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SPECTROSCOPIC ELEMENTS OF THE ECLIPSING VARIABLE GO CYGNI = H.D. 196628

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THE variable nature of the 8th magnitude star GO Cygni = B.D. +34°.4095, was discovered photographically in 1928 by Schneller[1]. In the following year, the star was shown to be a short period eclipsing variable by Kukarkin[2]. In 1931 Syczyrbak[3] gave the light elements:

$$\text{Min} = \text{J.D. } 2426509.467 + 0.717767\text{E}, \; D = 3^{h}.6$$

and considered the star an Algol variable.

Recently Kukarkin[4] published a light curve from his observations at Taschkent, Turkestan, from 1929-1931. The curve is a typical β Lyrae curve with $\text{Max}_1 = \text{Max}_2 = 8^{m}.40$; $\text{Min}_1 = 8^{m}.83$ and $\text{Min}_2 = 8^{m}.51$. The elements for the principal minimum computed from all published observations are:

$$\text{Min} = \text{J.D. } 2426509.462 \pm 0.004 + 0.717767\text{E} \pm 0.000005$$

The Observations

TABLE I—OBSERVATIONS AND REPRESENTATIONS H.D. 196628

Obs.	Julian Date 2,420,000+	Final Phase	Vel I	(O-C)	Vel II	(O-C)	Lines
1	6953.673	0.631	+ 41	....	.....	...	3
2	6953.725	0.683	+ 19	....	.....	...	7
3	6953.788	0.028	− 24	+ 5	.....	...	5
4	6953.847	0.087	− 93	− 4	+116	+5	6-5
5	6953.903	0.143	−121	+ 2	+155	+3	4-3
6	6955.751	0.556	+132	− 3	−148	+3	6-6
7	6955.818	0.623	+ 58	....	.....	...	7
8	6957.787	0.438	+100	+12	−104	−8	2-2
9	6957.860	0.511	+130	− 3	−157	−9	5-5
10	6957.945	0.596	+123	+ 3	−134	0	5-5
11	6959.690	0.188	−128	+ 2	+151	−8	7-6
12	6959.777	0.275	− 88	− 2	+101	−7	6-5
13	6959.868	0.366	+ 9	− 3			9

1Schneller, A.N. 235, 85, 1928.
2Kukarkin, N.N.V.S. 2, 26, 1929.
3Syczyrbak, S.A.C. 10, 44, 1931.
4Kukarkin, N.N.V.S. 4, 19, 1932.

Thirteen spectroscopic observations were recently obtained on four nights. These were well distributed in phase and sufficient for the determination of the orbital elements. The camera employed was the short-focus camera *I*S, having a dispersion of 49A per mm. at $H\gamma$. An average exposure of 1^{h} 40^{m} on a Barnet emulsion was given, the mean photographic magnitude of the star being 8.6.

The Spectrum

Like most eclipsing variables of early type the spectral lines are nebulous and ill-defined. The lines of both components were measured on 8 plates whose relative velocities exceeded 190 km./sec. The lines chiefly used were: λλ 4861, 4481, 4471, 4341, 4101, 4026, 3933, usually the only lines available in Class B9n. An average of 5 double lines on the 8 plates and 6 single lines on the 5 plates was observed. One observation secured during secondary minimum, when the fainter star is eclipsed by the brighter showed a typical B9 spectrum. The helium lines 4471 and 4026 on this plate are relatively much stronger than their appearance on the other plates. The two observations taken during principal minimum show a number of faint metallic lines of class A0. The spectral types of the component stars are, therefore, considered to be B9n-A0n.

In addition to double stellar calcium *K* lines which were measured on 11 plates one spectrum showed a faint line due to interstellar calcium between the two oscillating *K* lines. The velocity of this interstellar *K* line was −13 km./sec.

The Solution

The observations assembled on the period of Kukarkin $P=$ 0.717767 days, showed no appreciable eccentricity. The preliminary elements, Table II, were adopted, and a least-squares solution effected for correction to the elements γ_1, K_1, K_2 and T. The epoch of principal minimum was adopted for T. The radial velocity is then

$$V=\gamma-K \sin \theta, \text{ where } \theta=\mu\ (t-T)$$

The differential equation of condition is thus:

$$dV=d\gamma-\sin \theta\ dK+K\mu \cos \theta\ dT$$

The primary velocities were weighted according to the quality of the plates and number of lines measured. The secondary velocities were given 0.8 the weights of the primaries. The two blended velocities shown on the velocity diagram in phases 0.631 and 0.683 were omitted from the solution. Nineteen observational equations were formed from the eleven primary and eight secondary velocities.

TABLE II—SPECTROSCOPIC ELEMENTS

Element	Preliminary	Final
Period	P 0.717767	0.717767 days
Eccentricity	e 0.0 (assumed)	0.0
Longitude of Periastron	ω indeterminate	....
Periastron Passage	T J.D. 2426953.042	6953.0425±0.0122
Velocity of System	γ +3	3.2±1.04 km./sec.
Semi-amplitude of primary	K_1 130	133.2±1.74 km./sec.
Semi-amplitude of secondary	K_2 157	156.2±1.96 km./sec.

