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THE UNSTABLE ECLIPSING GIANT SYSTEM RZ CANCRI

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RIASSUNTO — Le curve di luce *U*, *B*, *V* della binaria ad eclisse *RZ Cnc*, le cui componenti sono *K*1 III e *K*4 III, sono state ricavate da osservazioni fotoelettriche fatte dal 1959 al 1967. Il periodo è costante. Le curve di luce invece variano leggermente, ad eccezione della parte centrale del Min I e della discesa al Min II. Le misure fotometriche confermano pertanto i risultati spettrografici di Hiltner, che la zona attiva che dà origine al Ca II in emissione è associata alla componente più brillante e non appartiene ad anelli gassosi attorno alle componenti. Tuttavia la zona instabile non è simmetrica rispetto alla congiungente i centri delle due stelle.

Sono poi state considerate delle curve di luce stagionali, durante le quali la instabilità è meno sensibile, e sono state calcolate alcune soluzioni per diversi valori del coefficiente di oscuramento al bordo. La componente più fredda riempie il proprio lobo di Roche. Lo stato evolutivo del sistema è incerto: esso può essere di formazione molto recente oppure molto vecchio.

SUMMARY. — *U*, *B*, *V* light curves of the late giant eclipsing system *RZ Cnc* have been obtained during the years from 1959 to 1967. The period seems constant. The system is intrinsically variable to a small degree. The photometrically unstable region is not visible during the central phases of the primary eclipse, as for the Ca II emission, so it belongs to the brighter star.

Some solutions have since been calculated by means of an 1620 IBM computer, for different limb darkening coefficients and taking the primary minimum alone or both the minima. The lighter component fills its Roche lobe

1. - INTRODUCTION

The eclipsing binary *RZ Cancri* was discovered by HERTZSPRUNG (1918). Some visual epochs of minimum have been derived by ESCH (1919; 1937) and a few others by NIJLAND (1931). With the latter we have computed two normal epochs (Table I). Further instants of minimum are given by HERTZSPRUNG (1928), PARENAGO (1933), MERGENTALER (1934), LAUSE (1935), ZACHAROV (1952), SZAFRANIEC (1955), LINNELL (1957) and LENOUVEL (1957), all reported in Table I.

(*) Ricevuta il 25 Gennaio 1973.

TABLE I - Epochs of minimum light.

Observer		E	Helioc.J.D. 24.....	Peso	O-C
Parenago	v	-31	18032.290	1	+0.692
Hertzsprung	pg(1)	0	18702.480	5	-0.051
Parenago	pg	103	20932.360	1	+ .600
Esch	v	151.5	21981.400	1	- .045
Esch	v(2)	203	23096.010±0.040	3	- .050
Mc Laughin	v	306	25325.260	1	- .028
Zacharov	pg	307.5	25357.600	1	- .153
Zacharov	v	308.5	25379.200	1	- .196
Zacharov	v	310	25412.200	1	+ .340
Nijland	v(3)	336	25974.510±0.100	1	- .068
Mergentaler	v(1)	388	27100.045±0.040	3	+ .031
Lause	v(1)	406	27489.557±0.011	3	- .031
Gaposchkin	pg(4)	414	27662.780	5	+ .048
Szafraniec	v	729	34480.329±0.043	3	+ .052
Szafraniec	v(1)	759	35129.440±0.050	3	- .126
Linnell	pe	775	35475.920±0.030	5	+ .066
Lenouvel	pe	778	35540.770±0.015	10	- .013
Broglia, Conconi	pe	827.5	36612.081±0.011	10	- .031
"	pe	846	37012.492±0.011	10	- .015
"	pe	859	37293.867±0.001	10	+ .001
"	pe	861.5	37347.994±0.003	10	+ .020
"	pe	863	37380.435±0.009	10	- .003
"	pe	876.5	37672.644±0.025	5	+ .025
"	pe	909	38376.039±0.001	10	+ .023
"	pe	927	38765.577±0.006	10	- .013

(1) Normal epoch.
(2) This normal was derived from seven individual epochs.
(3) This normal was computed from six minimum epochs.
(4) We have corrected the original value of the normal epoch 27664.780 for a supposed misprint.

A complete photographic light curve of this totally eclipsing system, from 1618 Harvard patrol plates, has been obtained by GAPOSCHKIN (1949). This Author also calculated a photometric solution and emphazised that both the components are giant stars. Later some photoelectric measures were obtained by LENOUVEL (1957), LINNELL (1957) and BROGLIA and LENOUVEL (1959), but they are too few to improve the elements of Gaposchkin.

Spectroscopically the components of the system have been classified as K 2 III and K 5 III by HILTNER (1946; 1947) and successively, from the colour indices, as K 1 III and K 4 III by POPPER (1957), which combining the light curve of Gaposchkin with its spectrographic measures derived also the masses and the radii. According to Hiltner the H and K emission lines are evident in all the phases except during the interval $-0^{d}.6$, $+0^{d}.5$ around the Min I. Hiltner interpreted this eclipse effect as an indication that the Ca II emission is localized on both ends of the tidally elongated primary star and is not associated with a possible ring or shell about the primary star. This behaviour is somewhat peculiar, because the majority of the eclipsing binaries with Ca II emission undergo an eclipse of the Ca II lines at the secondary minimum. According to POPPER (1962) for a conclusive discussion of the properties of the system more accurate photometric data are necessary.

