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PHOTOELECTRIC OBSERVATIONS OF THE COMPLEX LOW-AMPLITUDE RED VARIABLE, UX Dra

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UX Dra (HD 183556, SAO 9404, HIP 95154) is a luminous carbon star with Tc (Little et al. 1987) and has a spectral type of C5 II. According to the Combined GCVS (Kholopov et al. 1998), following earlier editions, it is an SRa variable with a period of 168 days. From times of minimum, Vetesnik (1983) found a constant lengthening of the period but more extensive photographic data suggested that this was part of a long term cycling of the period between 155 and 185 days, over about 5000 days. At the end of each cycle the period would apparently glitch back to the lower value. From an analysis of the historical visual data Kiss et al. (1999) found UX Dra to be a biperiodic variable, in common with about half of their sample, with periods of 176 ± 1 and 317 ± 2 days.

UX Dra has been observed almost continuously since mid-1994 as part of a programme to investigate known and suspected, small-amplitude red variables. Early observations covering the first two years data have been discussed previously by Lloyd & West (1996, Paper I). The observations were made using an SSP3 photometer and nominal V filter on a 20-cm Newtonian reflector using a $2'$ aperture. Each observation consisted of 2 or 3 sets of 3×10 second integrations. Differential extinction corrections were applied but these are small and are comparable to the errors. Details of the comparison stars are given in Table 1. The photometric data are taken from the compilation of Mermilliod et al. (1997) and are very similar to the values derived from Hp, V_T and B_T. HR 7199 = CCDM 18535+7547 is a close double star with a separation of $6''$ and magnitude difference of $0\overset{\mathrm{m}}{.}6$ at V. The revised magnitudes of the comparison stars are now in much better agreement with the observed magnitude difference, $\Delta V = -0\overset{\mathrm{m}}{.}231 \pm 0\overset{\mathrm{m}}{.}017$ than was the case in Paper 1.

The new V-band light curve of UX Dra is shown in Figure 1 and covers about four times the period reported in Paper I. Consequently the general behavior of the star is

Table 1: UX Dra comparison stars information

Comparison	V	$B-V$	Sp
HR 7199 = HD 176795	6.33	0.01	A1 V
HR 7247 = HD 178089	6.55	0.38	F2 V

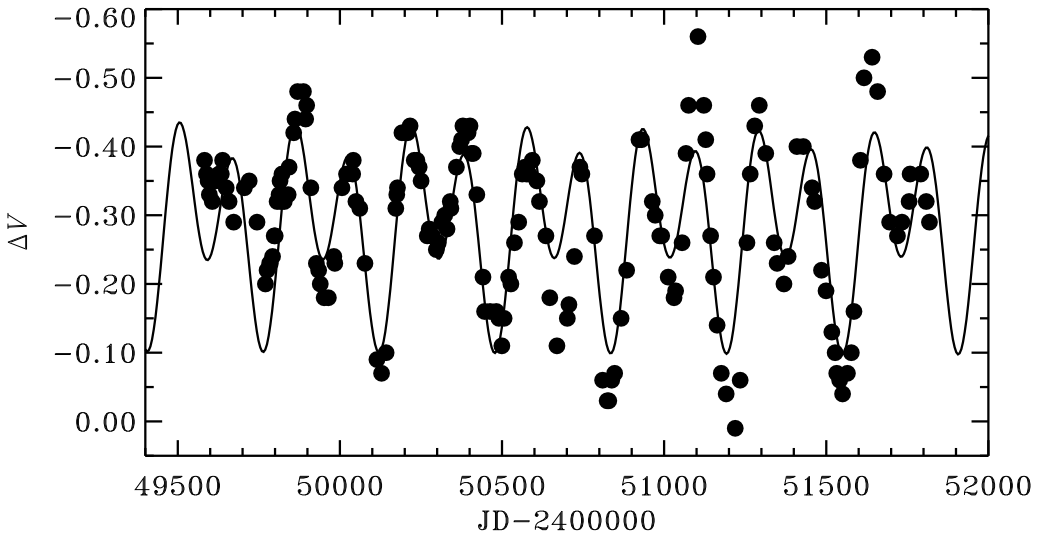

Figure 1. The V-band light curve of UX Dra from 1994 – 2000 relative to HR 7199, with the 178 and 359 day period fit over plotted.

rather clearer, but no simpler. The full range of variation during this time is nearly $0\overset{m}{.}6$, but the vast majority of the light curve covers less than $0\overset{m}{.}3$. The periodogram shows a main period of 178 days with a second period of approximately twice this value. There is very little difference in the fit to the light curve if the shorter period is treated as the first harmonic of the longer period, however, as will be seen the relationship between them is not fixed. A two-period fit to the data yields periods of 178 ± 1 and 359 ± 3 days and after these have been removed a period of ~ 665 days, and a long-term trend, remain above the general noise level. Including this additional period makes no obvious improvement in the fit to the light curve. Of the two principal periods the shorter one is very similar to that found in the historical visual data but the longer period is rather different, 359 as opposed to 317 days.

