

REDISCUSSION OF ECLIPSING BINARIES

V. RS CANUM VENATICORUM*

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ABSTRACT

New spectrographic observations of the eclipsing binary RS CVn show that the radii of the components are 8 per cent and the masses 22 per cent smaller than previous evaluations. The subgiant component, spectral type near K0 as estimated from its color, is slightly more massive than the smaller F-type star and does not fill the critical zero-velocity surface.

Photometric observations show that the light of the subgiant, as observed during total eclipse, increased by 0.3 mag. between June, 1956, and January, 1959, with essentially no change in color and no corresponding increase in light at the quadratures. The light of this component, at least, varies intrinsically both with time and over its surface. The long-observed asymmetry of the light-curve outside eclipse is found to have the same color as the K-type subgiant. This persistent asymmetry could be caused by a slight pulsation with the same period as the orbital motion. Nearly continuous photometric observations of high precision are required to determine the behavior of the star. Because of the asymmetries and variations of the light-curve, definitive values are established only for the masses of the components and the color of the cooler star. Probable ranges of the various properties of the system are given in Table 7.

The properties of the eclipsing binary RS CVn¹ have been discussed by Keller and Limber (1951) and by Plaut (1953). The spectrographic observations used were those of Joy (1930), the photometric observations those of Keller and Limber (1951; photoelectric observations) and of Sitterly (1930; visual observations). A light-curve of good quality, together with an analysis, has also been published by Schneller (1928; photographic observations). As in previous papers of this series, the aim of the present investigation is to obtain improved spectrographic orbits with observations of higher quality than those available in earlier years and to add to the existing photometric data sufficient observations on a standard photoelectric system so that the fundamental properties of the system can be established. Uncertainties in interpreting the light-curve because of intrinsic variations and other effects make this aim difficult to accomplish in the case of RS CVn.

I. SPECTROGRAPHIC DATA

Twelve spectrograms of RS CVn have been obtained with the coude spectrograph of the 100-inch telescope on Mount Wilson between February, 1954, and June, 1958. Both the blue-violet region of the spectrum, dispersion 10 Å/mm, and the visual region, dispersion 15 or 20 Å/mm, were usually photographed. The appearance of the spectrum of RS CVn is similar to that of Z Her (Popper 1956). The dispersion employed is too high for spectral classification by inspection. Joy's type of the hotter component, F4, must be nearly correct, although I do not understand his added designation, *n*, since at 10 Å/mm the lines are quite sharp (Fig. 1, *a*). As reported by Hiltner (1947), moderately strong emission lines of H and K, belonging to the fainter, larger component, are present. As in the case of Z Her, although there is evidence of the presence of the absorption lines of the second component measured by Joy (1930) in the blue-violet region, the coude spectrograms show nearly all lines of the secondary blended with lines of the primary (Fig. 1, *a*),

* This investigation was made possible by a co-operative agreement with the Mount Wilson and Palomar Observatories.

¹ HD 114519, var.; F8; α_{1900} : 13^h06^m0; δ_{1900} : +36°28'.

