ON THE PERIOD OF THE SPECTROSCOPIC BINARY 36 τ^9 ERIDANI

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ABSTRACT

The *period* of *36 τ^9 Eridani* was *re-examined* on the basis of observations recently published by the Lick Observatory and new plates lately secured at Yerkes Observatory. The mean *period* $0^d.85441$ previously found was *adjusted* to $0^d.85423$ to include the recent observations. As the previous results suggested that the period might be variable, the recent observations were compared with the earlier ones. The distribution of residuals indicated no secondary period.

Observations, being possible only near the meridian on account of the star's southern declination, made this case suitable for the use of the formula for the *alternative periods* $p_1=p_3/(1-p_3)$, $p_2=p_3/(2p_3-1)$, $p_3=0^d.85423$. In view of a large scattering p_2 was discarded; p_1, as well as p_3, gives a satisfactory velocity-curve, and either one can be used for determining the elements of the orbit. There is at present no way of deciding which is correct until a few spectrograms can be obtained at a longitude widely differing from that of the Yerkes Observatory. The elements were determined by Laves's hodographic method as modified by Pogo.

The recent volume on radial velocities of the *Publications of the Lick Observatory*[1] contains five observations of the radial velocity of

TABLE I

LICK OBSERVATIONS

Date, G.C.T.	Obs.	Qual.	Vel.	Mean Vel.	Phases			
					$p=0^d.8544075$	$p_3=0^d.8542336$	$p_2=1^d.1978984$	$p_1=5^d.9542159$
1909 Jan. 23.09	P	......	+40	+40	0.79	0.33	0.73	4.28
Aug. 17.39	M H	....	−19 12	−15.5	.32	.76	0.99	2.18
Aug. 29.38	M H	....	26 13	19.5	.35	.79	1.00	2.26
Dec. 21.08	P H	....	16 15	15.5	.42	.02	0.90	2.83
1910 Jan. 13.10	Mo H	....	17 −23	−20.0	0.37	0.83	1.16	2.03

The names of the observers are designated as follows: P=C. F. Paddock, M=J. H. Moore, H=Miss A. M. Hobe, Mo=Mrs. J. H. Moore.

36 τ^9 Eridani (α, $3^h55^m.7$; δ, $-24^\circ18'$, 1900). Since in our previous paper on the orbit of this spectroscopic binary[2] it was found that the

[1] *Op. cit.*, **16**, 50, 1928.

[2] O. Struve and C. Hujer, *Astrophysical Journal*, **65**, 300, 1927.

period may be variable, it seemed desirable to check this by means of these Lick observations. Four of them fall in the year 1909 and one in 1910 and so form a continuation of a group of early Yerkes spectrograms made in 1908. The mean period $0^{d}.8544075$ as given in the paper by Struve and Hujer referred to above is in agreement with the Lick observations, these being shifted in the direction of smaller phases by $0^{d}.15$.

