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SHORT TIME SCALE PERIOD VARIATIONS OF THE RRc STAR V468 Hya

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Introduction

The high luminosity and large age of RR Lyrae type variables make them ideal distance indicators and tracers for the study of the structure and kinematics of old Galactic subsystems – the halo and the thick disk. However, the number of RR Lyrae variables in the extended solar neighbourhood with both precise photometry and bona fide radial velocities is rather limited – a total of about 400 stars (Dambis et al. 2013). That is why we started a program aimed at obtaining photometric observations and radial-velocity measurements for the greatest possible number of RR Lyraes.

To ensure very efficient use of limited spectroscopic resources, for radial-velocity measurements of each star we use single-epoch spectra obtained with the Southern African Large Telescope (SALT). Ideally, the spectroscopic observation of every object should be accompanied by photometric observations carried out at the same time to construct the current light curve of the star and calculate the phase of the spectroscopic observation. This phase is needed to determine the systemic radial velocity using an appropriate template radial velocity curve. Alternatively, we have to study period variations for every object and determine the phases of spectroscopic observations using $O-C$ diagram or use some recently published light elements (ephemeris).

In this paper we give the results of a study of period changes for RRc star V468 Hya. To construct its $O-C$ diagram, we used Hertzsprung's (1919) method (whose computer implementation is described by Berdnikov (1992)) to reduce our own CCD observations obtained with the 76-cm and 1-m telescopes of the South African Astronomical Observatory (SAAO) as well as the data from NSVS (Wils et al. 2006), ASAS-3 (Pojmanski 2002), and CATALINA (Drake et al. 2013) surveys.

Table 1 lists the inferred $O-C$ values. The first and second columns give the inferred time of maximum brightness and its standard error, respectively; the third column gives the type of observations used; the fourth and fifth columns give the number of epoch, E,

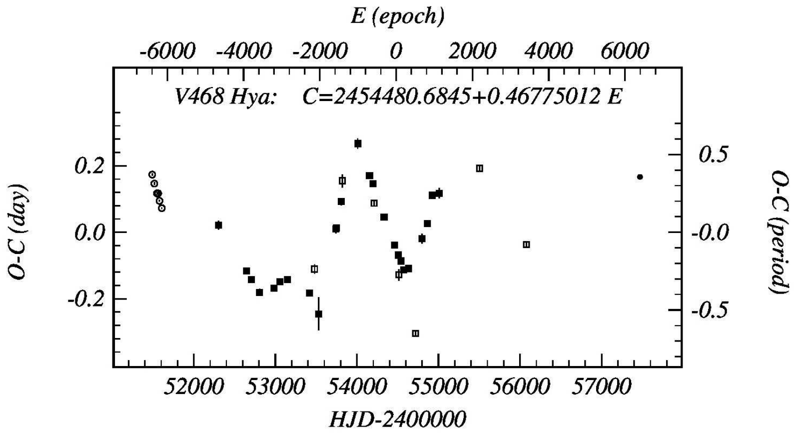

Figure 1. $O-C$ diagram of V468 Hya.

and the $O-C$ residual (in days), and the sixth and seventh columns give the number of observations, N, and the data source.

The data from Table 1 are shown in the $O-C$ diagram (Fig. 1) by different symbols with vertical error bars (which are usually smaller than symbols): open and filled circles for NSVS and our observations respectively, and open and filled squares for CATALINA and ASAS-3 data respectively. We used the following mean light elements (ephemeris):

$$HJDMax = 2454480.6845 + 0\overset{\text{d}}{.}46775012\ E. \tag{1}$$

The resulting $O-C$ diagram can be represented as a sequence of many straight-line fragments, and this behaviour is indicative of many abrupt period changes. It is worth noting that only the central part of the diagram is reliable because epoch miscalculations are possible in big gaps at its ends.

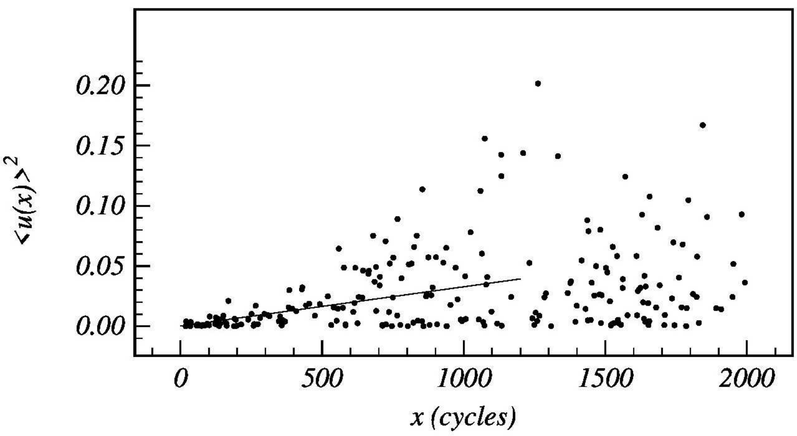

Figure 2. Relation between the square of the mean accumulated delay $\langle u(x) \rangle$, and the difference in the cycle number x, for V468 Hya. The line shows the fit of relation(2) for $x < 500$, giving the random period fluctuation $\varepsilon = 0\overset{\text{d}}{.}0057 \pm 0\overset{\text{d}}{.}0022$.