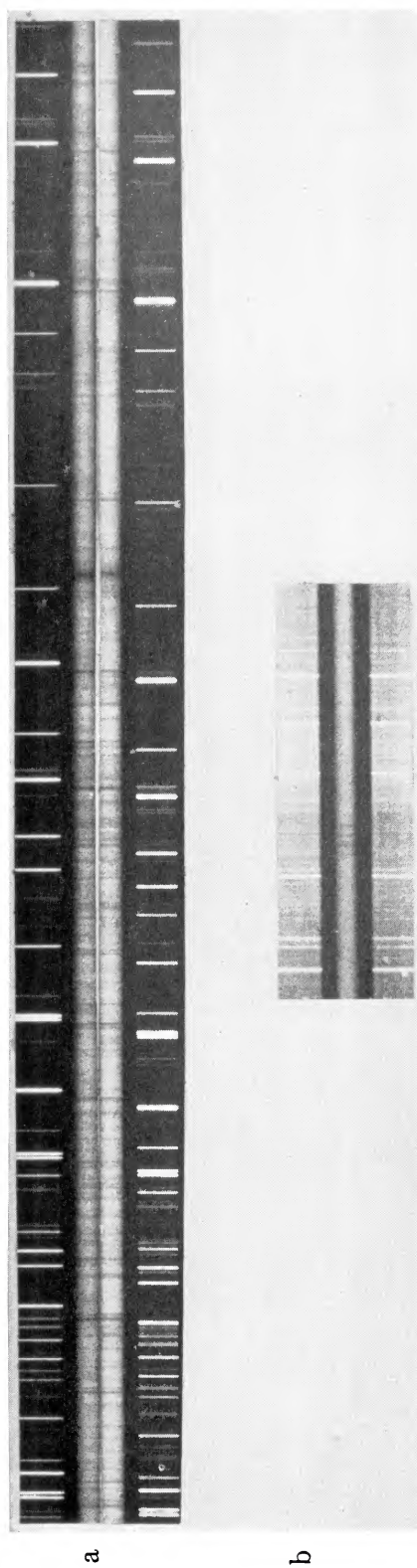


FIG. 1.—The spectrum of RS CVn. *a*, Between λ 4195 and λ 4430; *above*: Ce 10422, 0.25 phase; *below*: Ce 11946, 0.72 phase. *b*, Region of the D lines, Ce 11202, 0.17 phase.

so that reliable velocities of the fainter component cannot be expected from measurements in this region of the spectrum. The fainter component contributes roughly 25 per cent of the light of the system in blue light. The visual region of the spectrum is also similar to that of Z Her, in that the D lines of the two components are of comparable intensity (Fig. 1, *b*), those of the larger, cooler star being considerably the broader. Other lines of both components are also visible. At H α the absorption line of the F star is strong. The H α line of the cooler star is usually present in emission. The emission intensity is quite variable, the line appearing strongest when the stars are near the nodes of the orbital plane. The available observational material is inadequate for a systematic study of the variation. On some spectrograms weak H α emission is also present, displaced in the direction of the lines of the F star with greater displacement than that of the absorption line. Variations in the spectra associated with the changes of the light-curve discussed below have not been noted.

TABLE 1
COUDÉ VELOCITIES OF RS CVN

PLATE Ce	U.T	JD _{helio} 2430000+	PHASE	VELOCITIES (km/sec)		RESIDUALS (km/sec)	
				F Star	K Star	F Star	K Star
9080	1954 Feb. 12.572	4786 076	0 ^h 763	+ 75		+1	
10257	1956 Jan. 4 502	5477 003	772	+ 74	-106	0	-6
10340	Mar. 18 454	5550 958	187	- 98	+ 59	0	-5
10422	Apr. 21 356	5584 860	253	-104	+ 64	0	-7
10432	23 385	5586 889	676	+ 66	- 89	+1	+3
11195	1957 June 15 241	6004 741	768	+ 75	-102	+1	-2
11202	17 178	6006 678	172	- 94	+ 67	0	+6
11204	17 307	6006 807	199	-100	+ 75	0	+8
11806	1958 Mar. 3 404	6265 908	203	-100	+ 68	+1	+1
11867	Apr. 27 333	6320 836	651	+ 59	- 83	+1	+2
11946	May 31 222	6354 724	714	+ 70	-100	-3	-1
11952	June 2 251	6356 753	0 137	- 84	+ 50	-1	0

The spectral type of the secondary component was classified by Joy (1930) as dG8. Although Joy recognized from its radius that the star was intermediate in luminosity between giants and main-sequence stars, spectral classification procedures at that time did not provide for an intermediate category. Miss Roman's (1956) classification of the fainter component is K2 III. The color of this component, obtained at primary minima (see below), corresponds to spectral type G8 III or K0 IV. Miss Roman has classified the spectra of six secondary components of eclipsing binaries with radii between 3 and 5 solar radii and with spectral types near K0. In each case, including RS CVn, the radius and temperature place the star among the subgiants, whereas Miss Roman has classified each as luminosity class III. Further classification work is needed to determine whether the discrepancy between the luminosities and the luminosity classifications of these stars is real.

