PHOTOELECTRIC OBSERVATIONS OF NU ERIDANI

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ABSTRACT

The photometric observations of ν Eridani in January and February, 1951, December, 1951, and January, 1952, can be satisfied by the spectroscopic period, $P_2 = 0.1735089$ day. One outstanding discrepancy with the spectroscopic observations remains: the beat period determined from the photometric observations of December, 1951, and January, 1952, is $P_3 = 8.7$ days, while the spectroscopic $P_3 = 6.9808$ days. This disagreement and also the observations in January and February, 1951, suggest that both the period and the amplitude of the beat-curve are variable. For the December, 1951, and January, 1952, observations, $P_1 = 0.1770$ day, and the values of the light-variations associated with P_1 and P_2 are $R_1 = 0.067$ mag. and $R_2 = 0.114$ mag., respectively.

Photoelectric observations of ν Eridani in two colors, covering an interval of 29 days from December 21, 1951, to January 19, 1952, have been carried out with the 12-inch refractor of the Lick Observatory. ν Eridani has been listed as a doubtful member of the β Canis Majoris class for many years. The results obtained by the earlier observers had suggested that the period was variable and that, for this reason, the star should not be classed with the other β Canis Majoris stars. In 1921 F. Henroteau obtained a period of 0.23667 day for the variation in radial velocity.[1] This period predicted either a maximum or a minimum of the velocity-curve. In 1927 he was unable to verify this period or to find any other which would represent the observations.[2] About this same time R. H. Baker discovered that the light of the star was variable and derived a period of 0.15430 day.[3] Subsequently it was found by Zessewitch[4] and independently by the author[5] that Henroteau's observations can be represented by a period of 0.17351 day. This strongly suggested that the period is constant.

It was therefore planned to carry out a series of simultaneous spectroscopic and photometric observations of ν Eridani during the 1951–1952 season, similar to the program adopted for 16 Lacertae.[6,7] Unfortunately, weather conditions did not permit the program to be carried out completely; simultaneous observations were secured on only two nights. The nine photometric runs which were obtained form the basis of the present paper.

The photometer, filters, and recording system employed were the same as those used for 16 Lactertae.[7] The primary comparison star used was μ Eridani. Observations of ω Eridani and of HD 28749 were also obtained as a check on the constancy of μ Eridani. So far as could be determined, there was no significant variation in any of the comparison stars.

The observations have been reduced to no atmosphere, using extinction coefficients determined each night from the comparison stars. The magnitudes and colors have been left on the system defined by the telescope–filter-cell combination. The individual light- and color-curves are shown in Figures 1 and 2. The dots represent blue-magnitude differences and the circles color differences, ν Eridani minus μ Eridani. The abscissae of th

[1] *Pub. Dom. Obs. Ottawa*, Vol. **5**, No. 3, 1921.

[2] *Ibid.*, Vol. **9**, No. 4, 1927.

[3] *Pub. A.S.P.*, **38**, 86, 1926.

[4] *A.J. U.S.S.R.*, **21**, 94, 1944.

[5] *Pub. A.S.P.*, **63**, 176, 1951.

[6] O. Struve, D. H. McNamara, R. P. Kraft, S. M. Kung, and A. D. Williams, *Ap. J.*, **116**, 81, 195?

[7] M. F. Walker, *Ap. J.*, **116**, 106, 1952.

curves are heliocentric Julian dates. Each symbol represents a single deflection of about 1-minute duration registered on a Brown recorder. It was necessary to change battery boxes and photomultiplier cells during the course of the observations on January 18, so that the light-curve may be somewhat uncertain.

As in the case of 16 Lacertae, there is no evidence of a variation in color. In order to determine whether variations of temperature occur, it will be necessary to observe the star with a very long color base line.