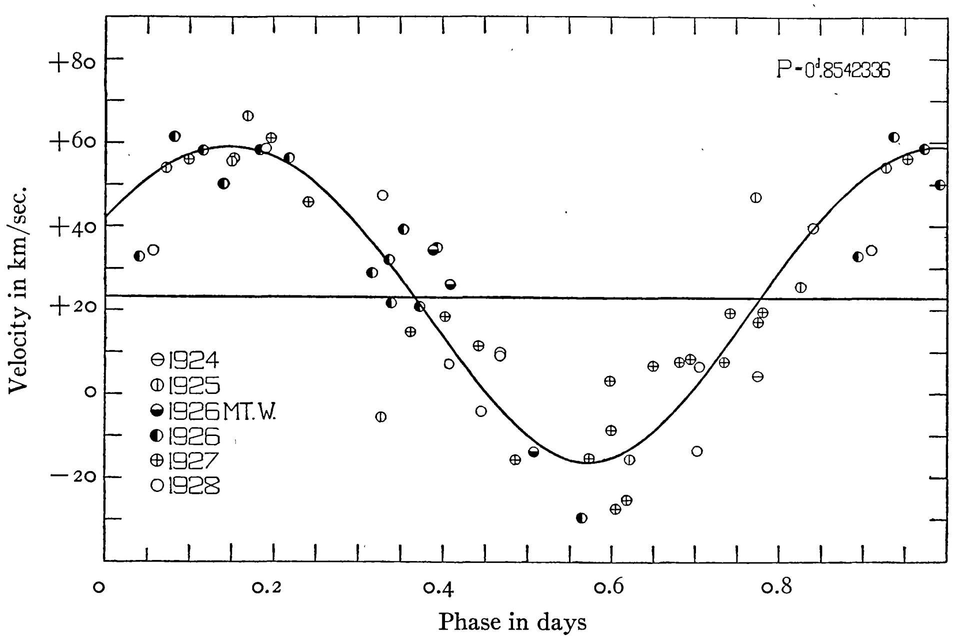

FIG. 1.—Velocity-curve of 36 τ^9 Eridani ($p_3 = 0^{d}.8542336$). Phases are counted from 1926 October 15.0. U.T.

A new series of observations has recently been obtained with the Bruce spectrograph. These, when plotted against the mean period, proved that the velocity-curve is shifted to the left by $0^{d}.1$.

Adjustment of the mean period.—The fact that our new observations were shifted by $0^{d}.1$ to the left led to an adjustment of the old period. As the mean separation of the new observations from the old ones is about 575 revolutions, the period was shortened by $0^{d}.00017$, which gave $p = 0^{d}.85423$. This new period gives a satisfactory curve including all observations since 1924. When the early Yerkes observations together with those of the Lick Observatory were plotted with this adjusted period, a good curve was obtained, but on account of the long interval of time between the early and recent observations, no attempt has been made further to adjust the period and to combine all observations since 1908.

An investigation of the distribution of the residuals was made for the purpose of finding some variability of long period. The adjusted curve was used for deriving the residuals. Considerable

TABLE II

NEW YERKES OBSERVATIONS

DATE, U.T.	OBS.	QUAL.	VEL.	PHASES			
				P=0ᵈ8544075	p_3=0ᵈ8542336	p_2=1ᵈ1978984	p_1=5ᵈ9542159
1928 Jan. 31.096.....	PBS	vg	+ 6.6	0.609	0.705	1.124	2.173
Feb. 4.108.....	HuS	f	− 4.0	.349	.446	0.344	0.771
Feb. 6.074.....	BHuS	g	−13.3	.606	.703	1.113	2.737
Feb. 10.049.....	BHu	g	+ 7.5	.309	.407	0.296	0.758
Feb. 10.110.....	HuS	f	9.4	.370	.468	.357	0.819
Feb. 19.026.....	BMP	f	39.5	.742	.842	.888	3.780
Feb. 19.095.....	BPS	g	34.1	.811	.056	.957	3.849
Mar. 3.042	σHuS	g	58.8	.087	.190	.727	4.888
Mar. 4.035.....	σHu	g	47.8	.226	.329	.522	5.881
Mar. 5.029.....	σHu	g	+ 9.7	0.365	0.468	0.318	0.921

The names of the observers and the quality of the plates are designated as follows: B=S.B. Barrett, σ=O. Struve, P=A. Pogo, M=W. W. Morgan, Hu=C. Hujer, S=F. R. Sullivan; vg=very good, g=good, f=fair, p=poor. The measures are by Hujer.

differences in the values of O.−C. were found even within the observations of the same night. The residuals were plotted against time but no periodicity could be found.

Alternative periods.—In view of the low southern declination of this star (−24°), our observations have necessarily been confined to small hour-angles. I have, therefore, followed a suggestion of Professor Struve and treated this star in a manner similar to that applied by him to the spectroscopic binary 27 Canis Majoris,[1] which presents a similar case. Under such conditions there always exist three distinct periods that will fit all observations almost equally well. This was first pointed out in connection with variable

[1] *Ibid.*, **66**, 113, 1927.

stars by C. Hoffmeister[1] and Harlow Shapley.[2] As has been shown by J. G Hagen,[3] $p_1 > p_2 > 1^d > p_3$ are expressed in the following way:

$$p_2 = p_1/(p_1 - 1) \qquad p_1 = p_2/(p_2 - 1)$$
$$p_3 = p_1/(p_1 + 1) \qquad p_1 = p_3/(1 - p_3)$$
$$p_2 = p_3/(2p_3 - 1) \qquad p_3 = p_2/(2p_2 - 1)$$

The values of p_1, p_2, p_3 must be expressed in sidereal time since our spectrographic observations were made at about the same hour-angles.

