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Period study of the short period RS CVn type eclipsing binary UV Piscium

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Abstract. The short period RS CVn type eclipsing binary UV Piscium was observed photoelectrically with standard *U*, *B*, *V* filters for three consecutive observing seasons during 1976-1979. A total of nine primary minima in each of *V* and *B* colours and seven primary minima in *U* colour were obtained. All these minima and those obtained by Carr, Oliver, and Sadik were corrected for the distortion wave superposed on the light curves. Using these wave-corrected times of minima the following improved light elements were derived: Hel. JD 2443080.1843 + $0^d.8610474\,E$. The $(O - C)$s obtained using these ephemeris suggest no detectable period variations during 1966–79. This result is not in confirmity with the earlier suggestions of period variation in this system.

Key words : Period study—RS CVn type eclipsing binary—UV Piscium

1. Introduction

The short period eclipsing binary UV Piscium was classified by Oliver (1974) as a member of the group of stars resembling RS CVn type characteristics. Hall (1976) listed this star as a member of the short period group of RS CVn systems. These late type binaries are spectroscopically outstanding by virtue of their strong Ca II H and K and Hα emissions. One puzzling photometric feature which makes them unique is the wave-like distortion seen in their light curves outside eclipse, which tends to migrate towards increasing or decreasing orbital phase on a timescale much larger than its orbital period. Of additional interest is the fact that like several other RS CVn candidates UV Piscium is a radio source (Spangler 1977) and also a source of soft x-rays (Agrawal *et al.* 1980). Another puzzling property, recognized for a long time but still not understood for most of the RS CVn type binaries, is the variability of their orbital periods.

As adequate number of the times of minima are available, the aim of our study is to detect any reliable period changes in the system UV Piscium, which property is found to be present in several other RS CVn binaries. Further, we wanted to inspect any possible correlation between the period variations and the phase of the migrating wave. This correlation is found to be present in the RS CVn binaries, RS CVn (Hall 1972), SS Cam (Arnold *et al.* 1973), and CG Cyg (Hall 1975). The existence of such a correlation should be important in providing a clue in understanding the back and forth period changes in most to the RS CVn binaries.

2. Observations

We have observed the system UV Psc on the 1.27m reflecting telescope of the Japal-Rangapur observatory on 47 nights in *U* filter and 54 nights in *B* and *V* filters of the Johnson & Morgan *UBV* standard system during the 1976–77, 1977–78 and 1978–79 observing seasons. The photometric equipment, the method of observing and the reduction techniques employed as well as the individual Δm (variable-comparison) values with their times of observation are published by Vivekananda Rao & Sarma (1981). A total of nine primary minima in each of *V* and *B* colours and seven primary minima in *U* colour were obtained during the entire period of observation.

3. Wave-corrected times of minima

Using the ephemeris

$$\text{Primary minimum} = \text{Hel. JD } 2428038.555 + 0^{d}.861046\, E \qquad \ldots(1)$$

of Huth (1959), Aslan (1978) and Sadik (1979) had suggested that the period of UV Psc was varying. Hall & Kreiner (1980) using the same ephemeris and taking the then available photographic, visual and photoelectric times of minima found evidence for a positive shift in the $(O - C)$s. These studies indicate that the period of the system may be varying.

Like several RS CVn binaries [RS CVn (Catalano *et al.* 1979), AR Lac (Hall *et al.* 1976), CG Cyg (Milone *et al.* 1976) and SS Cam (Arnold *et al.* 1979)] UV Piscium was found to exhibit a wave-like distortion outside the eclipses (Vivekananda Rao & Sarma 1982). As a consequence of this wave, the minima of the light curves become asymmetric making the derived times of minima (Catalano & Rodono 1974) erroneous. To get the correct times of minima, one has to remove the effect of the wave (Hall 1979 personal communication; Arnold *et al.* 1979). After getting a symmetric light curve during minima, the desired times should be determined. Since the secondary minima of UV Psc were shallow, we had used only the primary minima for the period determination.

