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The X-Ray Source 1E2119.7+1655 Is A W UMa System

From an examination of the Einstein Observatory Extended Medium Sensitivity Survey, Fleming et al. (1989) compiled a list of seven stars expected to be W UMa systems. In a continuing effort to model these systems we have observed two of these stars, 1E1654.0+3515 (Robb 1989) and 1E1806.1+6944 (Robb and Scarfe 1989). This is a preliminary report of my observations of another of the stars on the list. Its position at Right Ascension 21:19:43.8 and Declination +16:55:32 (Epoch 1950), brightness of 11.7 in the V band and spectral class of F6 were given by Fleming et al. (1989). A finder chart adapted from Papadopoulos et al. (1980) is given for this star in figure 1.

1E2119.7+1655 was observed using the 0.5 meter reflector of the Climenhaga Observatory at the University of Victoria on eighteen nights between 23 August 1989 and 03 October 1989. Computer control of the telescope allows us to point it at each of the stars at the beginning of the night and then leave it to follow a program of observations until dawn. Due to the proximity of the variable, comparison and check stars both in position and color, mean extinction and transformation coefficients were used to correct the differential magnitudes to the Johnson V and Cousins R system (Landolt 1983). The observations of the variable star were bracketed by observations of the comparison star SAO 107070, whose constant brightness was monitored with 23 observations of the check star, SAO 107064. The mean check star minus comparison star magnitude was 0.087 ± 0.019 in V and 0.285 ± 0.009 in (V-R). The errors are standard deviations about the mean, and assure the constancy of the comparison and check stars at this level.

Times of minimum and maximum brightness were found using a program based on the method of Kwee and Van Woerden (1956) and checked using the tracing paper method. Observations in each color were treated individually, but since there were no significant differences between the times obtained, they were combined in a mean, weighted inversely by the error in each color's determination. The heliocentric times of extrema based on all points within 0.06 days of the extrema are given in Table 1. The times of maximum light are included, to help determine the period of the system by removing the aliases. The period found from the times of maximum and minimum light was 0.45789 ± 0.00010 with a root mean square residual of about thirteen minutes. Asymmetry in the maxima and minima and the small amplitude of the light curve are probably responsible for these large residuals and the lack of precision in the determination of the period by this method.

Another estimate of the period was also found using a method based on the Phase Dispersion Minimization method of Jurkevich(1971). Plotted in figure 2 is the sum of the variances of twenty phase bins as a function of the period. The deep minimum at 0.458 days is the orbital period of the system and the shallow minimum at 0.423 days is an alias. The period given below is found from the parabolic fit to the deep minimum. A precise estimate of the epoch is the minimum of the light curve based on all the data points folded on the period below. The ephemeris best fitting the light curve is found to be:

$$\text{Helio. J. D. of Primary Minimum} = 2447762.7516(13) + 0.45774(4)E.$$

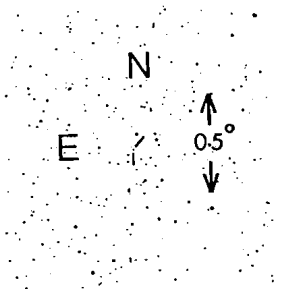

Figure 1. - Finder chart for X-Ray source, 1E2119.7+1655; centered on Right Ascension 21:19:43.8 and Declination 16:55:32 (1950.0)

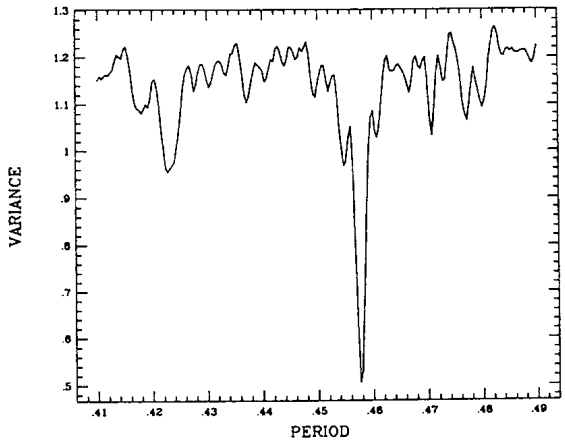

Figure 2. - Sum of the variances of twenty phase bins versus period.