The need for a more accurate light curve of the system was therefore obvious, considering also the geometry of the system favourable for an evaluation of the darkening coefficient for a late type giant, never obtained till now, as far as we know.

2. - THE PHOTOELECTRIC OBSERVATIONS AND THE PERIOD.

The variable was observed during 91 nights, between February 1959 and January 1967, on the 102 cm reflector of the Merate Observatory using a Lallemand S-4 photomultiplier and conventional d.c. techniques. Schott filters were used: UG 2 (1 mm) for U observations; BG 12 (1 mm) + GG 13 (4 mm) for B and OG 4 (1 mm) for V, the same filters used by LENOUVEL (1957). A total of about 3350 measures in U, B, V ranges were obtained; they are deposited with the Variable Star Archives of the Royal Astronomical Society Library. The observations were reduced using a IBM 1620 computer. *RZ Cnc* was compared with BD + 31° 1848 which is a red star like the variable; check star was BD + + 32° 1774. The magnitude and the colours of the comparison star, to which *RZ Cnc* was referred also by LINNELL (1957), have been given in the U, B, V system by LENOUVEL (1957); they agree with the values we obtained in two nights when we compared with some standards of Johnson-Morgan.

The adopted values for the comparison star are:

$$V = 8^{m}.485$$
$$B - V = + 1^{m}.263$$
$$U - B = + 1^{m}.436$$

The $\Delta m = m_{comp} - m_{check}$, with the corresponding mean error, number of measures N and standard deviation σ of a single Δm, were as follows:

	Δm	N	σ
U	$-0^m.622 \pm 0.002$ e.m.	118	$\pm 0^m.035$
B	$-0\ .129$ $\quad .002$	175	.023
V	$+0\ .164$ $\quad .001$	183	.019

Bearing in mind the rather high values of the standard deviations, we looked over the residuals and verified they nearly correspond to a gaussian distribution. However the plot of the Δm versus the time brings to light a little systematic trend similar in the three colours, so it arouses suspicions that one of the two comparisons is a little irregularly variable. The possible corresponding effect on the light curves, if the comparison but not the check star was the variable, is discussed later.

On account of the length of the eclipses ($3^d.2$), the epochs of minimum have been derived representing the Δm of both the branches of the eclipses, considering only the interval -1^d, $+1^d$ from the central instant, with a second degree polynomial, and then computing the middle instant corresponding to equal magnitudes over the two branches. In two cases the epoch has been computed as the instant corresponding to the vertex of the parabola fitted to the central part of the eclipses, in one we finally derived the moment combining two branches belonging to consecutive cycles. Altogether from our observations eight epochs have been derived, averages of the values calculated from the U, B, V curves. They are given in Table I, with the corresponding mean errors, after the data found in the literature. By least squares, assigning a suitable weight to the twenty five epochs, some of which are mean values we deduced from the single instants to obtain an indication of their precision, we computed the ephemeris:

$$\begin{array}{lll} \text{Min I} = \text{Helioc. J.D. } 2418702.531 & + \; 21.642998 & E \\ \qquad\qquad\qquad\qquad\quad \pm \;\; 37 & \qquad\quad 45 & \text{m.e.} \end{array}$$

The mean value of the O — C of the normal epochs is a little greater than their variance. Bearing in mind the inferior precision of the earlier epochs, the residuals plotted on Fig. 1, don't have a systematic trend, and the period during the approximate thousand cycles covered by observations seems constant.

3. - THE LIGHT CURVES AND THE PHOTOMETRIC INSTABILITY

The plot of the single magnitude of *RZ Cnc* against the phases, computed according to the above period and ordered with an IBM 360/40, displays a systematic disagreement between the measures belonging to different seasons. The difference is greater for the U measures and smaller for the V ones. We have seen more in detail, looking the V light curve which is more accurately defined, that the discordance is nearly growing with time and is almost negligible during the central part of the primary minimum. In the phase interval − 70°, − 13° and + 14°, + 40° reckoned from the primary eclipse, the system was brighter during the period J.D. 7258-7694 than during the previous interval J.D. 6600-7082, but the contrary happened at the secondary minimum between the phases 184°-210° , whilst in the descending branch of the Min II the different groups of observations more or less agree. The measures we obtained between J.D. 8052 and J.D. 8768 are in agreement with those of the precedent interval 7258-7694, excepting the Δm at the phases 184°-186°. Finally the few subsequent measures belonging to the period J. D. 9198-9500 confirm the progressive decreasing of brightness in the ascending branch of the secondary minimum, which for the U observations amounts to about $0^m.2$ in comparison with the first measures.