The new spectrograms and measured velocities are listed in Table 1. The velocities of the F star are based on the six lines $\lambda\lambda$ 4033, 4034, 4045, 4063, 4071, and 4077. The velocities of the fainter component are based on the emission lines K ($\frac{1}{2}$) and H ($\frac{1}{2}$) and

on the absorption lines D₂ (1), D₁ (1), Ca I 6102 ($\frac{1}{2}$), and Ca I 6122 ($\frac{1}{2}$), the numbers in parentheses being the weights assigned to the individual lines in forming the mean velocity from a plate. The phases in Table 1 are computed from the light-elements given later. Table 2 contains circular elements of the velocity variation. The individual velocities and curves computed from the elements are shown in Figure 2. The observations do not cover the complete cycle sufficiently well to test for the small orbital eccentricity indicated by the displacement of secondary minimum suspected by Keller and Limber. The value of K_K obtained from the emission lines alone is 87 ± 1 , not significantly different from the value obtained from emission and absorption together. Joy's (1930) radial-velocity elements are shown in Table 2 for comparison. The difference of 13 km/sec between Joy's and my value of K_K is not surprising in view of the difficulty mentioned of finding suitable absorption lines of the fainter component to measure in the blue-violet region of the spectrum. The smaller velocity amplitude leads to radii of the stars 8 per cent and masses 20 per cent smaller than those deduced from Joy's ele-

TABLE 2
CIRCULAR ELEMENTS OF VELOCITY VARIATION

	This Paper	Joy
$K_{F \text{ star}}$	-89.7 ± 0.2 km/sec	-92 km/sec
$\gamma_{F \text{ star}}$	-14.9 ± 0.2	-9
$K_{K \text{ star}}$	86 ± 1	99
$\gamma_{K \text{ star}}$	-15 ± 1	
P (assumed)	4.7978 days	4.7979 days
$a \sin i$	16.7 solar radii	18.1 solar radii
$M_P \sin^3 i$	1.32 solar masses	1.79 solar masses
$M_K \sin^3 i$	1.38 solar masses	1.66 solar masses

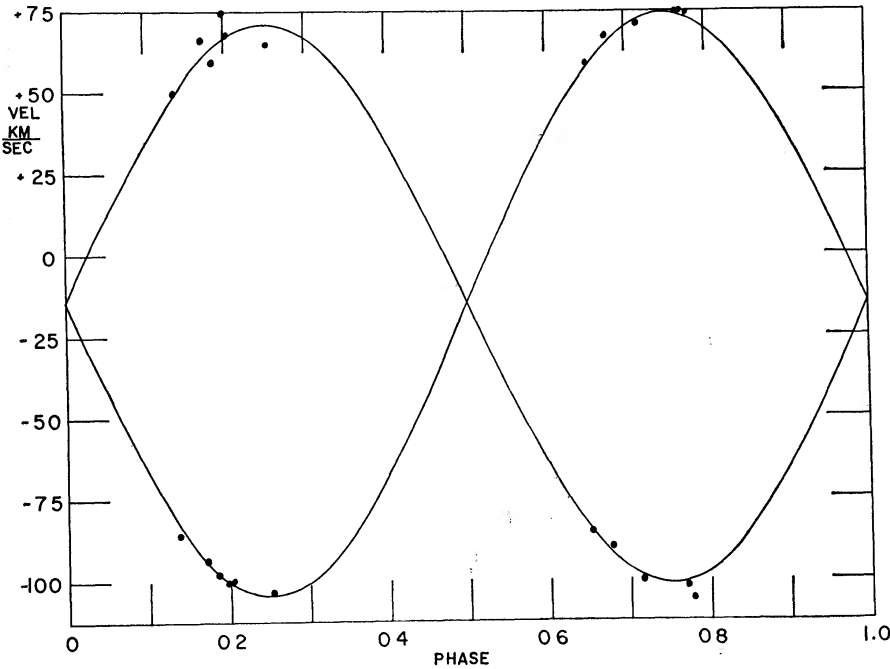


FIG. 2.—Radial velocities of RS CVn. Phases are in fractions of the period measured from mid-primary minimum.

ments. According to the new observations, the mass of the fainter, larger component is slightly greater than that of the brighter, smaller component. The difference of 6 km/sec between the center-of-mass velocities of the two sets of observations is probably large enough to be significant. Without a more nearly continuous spectrographic record, however, this difference cannot be interpreted.

