$$\langle T_{\text{eff}} \rangle = 6800 \pm 200 \text{ K}$$

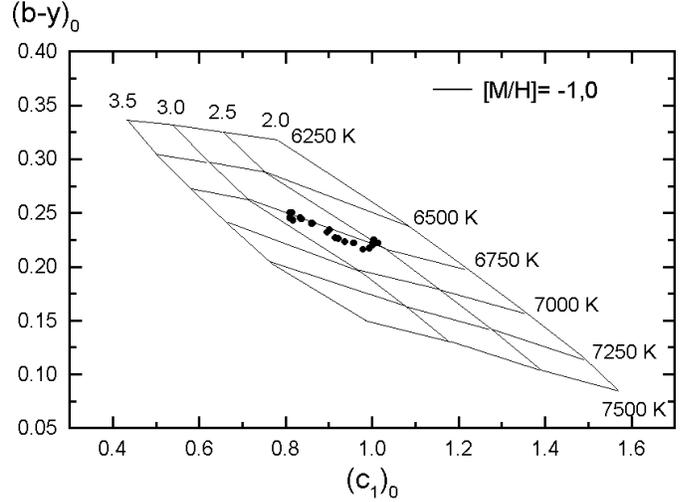
$$\langle \log g \rangle = 2.7 \pm 0.2 \text{ dex}$$

$$\langle R_* \rangle = 4.6 \pm 0.9 R_{\odot}$$

$$M_* = 0.5 \pm 0.3 M_{\odot}$$

#### 4. V2109 Cyg: a second overtone RR Lyrae

V2109 Cyg was classified as an RRc star based on the Hipparcos data. However, both the period and the shape of the V light curve resemble to those of a high-amplitude  $\delta$  Scuti star, too. But the finally adopted set of the physical parameters lies in the typical range of RR Lyrae properties. For instance, one of the brightest and nearest RRc stars, DH Peg (Fernley et al. 1990) has

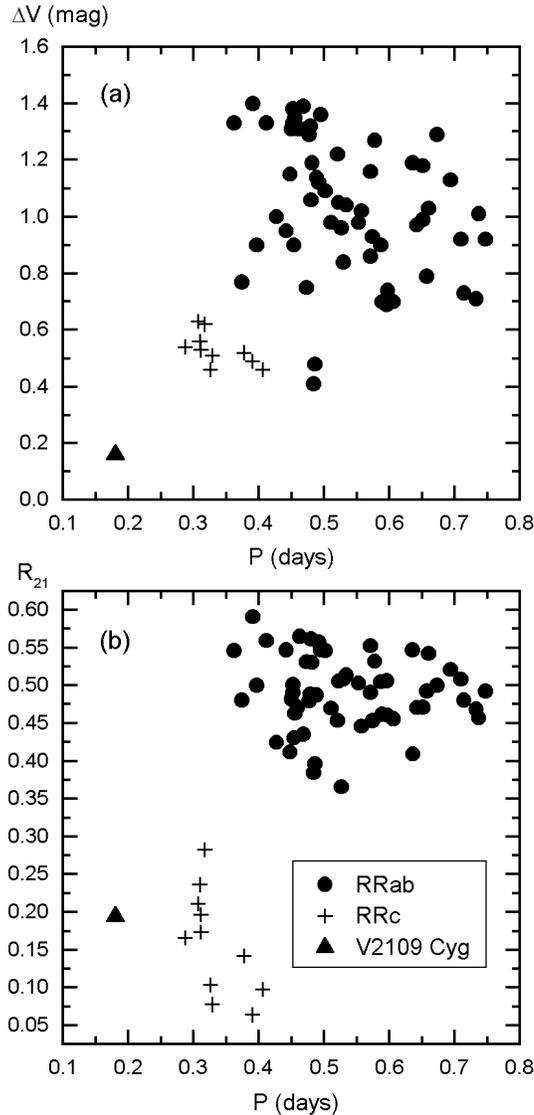
**Fig. 5.** The observed colour-colour variations plotted on the synthetic grid of Kurucz (1993).

almost the same parameters than V2109 Cyg (DH Peg:  $\langle T_{\text{eff}} \rangle = 7070 \pm 210$  K,  $\langle R_* \rangle = 4.4 \pm 0.9 R_{\odot}$ ,  $M_{\text{bol}} = 0.65 \pm 0.40$ ).

The relatively large radius and low mass also exclude the dwarf Cepheid possibility, since typical values of  $\langle R_* \rangle$  and  $M_*$  for these stars are  $1.5\text{--}3.0 R_{\odot}$  and  $1\text{--}1.5 M_{\odot}$  (Fernley et al. 1987). Also the small colour variation indicates very small change in the effective temperature during the pulsational cycle. Both high-amplitude  $\delta$  Scuti and SX Phoenicis stars exhibit at least 600–800 K variation, while the difference between the maximum and minimum photometric temperature in V2109 Cyg is only 100 K.

As has been mentioned in the Introduction, the period of V2109 Cyg is shorter than the shortest period of an RR Lyrae star listed in GCVS. This raises the question of the mode of the pulsation, since there are some pieces of evidence for ultra-short period RR Lyrae stars identified as candidate RRe stars in some globular clusters (e.g. Walker & Nemeč 1996).