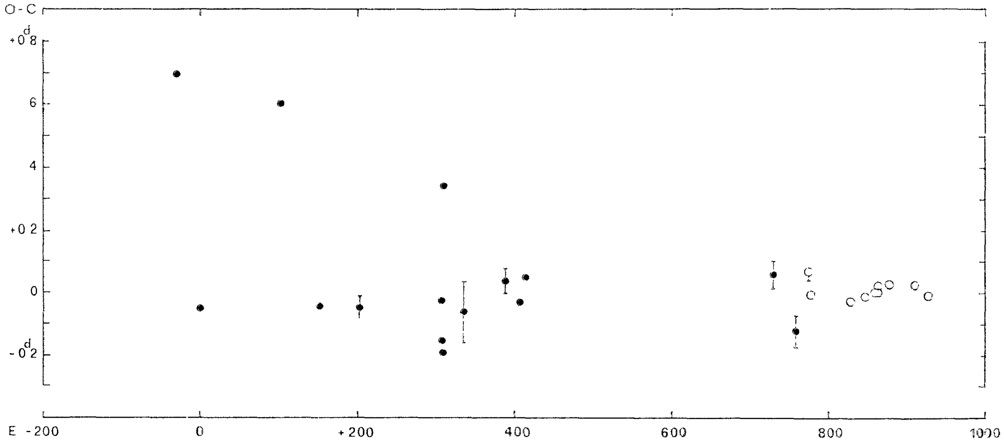

FIG. 1

The residuals of the times of visual or photographic (dots) and photoelectric (circles) minima of *RZ Cnc* with reference to a linear ephemeris.

Our observations during each of the above intervals cover the light curve only in part, so we cannot give a more detailed picture of the evolving photometric perturbation and in particular we cannot see any periodicity in the phenomenon. If there is, considering the variation in brightness during the secondary minimum, its period must be remarkably longer than the interval of 134 revolutions covered by our measures. What appears certain is that the intrinsic variability of *RZ Cnc*, suspected by LINNELL (1957), is real.

Concerning the matter of an influence on the light curves due to the possible variation of the comparison star, we remark that the above mentioned trend of the $\Delta m = m_{comp} - m_{check}$ is not progressive with time, as on the contrary it happens for the light curves, and moreover it is somewhat smaller. In addition we cannot discern which is the suspected variable, the comparison or the check star. Finally we remember that LINNELL (1957) judged both stars to be of constant luminosity.

4. - OUTSIDE ECLIPSE VARIATIONS

We have then derived three sets of normal points grouping separately the measures obtained during the different seasons. The groups are given successively for each color in the Tables II a, b, c and they are plotted in the Fig. 2. Only the first and the second group define sufficiently the light curves and although during each of the two seasons the system still suffered appreciable perturbations, as the dispersion of the normals shows, we hope the measures warrant the determination of the elements. From Fig. 2 we estimate the following magnitudes and colours for *RZ Cnc*:

	Max	Min I	Min II
V	$8^{m}.67$	$10^{m}.03$	$9^{m}.21$
B − V	+ 1 .20	+ 1 .42	+ 1 .11
U − B	+ 1 .00	+ 1 .57	+ 0 .88

As the primary minimum is a total eclipse, we see that the colours of the cooler, largest component correspond to a spectral subclass earlier than that extimed by HILTNER (1947) and agree with the POPPER (1957) value.

A least squares harmonic analysis of the normals outside the eclipses were carried out, separately for the two groups. At the first we have retained the terms up to cos 4ϑ and sin 4ϑ, then, after comparison of the coefficients with the corresponding mean errors, we have discarded the terms that are not significant and finally obtained the values reported in the Table III. N is the number of the equations considered in each solution, σ means the mean deviation of a normal with reference to the Fourier representation.

The values of A_2 show a quite a big ellipticity of the components, but whilst for the V colour the coefficients of the two seasons are equal, they differ for the B and U measures. The coefficient B_1 varies from the first season to the second one, but more for the B and U measures. We note moreover that the reflection coefficient A_1, small on account of the near surface temperature of the components, is not of the expected algebraic sign for the light curves of the second group, which extend over seventy orbital revolutions. However the sign is correct for the first season, spread over twenty-two cycles only. This fact can be attributed to the intrinsic variability of the system, which gives greater effects during longer intervals of time. However we are aware of its influence also over the light curves of the first group, so the determination of the elements appears a priori of no very great weight and the computation of the limb darkening coefficient must be disregarded also if the geometry of the system is favourable.

5. - RECTIFICATION AND SOLUTIONS

Only the light curves of the first group were considered and since the secondary minimum appears more perturbed (Fig. 2) we expect to have better results from the solutions based on the primary eclipse only. A preliminary

TABLE II *a* - Mean *U* points for the intervals J. D. 36600-7082; 37258-8768; 39198-9500.