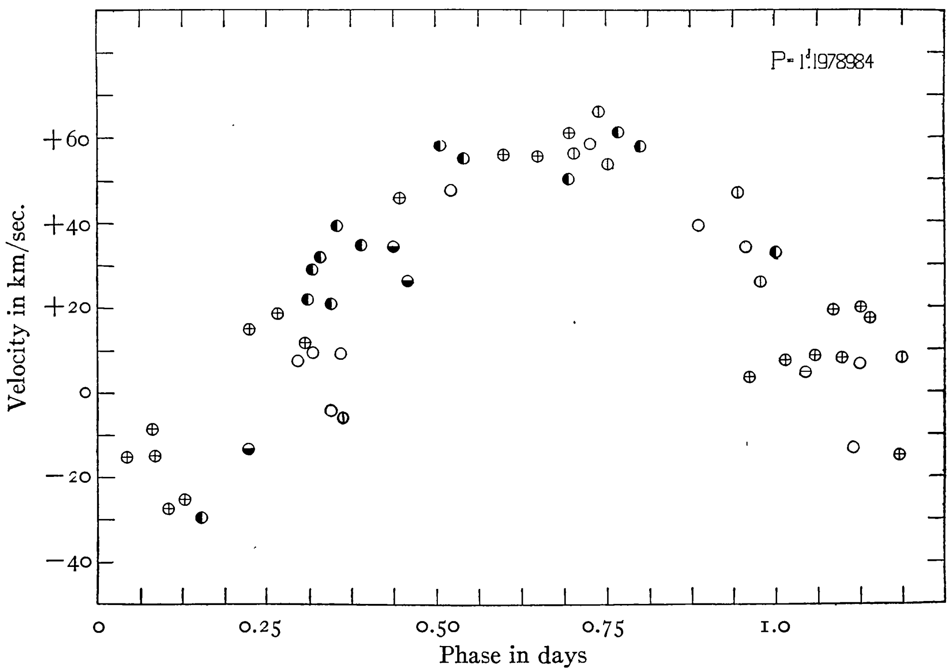

FIG. 2.—Velocity-curve of 36 τ^9 Eridani ($p_2 = 1^d.1978984$). Phases are counted from 1926 October 15.0. U.T. Observations of different seasons are indicated as in Fig. 1.

The period $p_3 = 0^d.85423$ gives a value of $0^d.85654$ in sidereal time. Thus there were computed two other periods, $p_2 = 1^d.20119$ in sidereal time $= 1^d.19790$ in mean solar time, and $p_1 = 5^d.97048$ in sidereal time $= 5^d.95422$ in mean solar time.

Velocity-curves.—The period p_2 was examined first and found to be impossible. Although the plotted observations have some tend-

[1] *Astronomische Nachrichten*, **196**, 399, 1913.

[2] *Ibid.*, p. 417, 1913. [3] *Die veränderlichen Sterne*, **1**, 624, 1920.

ency to form a curve, the scattering is far too great, and this period can safely be discarded.

The result is quite satisfactory in the case of the longer period p_1. Here we see that the observations give a definite curve with a scattering somewhat smaller than in the adjusted period, p_3. Now we have two periods: a short one p_3, and a long one p_1, correspond-