Table 1: Times of maximum brightness of V468 Hya

Max HJD	Error, *days*	Band	E	$O-C$, *days*	N	Data source
2451490.0636	0.0037	V	−6394	0.1734	25	Wils et al. (2006)
2451516.2306	0.0041	V	−6338	0.1464	25	Wils et al. (2006)
2451547.5404	0.0030	V	−6271	0.1169	25	Wils et al. (2006)
2451563.4439	0.0054	V	−6237	0.1169	25	Wils et al. (2006)
2451579.3250	0.0026	V	−6203	0.0945	25	Wils et al. (2006)
2451607.3681	0.0028	V	−6143	0.0726	33	Wils et al. (2006)
2452301.4583	0.0131	V	−4659	0.0216	24	Pojmanski (2002)
2452645.5838	0.0046	V	−3923	−0.1169	26	Pojmanski (2002)
2452707.7694	0.0032	V	−3790	−0.1422	25	Pojmanski (2002)
2452807.8295	0.0106	V	−3576	−0.1805	25	Pojmanski (2002)
2452980.4412	0.0070	V	−3207	−0.1687	25	Pojmanski (2002)
2453056.7036	0.0076	V	−3044	−0.1495	25	Pojmanski (2002)
2453147.4548	0.0091	V	−2850	−0.1419	25	Pojmanski (2002)
2453419.6450	0.0044	V	−2268	−0.1823	25	Pojmanski (2002)
2453480.5240	0.0132	V	−2138	−0.1107	12	Drake et al. (2013)
2453530.4385	0.0492	V	−2031	−0.2455	25	Pojmanski (2002)
2453740.2460	0.0126	V	−1583	0.0099	25	Pojmanski (2002)
2453748.6685	0.0102	V	−1565	0.0129	35	Drake et al. (2013)
2453810.0227	0.0103	V	−1434	0.0919	25	Pojmanski (2002)
2453819.4407	0.0195	V	−1414	0.1549	17	Drake et al. (2013)
2454010.3947	0.0153	V	−1006	0.2668	21	Pojmanski (2002)
2454154.3652	0.0052	V	−698	0.1703	25	Pojmanski (2002)
2454194.5675	0.0057	V	−612	0.1461	25	Pojmanski (2002)
2454211.3475	0.0088	V	−576	0.0870	12	Drake et al. (2013)
2454332.9205	0.0058	V	−316	0.0450	25	Pojmanski (2002)
2454464.2749	0.0049	V	−35	−0.0383	25	Pojmanski (2002)
2454505.4068	0.0043	V	53	−0.0685	25	Pojmanski (2002)
2454512.3634	0.0170	V	68	−0.1281	24	Drake et al. (2013)
2454540.0024	0.0043	V	127	−0.0864	25	Pojmanski (2002)
2454575.9930	0.0052	V	204	−0.1125	25	Pojmanski (2002)
2454633.0620	0.0094	V	326	−0.1091	15	Pojmanski (2002)
2454718.9331	0.0079	V	510	−0.3039	70	Drake et al. (2013)
2454797.7999	0.0149	V	678	−0.0192	26	Pojmanski (2002)
2454863.3304	0.0100	V	818	0.0264	25	Pojmanski (2002)
2454921.8840	0.0092	V	943	0.1112	25	Pojmanski (2002)
2455010.2951	0.0157	V	1132	0.1174	25	Pojmanski (2002)
2455502.9108	0.0066	V	2185	0.1923	25	Drake et al. (2013)
2456078.9497	0.0089	V	3417	−0.0370	33	Drake et al. (2013)
2457471.6452	0.0037	V	6394	0.1664	11	This paper

We analyzed the $O-C$ residuals for each maximum r, which we denoted as $z(r)$, for the presence of random fluctuations of the pulsation period using the method described by Eddington and Plakidis (1929). For this purpose, we calculated the delays $u(x) =\mid z(r+x)-z(r)\mid$ for maxima separated by x cycles. According to Eddington and Plakidis (1929), the mean value, $\langle u(x)\rangle$, is related to the random fluctuation of the period, ε, by the formula

$$\langle u(x)\rangle^2 = 2\alpha^2 + x\varepsilon^2, \tag{2}$$

where α characterizes the amount of random error in the measured epochs of maximum brightness.

Figure 2 shows the results of our calculations, which indicate the presence of a linear trend of $\langle u(x)\rangle^2$ for cycle number differences $x < 500$, where formal fit of formula (1) gives the solution

$$\langle u(x)\rangle^2 = 0.154\ 10^{-3}\ (\pm 0.279\ 10^{-2}) + 0.326\ 10^{-4}\ (\pm 0.49\ 10^{-5})\ x,$$

so that $\alpha = 0^{\rm d}\!.009 \pm 0^{\rm d}\!.037$, which is close to the mean uncertainty of the epochs of maximum brightness (second column of Table 1). The derived mean period fluctuation,

$\varepsilon = 0\overset{\text{d}}{.}0057 \pm 0\overset{\text{d}}{.}0022$ satisfies the combined dependence of ε on the period for all pulsating variables (Turner et al. 2009).

Thus, our data are indicative of the presence of big random period fluctuations $\varepsilon/P \approx 0.012$ dominating the $O - C$ diagram, which demonstrates no signs of periodicity. This diagram demonstrates how unsafe it is to use the published ephemeris to calculate the phase of spectroscopic observations.

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