n	Phase	U	n	Phase	U	n	Phase	U	n	Phase	U
6	2°1	12.939	7	237.0	10.947	7	16.2	11.235	8	203.6	11.049
5	3.2	12.793	8	250.7	10.901	7	16.9	11.250	8	205.2	11.044
6	3.5	12.760	9	262.2	10.917	5	17.4	11.163	6	208.5	11.036
2	5.2	12.516	9	279.5	10.914	5	18.0	11.200	7	242.4	10.888
2	9.2	11.902	8	281.6	10.906	4	18.6	11.198	6	293.8	10.901
3	11.6	11.657	8	284.9	10.961	5	19.8	11.143	2	325.4	10.996
7	14.6	11.558	10	296.1	10.977	5	20.6	11.031	5	343.1	11.252
8	15.6	11.438	9	312.6	11.010	6	21.5	10.980	5	343.6	11.290
7	16.1	11.372	8	317.8	11.019	8	23.3	10.926	5	344.6	11.344
8	37.0	10.916	9	320.1	11.047	8	27.5	10.895	5	345.9	11.473
6	42.3	10.991	8	325.4	11.073	9	29.1	10.928	5	346.4	11.518
6	43.8	10.930	8	325.6	11.096	6	34.0	10.919	5	347.7	11.630
4	60.2	10.950	3	335.7	11.153	6	35.9	10.969	5	349.0	11.741
9	68.3	10.878	6	342.3	11.333	6	37.0	10.862	5	350.1	11.871
10	69.6	10.910	7	342.8	11.372	6	38.4	10.841	5	351.0	11.972
9	87.0	10.858	6	345.2	11.512	7	47.1	10.910	5	352.1	12.135
7	102.9	10.866	6	346.6	11.615	7	47.8	10.935	5	352.6	12.193
7	118.4	10.887	5	347.3	11.666	7	48.9	10.899	5	352.9	12.245
6	126.2	10.922	3	350.0	11.989	5	132.7	10.961	5	353.1	12.280
8	134.7	10.964	3	352.3	12.250	5	156.8	10.982	5	353.2	12.304
9	136.2	10.942	3	353.8	12.469	5	168.4	11.062	5	353.7	12.379
8	151.1	11.014	7	357.2	12.953	6	169.9	11.165	5	354.6	12.504
6	167.0	11.056	7	358.3	13.101	6	170.1	11.135	5	355.4	12.638
6	168.3	11.083	6	359.0	12.986	8	170.8	11.161	5	356.0	12.726
6	169.4	11.102				9	171.3	11.162	5	356.6	12.811
4	171.2	11.135				9	172.9	11.171	5	357.1	12.838
4	183.1	11.184				7	173.6	11.170	5	357.8	12.919
5	184.8	11.194	5	0°4	12.991	7	175.1	11.163	5	358.5	12.964
7	185.3	11.117	5	0.8	12.980	6	179.2	11.196	5	358.9	12.978
7	186.4	11.109	6	4.3	12.681	7	180.6	11.205	5	359.3	13.015
7	187.1	11.105	7	4.4	12.659	8	181.3	11.206	6	359.8	12.990
7	188.0	11.077	5	7.4	12.263	9	181.7	11.210			
7	200.1	11.059	5	7.9	12.204	9	182.4	11.212			
7	202.1	11.027	5	8.8	12.092	8	183.3	11.197	3	14.7	11.282
7	203.1	11.028	6	9.8	11.992	8	184.4	11.202	8	182.8	11.342
8	203.6	11.028	7	10.2	11.956	8	185.6	11.192	7	183.4	11.343
7	208.4	10.946	7	13.6	11.504	8	186.5	11.187	5	185.7	11.248
7	209.5	10.947	8	14.6	11.365	7	187.9	11.178	5	343.9	11.203
8	217.1	11.003	7	15.3	11.322	7	191.9	11.134	4	344.9	11.243
9	219.1	11.007	7	15.5	11.307	7	193.1	11.116	4	358.4	13.007
8	222.0	10.965	7	15.9	11.226	8	195.0	11.091	4	359.3	13.001

Ttble II *b* - Mean *B* points for the intervals J.D. 36600-7082; 37258-8768; 39198-9500.