From a preliminary solution it was found that the primary minima were due to transit where the hotter component *i.e.* the component responsible for the wave was being eclipsed by the cooler one (Vivekananda Rao & Sarma 1982).

This minimum was corrected for the wave using the following equation given by Hall (1979).

$$l^{\text{corr}} = l^{\text{obs}} - (1 - f^{\text{tr}})\,[A_1(\text{wave}) \cos\theta + B_1 \sin\theta] - (1 - f^{\text{tr}})\,[A_2\,(\text{wave}) \cos 2\theta + B_2 \sin 2\theta] \qquad \ldots(2)$$

where

$$f^{\text{tr}}(x, k, p) = \tau(x, k)\, \alpha_0^{\text{tr}}\,(x, k, p)\, n \qquad \ldots(3)$$

is the fractional loss of light of the spotted star during its eclipse. In equation (3) τ and α_0^{tr} are constant for a given k and x and are taken from the solutions of Carr (1969) and Sadik (1979), and $n = \frac{1 - l}{1 - l_0}$ (where l and l_0 are rectified values) varies along the eclipse. To get the rectified values of l and l_0 an average light curve was drawn from the observations made during the three seasons. This curve was rectified using the theoretical Fourier coefficients A_1 and A_2 determined from Merrill's (1970) equations and data from previous solutions. The value of n at any phase can be read from this rectified curve.

All the nine minima observed by us were corrected for the wave as mentioned above. Data for the three primary minima (in each of *UBV*) of Carr (1969), one (in each of *UBV*) of Oliver (1974) and one (in *B* and *V* colours) of Sadik (1979) were also corrected in the same way. In determining the times of minima the method of Kwee & van Woerden (1956) was adopted. The mean times of minima obtained by averaging the values in different colours are given in table 1.

4. Improvement of period

Taking one of the times of minima given in table 1 and the period of Huth (1959) we have derived the following improved light elements from a least square solution of data listed in table 1 :

$$\text{Primary Minima} = \text{Hel. JD } 2443080.1843 + 0^{d}.8610474\, E \qquad \ldots(4)$$
$$\pm 4 \qquad\qquad \pm 2 \text{ (p.e.)}$$

The $(O - C)$s obtained from the above ephemeris are shown in table 1. These $(O - C)$s are small, indicating that the period of UV Psc remained constant during the period 1966–79.

Hall & Kreiner (1980) have given a list of non-wave removed photographic, visual and photoelectric times of minima available to them. They have calculated the $(O - C)$s using the ephemeris given by Huth (1959). Table 2 lists all the photographic, visual, photoelectric minima given by Hall & Kreiner (1980) and the photoelectric minima given in table 1. The $(O - C)$s obtained using the ephemeris given

Table 1. Times of photoelectric minima of UV Psc after wave removal

Times of minima Hel. JD 240000+	Weight	$(O - C)$	Reference*
39388.8736	3	−0.0005	1
39406.9565	3	+0 0004	1
39407.8167	3	−0.0004	1
40466.9057	3	+0,0002	2
43079.3230	3	−0.0003	4
43080.1840	3	−0.0003	4
43123.2362	3	−0.0005	4
43445.2691	2	+0.0007	4
43446.1302	2	+0.0008	4
43452.1564	3	−0.0004	4
43463.3493	2	−0.0011	3
43805.1877	3	+0.0015	4
43849.0996	3	0.0000	4
43861.1542	3	−0.0001	4

$(O - C)$ refers to the ephemeris $2443080.1843 + 0^{d}.8610474\, E$

*1. Carr (1969); 2. Oliver (1974); 3. Sadik (1979); 4. This work.

by equation (4) are tabulated in table 2. Figure 1 shows a plot of these $(O - C)$s against the number of cycles. It clearly indicates that there exist no systematic or abrupt period changes in the system UV Psc as suggested by earlier investigators except for the large $(O - C)$s exhibited by the photographic and visual minima.

