COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS
Number 4486

Konkoly Observatory
Budapest
4 June 1997

HU ISSN 0374 – 0676

THE ECLIPSING BINARY RX J1326.9+4532

The sky was surveyed in the X-ray region of the spectrum by the ROSAT satellite (Voges et al., 1997) and catalogs of the sources included RX J1326.9+4532 = GSC 3460_780 (Jenkner et al., 1990). A literature search using SIMBAD shows that the star has a large proper motion measured (Giclas et al., 1965) to be −.18"/an in right ascension and −.20"/an in declination. The star was one of the objects found in a survey by Beers et al. (1994), who concluded from objective prism spectral observations that it was "a faint star displaying moderate CaII H&K emission".

The automated 0.5-m. telescope, Cousins R filter and CCD camera of the Climenhaga Observatory of the University of Victoria (Robb and Honkanen, 1992) were used to make photometric observations of RX J1326.9+4532. Using IRAF [1] routines the frames were de-biased and flat fielded, and the magnitudes were found from 6 arc second aperture photometry after using the Gaussian centering option of the PHOT package.

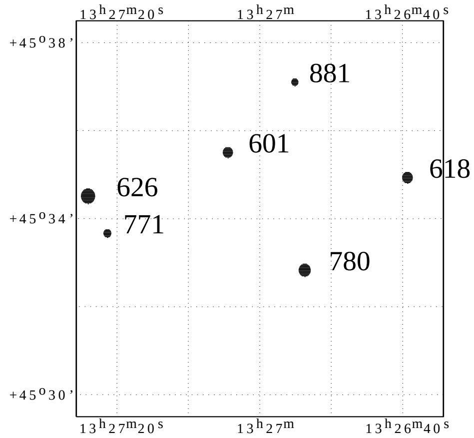

Figure 1. Finder chart of the field labelled with the GSC numbers (Jenkner et al., 1990)

The field of stars is shown in Figure 1 and their designations, coordinates (J2000) and magnitudes from the Hubble Space Telescope Guide Star Catalog (GSC) (Jenkner et al., 1990) and the ΔR magnitudes are tabulated in Table 1. The ΔR differences in magnitude are found from our data in the sense of the star minus GSC 3460_626. To look for brightness variations during a night the standard deviation of the differential magnitudes for each star during a night were calculated and ranged from $0^{m}_{.}006$ for a bright star on a good night to $0^{m}_{.}030$ for the faint stars on poor nights. To measure night to night variations a run mean of the seven nightly averages was calculated and is shown

[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

Table 1. Stars observed in the field of RX J1326.9+4532

GSC No.	RA J2000	Dec. J2000	GSC Mag.	ΔR Mag.	V	$(V-R)_C$
3460_780	$13^h26^m54^s$	+45°32'50"	12.5	variable	12.80	0.88
3460_601	$13^h27^m04^s$	+45°35'30"	13.4	$+1.966 \pm .009$	13.58	0.37
3460_626	$13^h27^m24^s$	+45°34'31"	11.6	–	11.81	0.54
3460_771	$13^h27^m21^s$	+45°33'40"	14.5	$+2.885 \pm .019$	-	-
3460_881	$13^h26^m55^s$	+45°37'06"	14.8	$+3.404 \pm .048$	-	-
3460_618	$13^h26^m39^s$	+45°34'56"	13.2	$+1.792 \pm .031$	-	-

as ΔR in Table 1. We consider GSC 3460_780 to be the only significantly variable star. Due to the small field of view extinction effects were negligible and no corrections have been made for them. No corrections have been made to transform the R magnitude to a standard system.