n	Phase	B	n	Phase	B	n	Phase	B	n	Phase	B
5	2°5	11.376	5	202.3	10.043	6	3.5	11.308	10	183.7	10.329
5	2.9	11.368	5	203.0	10.031	5	4.1	11.278	10	184.1	10.283
5	3.5	11.297	5	203.6	10.051	5	4.4	11.236	10	184.7	10.293
5	4.1	11.213	6	203.8	10.048	6	4.9	11.206	10	185.4	10.281
4	5.2	11.151	5	207.9	9.985	6	6.9	11.020	10	187.1	10.251
4	7.4	10.897	6	209.7	9.977	6	7.9	10.938	9	189.9	10.208
4	7.7	10.873	7	216.9	10.009	6	9.0	10.831	9	191.7	10.184
5	9.0	10.765	7	218.7	10.006	5	9.6	10.763	9	194.1	10.146
6	9.5	10.703	5	220.4	10.002	6	12.6	10.475	9	197.3	10.129
5	12.0	10.535	5	222.9	9.989	6	13.2	10.423	10	204.7	10.056
5	15.4	10.338	6	236.1	9.953	6	13.9	10.355	5	208.1	10.040
5	15.5	10.327	9	250.9	9.918	6	14.4	10.334	5	242.8	9.916
5	15.7	10.328	5	262.0	9.918	6	14.9	10.275	5	294.1	9.880
5	15.9	10.302	5	262.5	9.914	6	15.4	10.284	7	325.2	9.937
5	16.4	10.322	7	279.0	9.901	7	15.7	10.225	5	336.8	10.050
5	19.7	10.153	6	281.3	9.898	7	16.0	10.211	5	343.1	10.180
4	20.1	10.137	8	285.1	9.937	7	16.5	10.215	6	344.3	10.242
4	25.6	10.021	5	295.4	9.939	6	16.8	10.239	6	345.0	10.309
5	25.9	10.031	6	296.8	9.938	6	17.1	10.196	6	345.9	10.372
10	32.5	10.002	8	311.9	9.968	6	17.4	10.178	6	347.4	10.456
9	37.1	9.949	9	313.7	9.952	6	18.1	10.184	6	349.2	10.596
8	41.6	9.990	7	316.4	10.003	7	20.2	10.084	5	350.2	10.685
6	51.7	9.935	8	320.1	10.018	7	21.1	9.996	6	352.0	10.864
7	65.6	9.933	7	325.2	10.035	7	22.7	9.952	6	352.5	10.924
7	68.3	9.893	7	325.7	10.033	6	27.9	9.918	6	352.9	10.954
6	69.6	9.910	7	328.1	10.010	7	28.8	9.932	6	353.2	10.983
7	82.1	9.913	6	329.9	9.995	7	31.9	9.946	6	353.9	11.069
7	86.3	9.849	6	330.5	10.077	7	36.0	9.903	6	355.2	11.206
7	100.3	9.860	5	335.4	10.061	8	46.9	9.903	6	356.3	11.291
7	118.4	9.891	4	336.0	10.075	8	48.4	9.897	6	356.5	11.308
7	125.8	9.917	5	342.1	10.249	2	82.2	9.898	6	356.7	11.308
7	134.4	9.984	6	342.8	10.271	4	132.2	9.949	6	357.3	11.375
7	135.1	9.947	5	344.5	10.345	12	156.9	9.994	6	357.6	11.381
6	136.7	9.961	4	345.0	10.377	9	168.1	10.117	6	357.9	11.400
8	151.1	10.020	5	346.3	10.473	9	169.2	10.159	6	358.4	11.436
5	167.0	10.120	4	346.9	10.514	9	169.6	10.167	6	358.8	11.441
5	168.1	10.135	4	347.9	10.567	9	170.6	10.195	7	359.5	11.436
6	169.2	10.176	4	351.2	10.851	9	171.7	10.213			
7	170.8	10.212	4	353.6	11.088	10	173.4	10.245			
7	183.5	10.300	4	355.8	11.305	10	174.9	10.253	8	0°5	11.490
7	184.7	10.246	4	356.6	11.280	10	176.0	10.271	5	14.8	10.287
6	185.2	10.238	5	357.0	11.312	10	176.7	10.307	4	16.5	10.220
6	186.5	10.209	5	357.6	11.365	10	178.1	10.302	7	182.7	10.415
6	186.8	10.210	5	358.1	11.411	10	179.9	10.313	7	183.4	10.409
6	188.0	10.171	6	358.6	11.431	10	181.1	10.320	7	185.1	10.321
5	193.1	10.076				10	181.8	10.322	7	185.9	10.293
4	193.3	10.069				10	182.6	10.362	9	344.4	10.176
5	199.8	10.080	6	0°2	11.439	10	182.8	10.298	7	357.5	11.406
5	201.3	10.069	6	1.1	11.457	10	183.1	10.355	6	359.0	11.436

TABLE II *c* - Mean *V* points for the intervals J.D. 36600-7082; 37258-8768; 39198-9500.