We plot the the visual amplitude of V2109 Cyg versus the period in Fig. 6a with field RRab and RRc stars taken from Simon & Teays (1982). Accepting that RRab and RRc stars are fundamental and first-overtone pulsators, the position of V2109 Cyg strongly suggests a possibility of a second overtone variation. Fig. 6b shows the Fourier amplitude ratio parameter  $R_{21}$  (0.19 for V2109 Cyg) for the same sample. Again, V2109 Cyg lies far from the two populated regions of RRab and RRc variables. The mentioned value for  $R_{21}$  was calculated from the Johnson V data, as Simon & Teays (1982) used V-observations. The Strömrgren y (transformed to V) data give slightly different result of  $R_{21}=0.12$ , but the difference does not affect our conclusions. Fig. 6a has essentially the same structure than e.g. Figs. 2–3 of Sandage (1981), where this distribution is plotted for two globular clusters (M3 and  $\omega$  Cen), illustrating that it is a general property of RR Lyrae variables. To our knowledge, there is no similar study concerning the Fourier decomposition of the observed radial velocity curves, only Simon (1985) studied theoretical velocity curves of different pulsational modes. Plotting



**Fig. 6a and b** A comparison of the visual amplitude vs. period **a** and Fourier amplitude parameter  $R_{21}$  vs. period **b** for V2109 Cyg and field RRab and RRc variables.

$R_{21}(\text{rad. vel.})=0.13$  for V2109 Cyg in Fig. 5 of Simon (1985), the position is similarly deviant from the first-overtone models as in the photometric case.

Furthermore, we can compute the pulsational constant, although its usefulness is questionable being a complex function of mass, temperature, luminosity, metallicity, etc. For  $P = 0.18605$ ,  $R = 4.6 \pm 0.9 R_{\odot}$  and  $M = 0.5 \pm 0.3 M_{\odot}$  we get  $Q = P(M/R^3)^{1/2} = 0.013 \pm 0.009$ . This small pulsational constant could be a sign of the second overtone mode (we recall Fernley et al. 1990 for a similar discussion on the real nature of DH Peg).

Finally, the second overtone interpretation fits very well the recent theoretical results by Kovács (1997) and Kovács (1998). Kovács (1997) examined the possibility of the existence of second overtone RR Lyrae stars employing the results of linear non-adiabatic (LNA) and evolutionary calculations. He failed

to explain the 0.28 day peak in the MACHO RR Lyrae sample (Alcock et al. 1996) as a result of the second overtone stars, since the different parameter combinations and the calculated growth rates of the first and second overtone modes excluded strongly excited second overtone mode with period around 0.28 day. However, LNA calculations suggested strong excitation of the second overtone mode for short ( $\leq 0.23$  days) period with high temperature and low luminosity. On the other hand, combining the evolutionary parameters with the results of LNA calculations, Kovács (1997) concluded that the only possible scenario is the one when the star evolves from low temperatures and loses its stability in the fundamental pulsation. One can find different parameter settings where both the first and second overtones have stable limit cycles and it is possible that the second overtone switches on instead of the first one. In the second paper, Kovács (1998) tested the second overtone candidates in M68 and IC 4499 and found that in a parameter regime of  $M/M_{\odot} = 0.65 \pm 0.20$ ,  $L/L_{\odot} = 50 \pm 20$  and  $T_{\text{eff}} = 6500 \pm 500$  the resulting second overtone periods lie close to 0.22 days with an error of 0.03 days. Both period and determined physical parameters of V2109 Cyg fall in the ranges suggested by these theoretical calculations, strongly supporting our hypothesis.

## 5. Summary

Based on the conclusions presented in the previous sections, we can summarize our results:

1. We present the first continuous *UBV* and *uvby* photometry of the newly discovered bright Hipparcos variable V2109 Cyg. We obtained the radial velocity curve based on medium-resolution spectroscopy. Our spectroscopic observations clearly show that V2109 Cyg is indeed a pulsating variable.
2. The reddening of the star was determined with different photometric methods, resulting in  $E(B-V)=0.03 \pm 0.02$ . The metallicity value from the Strömgen calibration of Malyuto (1994) is  $[\text{Fe}/\text{H}]=-0.9 \pm 0.2$ , suggesting a relatively metal rich field RR Lyrae star.
3. Using the parallax measured by the Hipparcos satellite and the most recent synthetic grids of Kurucz (1993), we have determined the fundamental physical parameters (luminosity, effective temperature and surface gravity, mean radius, mass) which are typical among the RR Lyrae variables.
4. We suggest that V2109 Cyg probably pulsates in the second overtone. This conclusion is based on the following pieces of evidence. First, its period is the shortest one among the classified RR Lyrae stars. Second, the occupied position on the  $\Delta V$  vs. period and  $R_{21}$  vs. period diagrams is highly deviant both from the RRc and RRab variables. This deviation is in the same direction and distance where one can expect the location of the second overtone pulsators. Third, recent theoretical results concerning the second overtone pulsation in RR Lyrae stars suggested such a parameter range that corresponds exactly to those ones derived for V2109 Cyg. The small value of the pulsational constant ( $Q=0.013$ ) also supports this hypothesis.

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