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THE ECLIPSING BINARY STAR MS 1428.2+0732

The sky was surveyed in the X-ray region of the spectrum by the Einstein satellite, and the Extended Medium Sensitivity Survey (Stocke et al. 1991) included MS1428.2+0732 with the brightness given as 11.06 in V and the spectral type as F7V. This star is also listed in the Hubble Telescope Guide Star Catalog (GSC)(Jenkner et al., 1990) as GSC 0331_665.

The automated 0.5-m. telescope, Cousins R filter and CCD camera of the Climenhaga Observatory of the University of Victoria was used to make these photometric observations (Robb et al. 1992). The frames had the bias subtracted and were flat fielded in the usual manner using IRAF [1] . The magnitudes were found from aperture photometry using the package PHOT. The x y pixel coordinates of each star for photometry were found from inspection of a few frames and were used as starting points for the Gaussian centering option which precisely centered the 12 arc second aperture on each star for each frame.

The primary comparison star used was SAO 120507=GSC 0331_243 and the check star was GSC 0331_089. The precision of the photometry can be estimated from the standard deviation of the differences in R magnitude for these two stars for each night. This standard deviation varies from 0.011 on a clear night to 0.033 on a poor night. Night to night variations can be estimated from the mean and standard deviation of the nightly mean R magnitude differences between the comparison and check stars. The overall mean is -4.100 and the standard deviation of a night about this mean is 0.012. The uncertainty in a measurement between the comparison and variable star is usually smaller because the check star was fainter. Due to the small field of view first order extinction effects were negligible and no corrections have been made for them. Nor have corrections been made for the colour difference between the stars to transform it to a standard system.

Photometric observations were begun April 1994, continued on fifteen more nights in the spring of 1995, one night in 1996, and one night in 1997. Variations of brightness from night to night were soon obvious and the few long nights showed that the period of the variation must be more than a few hours. A sine curve was fit to various periods and reveals a minimum average chi squared at an inverse period of 1.21 ± 0.01 days^{-1}, as seen in Figure 1. This is half the orbital period and other minima in the figure correspond to aliases and multiples of the real period. Times of minimum light have been found from the method of Kwee and Van Woerden (1956) to be 2449481.7650(14), 2449499.9204(16), 2449859.7620(5) and 2450549.7339(8) which yield a period of:

$$\text{HJD of Primary Minimum} = 2449481.7640(6) + 1.650649(2) \times \text{E}$$

where the uncertainties in the final digit are given in brackets. These uncertainties have been underestimated, because no allowance has been made for the asymmetry in the

[1] IRAF is distributed by National Optical Astronomy Observatories, which is operated by the Association of Universities for Research in Astronomy, Inc., under contract to the National Science Foundation

minima. A plot of the differential R magnitudes phased at this period is shown in Figure 2 for the data from 1994 above and 1995 below. Different runs are plotted with different symbols so that brightness variations from night to night can be seen. The 1994 data have been shifted up 0.05 magnitudes, but the apparent difference between mean curves is about 0.09 magnitudes, indicating that most of the light curve has shifted fainter about 0.04 magnitudes from 1994 to 1995. The bottom of primary minimum was at an intermediate level in 1996 and 1997.