n	Phase	V	n	Phase	V	n	Phase	V	n	Phase	V
5	2°5	9.963	7	208°3	8.815	5	6.8	9.677	8	185.3	9.142
5	2.9	9.928	7	212.7	8.804	6	7.7	9.620	8	186.7	9.110
5	3.5	9.903	7	217.7	8.810	6	8.8	9.557	7	188.3	9.064
5	4.2	9.845	7	219.5	8.809	6	9.6	9.491	7	191.2	9.008
4	5.2	9.765	7	222.2	8.793	6	12.7	9.218	8	192.5	8.993
6	7.5	9.581	6	236.1	8.747	6	13.2	9.182	8	194.8	8.955
6	8.6	9.501	8	250.7	8.711	6	13.9	9.143	8	197.8	8.932
6	9.3	9.423	10	262.2	8.709	6	14.5	9.112	10	204.7	8.865
6	11.6	9.279	7	279.0	8.706	6	15.0	9.073	5	208.1	8.846
8	15.0	9.103	7	281.8	8.701	6	15.4	9.069	5	242.8	8.719
8	15.3	9.103	7	285.2	8.718	6	15.7	9.017	6	294.1	8.682
7	15.8	9.092	11	296.2	8.733	6	15.9	9.020	7	325.2	8.761
7	16.2	9.096	7	297.6	8.768	6	16.4	9.008	4	335.3	8.826
10	19.9	8.929	7	313.4	8.759	6	16.7	9.036	6	343.0	8.986
10	25.8	8.824	7	315.9	8.785	7	17.0	9.010	6	344.3	9.035
5	32.4	8.812	7	319.0	8.803	7	17.3	8.977	6	345.0	9.092
5	32.7	8.801	7	324.4	8.831	7	18.1	8.997	6	346.0	9.147
9	37.1	8.766	7	325.4	8.830	7	20.2	8.902	6	348.1	9.265
9	41.6	8.802	7	325.9	8.833	7	21.0	8.828	6	349.6	9.356
6	51.7	8.738	8	329.6	8.813	7	22.7	8.783	6	351.1	9.485
8	65.4	8.737	9	330.2	8.825	8	28.1	8.751	6	352.2	9.570
7	67.5	8.703	8	330.5	8.846	8	29.0	8.761	6	352.7	9.612
8	69.3	8.706	10	335.8	8.868	6	33.9	8.750	5	352.9	9.632
7	82.9	8.691	7	342.3	9.038	6	36.3	8.734	5	353.3	9.653
7	88.7	8.667	7	343.5	9.086	8	46.9	8.729	5	353.9	9.702
6	104.7	8.672	6	345.4	9.163	8	48.4	8.716	5	354.9	9.781
5	119.1	8.702	6	346.6	9.223	4	132.2	8.750	5	355.8	9.842
7	125.8	8.717	6	347.3	9.263	5	156.5	8.807	5	356.5	9.897
7	134.4	8.782	5	350.8	9.485	6	157.2	8.811	6	356.8	9.908
7	135.1	8.757	5	353.9	9.714	8	168.0	8.947	6	357.4	9.959
6	136.7	8.767	5	356.2	9.882	8	169.2	8.991	6	357.7	9.970
9	151.1	8.827	5	356.9	9.897	8	169.6	9.001	6	358.0	9.977
5	167.0	8.952	5	357.5	9.940	8	170.3	9.024	6	358.5	10.011
5	168.0	8.969	5	358.0	9.970	8	171.4	9.057	6	358.9	10.007
5	168.9	9.010	5	358.3	10.003	8	172.6	9.083	6	359.5	10.016
5	170.0	9.025	5	358.4	10.008	8	173.8	9.106			
4	171.2	9.053	5	358.7	10.010	8	175.1	9.099	8	0°5	10.038
6	183.4	9.172	5	359.2	10.001	8	175.9	9.108	4	14.8	9.104
6	184.7	9.121	5	359.4	9.999	8	176.2	9.135	3	16.5	8.965
6	185.2	9.111	5	359.6	10.002	8	176.4	9.154	9	182.8	9.291
6	186.5	9.072	5	359.8	10.001	8	176.8	9.165	8	183.7	9.260
6	186.8	9.071	4	359.9	10.016	8	178.1	9.191	7	185.1	9.197
7	187.9	9.043				8	179.4	9.201	7	185.9	9.166
6	192.6	8.937				8	180.6	9.211	5	343.9	8.969
7	193.1	8.933	5	0°2	10.017	8	181.3	9.206	4	344.9	9.007
6	199.8	8.894	5	1.2	10.030	8	181.8	9.204	5	357.4	9.968
6	201.7	8.874	5	3.4	9.914	8	182.4	9.200	5	358.0	10.014
6	202.7	8.841	5	4.1	9.881	8	183.3	9.175	4	359.4	10.029
6	203.5	8.850	5	4.4	9.849	8	184.4	9.150			
6	203.8	8.855	6	4.8	9.828						

