COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS
Number 4277

Konkoly Observatory
Budapest
11 December 1995

HU ISSN 0374 – 0676

V-BAND PHOTOMETRY OF XY UMa IN 1993 AND 1995

XY UMa (= SAO 27143 = BD+55°1317, G2V + K5V) is a chromospherically active, close, eclipsing binary system, with a period of 0.48 days. It has been the subject of close scrutiny recently, at both optical and X-ray wavelengths, where the eclipses can be used to spatially probe magnetic structures on and above the surface (Bedford et al. 1990; Hilditch & Bell 1994 – hereafter HB94). Hilditch & Collier Cameron (1995 – hereafter HC95) have developed a model to explain the changing optical light curve of XY UMa in terms of starspots covering a wide range of latitudes on the surface of the primary star. The most recent analysis of the O−C times of minima was performed by Pojmański & Geyer (1990 – hereafter PJ90). They find evidence for a quasi-sinusoidal variation in the O−C's, which can be explained if there is a third low-mass star in the system, with an orbital period of either 25 or 40 years. Arévalo et al. (1994) claim to have detected a third body about 2 arcseconds away from the close binary system. As a further contribution to the wealth of historical data that is accumulating for this fascinating object, we present two V-band light curves obtained in 1993 and 1995.

Both data sets were taken with a CCD camera attached to the University of Birmingham 0.4-m telescope. A V-band filter manufactured by Murnaghan Instruments was used. This had a peak throughput at 525 nm and a FWHM of 110 nm. The 1993 data were taken at the f/19 Cassegrain focus on the nights of the 19 February, 8/9 March and 13/14 March. The 1995 data were taken at the f/5 prime focus on 26/27 February, 3 March, 15 March and 17 March. The CCD frames were bias subtracted, flat-fielded and counts were integrated using a 24 arcsecond radius aperture. The comparison star used in each case was BD+55° 1320AB. Both components were included well inside the software aperture. The derived V-band differential magnitude light curves are shown in Figures 1 and 2. Phases were calculated according to the least squares linear ephemeris of HJD 2435216.5018 + 0.47899493E from PJ90. The full heliocentric observation times and differential magnitudes can be obtained from the authors. Two new epochs of primary minima were derived by fitting parabolas to the bottom half of the primary eclipses. We obtain HJD 2449055.6183 $\pm$ 0.0004 and HJD 2449775.5469 $\pm$ 0.0008 where the quoted errors are 68% confidence limits. The O−C values are -0.0050 days and -0.0058 days respectively.

A comparison with the various attempts to explain the O−C variations in PJ90, reveals that neither their short or long period, circular or eccentric third body hypotheses adequately fit our times of minima. In both cases (and also for the times of minima in 1992 given by HB94) the O−C's are significantly positive (by 0.003 to 0.006 days). The short period ($\sim$ 25 yrs) hypothesis is marginally worse than the long period ($\sim$ 40 yrs) solution. A complicating factor may be errors in the minima determinations caused by light curve asymmetries, but both our 1993 light curve and HB94's 1992 light curve have

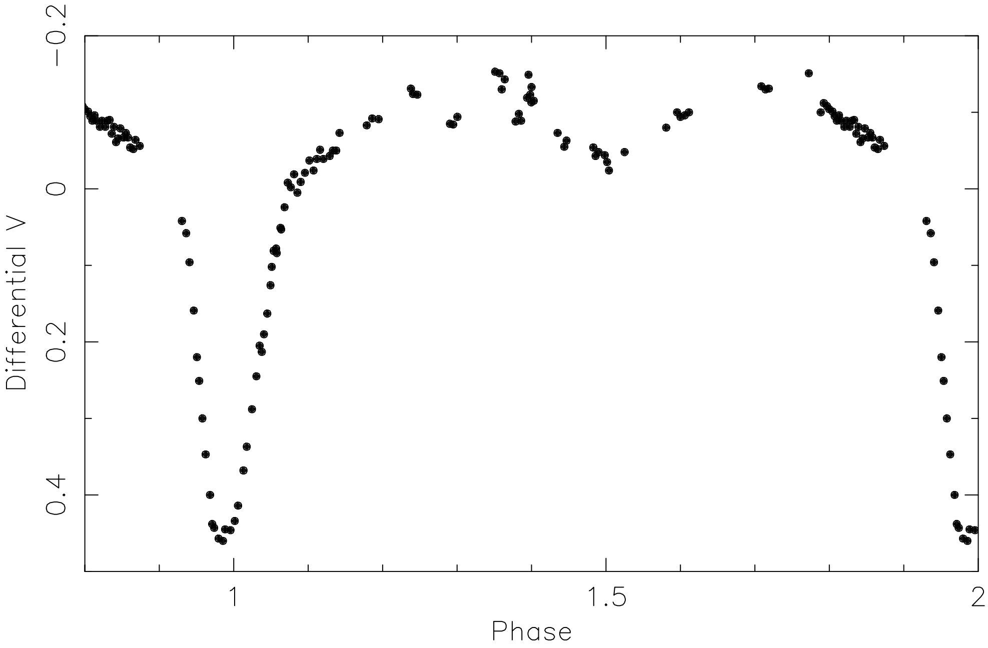

Figure 1. Phased differential V-band light curve of XY UMa taken during February/March 1993.

