PHOTO-ELECTRIC LIGHT-CURVES IN BLUE AND YELLOW LIGHT OF THE ECLIPSING VARIABLE RR TRIANGULI AUSTRALIS

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Photo-electric observations of the eclipsing binary RR TrA in blue and yellow light are discussed. The elements for primary minimum are: 2435629.36939 + .7130882 *E*. The normal points of the mean light-curves in blue and yellow have been plotted in Figure 1 and have been tabulated in Tables 3 and 4. The derivation of the photometric elements has met with some difficulties. The coefficient of reflection is considerably smaller than its theoretical value and further there exists a discordance between the values of the geometrical elements as derived from the blue and from the yellow light-curve. In Table 5 the geometrical and physical elements have been collected, as derived in separate solutions from the two light-curves and as determined from a combined solution.

During the months of May to August 1956 the second author worked at the southern station of the Leiden Observatory in Johannesburg to help Dr A. B. MULLER complete the photo-electric measures of southern Cepheids. At the end of May some time became available for another programme and during June and July a number of observations in blue and yellow light were made of the eclipsing variable RR TrA, which had a suitable right ascension for that time of year and a short period so that a complete light-curve could be obtained in a reasonably short time.

RR TrA was discovered on Harvard plates by Miss CANNON, who suspected the star to be an eclipsing variable. HOFFMEISTER [1]) derived the elements:

$$\text{minimum} = 2428334.431 + {}^{d}.713113\, E,$$

an amplitude from $10^{m}.2$ to $11^{m}.8$, a duration of minimum of $2^{h}.9$ and no indication of a secondary minimum. The spectrum had been classified earlier as B8.

The observations were made with one Zeiss objective of the twin Rockefeller astrograph in combination with a photometer constructed by Dr WALRAVEN for the programme on Cepheids. Measures in blue and yellow made with this equipment were compared by the second author [2]) with the magnitudes of the 1953 S-system of the Cape. In this note it was stated that the Corning glass filters 5551 and 3385 had been used for the blue and yellow respectively. This statement was not correct, as a 2 mm Schott glass filter GG 11 was used for the yellow. There is however very little difference between the transmission curves of the Corning 3385 and of the Schott GG 11 filters and so we may adopt for the effective wavelength of the blue measures .415 μ and for the yellow .532 μ.

RR TrA is identical with CPD − 62°5265. The star CPD − 62° 5260 was used as a comparison star. The arrangement of the measures was usually the following: one measure in blue and one in yellow of the comparison star followed by three such sets of measures of the variable, and so on.

The readings from the records and the further reduction were performed by the third author. The correction for differential extinction between variable and comparison star remained smaller than $^{m}.002$, but was nevertheless applied. The individual observations are given in Table 1 for the blue measures and in Table 2 for the yellow measures, the first column giving the heliocentric Julian Days, the second the magnitude difference between variable and comparison star and the third the phase, computed with the formula:

$$\text{phase} = 1.40234\ (\text{J.D. hel.} - 2430000).$$

From the observations covering most of the minimum, epochs of minimum were derived according to HERTZSPRUNG's method. The mean errors were computed with the formula given by KWEE and VAN WOERDEN [3]). The resulting epochs are:

epochs from blue measures	m.e.	epochs from yellow measures	m.e.
2435629.36947	± .00019	2435629.36908	± .00025
34.36130	± .00013	39.35181	± .00028
39.35222	± .00056	64.31037	± .00017
64.31098	± .00024	69.30264	± .00038
69.30178	± .00042	89.26860	± .00017
89.26919	± .00018		

From these eleven epochs of minimum elements were derived by least squares. These elements are:

$$\text{Min.} = 2435629^{d}.36939 + {}^{d}.7130882\, E$$
$$\pm\ 17 \quad \pm\ 34 \text{ m.e.}$$

The epochs with their adopted relative weights, with the number of periods elapsed and with the residuals from this formula are:

epoch	weight	*E*	*O* − *C*
			d
2435629.36947	28	0	+ .00008
.36908	16	0	− .00031
34.36130	59	7	+ .00029
39.35222	3	14	− .00040
.35181	13	14	− .00081
64.31098	17	49	+ .00027
.31037	35	49	− .00034
69.30178	6	56	− .00055
.30264	7	56	+ .00031
89.26919	31	84	+ .00040
.26860	35	84	− .00019

[1]) *Kleinere Veröff. Berlin-Babelsberg* Nr 27, 51, 1943.
[2]) *B.A.N.* **12**, 271 (No. 460), 1955.
[3]) *B.A.N.* **12**, 327 (No. 464), 1956.