Not surprisingly the near-harmonic two-period fit produces a light curve with oscillating maxima and minima. The phasing of the fit throughout this time is relatively good but it does occasionally wander off, and there are clearly very significant deviations in amplitude of both the maxima and minima. Also, as was reported in Paper I, but is not clearly visible in Figure 1, the behavior at the start of the observations is rather different. The amplitude is much lower, $< 0\overset{m}{.}1$, and the characteristic time scale of the variations is ~ 75 days, which is close to the second harmonic of the long period. The reduction in amplitude at this time is typical of the beating together of two periods but the time scale of the variations should not change. It is possible that other, low-amplitude variations may be revealed at these times, but if they are always present then they should also appear in the periodograms, and there are no consistent features above the noise at periods < 100 days.

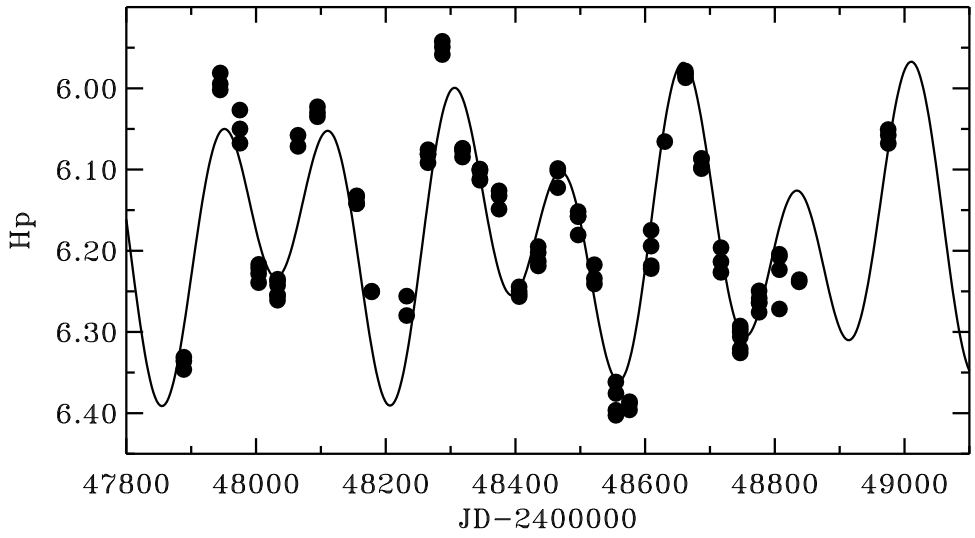

Figure 2. The Hipparcos light curve of UX Dra from 1990 – 1992, with the 179 and 322 day period fit over plotted.

Hipparcos has also observed UX Dra, for approximately three years about two years prior to the start of the V-band observations. The Hipparcos light curve is shown in Figure 2 and the general behavior is very similar to that in Figure 1. The periodogram of the Hipparcos data also reveals similar periods; the best fit is with 179±1 and 322±5 days. The shorter period is practically identical to that of the V-band data and both are close to the values found in the historical visual data. Any remaining periods are dominated by a long-term trend in the data.

The two data set have been combined by subtracting their respective means, which are also very close to the zero points of their two-period fits. The combined data yields best fit periods of 175 ± 1 and 334 ± 2 days but the periodogram does not offer an unambiguous choice of second period. It also shows other periods remaining above the noise after the principal periods have been removed, the two most prominent being at 186 and 301 days. Interestingly, when these two periods are included in the fit to the data, their amplitudes are essentially identical to that of the 334 day period, at $0\overset{\mathrm{m}}{.}05$. The amplitude of the dominant period, 175 days, is $0\overset{\mathrm{m}}{.}10$. Another curious feature of including these additional two periods is that the frequency spacing of the longer and shorter pairs is identical, 0.00032 cycles day^{-1}, corresponding to 3125 days. Similarly, the alternative pairings give frequency spacings of 0.00238 cycles day^{-1}, corresponding to 420 days. Neither of these time scales have any apparent correspondence in the data, nor do the periods appear clearly in the periodograms of the individual data sets, although the 301-day period does appear weakly in the V-band data. The significance, or otherwise, of these additional periods and the frequency spacings they generate, is at present unclear, but tests have shown that they are not due to the misalignment of the two data sets.