II. PHOTOMETRIC ANALYSIS

a) *New Observations*

The nature of the light-curve of RS CVn is well exhibited by the photoelectric observations of Keller and Limber (1951). Their paper also contains references to the earlier literature. Because of the numerous peculiarities in the light-curve (in particular, the asymmetry of primary minimum and the asymmetry of the light-curve outside eclipse), one cannot expect to obtain geometric elements of high precision.

The color index of each component on a standard color system is among the basic quantities describing the stars and is to be obtained from photometry. Since Keller and Limber did not employ filters with their photomultiplier, additional observations are necessary. They were obtained with the 20-inch reflector on Palomar Mountain in June–July, 1956 (one primary minimum observed), January, 1958, and January, 1959 (two primary minima observed). The method of observation and color system have been described (Popper 1957).² The comparison star used throughout was HD 114778. The magnitude and colors of this star, obtained on six nights in 1956, three in 1958, and one in 1959, are

$$V = 8.42, \quad B - V = +0.46, \quad U - B = -0.04.$$

Although the colors of the comparison star from the three seasons are in good agreement, the magnitude obtained in 1956 was 0.03 mag. fainter than that obtained in 1958–1959. It is not certain whether this difference is real or is a result of the different zenith distances and different standard stars used in the different observing seasons. Table 3 gives the observations of RS CVn on the instrumental system. The quantities tabulated are the light-ratios, RS CVn/comparison star. The phases of Table 3, as well as those of Table 1, were computed from the light-elements of mid-primary minimum,

$$JD_{\text{helioe}} = 2433016.819 + 4.79781E.$$

The epoch is that of Keller and Limber. The period (last decimal quite uncertain) is obtained by comparison of my times of the end of total eclipse (1956) and the beginning of total eclipse (1959) with the corresponding times from Keller and Limber's data. Examination of Figure 5 of Keller and Limber's paper, with the addition of eight times of primary minimum listed by Plavec and Smetanova (1959), shows that the period of RS CVn has been about 4.7978 days since approximately JD 2429000. This is the same value it had before approximately JD 2420000, the period having been longer between these dates.

The observations in blue light are shown in Figure 3, along with the principal features of Keller and Limber's curve (excepting primary minimum). In view of the variations in the light-curve shown and discussed below, there is satisfactory agreement between the two sets of observations, including the depth of secondary minimum and the difference in height of the two maxima. Sitterly's (1930) visual curve is similar except for the smaller depth of secondary minimum. The observations of Table 3 show, as expected, that primary minimum is deeper for shorter wave lengths and that secondary minimum

² In 1959, the ultraviolet filter used was Corning 9863, giving a $U-B$ color conversion coefficient $A_4 = 1.05$. The filter used in 1956 and 1958 was Corning 5840 instead of the Corning 9863 reported in the paper cited. The value, $A_4 = 1.16$, obtained for the 1956 observations, resulted from use of the Corning 5840 filter.

is deeper in yellow than in blue light. The new observations were obtained primarily for the purpose of evaluating the colors of the components rather than of covering the entire light-curve.

Table 4 summarizes the observations at primary minima. The light-unit in the first three columns is the light of the comparison star. The colors in the last two columns are obtained from the colors of the comparison star and the light-ratios.

