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A PHOTOELECTRIC LIGHT CURVE OF GR CARINAE

The meager history of GR Car is undoubtedly due to its faintness. The discovery by Kruytbosch (1936) and the follow-up by Kruytbosch and Hertzsprung (1936) resulted in an erroneous period and Algol–type designation. With Prager's (1943) corrected period, it is possible to see that the system is likely an unevolved one with a very eccentric orbit.

In 1974 and 1975 E.J.W. observed GR Car as part of her Cerro Tololo program working on eccentric pairs. Both the Lowell 0.6–m and Yale 1.0–m reflectors were used and conventional *UBV* filters were mounted in the photometers. Integration intervals were 30–sec long. Most of Prager's stars and two anonymous ones were checked for suitability as comparison stars. None appeared to be certainly variable but Prager's "a" and "e" and an anonymous one ("x") are recommended for future observing. These are indicated in Fig. 1. Since GR Car is almost circumpolar from CTIO, it can be observed to large hour angles. At full moon, sky background is comparable to Prager's "e" itself through an ultraviolet filter.

On several nights 5 *UBV* standards were observed and these were used to standardize the objects noted in the following table:

STAR	*V*	*B–V*	*U-B*
GR Car at max	+13.63	+0.67	+0.12
Prager's "a"	+13.21	+0.57	−0.02
Anonymous "x"	+13.15	+0.18	+0.13

Errors for the magnitudes are of the order of ±0.05 and for the color indices of the order of ±0.03. The color indices lead to no unique value of reddening. GR Car itself may be inferred to suffer little reddening and to be a mid–F type object or to be reddened by $E(B-V) = 0.80$ and to be a mid–B type star.

During a sequence of personal moves, most of the reduced data were misplaced and cannot be recovered conveniently. The present note concerns only the yellow data which were, in fact, studied from a plot of the measures.

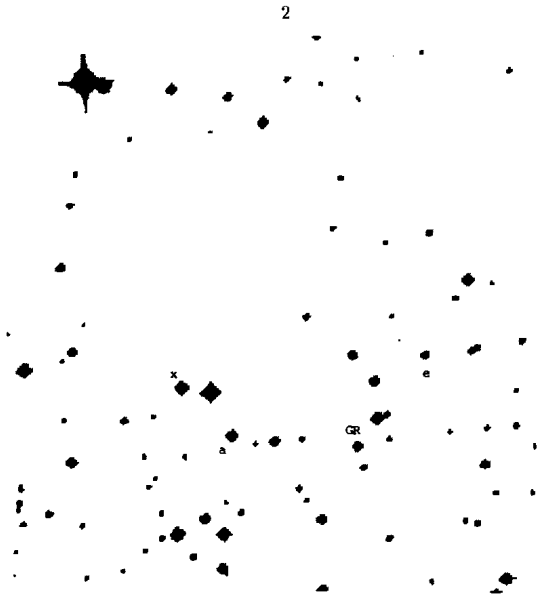

Fig. 1. The neighborhood of GR Car showing the recommended comparison stars, Prager's "a" and "e", and a new one "x". In the figure, north is up and east is to the left. The declination dimension in the figure subtends 7.5′. The chart has been prepared by optically scanning the appropriate field on the J-print of the SRC Schmidt survey atlas.

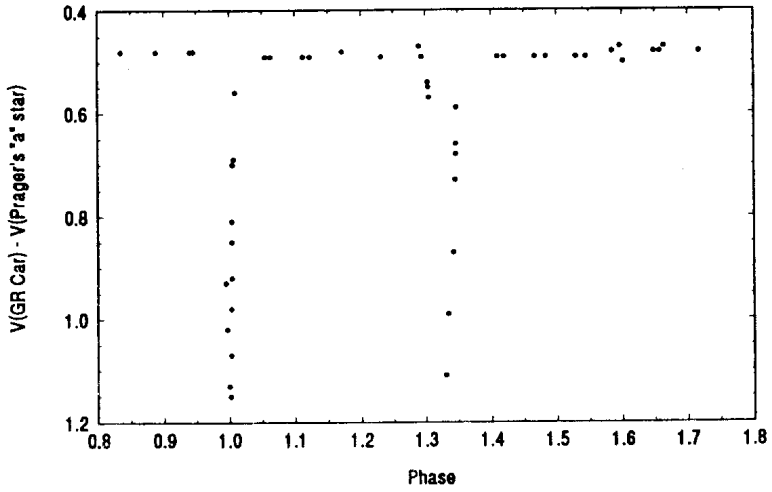

Fig. 2. The differential V light curve for GR Car against star "a" used by R. Prager.

GR Car was at minimum light at HJD 2,442,211.52. Prager's ephemeris shows this to be a primary eclipse with respect to his epoch. There appears to be no need to improve his period of 17.13952 days. The V light curve, in the sense of GR Car *minus* Prager's "a" appears in Fig. 2. The spacing between the minima is the same as for the Leiden and Prager's light curves of photographic estimates, indicating no measurable rotation of the apse since 1924. The apsidal period must be very long.

Even though the data are few, it appeared possible to recover some information from the Tololo light curve useful for future observers. Accordingly, it was studied with the *EBOP* code of Popper and Etzel (1981). A certain amount of trial and error, lengthy because of the incomplete coverage of the secondary eclipse shoulder, resulted in values of $e = 0.50$ and $\omega = 119°$. More numerical experiments on the data, iterating back and forth to the eccentricity components, led to the following parameters: $k = 1.00$, $i = 89°$, $J_s = 1.00$, and $r = 0.06$ for $x = 0.7$. The systemic light ratio is 0.51/0.49. These results are obviously not of high weight and parameter precision is about ± 2 in each last quoted figure.

Even the small amount of information gleaned from the Tololo light curve has value. The light curve gives every indication of deriving from very young stars which are widely separated. Kepler's Third Law applied to the system appears as:

$$M_1 + M_2 = 454.11a^3$$

(in the conventional units of solar mass, years, and Astronomical Units). It was assumed that the component masses are equal just as appears to be the case for the stellar radii. For successive trial values of mass, values of the semi-major axes and then the stellar radii (from the *EBOP* results) were calculated. This Mass–Radius "relation" for the GR Car stars was then mapped and compared to the empirical one for unevolved stars. The intersection of the loci indicates the components of GR Car to be B1 stars, consistent with the possible reddening of about 0.8 noted above.

Although it will be a very long time before their internal density distributions can be evaluated, more complete photometry and thorough radial velocity study should give precise global parameters for this system. It is certainly to be counted among the presently known young, massive binaries.

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