These new elements are the best for future use. The interval between the old epoch given by HOFFMEISTER and that of the new elements is $7294^d.93839$. This interval contains 10230.06 of the newly derived periods. Assuming that the interval contains 10229 or 10231 periods, we find values of the period of $^d.713162$ or $^d.713023$ respectively. Both values differ from the period derived above by nearly 20 times its mean error. Consequently if the period has remained constant since HOFFMEISTER's observations, the counting of periods in this large time interval seems to be well determined. The combination of HOFFMEISTER's epoch with those of this paper yields the period:

$$^d.71309268$$
$$\pm \quad 18 \text{ m.e.}$$

Phases were computed for all the observations with the formula given above. As the observations showed that the quality of the nights of observing was far from constant, weights had to be determined before mean light-curves could be formed. The number of observations of the comparison star are too few to derive the weights from them. So the weights were derived from the differences between successive observations of the variable for the parts of the light-curve outside eclipse. From the observations inside the minimum a provisional light-curve was formed and weights determined from the residuals of the observations with respect to this curve. The assumed weights vary from 0 to 12. Weight 1 corresponds approximately with a mean error of $\pm^m.030$.

The mean light-curves in blue and in yellow are shown in the accompanying figure. Mean phase, mean brightness and weight of the normal points are given in Tables 3 and 4. In these tables phases have been counted from the phase of primary minimum.

Some of the measures of the comparison star have been reduced to no atmosphere in such a way that the formulae given in *B.A.N.* **12**, 271 for the reduction to the 1953 S-system of the Cape could be applied. The following results were derived:

Comparison star	SPg = 11.05
,, ,,	SPv = 10.83
Variable max.	SPg = 10.37
,, ,,	SPv = 10.39
min.	SPg = 12.16
,,	SPv = 11.86
sec. min.	SPg = 10.57
	SPv = 10.63
total range	ΔSPg = 1.79
	ΔSPv = 1.47
range sec. min.	ΔSPg = .20
	ΔSPv = .24