The most striking feature of the new photometric observations is the large difference, shown in Table 4, of 0.3 mag. in the light of primary minimum in 1959 as compared with that observed with identical equipment (except for the ultraviolet filter) in 1956. Since the eclipse is total, the difference is due entirely to changes in the cooler, larger star. The two points observed outside minimum in 1959 do not show corresponding differ-

TABLE 3A
PHOTOMETRIC OBSERVATIONS OF RS CVn
(Outside Primary Minimum)

JD _{helio} 2435000+	NO OF OBSERVA- TIONS	PHASE	LIGHT (UNIT = COMPARISON STAR)		
			<i>y</i>	<i>b</i>	<i>u</i>
634 753	3	0 ^p 652	1 361	1 221	1 124:
638 690	3	473	1 324	1 182	1 101:
639 717	3	687	1 370	1 209	1 087
641 684	2	097	1 315	1 191	1 088
643 678	3	512	1 216	1 129	
643 692	4	515	1 215	1 121	
643 706	3	518	1 223	1 132	
645 725	3	939	1 277	1 176	
647 695	3	349	1 440	1 282	
649 694	3	766	1 333	1 195	1 121:
651 701	3	184	1 412	1 259	
653 686	3	598	1 379	1 224	1 114
654 692	3	808	1 318	1 192	1 095
1225 041	3	685	1 251	1 140	1 058
1226 044	4	894	1 331	1 193	1 090
1227 033	4	100	1 417	1 254	1 128
1227 954	5	292	1 511	1 328	1 190
1570 963	5	785	1 300	1 175	1 079
1956 955	4	0 203	1 468	1 298	1 143

ences from the 1956 curve, a result indicating that the change was not uniform over the surface of the cooler star. Because of the different spectral responses, it is not possible to compare my depths of minima directly with those of Keller and Limber. It appears, however, that the 1956 depth was similar to the depths occurring in 1949, while the 1959 depth is considerably smaller. Keller and Limber suspected intrinsic fluctuations in the light at total eclipse over a period of 2 months in 1949. The two minima observed in 1959 also show small, though significant, differences. It is evident that RS CVn should be kept under constant observation, particularly at primary minima.

b) "Distortions" of the Light-Curve

Kron (1952) has applied the term "distortions" to the light-variations of eclipsing binaries due to causes other than eclipses, tidal deformation, limb darkening, and reflection. In the case of RS CVn, distortions of various kinds are present. First is the large

variations, with time and over the surface, of the light of the cooler star referred to in the preceding paragraph. These large differences in light ought to be accompanied by changes in radius or changes in color, or both, at least for that hemisphere of the star facing us during total eclipse. The observational data are clearly insufficient to decide whether the radius of the cooler star changed between June, 1956, and January, 1959. The data of Table 4 indicate that the color of the star may have changed in the appro-

TABLE 3B
PHOTOMETRIC OBSERVATIONS OF RS CVN
(Primary Minimum, Individual Observations)

JD _{helio} 2435000+	PHASE	LIGHT (UNIT = COMPARISON STAR)		
		<i>y</i>	<i>b</i>	<i>u</i>
655 682	0 ^p 0141	0 454	0 296	0 175:
688	0154	443	292	169
694	0167	453	294	199
701	0181	447	301	186
708	0196	498:	323	239
719	0218	518	357	254
726	0233	553	380	
731	0243	569	409	
736	0254	583	430	
742	0265	629	469	
1571 882.	9766	671	476	
888	9779	693	479	
896	9797	632	430	
902	9809	605:	417	
908	9820	608	417:	
913	9831	600	400:	
918	9843	594:	392	
927	9860	588:	405:	
932	9872	594	401	...
938	9885	581	394	252
947	9902	585	393	244
955	9919	581	402	256
962	9934	584	387	247:
969	9948	587	396	.
974	9958	591	386	
979	9969	606	409	.
985	9981	584	390	
990	9992	573	375	
1595 971	9975	630:	422:	...
980	9994	590:	404:	253:
1596 033	0105	603	396	251
012	0124	604	400	257
053	0 0146	0 605	0 413	0 269

priate sense, but by too small an amount to account for the 0.3-mag. increase in light. If the increase were due entirely to an increase in temperature, $B-V$ would have changed by about 0.30 mag.

The distortions of light outside eclipse are of two kinds. First is the difference, persistent over a good many years, between the light at one quadrature and that at the opposite one. Second are the variations of the light-curve with time. As with the variation at primary minimum, these variations appear to be greater over long periods of time (years) than over short periods (months). The distortions of both kinds have

essentially the same color, in both y/b and b/u , as the light of the cooler star, a result leading to the conclusion that these variations, as well as those among different primary minima, are caused primarily by this component.