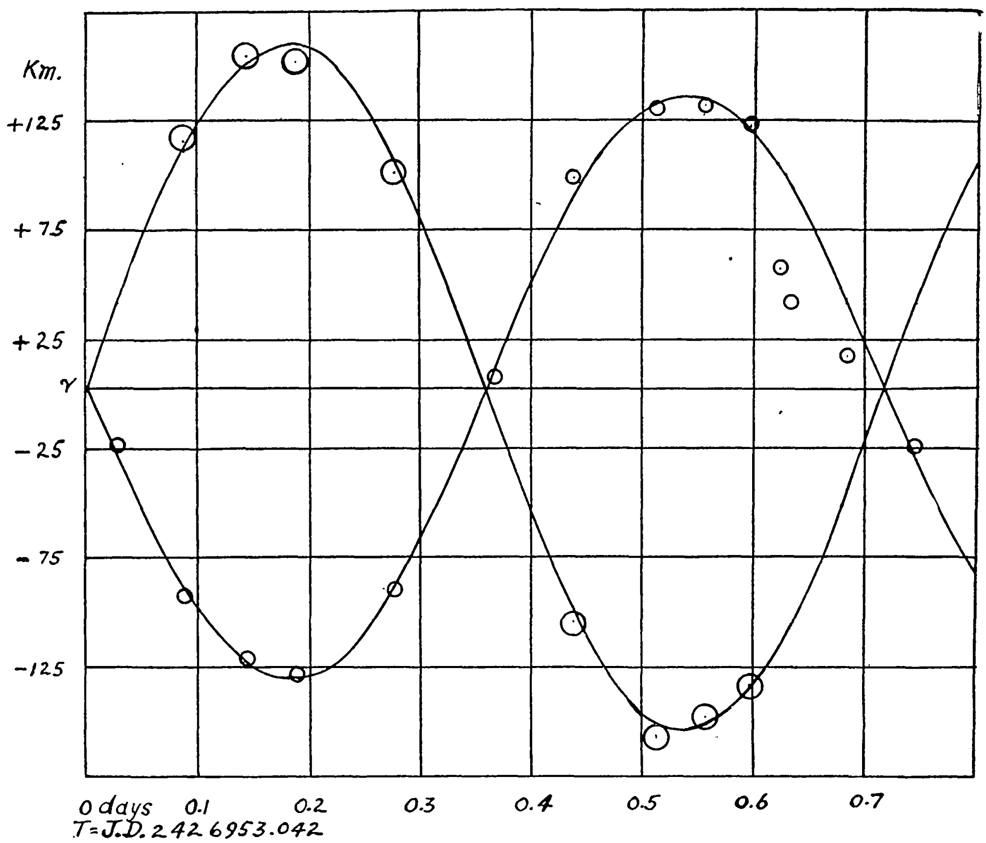
$a_1 \sin i = 1{,}314{,}600$ km.
$a_2 \sin i = 1{,}541{,}700$ km.
$M_1 \sin^3 i = 0.98\odot$
$M_2 \sin^3 i = 0.83\odot$
$M_2/M_1 = 0.85$

The final elements with their probable errors are given in table II. The least-squares solution resulted in an 8.5 per cent. reduction of $\Sigma\, pvv$. The probable errors of a single observation of weight unity are ±3.0 km./sec. for the primary and ±5.6km./sec. for the secondary.

The representation of the observations by the elements is shown on the velocity diagram, the radii of the plotted circles being equal to the probable errors of the component spectra.

The system is composed of two dwarf stars of spectral types B9 and A0 with masses similar to that of our sun. They revolve in sensibly circular orbits whose radii are approximately 1,000,000 miles, indeed not much greater than our sun's diameter. The period of rotation is $17^h\ 13^m\ 35^s.07$, which is also considered to be that of their axial rotation. It is well known that in such systems whose component stars are close together, their mutual attractions render the stars ellipsoidal in figure their largest axes being coincident with the line joining their centres.

Such revolving ellipsoids whose inner surfaces are seldom separated by distances exceeding their own diameters introduce variations in light due to their ellipticity of figure and mutual reflections. These small variations must be computed and allowed for before the light elements due to the mutual eclipses of the binary system may be determined. The light changes of such an eclipsing system are continuous, with maximum light midway



Radial Velocity Curve of H.D. 196628

between the minima. The interpretation of a β Lyrae light curve of small amplitude, in this case about four-tenths of a magnitude, is thus beset with difficulties and uncertainties, frequently being indeterminate. The light curve of Kukarkin for GO Cygni, indicates the presence of small reflection and ellipticity effects. An effort will be made to interpret the curve, so that the absolute densities, masses and separations for these stars may be determined.

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