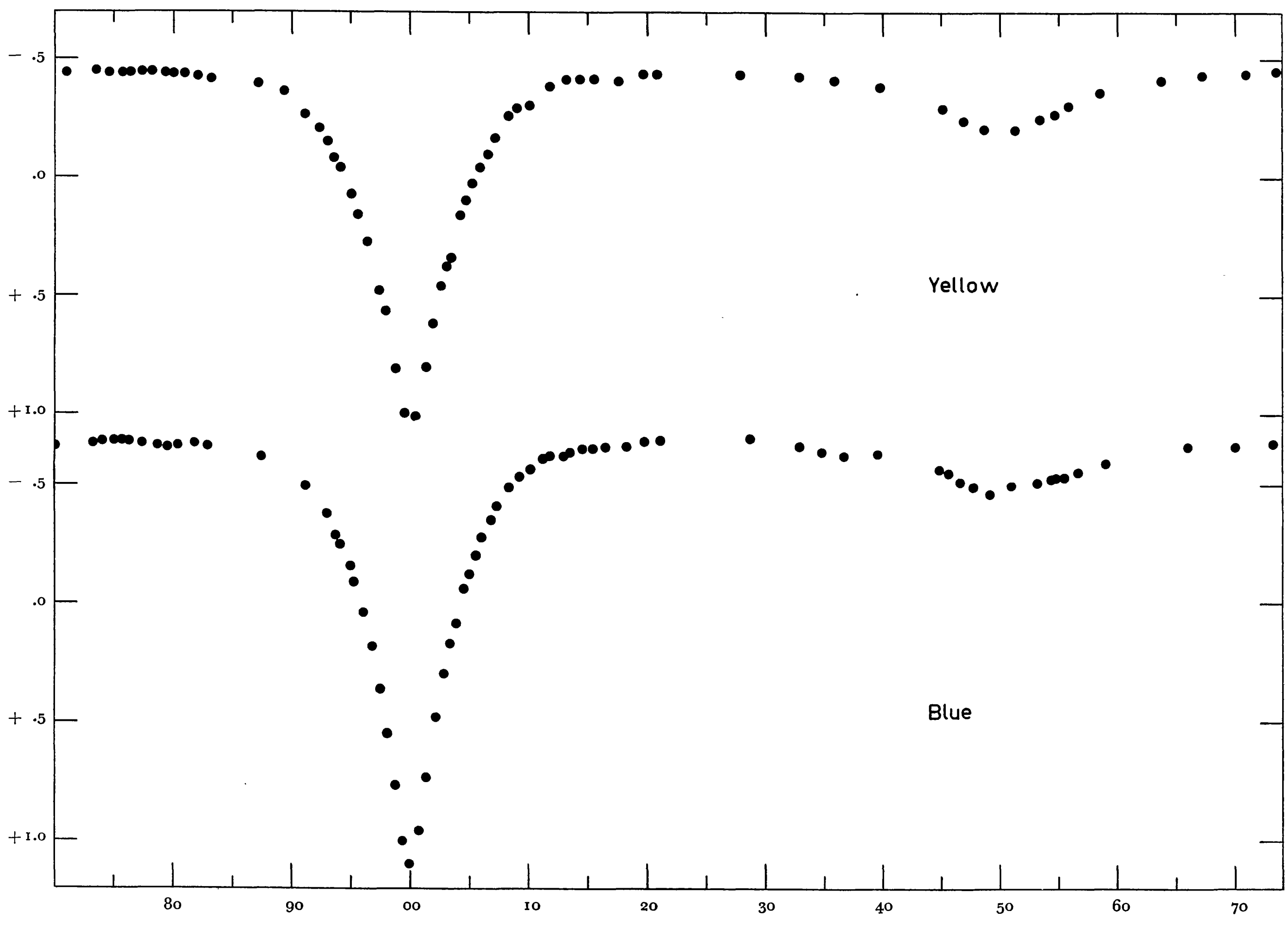

TABLE 1

J. D. hel. —2435600	Δm	phase
d	m	P
24.3092	— .492	.1937
.3192	— .416	.2078
.3281	— .283	.2202
.3350	— .310	.2299
.3389	— .037	.2354
.3636	+ .585	.2700
.3680	+ .788	.2762
.3721	+ .966	.2820
.3833	+ .906	.2976
.3876	+ .676	.3036
.3920	+ .493	.3099
.3956	+ .343	.3150
.4039	+ .081	.3266
.4076	— .019	.3317
.4187	— .263	.3473
.4226	— .322	.3528
.4268	— .385	.3587
.4388	— .499	.3754
.4421	— .536	.3801
.4452	— .556	.3844
.4485	— .586	.3891
.4582	— .611	.4028
26.3683	— .661	.0814
.3720	— .677	.0865
.3748	— .666	.0905
.3816	— .659	.0999
.3846	— .681	.1042
27.3215	— .619	.4181
.3246	— .631	.4224
.3275	— .626	.4265
.3348	— .646	.4367
.3379	— .651	.4410
.3409	— .651	.4453
.3687	— .683	.4842
.3721	— .681	.4889
.3761	— .674	.4946
28.3867	— .627	.9118
.3912	— .675	.9181
.3948	— .636	.9231
29.3140	— .428	.2122
.3249	— .278	.2274
.3283	— .224	.2323
.3313	— .167	.2364
.3383	— .005	.2463
.3420	+ .095	.2514
.3450	+ .134	.2557
.3521	+ .397	.2656
.3554	+ .540	.2702
.3588	+ .695	.2750
.3623	+ .845	.2799
.3667	+1.055	.2860
.3708	+1.040	.2918
.3746	+ .951	.2971
.3850	+ .466	.3117
.3887	+ .309	.3169
.3920	+ .186	.3216
.4007	— .050	.3307
.4043	— .111	.3388
.4079	— .190	.3438
.4168	— .342	.3564
.4201	— .402	.3610
30.3997	— .540	.7346
.4032	— .520	.7396
.4065	— .520	.7442
.4144	— .477	.7553
.4176	— .493	.7598
.4211	— .479	.7648
.4287	— .454	.7754
.4324	— .452	.7806
.4358	— .442	.7854
34.2770	— .607	.1720
.3155	— .317	.2260
.3167	— .311	.2277
.3179	— .281	.2294
.3192	— .257	.2311
.3222	— .225	.2355
.3235	— .189	.2372
.3248	— .166	.2390
.3260	— .148	.2408
.3304	— .040	.2469
.3316	+ .009	.2486
.3329	+ .038	.2504
.3360	+ .128	.2548
.3373	+ .183	.2565
.3386	+ .207	.2584
.3398	+ .259	.2600
.3428	+ .367	.2643
.3442	+ .423	.2662