The distortions of light outside eclipse make evaluation of ellipticity and reflection effects from the observations very uncertain. Nevertheless, it is of interest to compute the light-changes to be expected from these two causes. Using the elements of the system adopted later, we find the maximum difference in light due to reflection, i.e., between phases 0 and 0.5, to be 0.02 light-units in both yellow and blue light. The unit of light is the combined light of the system. The maximum light-change expected from the effect of ellipticity of components is 0.06 light-units in yellow light and 0.04 in blue. These numbers are computed from the dynamical ellipticity and from an adopted ratio, 2.5, of photometric to dynamical ellipticity. In both reflection and ellipticity effects, the predicted change is due entirely to the change in the light of the cooler star. The observed systematic increase in light following primary minimum is about twice that predicted for the ellipticity effect and has the color of the cooler star, whereas the observed variation following secondary minimum is essentially zero. Thus the average of the effects at the two quadratures is in rough agreement with prediction, although the form of the

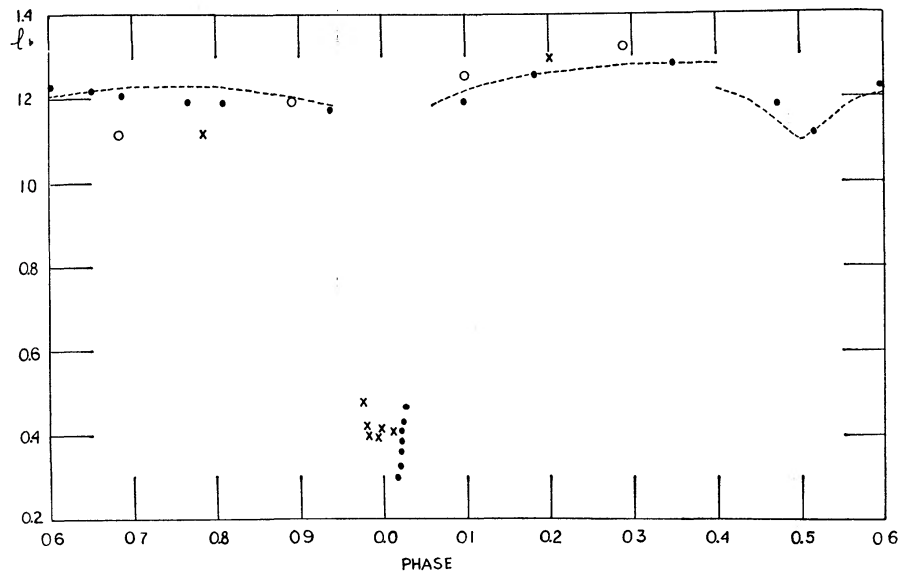


FIG. 3—Photometric observations in RS CVn in blue light. *Dots*, 1956; *circles*, 1958; *crosses*, 1959. The dotted curve represents Keller and Limber's observations of 1949.

TABLE 4
PRIMARY MINIMA OF RS CVN

DATE	LIGHT (UNIT = COMPARISON STAR)			$B-V$	$U-B$
	y	b	u		
July 1, 1956	0 449	0 296	0 183	$+0.92 \pm 0.01$	$+0.58 \pm 0.03$
Jan. 3, 1959	587	393	.250	$+0.90 \pm 0.01$	$+0.49 \pm 0.02$
Jan. 27, 1959	0 605	0 406	0 258		

light-curve between minima must be considered unexplained by effects of ellipticity and reflection alone. The facts that the persistent difference between the light at the two quadratures has the color of the cooler star and that the photometric ellipticity obtained from the average of the two quadratures approximates that to be expected suggest that the persistent difference may be caused in part by a pulsation of the cooler star with the same period as that of orbital motion, this star having an average shape determined by considerations of dynamical equilibrium. Forced pulsations have been proposed as a cause for distortions of light-curves of close binary systems by Taylor (1941) and were further discussed by Kopal (1949) and by Owen (1957).