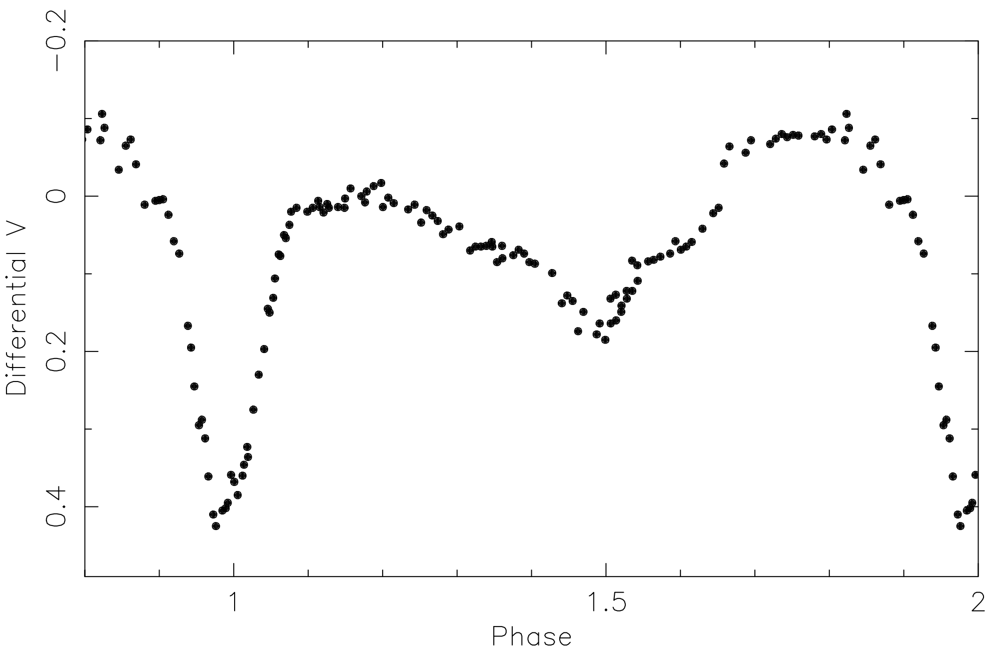

Figure 2. Phased differential V-band light curve of XY UMa taken during February/March 1995.

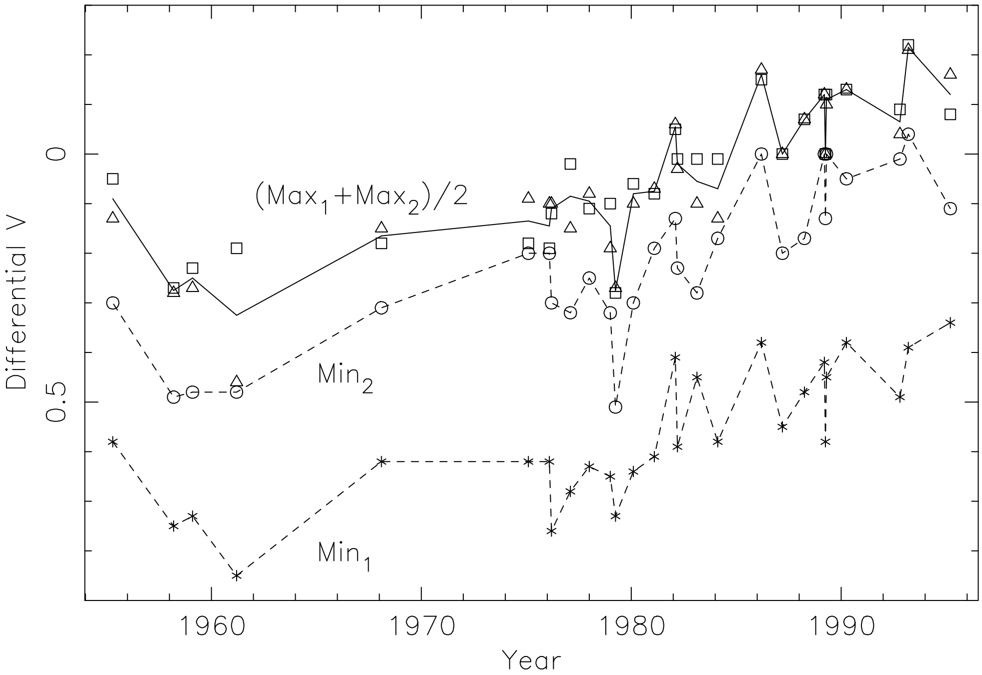

Figure 3. Historical brightness of XY UMa relative to SAO 27139 at primary minimum (stars), secondary minimum (circles), maximum after primary eclipse (squares), maximum after secondary eclipse (triangles). The solid line is the mean of the two maxima.

relatively symmetric primary minima. Thus our eclipse timings *do not* necessarily support the third body hypothesis for XY UMa, although a longer period might be indicated.

