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# A SUDDEN PERIOD CHANGE IN THE RRc VARIABLE GSC 6199-0755

WILS, P.[1]; OTERO, S.A.[2]; HAMBSCH, F.-J.[1,3]

[1] Vereniging Voor Sterrenkunde, Belgium; e-mail: patrickwils@yahoo.com

[2] Grupo Wezen 1 88, Centro de Estudios Astronómicos (CEA); e-mail: varsao@fullzero.com.ar

[3] Bundesdeutsche Arbeitsgemeinschaft für Veränderliche Sterne e.V. (BAV), Germany;
e-mail: hambsch@telenet.be

The All Sky Automated Survey (*ASAS-3*; Pojmanski & Maciejewski, 2004) found the star ASAS 155552-2148.6 = GSC 6199-0755 to be a new first overtone RR Lyrae (RRc) variable with a period of 0.254144 days (coordinates for equinox 2000.0: $\alpha = 15^{h}55^{m}51\overset{s}{.}59$, $\delta = -21^\circ 48' 32\overset{''}{.}8$). However, phase plots show that it is impossible to find one single fixed period to fit the *ASAS-3* data for the years 2001–2006 and the data from the Northern Sky Variability Survey (*NSVS*; Wozniak et al., 2004) for the years 1999 and 2000. This indicates that the period has changed in the interval. In general, the study of period changes in variable stars is based on $O-C$ diagrams. These studies are often hindered by large gaps between observations, as they cause difficulties to obtain unambiguous cycle counts. For GSC 6199-0755 this is not a problem since eight years of nearly continuous data exist.

To further investigate the period of this star, the two *NSVS* data sets were shifted by 0.14 magnitude to align them with the *ASAS-3* data set. Heliocentric correction of the *NSVS* times of observations were taken into account. No attempt was made to convert the red sensitive *NSVS* magnitudes to the $V$ system of *ASAS-3*. The amplitude of the star in the *NSVS* data is therefore slightly less than in $V$. In addition FJH collected data of this star with a 50-cm Ritchey–Chrétien telescope with an unfiltered STL11000XM CCD camera during 11 nights early 2007. Fig. 1 gives the phase plot of all available data using the average period for the total observing interval. The data have been plotted with a different symbol for each year. Uncertainties on the magnitude values (not plotted for clarity) are generally of the order of 0.03 magnitude for the survey data, and about 0.01 mag for the data of FJH. The latter are presented in the plot as averages of 5 consecutive data points. It is obvious that there is a considerable phase shift over the years.

The period change was studied in more detail in two ways. First normal maxima were calculated for each of the eight available years. The light curve of GSC 6199-0755 shows a hint of a short pre-maximum hump that is often seen in other RRc stars as well. This is fairly obvious from our recent data. There is an indication that the magnitude of this hump varies from cycle to cycle, but this has to be investigated further. This hump also makes it difficult to get a reliable time of maximum for the years with less data. Since there is no indication that the general shape of the light curve has changed over the

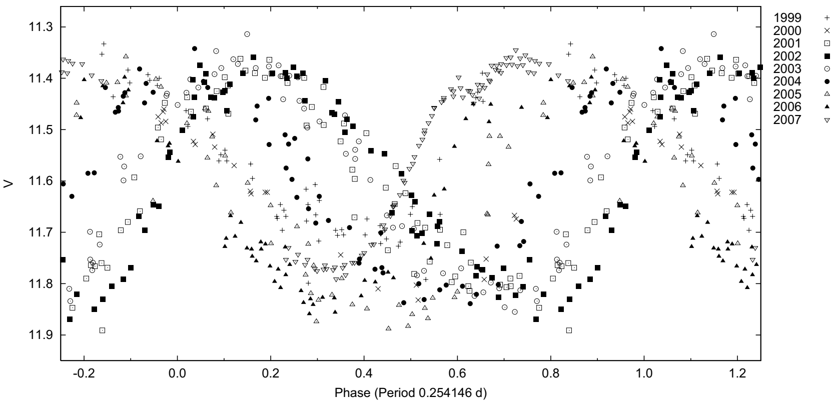


**Figure 1.** Phase plot of GSC 6199-0755 with one fixed period for the years 1999–2000 (*NSVS*), 2001–2006 (*ASAS-3*), 2007 (HMB)

years, a model curve (a Fourier series with the main frequency and two harmonics) was therefore calculated from the *ASAS-3* data for 2002. This model was then fitted to the data of the other years to get a time of maximum (allowing for differences in amplitude for the unfiltered data), giving a consistent set of maxima timings over the years. The calculated times of maxima are presented in Table 1. Uncertainties of these times are of the order of 0.01 days or better.

Table 1: Normal times of maximum of GSC 6199-0755

| HJD − 2450000 | $E$ | $O-C$ (1) | $O-C$ (2) | $O-C$ (3) | $O-C$ (4) | Source |
|---|---|---|---|---|---|---|
| 1313.554 | −2912 | −0.062 | −0.011 | +0.000 | | NSVS |
| 1614.752 | −1727 | −0.022 | −0.005 | −0.000 | | NSVS |
| 2053.713 | 0 | +0.037 | +0.018 | +0.000 | | ASAS-3 |
| 2396.567 | 1349 | +0.054 | +0.019 | | −0.003 | ASAS-3 |
| 2834.948 | 3074 | +0.040 | +0.001 | | +0.007 | ASAS-3 |
| 3129.477 | 4233 | +0.019 | −0.013 | | +0.002 | ASAS-3 |
| 3518.032 | 5762 | −0.009 | −0.020 | | −0.005 | ASAS-3 |
| 3812.566 | 6921 | −0.025 | −0.011 | | −0.006 | ASAS-3 |
| 4174.964 | 8347 | −0.033 | +0.022 | | +0.005 | HMB |