The distortions of the light-curve that are not persistent must have some other origin, such as the "spottedness" attributed to YY Gem and AR Lac by Kron (1947, 1952). The more imaginative reader will wish to supply more complete explanations for the distortions of the light-curve of RS CVn than those suggested here. Even greater contributions to the solution of the problems posed by this system would result from an accumulation of precise photometric observations in at least two colors, carried out as nearly continuously as possible over a number of years. The present writer is not in a position to obtain such an accumulation.

In connection with the interpretation of this system, it may be well to point out that both stars are considerably smaller than the limiting zero-velocity surface passing through the inner Lagrangian point.

c) Analysis of the Photometric Observations

Since a satisfactory model is not on hand for explaining the distortions in the light-curve, in particular the large variations at primary minima unaccompanied by corresponding changes of light outside eclipse, the luminosities and radii of the components do not have definite meaning. On the other hand, numerical values of the properties of the components are listed in the usual compilations (Plaut 1953; Kopal 1955), and it is desirable to assess their validity.

In the light-curves both of Sitterly and of Keller and Limber the durations of primary minimum and of the total phase are well determined. The phases of beginning and end of totality and beginning and end of eclipse are, respectively, ± 0.018 and ± 0.055 in units of the period of revolution. In order to obtain the radii of the stars and the orbital inclination, one may use, in addition to these quantities, either the shape of the light-curve during partial phases or the depths of the two minima. Both Sitterly and Keller and Limber used the shape of the curve. That their adopted values of the ratio of the radii, k , are in fair agreement (0.30 and 0.365) appears quite accidental. Sitterly's solution is for uniformly illuminated disks, whereas Keller and Limber used a darkening coefficient of 0.8. Sitterly obtained a value of $k = 0.5$ for a darkening coefficient of 1.0. Keller and Limber's detailed observations show so much variation from minimum to minimum, as well as between ascending and descending branches of minimum, that the value of k cannot be considered determined, although 0.3 and 0.5 appear to be limits within which k may reasonably be expected to lie. Keller and Limber note that their adopted value of k , together with the observed depth of primary minimum, leads to a depth of secondary minimum equal to 0.04 times the combined light of the two stars. On the other hand, a glance at their Figures 2 and 4 shows that the depth of secondary minimum, although not well determined, is not less than 0.07 times the light outside eclipse. Such a depth leads to a value of k of approximately 0.5.

Use of my 1956 observations of the depths of primary and secondary minima and the phases of beginning of eclipse and of totality given above leads to values of k of 0.46 (yellow) and 0.42 (blue). Use of the 1959 primary depth leads to values of k between 0.35 and 0.40. In this discussion no rectification has been employed, and the light outside both minima has been assumed to be 1.52 on Keller and Limber's scale and 1.31 and 1.18 in yellow and blue light, respectively, on my scales. In my opinion, the ranges of geo-

metrical elements allowed by the available observations are those shown in Table 5. Here r_1 and r_2 are the radii of the cooler and hotter star, respectively, in units of the radius of the relative orbit, and i is the orbital inclination.

The light and surface-brightness ratios are also poorly defined because of the intrinsic variations. Furthermore, the quantities obtained from Keller and Limber's observations are ambiguous because of the very broad spectral response of their photocell used without a filter. Table 6 shows values of the light-ratios based on the 1956 and 1959 depths of primary minimum and also the range of J_2/J_1 , the surface-brightness ratio, for each year corresponding to the range of k in Table 5. The ranges of solution shown in Tables 5 and 6 may decrease as more precise observations are obtained. On the other hand, until the causes of the intrinsic variations are known, elements obtained from any set of data will be of only limited significance.