The appearance of the light curve has changed markedly between 1993 and 1995, with the secondary minimum becoming more prominent with respect to primary minimum. The scatter apparent in the 1993 light curve from phases 0.2 and 0.4 seems to be genuine variation of the light curve, between data taken on different nights (see also HB94). We have parameterised the light curves by estimating the differential V magnitudes of primary and secondary minima (Min_1 and Min_2) and the maxima between phases 0 and 0.5 (Max_1) and between phases 0.5 and 1.0 (Max_2). These estimates should be accurate to ± 0.02 and are with respect to BD $+55°$ 1320.

Year	Min_1	Min_2	Max_1	Max_2
1993	0.46	0.03	−0.15	−0.14
1995	0.41	0.18	−0.01	−0.09

To compare our results with previous work, we standardise the differential magnitudes above to what they would be had the more commonly used SAO 27139 been the comparison star. This is simply achieved by subtracting 0.07 magnitudes, because SAO 27139 is 0.07 magnitudes fainter than BD $+55°$ 1320 (HB94). Data from our two light curves is added to the data in HC95 along with a compilation of differential magnitudes of maxima and minima taken between 1955 and 1984, from Lee (1985). The full dataset is shown in Figure 3. As suggested by Lee (1985) and HC95 there is a definite trend in the data indicating that the whole system has been getting brighter, in a phase independent way, since about 1961. We interpret this in terms of the model developed by HC95, where long term system brightness changes over decades, are likely to be caused by changes in the area covered by both high and low latitude spots, visible both in and out of eclipse. Short term changes from year to year are more likely caused by changes in the coverage and axial symmetry of low latitude spots which may be obscured during primary eclipse, as the system inclination is 82°(HB94). If a magnetic cycle, similar to the Sun's exists, then it appears to be at least 40 years in length.

HC95 also suggest that, having gone through a period of low spot activity in the last ten years, XY UMa may now be commencing a period of increasing spot activity. Some interesting, but inconclusive evidence for this comes from our 1995 light curve. Figure 3 shows that while the primary minimum brightness is still increasing, the hemisphere facing away from the secondary appears to be growing darker. Such anti-correlations do not seem common in Figure 3. A possible interpretation is that while the area covered by high latitude spots is still decreasing, and thus the brightness at primary eclipse increasing, there has been an eruption of spots at lower latitudes, causing a decrease in system brightness at phases other than primary eclipse. It maybe that these will then migrate towards higher latitudes, presaging a new cycle of overall decreasing system brightness and increasing spot activity. An alternative explanation would be that the low latitude spots have simply become highly asymmetric, favouring the hemisphere facing away from the secondary. Further observations over the next couple of years should provide some answers.

Historical brightness of XY UMa relative to SAO 27139 at primary minimum (stars), secondary minimum (circles), maximum after primary eclipse (squares), maximum after secondary eclipse (triangles). The solid line is the mean of the two maxima.

R. D. JEFFRIES
Department of Physics
Keele University
Keele, Staffordshire ST5 5BG, UK.
e-mail rdj@astro.keele.ac.uk

C. COLLINS,
K. H. ELLIOTT,
S. F. HELSDON,
J. M. PITTARD
S. B. TAYLOR
School of Physics and Space Research
University of Birmingham
Birmingham B15 2TT, UK

References:

Arévalo, M. J., Lázaro, C., Martinez-Roger, C., Fuensalida, J. J., 1994, in *8th Cambridge Workshop on Cool Stars Stellar Systems and the Sun*, ed. J. P. Caillault, ASP Conference Series Vol. 64, p. 548

Bedford, D. K., Jeffries, R. D., Geyer, E. H., Vilhu, O., 1990, *Mon. Not. R. astr. Soc.*, **243**, 557

Hilditch, R. W., Collier Cameron, A., 1995, *Mon. Not. R. astr. Soc.*, **277**, 747

Hilditch, R. W., Bell, S. A., 1994, *Mon. Not. R. astr. Soc.*, **267**, 1081

Lee, W-B., 1985, *PhD thesis*, Universität Bonn

Pojmański, G., Geyer, E. H., 1990, *Acta. Astron.*, **40**, 245