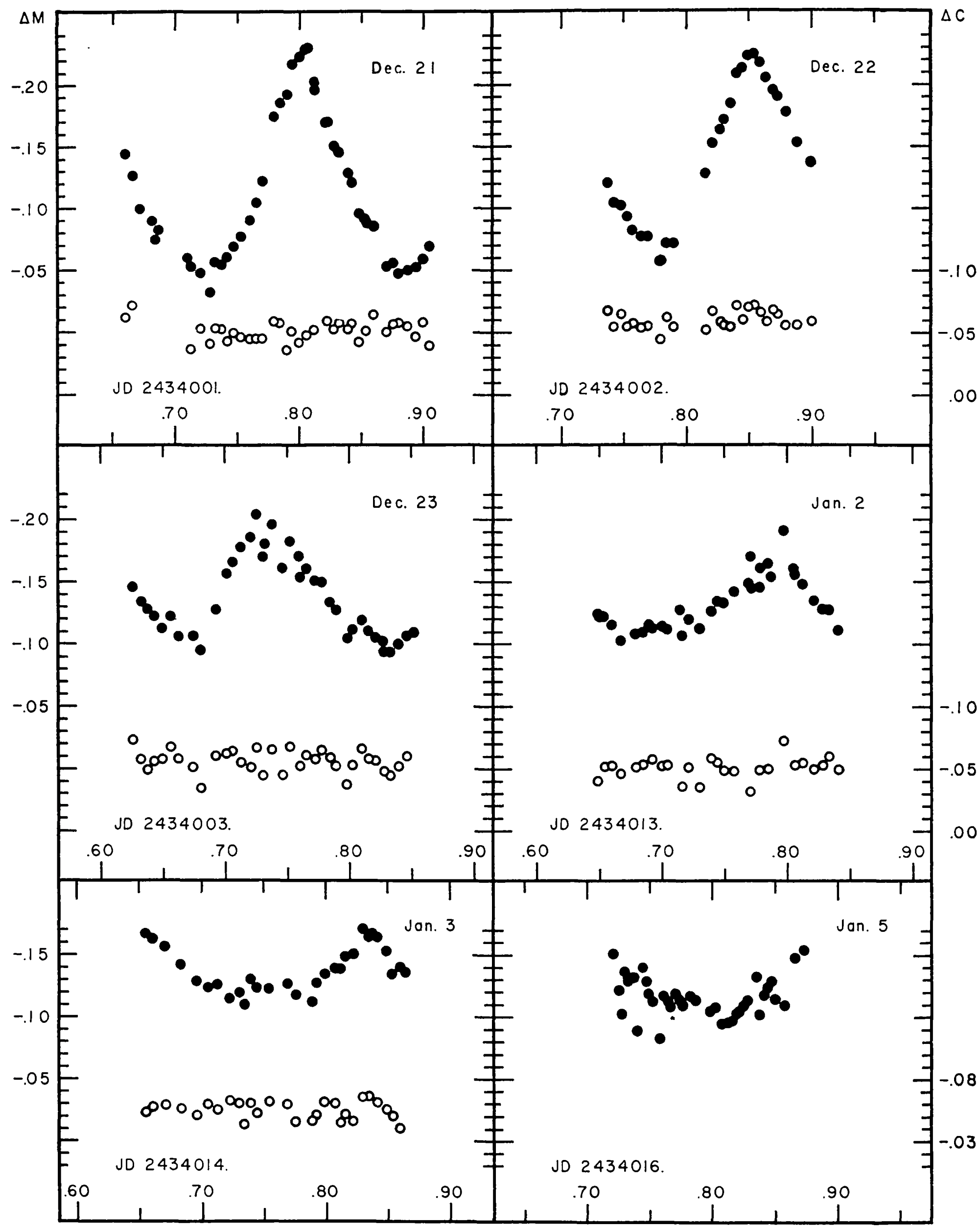

FIG. 1.—Photometric observations of ν Eridani in 1951 and 1952. The dots represent blue-magnitude differences, and the circles color differences, ν Eridani minus μ Eridani, reduced to no atmosphere. Each symbol represents a single deflection of about 1-minute duration registered on a Brown recorder.

The observations show the existence of a very large beat phenomenon; the light-range varies at least between 0.181 and 0.048 mag., while the value of the mean light remains essentially constant. The values of the light-variation observed in December, 1951, and January, 1952, together with those observed in January and February, 1951,[5] are listed in Table 1. The present observations are best represented by a period of P_3 = 8.7 days, as shown in Figure 3; the phases have been arbitrarily computed from zero phase =