J. D. hel. —2435600	Δm	phase
d	m	P
34.3455	+ .495	.2681
.3467	+ .572	.2697
.3498	+ .678	.2740
.3510	+ .738	.2757
.3522	+ .775	.2775
.3536	+ .852	.2794
.3570	+1.052	.2842
.3584	+1.094	.2861
.3596	+1.109	.2879
.3609	+1.131	.2896
.3642	+1.039	.2942
.3655	+ .992	.2961
.3669	+ .911	.2980
.3681	+ .869	.2998
.3746	+ .528	.3088
.3759	+ .483	.3106
.3772	+ .435	.3125
.3787	+ .356	.3146
.3834	+ .176	.3212
.3848	+ .164	.3231
.3860	+ .117	.3248
.3873	+ .085	.3266
.3913	— .027	.3323
.3925	— .072	.3340
.3938	— .089	.3358
.3951	— .113	.3376
.3987	— .199	.3426
.4000	— .220	.3445
.4013	— .241	.3463
.4026	— .272	.3481
.4080	— .345	.3558
.4093	— .363	.3575
.4106	— .386	.3594
.4118	— .405	.3611
.4160	— .440	.3669
.4172	— .478	.3686
.4184	— .481	.3704
.4201	— .470	.3727
36.2535	— .653	.9347
.2571	— .652	.9488
.2606	— .669	.9537
.2685	— .675	.9648
.2720	— .663	.9697
.2754	— .667	.9744
.3226	— .686	.0406
.3260	— .679	.0454
.3294	— .681	.0501
.3373	— .683	.0612
.3405	— .677	.0657
.3437	— .666	.0702
.3513	— .666	.0808
.3546	— .659	.0855
.3578	— .662	.0900
.3709	— .680	.1083
.3740	— .660	.1128
.3772	— .675	.1172
37.3399	— .667	.4672
.3431	— .648	.4717
.3460	— .642	.4758
.3532	— .661	.4859
.3562	— .683	.4900
.3591	— .669	.4941
38.3577	— .631	.8945
.3608	— .674	.8990
.3641	— .649	.9036
.3723	— .656	.9150
.3754	— .620	.9193
39.2883	— .496	.1995
.2915	— .479	.2040
.2946	— .456	.2083
.3030	— .366	.2202
.3060	— .321	.2244
.3092	— .272	.2289
.3168	— .129	.2395
.3198	— .059	.2437
.3227	+ .019	.2478
.3335	+ .344	.2629
.3364	+ .459	.2671
.3384	+ .603	.2698
.3462	+ .922	.2807
.3492	+1.069	.2849
.3522	+1.054	.2892
.3592	+ .876	.2989
.3621	+ .735	.3031
.3648	+ .602	.3069
.3784	+ .124	.3259
.3816	+ .028	.3304
.3846	— .050	.3346
.3915	— .202	.3442
.3944	— .259	.3483