Brightness variations in RX J1326.9+4532 were evident during a night. A least squares fit of a single sine wave to all the the data shows a deep minimum in χ^2 at a period of $0^{\rm d}.18$, but a plot of the light curve shows unequal maxima which led us to double the period. An eclipse was also apparent with ingress and egress not resolved. On three occasions the observations were terminated by clouds or dawn during the eclipse, but we could clearly see the ingress of the primary minimum seven times and the Heliocentric Julian Dates (2450000+) were 550.9137, 560.0163, 560.7451, 562.9295, 570.9392, 576.7641, and 578.9498 with an uncertainty of about 0.0008 days. A fit to these times, corrected to mid eclipse gives the ephemeris:

$$\text{HJD of Minima} = 2450550^{\rm d}.9246(3) + 0^{\rm d}.364095(7) \times \text{E}.$$

A plot of the differential (GSC 3460_780−GSC 3460_626) R magnitudes phased at this period is shown in Figure 2 for our two best nights. Clearly there is a difference of about $0^{\rm m}.02$ after the first maximum, but no difference in the second maximum. Most of the other nights agreed with the data marked with "+" symbols.

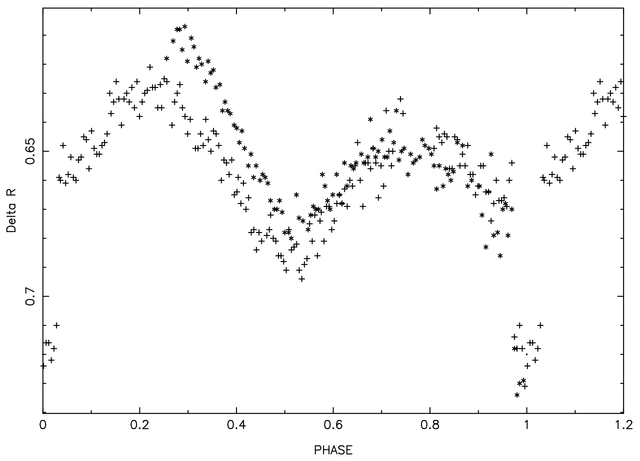

Figure 2. R band light curve of RX1326.9+4532 for HJD 2450560(+) and 2450562(∗)

To help classify the variable star V and R frames were obtained under photometric conditions along with observations of the nearby bright standard star HR 5112 (Moffett and Barnes, 1979). The V band brightness and $(V-R)_C$ colors are listed in Table 1 for the three brightest stars. However great caution should be exercised in using these data since they are derived from only one standard star and its (V−R) was transformed from the Johnson system to the Cousins system using Taylor's (1986) equations. While certainly not definitive these colors confirm that RX J1326.9+4532 is a late type (approximately M0V) star (Cousins 1981). A dwarf star of this color would be expected to have an absolute magnitude of approximately V=9.0 (Allen 1976) so from our apparent magnitude we find the distance to be about 60 parsecs. Combined with the proper motion we find a large tangential velocity of 76 km/sec. Observations were continued in the V and R filters through the eclipse and the depths were measured to be $0^m_.054 \pm 0^m_.010$ in R and $0^m_.128 \pm 0^m_.029$ in V.

Since no points were observed on the descending or ascending branches of any primary minimum, we observed with no filter and decreased the exposure time to 33 seconds for a repetition rate of 54 seconds. Still no points were seen on the descending branch and only one possibly on the ascending branch. The duration of the primary minimum was $0^d_.0212 \pm 0.0006$ so the ratio of the radii of the two stars must be less than 0.028. All other eclipses were consistent with this duration.