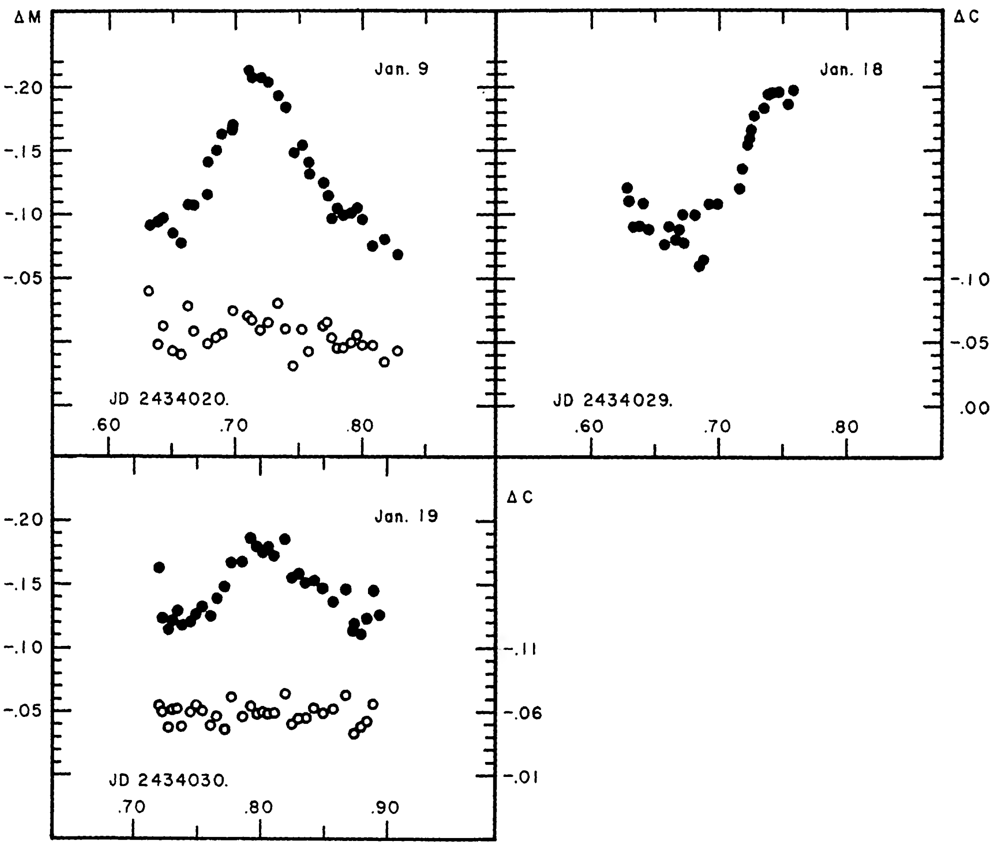

FIG. 2.—Photometric observations of ν Eridani in 1952. Ordinates and symbols as in Fig. 1

TABLE 1

OBSERVED LIGHT-VARIATIONS OF ν ERIDANI

JD	Light-Range R (Mag.)	Phase (P=8.7 Days)	JD	Light-Range R (Mag.)	Phase (P=Days 8.7)
2433			2434		
670.7........	0.122	....	003.7........	0.092	0.22
671.6........	.098	....	013.8........	.054	.38
672.7........	.088	....	014.8........	.048	.49
677.7........	.075	....	016.8........	.060*	.72
679.7........	.088	....	020.7........	.130	.17
2434			029.7........	.107	.21
001.8........	.181	0.00	030.8........	0.060	0.33
002.8........	0.154	0.12			

* Low weight; probable error ± 0.02 mag.