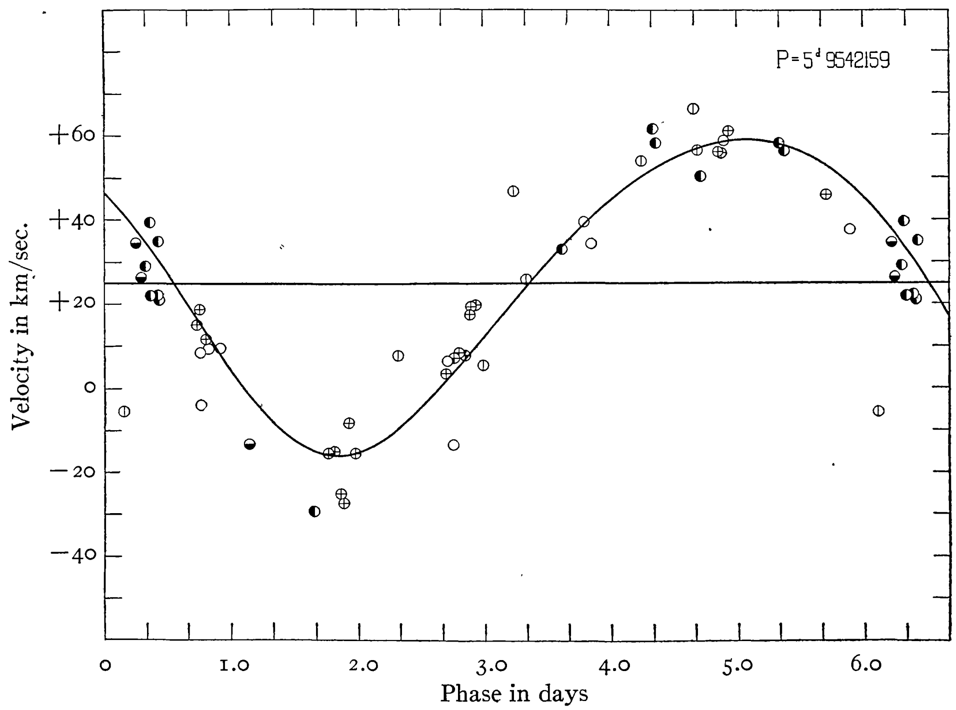

FIG. 3.—Velocity-curve of 36 τ^9 Eridani ($p_1=5^d.9542159$). Phases are counted from 1926 October 15.0. U.T. Observations of different seasons are indicated as in Fig. 1.

ing to two definite velocity-curves. Taking into consideration all the observations, there is no way to decide which of these two periods is the correct one.

The two Mount Wilson observations of September 15, 1926, referred to in our earlier paper,[1] seemed to show a slope corresponding to the shorter period. However, other series of plates, such as the one of January 15, 1927, show a slope that is much too small for the short period. The five-day period gives a better representation

[1] *Astrophysical Journal*, **65**, 302, 1927.

for this date. Evidently, the range in hour-angle during which this star is accessible in our northern latitudes is not sufficient to settle the question. Neither can a conclusion be drawn from the fact that both the Lick and the Mount Wilson observations were obtained at longitudes about 30° to the west of Williams Bay. They are sufficiently well represented by either period. It should be noted that the scattering is in both curves greater than would be expected

TABLE III

ORBITAL ELEMENTS

Element	Designation	$p_3 = 0^d8542336$	$p_1 = 5^d9542159$
Velocity of system........	γ	+23.4 km/sec.	+25.0 km/sec.
Period..................	P	$0^d8542336$	$5^d9542159$
Eccentricity............	e	0.052	0.115
Half-amplitude...........	K	37.5 km/sec.	37.5 km/sec.
Longitude of periastron...	ω	180°	142°
Time of periastron........	T	0^d572	1^d332
Major-semiaxis..........	$a \sin i$	440.000 km	3000.000 km
Mass function...........	$m_2^3 \sin^3 i_1 (m/+m_2)^2$	0.00047 ☉	0.0324 ☉

The phases are counted from 1926 October 15.000 U.T.

from the internal agreement of the measurements, but there is a slight advantage in favor of the five-day period.

It is unfortunate that practically all spectrographic observations are being made on the American continent. A few observations taken somewhere in India, Australia, or China would immediately settle the question of the period.

For the present it seems best to give both periods and to derive for each curve a set of elements. This was done by the hodographic method as proposed by Laves and modified by Pogo.[1]

YERKES OBSERVATORY
WILLIAMS BAY, WIS.
April 3, 1928

[1] *Ibid.*, **67**, 262, 1928.