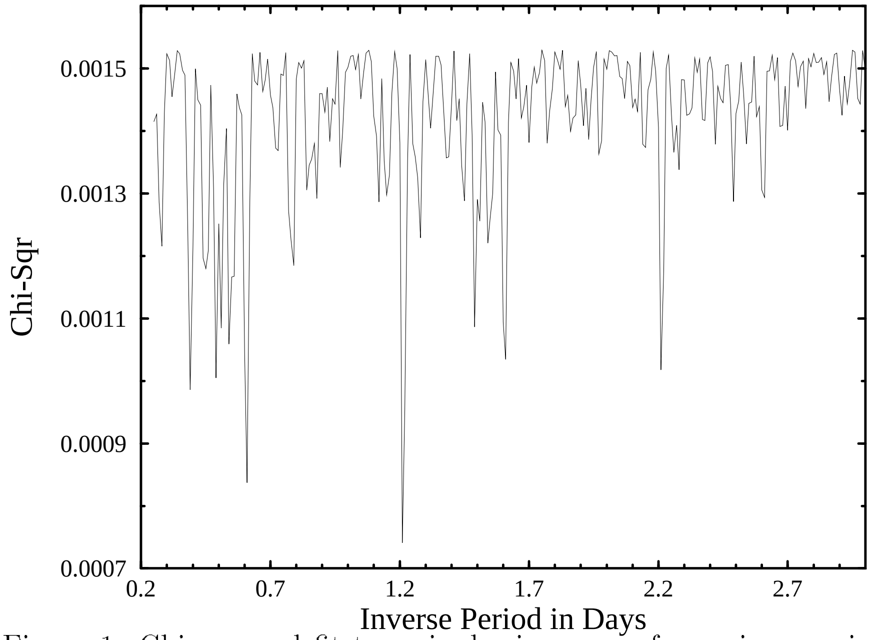

Figure 1. Chi squared fit to a single sine curve for various periods

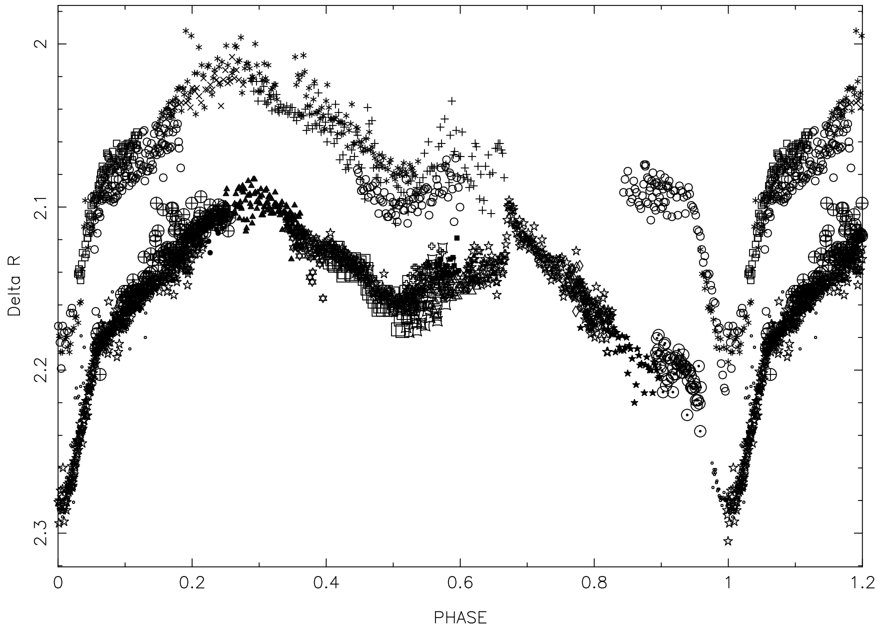

Figure 2. The light curve in R for 1994 above and 1995 below

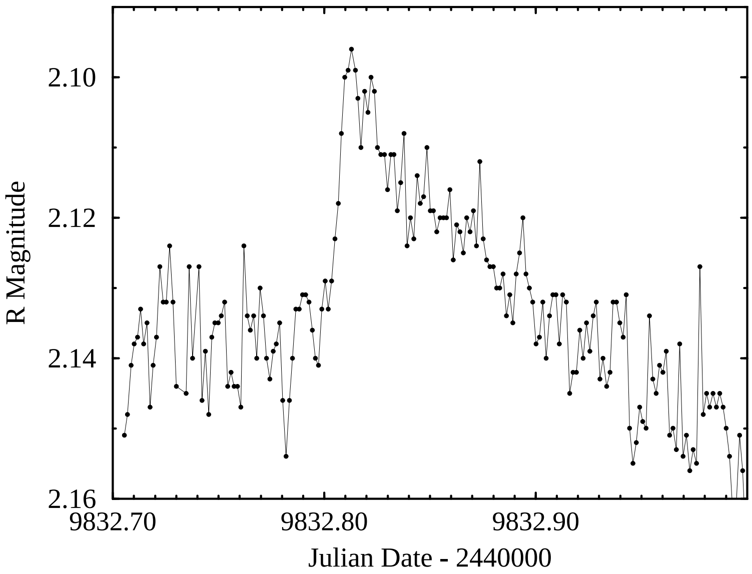

Figure 3. Differential R magnitudes for Julian Date 2449832 showing a flare

Observations on the Julian Date 2449832 are plotted in Figure 3. A large flare occured at approximately 7:30 UT and lasted until 9:30 UT with an amplitude of 0.04 magnitudes. The peak power of the flare is of the same order of magnitude as that of the active star RE0041+342 (Robb 1995), which is one of the largest ever seen.

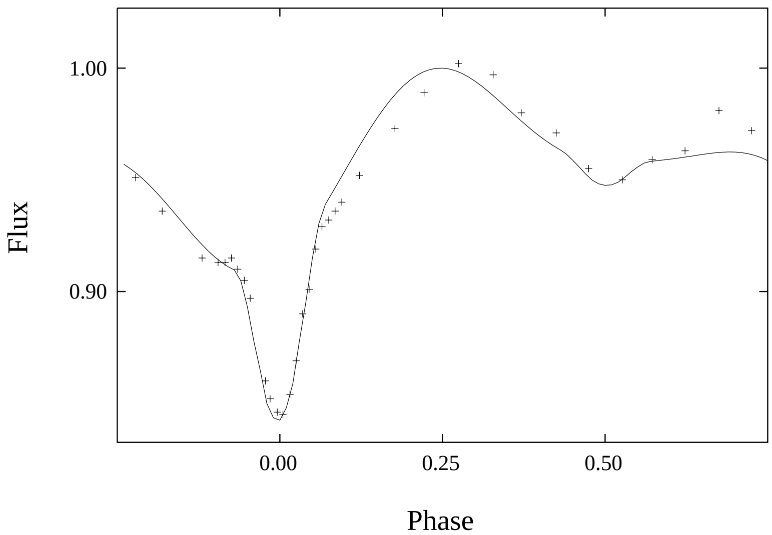

Figure 4. Differential R magnitudes with example model

The light curve modelling program Binmaker 2.0 (Bradstreet 1993) was used to make a light curve which approximates the data as seen in Figure 4. The parameters used are temperatures of 6280 K and 3500 K, and relative polar radii of 0.337 and 0.203 for the hot and cool star respectively. The mass ratio was assumed to