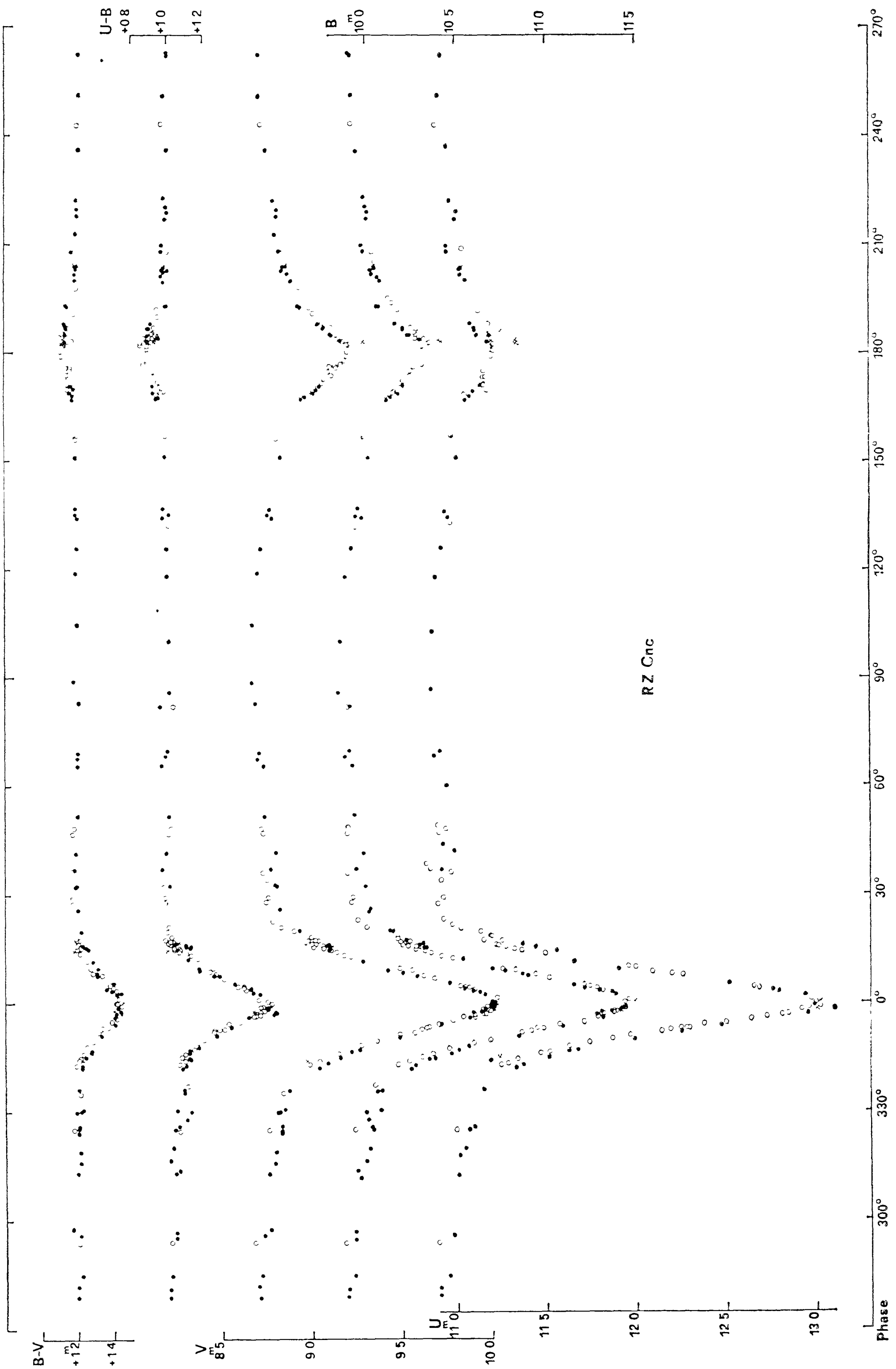

Fig. 2

Normal light and colour curves of *RZ Cnc* during the 1959.1-60.4 season (dots), during the 1960.9-65.0 season (circles) and the 1966.2-67.0 season (crosses).

rectification gave the value θ' = 27° for the angle of the external contact. By means of this value and the constants reported in Table III, the intensities and the phase angles were rectified according to the usual formulas (Russell and Merrill 1952). For each light curve the rectifications were computed for different values of the darkening coefficients.

Correspondingly some trial nomographic solutions were made. The primary minimum seems to be an occultation in agreement with Gaposchkin's results. As it was difficult to judge the best solution by a simple comparison of the observed with the computed light curves, we preferred to calculate the differential corrections to the preliminary elements and the corresponding errors, according to the method of Irwin (1947). No correction was tried for L_g, which is fixed accurately in each colour by observations during the totality. The equations of condition, weighed according to their intrinsic and observational precision, were therefore of the form:

Table III. - Fourier coefficients.

Filter	Group	A_0	A_1	A_2	B_1	σ	N
U	I	.9015 ± 19	-.0248 29	-.0689 34	.0250 23	.019	30
	II	.9175 ± 54	.0390 86	-.0480 120	.0040 89	.026	14
B	I	.8928 ± 11	-.0058 17	-.0678 20	.0141 14	.014	40
	II	.9458 ± 24	.0415 36	-.0592 46	.0052 32	.010	12
V	I	.9001 ± 8	-.0042 11	-.0735 13	.0112 9	.009	39
	II	.9211 ± 13	.0304 20	-.0732 28	.0060 19	.006	11

$$-\sqrt{w}\,L_s\left(\frac{\partial\alpha}{\partial r_g}\,\Delta r_g+\frac{\partial\alpha}{\partial r_s}\,\Delta r_s+\frac{\partial\alpha}{\partial(\cos^2 i)}\,\Delta(\cos^2 i)\right)=\sqrt{w}\,\Delta l_{(o-c)}$$

For each normal the coefficients were calculated according to the preliminary solution by means of punched Irwin's (1947) Tables, with an IBM 1620. Then solving of the equations by least-squares were obtained. In Fig. 3 we have plotted for every trial the mean variance σ of a normal, in light units, with reference to the computed light curve, against the corresponding value of the ratio of