UX Dra appears to have two dominant periods but it is clear that a stationary solution, even with several additional periods will not adequately describe the light curve. Shifting periods, and phase changes, are a recognized feature of long-period variable light curves

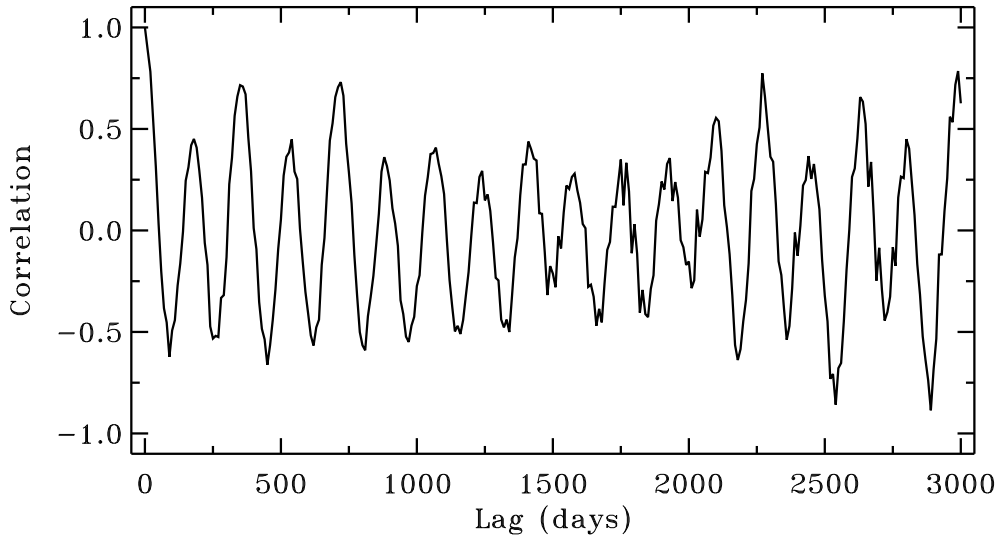

Figure 3. The autocorrelation function of the combined data set showing the stability of the 175 day period.

but within the data studied here the shorter period, 175 days, seems to have been the more stable. The autocorrelation function of the combined data set is shown in Figure 3 and clearly demonstrates the stability of this period over eleven years. On the other hand the longer period does differ between the two data sets, and the long term visual value. It seems likely that the interaction of the two periods, along with some instability can account for the changing behavior seen by Vetesnik (1983). However, variation of the longer period will not account for the large, and relative short time scale, of the amplitude variations, which cause the main discrepancy between the observed and modelled light curve. These seem to be on the time scale of the 175 day period or shorter, as do the variations at the beginning of the V-band data described earlier. While it may possible to explain some of the residuals by shifts in period or phase, the main difficulty in describing the large excursions in amplitude in the context of multiperiodic variations, is the lack of any periods < 100 days.

References:

Kholopov P.N., Samus N.N., Frolov M.S., Goranskij V.P., Gorynya N.A., Karitskaya E.A., Kazarovets E.V., Kireeva N.N., Kukarkina N.P., Kurochkin N.E., Medvedeva G.I., Pastukhova E.N., Perova N.B., Rastorguev A.S., Shugarov S.Yu., 1998, The Combined General Catalogue of Variable Stars, 4.1 Edition

Kiss L.L., Szatmáry K., Cadmus Jr. R.R., Mattei J.A., 1999, *A&A*, **346**, 542

Little S.J., Little-Marenin I.R. & Bauer W.H., 1987, *AJ*, 94, 981

Lloyd C., West K., 1996, *IBVS* No. 4335 (Paper 1)

Mermilliod J.-C., Hauck B., Mermilliod M., 1997, *A&AS*, **124**, 349, *The General Catalogue of Photometric Data*,
`http://obswww.unige.ch/gcpd/gcpd.html`

Vetesnik M., 1983, *IBVS* No. 2329