be 0.6 and the inclination was 66°. One spot was used which had a co-latitude of 60°, longitude of 300°, radius of 21° and a temperature factor of 0.9. All other inputs were set at values appropriate for these temperatures.

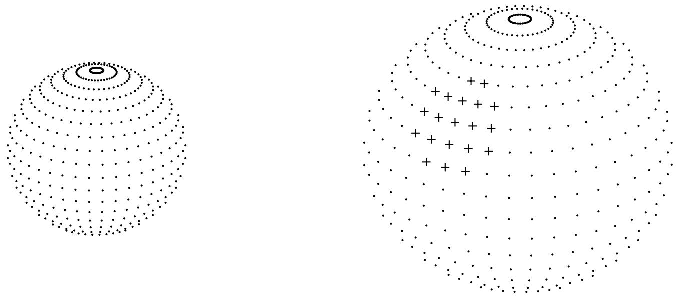

Figure 5. Scale model of the system at phase=0.75

A scale model of the system at phase 0.75 is shown in Figure 5 again produced by Binmaker 2.0 (Bradstreet 1993). The sizes and shapes of the stars are approximately correct for a F7V primary and a K5V secondary star. The size and longitude of the spot are well constrained but the latitude of the spot is arbitrary. A better fit can be obtained by adding more spots, but with less confidence in their properties.

MS 1428.2+0732 is an eclipsing binary star with active regions on its surface causing brightness variations, flares and X-ray emission from an active corona. Further observations will be interesting to increase the precision of the period in order to look for mass transfer and magnetic braking.

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