Table 2. Photographic, visual and photoelectric times of minima of UV Psc

Times of minima Hel. JD 2400000+		(O − C)	Reference*
27061.293	p	+0.035	1
28038.563	p	+0.016	1
28107.428	p	−0.003	1
28164.288	p	+0.028	1
28373.499	p	+0.005	1
28398.464	p	−0.001	1
28423.435	p	0.000	1
28453.555	p	−0.017	1
29110.557	p	+0.006	1
29166.529	p	+0.010	1
29230.243	p	+0.006	1
29514.403	p	+0.021	1
29531.608	p	+0.005	1
29639.270	p	+0.036	1
30201.536	p	+0.038	1
31738.461	p	−0.007	1
31845.247	p	+0.009	1
32885.387	p	+0.004	1
33888.484	p	−0.019	1
33894.508	p	−0.022	1
34607.510	p	+0.032	1
35369.482	p	−0.022	1
35691.542	p	+0.006	1
36075.550	p	−0.013	1
36850.510	p	+0.004	1
39388.8736	pe	−0.0005	2
39406.9565	pe	+0.0004	2
39407.8167	pe	−0.0004	2
40466.9057	pe	+0.0002	3
40854.351	v	−0.025	1
40860.4014	pe	−0.0027	1
40953.384	v	−0.013	1
41163.4933	pe	+0.0005	1
41276.281	v	−0.009	1
41282.304	v	−0.013	1
41301.250	v	−0.010	1
41319.340	v	−0.002	1
41350.333	v	−0.007	1
41534.609	v	+0.005	1
41565.610	v	+0.008	1
41571.630	v	+0.001	1
41598.333	v	+0.012	1
41610.374	v	−0.002	1
41616.407	v	+0.004	1
41622.433	v	+0.002	1
41623.303	v	+0.011	1
41648.263	v	+0.001	1
41888.4942	pe	−0.0005	1
41894.526	v	+0.004	1
41900.555	v	+0.006	1
41989.241	v	+0.004	1
42020.223	v	−0.012	1
42026.268	v	+0.006	1
42044.339	v	−0.005	1
42272.523	v	+0.001	1

(*Continued*)

Table 2.—*Continued*

Times of minima Hel. JD 2400000+		(O – C)	Reference*
42272.525	v	+0.005	1
42291.470	v	+0.003	1
42375.517	v	+0.002	1
42385.315	v	−0.004	1
42423.214	v	+0.009	1
42429.231	v	−0.001	1
42435.265	v	+0.005	1
42680.663	v	+0.005	1
42681.523	v	+0.004	1
42738.353	v	+0.005	1
42776.240	v	+0.006	1
42782.262	v	0.000	1
42806.368	v	−0.003	1
43015.608	v	+0.002	1
43041.442	v	+0.005	1
43053.4926	pe	+0.0008	1
43079.3230	pe	−0.0003	1
43080.1840	pe	−0.0003	1
43123.2362	pe	−0.0005	1
43400.4952	pe	+0.0013	1
43406.5225	pe	+0.0012	1
43425.4660	pe	+0.0017	1
43428.4806	pe	+0.0026	1
43445.2691	pe	+0.0007	5
43446.1302	pe	+0.0008	5
43452.1564	pe	−0.0004	5
43463.3493	pe	−0.0011	4
43734.582	v	+0.002	1
43772.471	v	+0.005	1
43785.3834	pe	+0.0013	1
43791.408	v	−0.002	1
43803.472	v	+0.008	1
43805.1877	pe	+0.0015	5
43809.489	v	−0.003	1
43821.548	v	+0.002	1
43835.324	v	+0.001	1
43841.345	v	−0.005	1
43848.241	v	+0.002	1
43849.0996	pe	0.0000	5
43861.1542	pe	−0.0001	5

p = photographic, v = visual and pe = photoelectric

$(O - C)$ refers to the ephemeris 2443080.1843 + $0^d.8610474E$

*1. Hall & Kreiner (1980); 2. Carr (1969); 3. Oliver (1974); 4. Sadik (1979); 5. Present work.