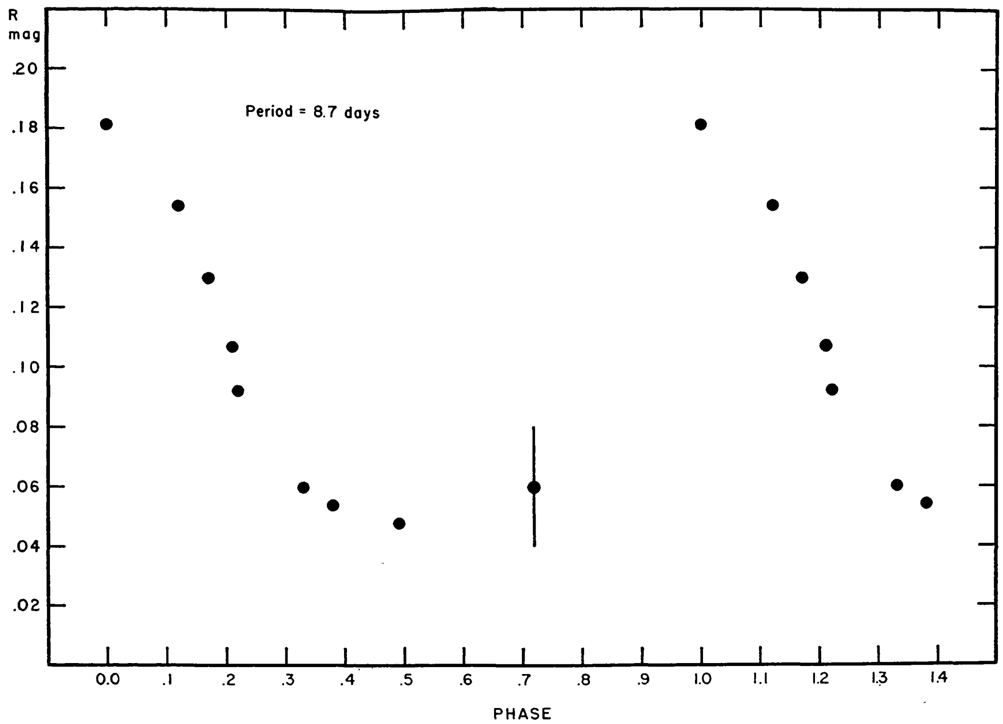

FIG. 3.—The beat period in the amplitudes of the light-curves observed in December, 1951, and January, 1952. The ordinate is the light-variation, the abscissa is the phase computed from zero phase = JD 2434001.8 + 8.7E days. The vertical line indicates the uncertainty in the observation of January 5.

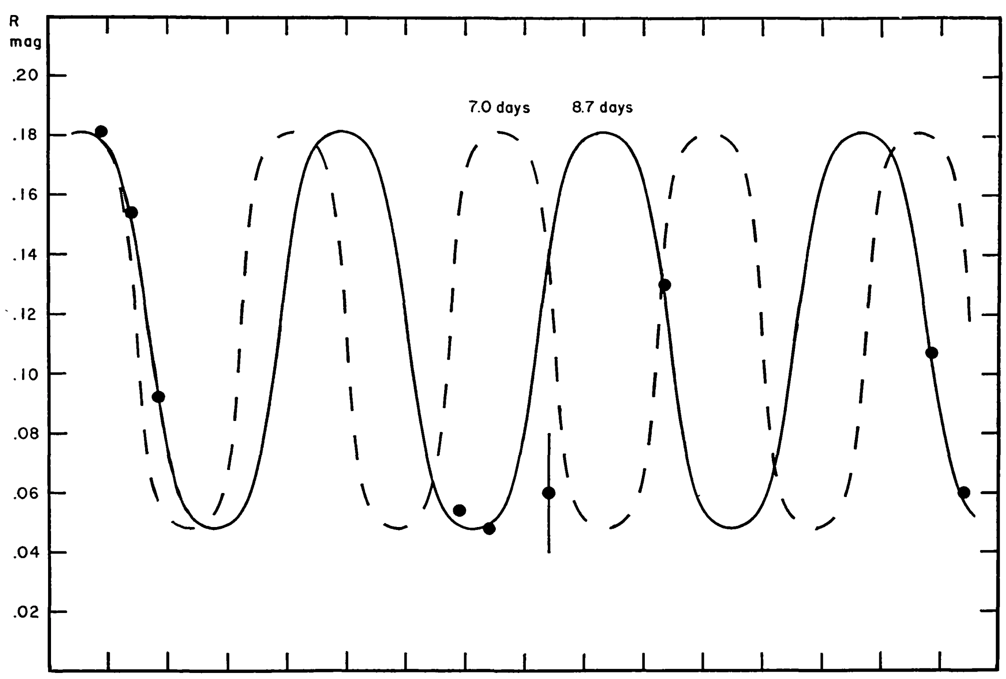

FIG. 4.—Amplitudes of the light-curves observed in December, 1951, and January, 1952. Ordinate and symbols as in Fig. 3. The abscissa is the Julian date. Curves having periods of 7.0 and 8.7 days have been drawn to illustrate the difficulty of fitting the observations to a 7-day period. The curves are only for purposes of illustration and are not intended to be curves of best fit.