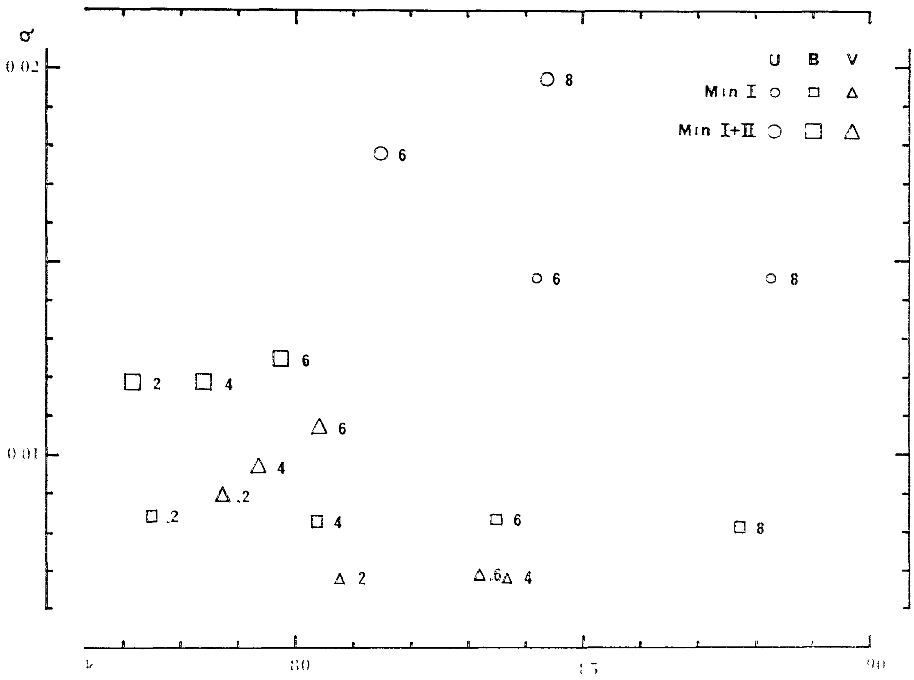

Fig. 3

Orbital solutions of *RZ Cnc* (see text). The larger symbols represent the solutions with both minima, the smaller ones those with only the primary. The numbers next to each symbol give the corresponding darkening coefficient.

the radii k. Some limb darkening coefficients were adopted and solutions with only the observations of the primary minimum, or with the normals of both the eclipses, were computed. We remark the inferior precision of the latter group of solutions and the systematic shift of k towards smaller values. Probably the effect is due to the photometric instability, greater during the secondary eclipse, as the spectrographic observations confirm (Hiltner 1947), and is not completely removed by subtraction of the term B_1. As expected the value of σ do not change much when the darkening coefficient varies.

Among the solutions based upon the primary minimum only, we have reported in Table IV those which give a set of geometrical elements which are the most similar in the three colours. θ' and θ'' denote the rectified phase angles of external and internal tangency and i the rectified inclination. The mean errors of L_g have been estimaed directly from the observations during the totality.

6. - Conclusions

From the colour index of the cooler component and from the values $L_{1,2}$ of Table IV for the brighter component, we have the following result:

$$B - V = + 1^m.08 \qquad U - B = + 1^m.00$$

These colours correspond to a K 1 III star.

TABLE IV. - Solutions for RZ Cancri.

	U	B	V
x	0.6	0.6	0.4
z	0.117	0.117	0.138
k	0.84	0.84	0.84
r_g	0.265 ±.004	0.257 ±.002	0.255 ±.002
r_s	0.223 ±.012	0.215 ±.005	0.213 ±.005
i	88°.2 ± 1.5	87°.7 ± .7	87°.8 ± .8
L_g	0.206 ±.006	0.305 ±.002	0.372 ±.002
L_s	0.794	0.695	0.628
J_1/J_2	0.18	0.31	0.41
θ'	29°.1	28°.1	27°.8
θ''	1°.6	0°.9	1°.0
	0.015	0.008	0.007

Combining the spectrografic data (POPPER 1967) with the photometric ones, the absolute dimensions of the sistem, in solar units, are as follows:

Component	Mass	Radius	Distance of the centers
K 1 III	3.1 ± 0.2 m.e.	11 ± 0.3 m.e.	50 ± 1 m.e.
K 4 III	0.55 ± 0.05	13 ± 0.3	

We note that the system has a semidetached configuration because the cooler component fills its critical zero-velocity surface. The mass of the K 4 star is much smaller than for a normal giant and the radii of both the components, and particularly that of the cooler one, are also smaller than expected.

The position compared to the orbital revolution of the photometric instability of the light curve, and in particular its non-appearance during the same phase interval of the Min I when the Ca II emission is also missing, confirms the conclusion of HILTNER (1946) that the unstable region is on the brighter, heavier component and it does not belong to gaseous rings around one of the stars. However the light constancy at the descending branch of the secondary minimum, whilst the rising one varies from one season to the other, disproves the Hiltner suggestion that the active region is localised also at the external tidal bulge of the elongated primary star. On the contrary the asymmetric position of the perturbation compared to the line joining the centers of the two components appears evident. We note that Hiltner does not specify if the intensity of the emission varies outside eclipses and how, and moreover we remember that his observations were made about twenty years before ours, so it is possible that in the meantime the position of the active region has migrated over the star.

The evolutionary status of *RZ Cnc* is not settled at present. According to Koch (1970) the system can be interpreted or as highly evolved, with the K 4 star in the He burning stage, or alternatively as a very young binary. Koch in fact has verified that the two components can be located satisfactorily on contracting traks and that an age of 10^4-10^5 years can be attributed to both the stars. This interpretation is supported by the presence of the Ca II emission which is a characteristic feature of young stars. No nebulosity around the system and no other feature of T Tau-type stars is however seen and moreover, as Koch remarks, *RZ Cnc* is quite far from the galactic plain ($b = + 37°$).

Finally we note that the intrinsic small variability of the light curves and the substantially constant period indicate that at the present the system is only moderately unstable.

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