J. D. hel. —2435600	Δm	phase
d	m	P
39.3973	— .292	.3524
.4044	— .405	.3624
.4075	— .447	.3667
.4105	— .473	.3709
.4174	— .510	.3806
.4205	— .528	.3850
.4237	— .559	.3890
.4308	— .602	.3994
.4339	— .613	.4038
.4372	— .602	.4084
40.3236	— .640	.6514
.3270	— .654	.6562
.3301	— .649	.6605
.3373	— .634	.6706
.3404	— .619	.6749
.3438	— .630	.6797
.3511	— .630	.6900
.3542	— .640	.6943
.3573	— .630	.6986
.3897	— .560	.7441
.3927	— .537	.7483
.3959	— .535	.7528
.4033	— .497	.7631
.4059	— .498	.7668
.4088	— .495	.7709
.4164	— .497	.7815
.4194	— .485	.7858
.4224	— .478	.7900
.4360	— .495	.8090
.4389	— .393	.8130
.4420	— .502	.8175
.4489	— .507	.8271
.4517	— .510	.8311
.4547	— .522	.8352
.4619	— .525	.8453
.4647	— .525	.8493
.4743	— .535	.8628
.4772	— .542	.8668
41.3022	— .691	.0237
.3054	— .691	.0282
.3084	— .691	.0325
.3163	— .699	.0435
.3195	— .683	.0480
.3226	— .676	.0523
.3297	— .682	.0623
.3327	— .675	.0665
.3357	— .671	.0707
.3430	— .660	.0810
.3460	— .653	.0852
.3491	— .652	.0895
.3629	— .649	.1088
.3658	— .649	.1129
.3687	— .659	.1170
.4029	— .613	.1650
.4058	— .604	.1691
.4088	— .600	.1732
.4158	— .577	.1831
.4188	— .566	.1873
.4217	— .555	.1913
42.2241	+ .363	.3166
.2274	+ .241	.3212
.2306	+ .135	.3257
.2380	— .070	.3360
.2411	— .140	.3404
.2442	— .189	.3447
.2517	— .313	.3552
.2547	— .357	.3594
.2577	— .381	.3636
.2701	— .527	.3810
.2732	— .528	.3853
.2762	— .553	.3896
.2842	— .592	.4008
.2872	— .607	.4050
.2902	— .629	.4092
.3005	— .622	.4237
.3044	— .644	.4291
.3117	— .636	.4393
.3146	— .632	.4435
.3177	— .644	.4478
.3248	— .648	.4577
.3277	— .648	.4618
.3308	— .648	.4662
.3430	— .691	.4832
.3459	— .684	.4873
.3489	— .691	.4915
.3560	— .695	.5015
.3588	— .690	.5055
.3618	— .687	.5096
.4354	— .662	.6129
.4385	— .660	.6172
.4416	— .659	.6216