JD 2434001.8 + 8.7E days. This 8.7-day period is at variance with the beat period of 6.9808 days derived by O. Struve *et al.*[8] The observed values of the light-variation are plotted against Julian date in Figure 4. Their distribution would seem to rule out any possibility of representing the observations with the 7-day period. All the spectroscopic observations, both Henroteau's and Struve's, can be represented by the 7-day period. However, during the interval covered by the recent photoelectric observations, only two complete velocity-curves were obtained. It is therefore not possible to ascertain whether the radial velocities obeyed the 7-day or the 9-day period during this one-month interval.

The most likely explanation would seem to be that the length of the beat period is variable in some manner. The light-variations observed in January and February, 1951, shown in Figure 5, appear to bear out this supposition. They apparently will not fit either the 7-day or the 9-day period but require a still longer one of around 12 days, although this is very uncertain, since there are so few observations. The general appearance of the curve, incomplete though it is, suggests that the amplitude of the beat-curve was smaller at that time than in the more recent set of observations. In a general way, this agrees with the spectroscopic results,[8] which also indicate that there are changes in the amplitude of the beat-curve and suggest that it was passing through a minimum at about that time. This difference in the values of the beat period shows again the desirability of obtaining simultaneous spectroscopic and photometric observations.

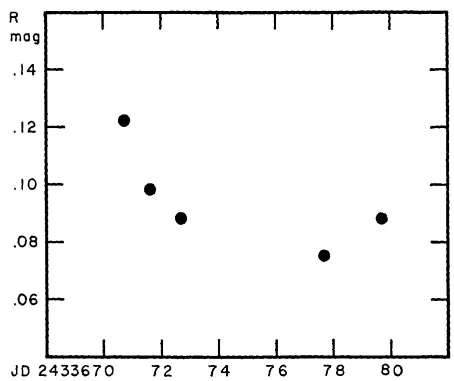

FIG. 5.—Amplitudes of the light-curves observed in January and February, 1951, plotted against Julian date. The ordinate is the light-variation.

There is obviously not enough photometric material as yet available to attempt an accurate determination of the short, 4-hour period. About all that can be said at the present time is that the photometric observations can be represented by the spectroscopic period. The observed times of maximum light of ν Eridani are listed in Table 2, together with the residuals between the observed maxima and those computed from the formula:

$$\text{Helioc. max.} = \text{JD } 2433670.731 + 0.1735089E \text{ day.}$$

The epoch has been arbitrarily chosen as the time of the first observed maximum. The residuals for December, 1951, and January, 1952, have been combined with the 8.7-day period according to the formula: Zero phase = JD 2434001.8 + 8.7E days. Because of the uncertainty in the value of the beat period, no attempt has been made to include the earlier observations. Figure 6 shows that they exhibit a variation in the 9-day period. The exact amplitude and form of the residual curve cannot be determined, since there are observations only over half the cycle. However, it appears that the amplitude is of the same

[8] O. Struve, D. H. McNamara, S. M. Kung, R. P. Kraft, and A. D. Williams, *Ap. J.*, **116**, 398, 1952

order of magnitude as for the corresponding curve of residuals of times of minimum velocity found by Struve.[8]

If, following Struve's notation, we call $P_2 = 0.1735089$ day and $P_3 = 8.7$ days, then, since the residuals tend to become more positive after the time of maximum light-variation,[6,7]

$$\frac{1}{P_3} = \frac{1}{P_2} - \frac{1}{P_1},$$

TABLE 2

OBSERVED MAXIMA OF ν ERIDANI
(Max. Light = Helioc. JD 2433670.731 + 0.1735089E Day)

Helioc. JD	O−C (Day)	Phase (P=8.7 Days)	Helioc. JD	O−C (Day)	Phase (P=8.7 Days)
2433			2434		
670.731......	0.000	....	002.854......	+0.027	0.12
671.784......	+ .012	....	003.732......	+ .037	.22
672.663......	+ .023	....	013.794......	+ .036	.38
677.681......	+ .010	....	014.832......	+ .033	.49
679.774......	+ .021	....	020.719......	+ .021	.17
2434			029.755*.....	+ .034	.21
001.801......	+0.015	0.00	030.798......	+0.036	0.33

* Low weight.