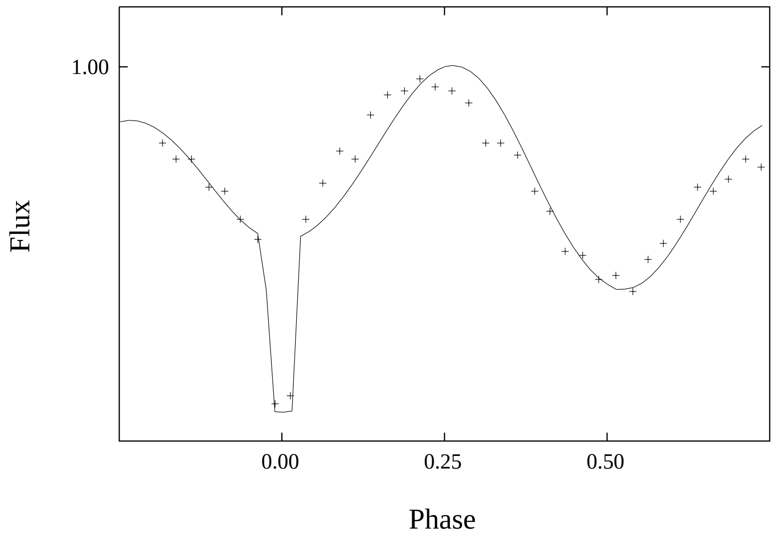

Figure 3. R band light curve (points) with example model (line) of M0V and white dwarf

From the color information and the duration of the eclipse we can surmise that the primary star is a M0V and the secondary star is a white dwarf. Assuming 0.70 and 0.47 solar masses and 0.63 and 0.014 solar radii for the primary and secondary stars respectively (Allen 1976), we find from our period and Kepler's 3^{rd} Law the relative radii of 0.29 and 0.0065. The temperature of the cool star was assumed to be 3480K and from the depths of the minimum the temperature of the white dwarf was estimated, but needed to be adjusted to 10000K. Using these radii, masses and temperatures a model light curve was made with Binmaker 2.0 (Bradstreet 1993) and is shown in Figure 3. The inclination was adjusted to 76° to fit the data, however assuming different masses and radii would require an inclination different by a few degrees. To model the asymmetry in the maxima one spot was used which had a co-latitude of 130°, longitude of 60°, a radius of 13° and a temperature factor of 0.8. All other inputs were set at values appropriate for these temperatures. The cool star is well inside its Roche lobe and it is not likely we will see much evidence of mass transfer.

The star RX J1326.9+4532 is therefore one of a small group of stars very similar to the famous eclipsing binary V471 Tau. Both stars have white dwarf secondary stars and late type primary stars with evidence of starspots from asymmetrical and changing light curves, and X-Ray emission. Further photometric observations with a larger telescope will be valuable to measure the relative radius, the color and thus the temperature of the white dwarf star. Spectroscopic observations will be important to get a good spectral class for the late type dwarf and radial velocities will measure the scale of the system and the masses. The space velocity is also of interest since the tangential velocity implies that the star may belong to Pop II. RG would like to thank the Austrian Ministry of Science for financial support.

R.M. ROBB
R. GREIMEL
Climenhaga Observatory
Dept. of Physics and Astronomy
University of Victoria
Victoria, BC, CANADA, V8W 3P6
Internet: robb@uvic.ca

References:

Allen, C.W., 1976, Astrophysical Quantities, the Athlone Press, University of London, London, UK

Beers, T.C., Bestman, W. and Wilhelm, R., 1994, *AJ*, **108**, 268

Bradstreet, D.H., 1993, Binary Maker 2.0 Usermanual, Contact Software, Norristown, PA 19401-5505, USA

Cousins, A.W., 1981, *SAAO Circ.*, **6**, 4

Giclas, H.L., Burnham, R. Jr., Thomas, N.G., 1965, *Lowell Obs. Bull.*, No. 6, 197

Jenkner, H., Lasker, B., Sturch, C., McLean, B., Shara, M., Russell, J., 1990, *AJ*, **99**, 2082

Moffett, T.J. and Barnes, T.G. III, 1979, *PASP*, **91**, 180

Robb, R.M. and Honkanen, N.N., 1992, in *A.S.P. Conf. Ser.*, **38**, Automated Telescopes for Photometry and Imaging, ed. Adelman, Dukes and Adelman, 105

Taylor, B.J., 1986, *ApJS*, **60**, 577

Voges, W., Aschenbach, B., Boller,T., Braeuninger, H., Briel, U., Burkert, W., Dennerl, D., Englhauser, J., Gruber, R., Haberl, F., Hartner, G., Hasinger, G., Kuerster, M., Pfeffermann, E., Pietsch, W., Predehl, P., Rosso, C., Schmitt, J.H.M.M., Truemper, M. and Zimmermann, H.-U., 1997, *A&A*, preprint