5. Conclusions

From the present study we find that any variation in the period of eclipsing binaries can be established clearly only if the $(O - C)$ diagram is constructed using photoelectric minima. When visual and photographic minima are used the real variations are masked leading to spurious results. A similar conclusion was also arrived at by Panchatsaram & Abhyankar (1982a, b). In RS CVn binaries, the presence of the distortion wave further complicates the study of period variations using such data. Hence, only photoelectric times of minima corrected for the wave should be taken for determining reliable period variations in RS CVn binaries. As far as UV Psc is concerned we could not find any systematic trend or abrupt changes in the $(O - C)$ diagram except for the large $(O - C)$s exhibited by the photographic and visual minima. Furthermore, since there are no reliable period changes in this system, a

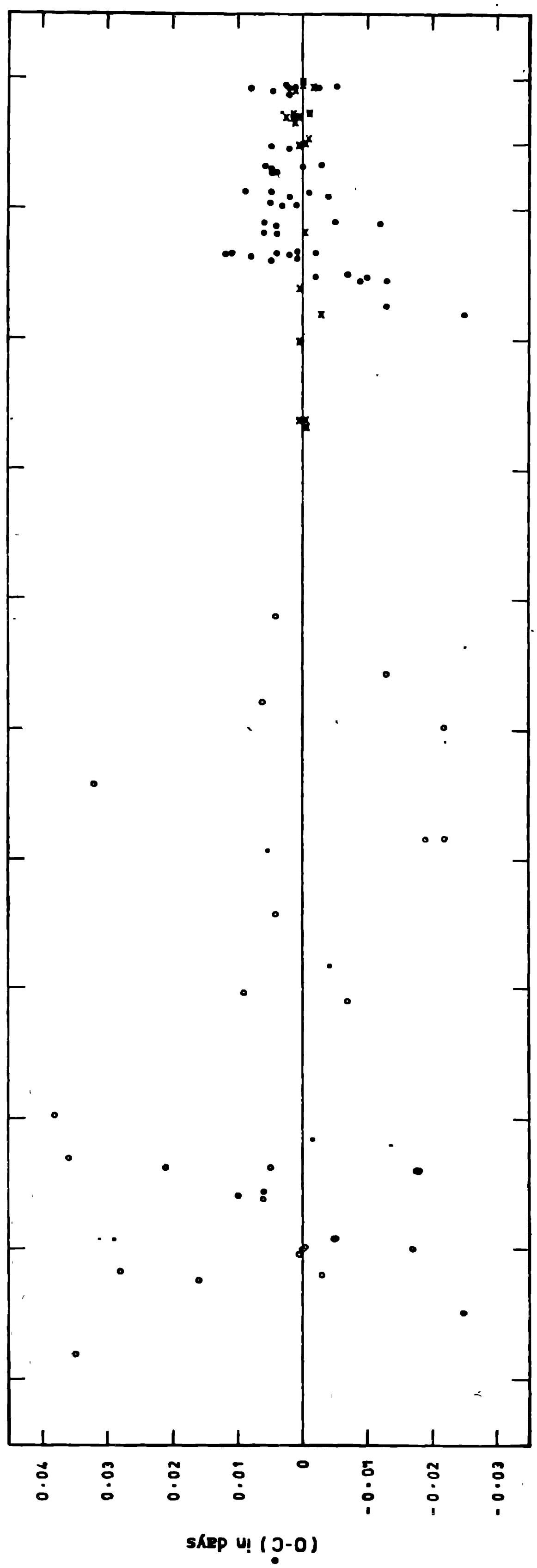

Figure 1. The $(O - C)$ curve for UV Psc. These $(O - C)$s are obtained by using the ephemeris Hel. JD 2443080.1843 $+0^d.8610474E$ which is derived by using the photoelectric minima determined after the removal of the distortion wave. ○ represents photographic minima. ● represents visual minima. x represents photoelectric minima.

correlation between the period variations and the phasing of the wave minima does not exist.

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