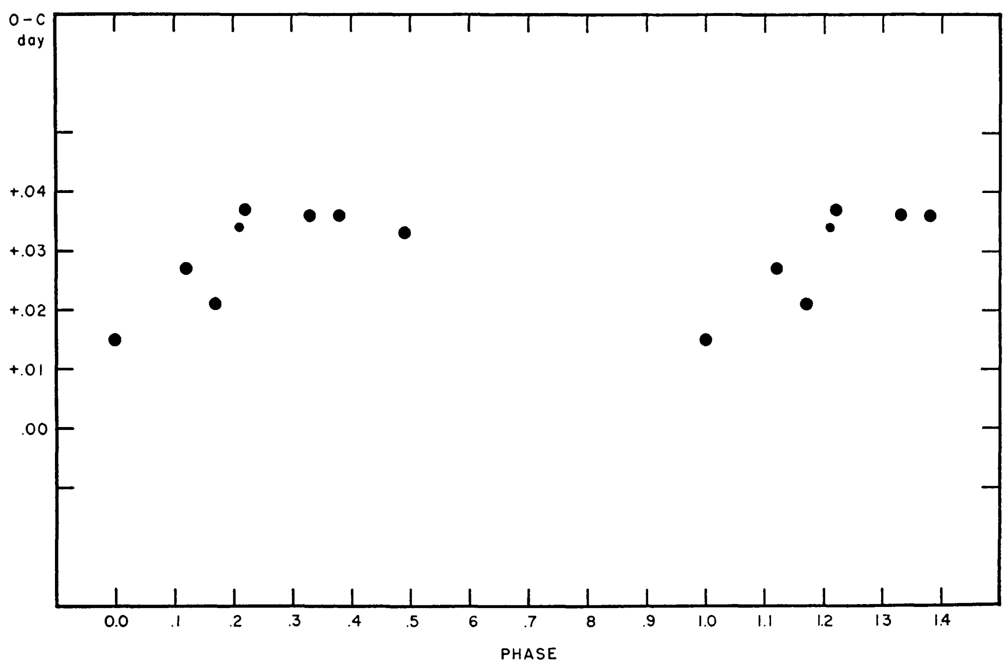

FIG. 6.—Periodic variations in the time of maximum light. The ordinate is the residual, observed maximum minus maximum predicted from the formula: Helioc. max. = JD 2433670.731 + 0.1735089E day. The phases are computed from Zero phase = JD 2434001.8 + 8.7E days. Only the observations of December, 1951, and January, 1952, have been included. The small symbol indicates low weight.

and therefore $P_1 = 0.1770$ day. Whether or not this period is correct depends upon the correctness of the beat period. It is probably significant, however, that the residuals, like the beat amplitudes during the period covered by the observations, fit the 9-day period and not the 7-day period and that they, like their spectroscopic counterparts, indicate that $P_1 > P_2$.

The light-variations associated with P_1 and P_2 are $R_1 = 0.067$ mag. and $R_2 = 0.114$ mag., respectively. The ratio of $R_2/R_1 = 1.7$. Since the value of $2K$ observed by McNamara on December 21 was about 76 km/sec, we may assume that K_1 was near its maximum value of 15 km/sec,[8] so that the ratio of $K_2/K_1 = 1.6$. Thus it appears that in ν Eridani, unlike 16 Lacertae,[7] the ratios of the light- and velocity amplitudes are approximately the same.

TABLE 3

SIMULTANEOUS OBSERVATIONS OF LIGHT AND VELOCITY

JD	Light-Range R (Mag.)	$2K$ (Km/Sec)	ΔT* (Day) 1	ΔT* (Day) 2
2433				
671.6	0.098	48	−0.005	−0.003
672.7	.088	55	+ .005	− .020
2434				
001.8	.181	76	− .004	0.000
030.8	0.060	22	−0.008	....

* 1, Maximum light minus gamma velocity; 2, minimum light minus gamma velocity.

So far we have simultaneous spectroscopic and photometric observations of ν Eridani on only four nights. Thus there are not enough data profitably to discuss the relationships between the light- and velocity-curves. The existing material has been collected in Table 3.

I am indebted to Dr. C. D. Shane for permission to use the facilities of the Lick Observatory and to the members of the staff for their kind interest and co-operation.