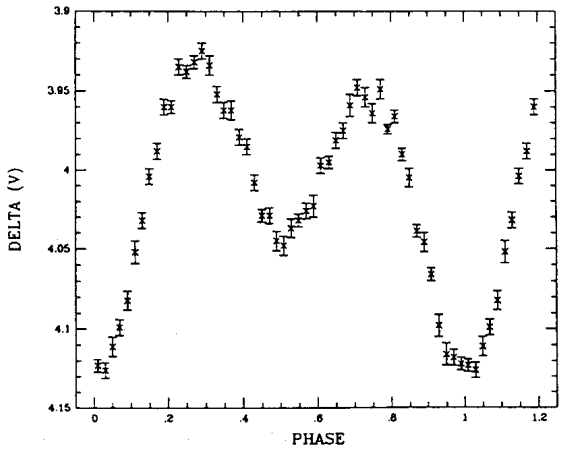

Figure 3. - V filter light curve plotted with PHASE=(JULIAN DATE - 2447762.7516) / 0.45774 .

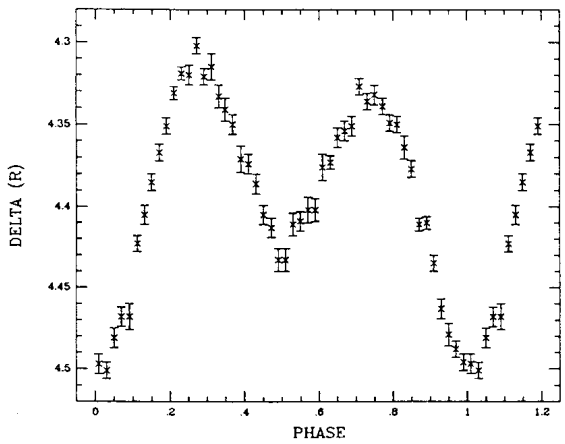

Figure 4. - R filter light curve plotted with PHASE=(JULIAN DATE - 2447762.7516) / 0.45774 .

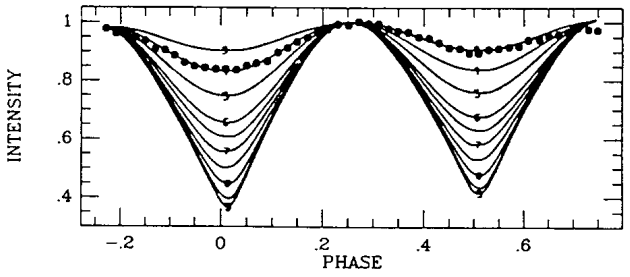

Figure 5. - Average of V and R normal points plotted with theoretical light curve form Anderson and Shu (1979) for a convective atmosphere with full limb darkening, a mass ratio of 0.8 and a filled fraction of 1.0. Curves are plotted in ten degree increments of inclination.

Table I.
Heliocentric Julian Date of Extrema - 2440000.0.

Primary Minima	Secondary Minima	Second Maxima	First Maxima
7772.8227 6	7775.7997 16	7765.8323 19	7763.7918 26
7773.7518 12		7777.7388 12	7768.8341 16
7777.8680 9			7801.7924 18
			7802.7055 24

This period is in good agreement with the period-color relation of Eggen (1967) for contact binaries and agrees with the period found from the times of maxima and minima.

Due to the relative faintness of the star, modest size of our telescope and low declination, the errors of individual observations are large especially in comparison with the small amplitude of the light curve. Therefore the 974 observations have been combined into the fifty V and R band normal points plotted in figures 3 and 4. The error bars represent one standard deviation of the mean. This curve clearly shows the variation expected for a W UMa system as predicted by Fleming et al. (1989). The (V-R) color curve shows no reddening at the primary minimum, consistent with the system being a W UMa system.

An atlas of theoretical light curves of contact binary stars has been published by Anderson and Shu (1979), for different mass ratios, filled fraction, orbital inclination, and type of atmosphere. Since 1E2119.7+1655 has a F6 spectral type (Fleming et al. 1989), a convective envelope with full limb darkening was assumed. As shown in figure 5 the best match was found for a filled fraction f of 1.0, mass ratio q of 0.8 and an inclination of 35 degrees. If this inclination is correct then most if not all of the observed light variation must be due to aspect changes and not to any eclipse. However these numbers must be regarded as very preliminary values, since the theoretical light curves are for bolometric intensity and the data are the average of the V and R band normal points. The observed light curve also shows some asymmetry in the brightness of the maxima and minima.

The X-ray source 1E2119.7+1655 is a W UMa system with a period of 0.458 days and an amplitude of 0.2 magnitudes. Spectroscopic observations of this system will be important to find the component masses and mass ratio. Further photometric observations will be important to refine the orbital period and to permit a more detailed solution than has been attempted here. Photoelectric observations of the remaining stars on the list published by Fleming et al. (1989) are planned.

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