Using these times of maximum a linear and a parabolic ephemeris were calculated. These are given below with formal uncertainties on the last digit between brackets.

$$\mathrm{HJD(Max)} = 2452053.677(15) + 0.254142(3) \times E, \qquad (1)$$

$$\mathrm{HJD(Max)} = 2452053.695(7) + 0.254157(3) \times E - 2.9(4) \times 10^{-9} E^2. \qquad (2)$$

The $O-C$ values for both sets of elements are given in Table 1, those for the linear ephemeris are also plotted in Fig. 2, together with the calculated parabolic elements.

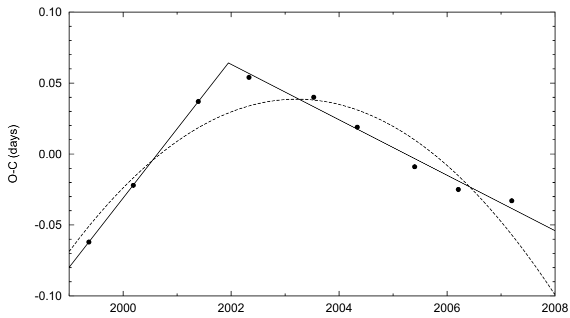


**Figure 2.** $O - C$ plot for GSC 6199-0755 with the period of equation (1). Also given are the parabolic elements (dashed line) and line segments (solid lines) corresponding to the elements with a sudden period change

From the latter a period decrease $dP/dt = 0.72 \pm 0.11$ s/yr would follow, much higher than what is expected from evolutionary considerations (Smith, 1995). However, neither the linear nor the parabolic ephemeris gives a good fit to the available times. Fig. 2 rather suggests an abrupt period change at the end of 2001. Fitting linear elements for these two intervals results in the following equations:

$$\mathrm{HJD(Max)} = 2452053.713(1) + 0.2541756(1) \times E \tag{3}$$

before JD 2452258 and

$$\mathrm{HJD(Max)} = 2453129.476(2) + 0.2541281(9)(E - 4233) \tag{4}$$

after JD 2452258.

These are also plotted in Fig. 2, and $O - C$ values for the relevant maxima are given in Table 1. From these it follows that the period decreased by $4.1 \pm 0.1$ seconds around $\mathrm{HJD} = 2452258 \pm 12$.

The above calculations only make use of the times of extrema, and not of all data points. To make sure that all the data fit the suggested change in period, the following procedure was followed. A time of period jump $t_0$ was chosen, and all observation times after $t_0$ were transformed from $t$ to $t' = t_0 + q(t - t_0)$, with $q$ a parameter denoting the fractional period change. For times before $t_0$, $t' = t$ was taken. With these modified times $t'$ a new period may be calculated, based on all the data. Using the downhill simplex minimization method (Nelder & Mead, 1965), the values of $t_0$ and $q$ were determined for which a Fourier series with two harmonics gave the best fit. This resulted in a calculated period decrease of 4.0 seconds at $t_0 = 2452272$, in excellent agreement with the results found above. The phase plot taking into account this sudden period decrease is presented in Fig. 3 (with a period 0.254174 days, as determined before the change). A similar procedure as above, but with $t' = rt^2$, where $r$ represents a constant rate of change of the period (for parabolic elements) yielded a worse fit. The sudden period jump is therefore favoured to a constant rate of change. At this moment cyclic period changes cannot be entirely excluded.

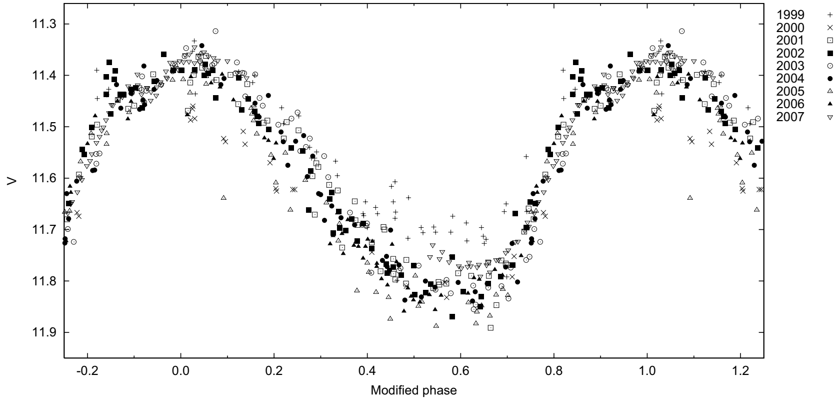


**Figure 3.** Phase plot of GSC 6199-0755 with the same data as Fig. 1 but taking into account a sudden period decrease of 4.0 seconds at HJD = 2452272

Similar period jumps are seen in other RR Lyrae stars as well (see e.g. Smith, 1995, and Schmidt & Lee, 2000), although some are poorly documented. One example is the RRc star HY Com (Oja, 1995), which is known to undergo frequent abrupt period changes. The explanation for these period jumps are yet unclear.

It is important to follow GSC 6199-0755 in the coming years to see whether other changes will occur like in HY Com or whether the period changes are cyclic. Also an archival plate search would be worthwhile to study the early period history.

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