In addition to the quantities of Tables 5 and 6, basic data to be obtained from the photometric observations are the color indices of the components. The colors of the larger

TABLE 5
LIMITING GEOMETRICAL ELEMENTS

k	0 33	0 50	r_2	0.09	0.12
r_1	0 27	0 20	i	82°	90°

TABLE 6
LIGHT AND SURFACE BRIGHTNESS OF COMPONENTS

	1956		1959	
	y	b	y	b
L_1 . .	0 34	0 25	0 46	0 34
L_2 . .	0 66	0 75	0 54	0 66
J_2/J_1 (range in yellow light)	8-18		5-11	

star, as observed at total eclipse, are given in Table 4. The value of $B-V$ is that of a star of spectral type K2 V, K0 IV, or G7 III. The values of $U-B$ are somewhat smaller than normal for stars having the observed value of $B-V$ (Morgan, Harris, and Johnson 1953), although not smaller than the value of $U-B$, for example, of the standard G8 IV star β Aql ($B-V = 0.86$, $U-B = 0.49$). The color of the hotter star should be simply obtainable by subtracting from the light outside eclipse the light of the cooler star corrected for photometric ellipticity. From the 1956 observations the hotter star is found in this manner to be approximately 0.02 mag. bluer than the comparison star in both $B-V$ and $U-B$, a result yielding colors $B-V = 0.44$ and $U-B = -0.05$. These values correspond to spectral type F5. If the light of minimum in the 1959 eclipses is subtracted from the light outside minimum (only two observations), the resulting colors of the hotter star are $B-V = 0.39$ and $U-B = -0.07$, values corresponding to type F2 or F3. The 1956 colors are in somewhat better agreement with the observed spectral type. The photometric ellipticities used in these evaluations are zero for the hotter star and 0.07 for the cooler. The latter value is obtained from a dynamical ellipticity, ϵ , of 0.028 and a ratio, N , of 2.5.

The surface-brightness ratio of the components in the yellow region of the spectrum can be predicted from the effective temperatures (6500° and 4700° , 1956 observations;

6750° and 4700°, 1959 observations) and bolometric corrections (0.0 and -0.30 mag.) corresponding to the observed values of $B-V$ (Popper 1959). The resulting ratio is $J_2/J_1 = 4.8$ (1956) and 5.6 (1959). Reference to the last row of Table 6 shows that these values are smaller in general than those obtained from the minima of the light-curve. In the case of the 1959 observations the values obtained from the light-curve and from the colors are not in complete disagreement. Comparisons of this kind do not have a great deal of meaning because of the intrinsic variations. In view of the many uncertainties (including those of the temperature scale; Popper 1959), one may be justified in saying that there may well be a discrepancy between the ratio of surface brightness obtained from the light-curve and that obtained from the colors or spectral types, but that the discrepancy is not so large as indicated by Keller and Limber, and that much more study is required to come to a definite conclusion in the matter.

III. PROPERTIES OF THE SYSTEM

It must be clear from the preceding discussion that the masses and the color of the larger star are the only well-determined properties of the components of RS CVn and that the masses are appreciably smaller than the previously published values, with the mass of the larger, cooler component being slightly the greater of the two.

Table 7 lists for each of various quantities the range within which it probably lies,

TABLE 7
PROPERTIES OF THE SYSTEM

	Hotter Star	Cooler Star
$a \sin i$ (solar units)	16 7	
$M \sin^3 i$ (solar units)	1 32	1 38
i	82°–90°	
a (solar units)	16 7–16 85	
r	0 09–0 12	0 20–0 27
$B-V$	0 39–0 44	0 91
T_{eff}	6500°–6800°	4700°
Bol. corr	0	-0.3 mag.
M (solar units)	1.32–1.36	1.38–1.42
R (solar units)	1.5–2.0	3.3–4.6
L (solar units)	3.7–7.8	5.0–9.1
M_{bol}	2.5–3.4	2.4–3.0
M_V	2.5–3.4	2.7–3.3

according to existing observations. The range of effective temperatures given corresponds only to the range of $B-V$ permitted by the observations, not to uncertainties in the temperature scale itself. The spectral classifications corresponding most closely to the colors and absolute magnitudes of the components listed in Table 7 are F4 IV–V and K0 IV. The principal interest in this system lies not in the possibility that it can furnish definitive values of fundamental stellar parameters but rather in the fascinating changes exhibited in the light-curve of a system, the properties of which are moderately well known. On the basis of available evidence, concomitant spectral changes are not pronounced. It is greatly to be hoped that photometric observers will keep the system under continuous observation.

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