J. D. hel. —2435600	Δm	phase
d	m	P
42.4490	— .642	.6320
.4522	— .632	.6365
.4552	— .626	.6406
.4626	— .604	.6510
.4659	— .612	.6556
.4690	— .606	.6599
43.3066	— .524	.8345
.3096	— .531	.8388
.3127	— .526	.8431
.3196	— .556	.8529
.3227	— .561	.8572
.3256	— .570	.8612
.3319	— .581	.8701
.3349	— .596	.8742
.3378	— .594	.8784
44.3622	+ .382	.3150
.3654	+ .307	.3193
.3686	+ .188	.3239
.3760	— .005	.3343
56.2694	— .664	.0128
.2726	— .667	.0172
.2755	— .671	.0214
.3007	— .683	.0567
.3037	— .666	.0609
.3156	— .661	.0776
.3186	— .646	.0818
.3214	— .653	.0857
.4172	— .351	.2201
.4201	— .255	.2241
.4231	— .224	.2284
57.2570	— .593	.3978
.2599	— .619	.4019
.2628	— .630	.4059
.2694	— .623	.4152
.2724	— .625	.4194
.2752	— .631	.4233
.2889	— .635	.4425
.2919	— .657	.4467
.2946	— .655	.4505
.3019	— .663	.4608
.3048	— .662	.4648
.3077	— .645	.4689
.3144	— .676	.4783
.3173	— .685	.4824
.3202	— .665	.4865
.3609	— .686	.5435
.3640	— .711	.5478
60.3141	— .628	.6849
.3169	— .614	.6888
.3197	— .606	.6927
.3501	— .593	.7353
.3538	— .596	.7406
.3570	— .572	.7450
.3636	— .541	.7543
64.2725	— .155	.2359
.2757	— .096	.2403
.2787	— .020	.2446
.2858	+ .156	.2545
.2889	+ .234	.2588
.2918	+ .340	.2629
.2990	+ .653	.2730
.3021	+ .835	.2775
.3053	+ .964	.2819
.3150	+1.053	.2954
.3181	+ .848	.2999
.3215	+ .700	.3046
.3292	+ .370	.3154
.3326	+ .258	.3202
.3361	+ .130	.3251
.3434	— .039	.3353
.3467	— .131	.3400
.3496	— .193	.3441
67.2242	— .497	.3752
.2273	— .511	.3796
.2306	— .539	.3841
.2409	— .582	.3986
.2439	— .619	.4029
.2470	— .618	.4072
.2556	— .616	.4192
.2587	— .634	.4235
.2616	— .648	.4277
.2698	— .660	.4391
.2726	— .657	.4431
.2754	— .672	.4470
68.3739	— .679	.9875
.3769	— .693	.9917

TABLE 1 (*continued*)

J. D. hel. —2435600	Δm	phase
d	m	P
68.3799	— .705	.9958
.3878	— .637	.0069
.3908	— .629	.0111
.3938	— .637	.0153
69.2166	— .629	.1692
.2195	— .642	.1733
.2225	— .649	.1774
.2301	— .567	.1881
.2330	— .514	.1922
.2359	— .528	.1963
.2432	— .487	.2064
.2459	— .426	.2103
.2487	— .394	.2142
.2576	— .232	.2268
.2603	— .218	.2305
.2631	— .143	.2344
.2705	— .013	.2448
.2734	+ .055	.2488
.2762	+ .108	.2529
.2833	+ .349	.2627
.2860	+ .465	.2665
.2888	+ .575	.2705
.2960	+ .937	.2805
.2988	+1.067	.2845
.3017	+1.143	.2885
.3085	+ .898	.2981
.3115	+ .749	.3023
.3145	+ .585	.3065
.3211	+ .339	.3157
.3242	+ .238	.3201
.3271	+ .154	.3242
.3348	— .069	.3349
.3377	— .134	.3390
.3406	— .196	.3431
.3478	— .337	.3532
.3508	— .378	.3574
.3536	— .398	.3614
.3612	— .493	.3720
.3640	— .510	.3760

J. D. hel. —2435600	Δm	phase
d	m	P
69.3671	— .531	.3802
.3769	— .586	.3940
.3798	— .589	.3981
.3827	— .596	.4021
.3896	— .611	.4119
.3924	— .609	.4158
.3952	— .609	.4197
72.3363	— .644	.5441
.3394	— .701	.5484
.3423	— .690	.5525
.3495	— .793	.5625
.3526	— .714	.5670
.3556	— .699	.5712
.3812	— .676	.6070
.3841	— .648	.6111
.3871	— .676	.6153
81.2342	— .666	.0220
.2370	— .677	.0258
.2398	— .658	.0299
.2478	— .700	.0410
.2507	— .687	.0451
.2534	— .697	.0489
.2614	— .664	.0601
.2644	— .652	.0643
.2672	— .666	.0683
.2769	— .666	.0818
.2798	— .664	.0859
.2827	— .650	.0900
.2958	— .660	.1084
.2987	— .660	.1124
.3018	— .654	.1167
.3093	— .652	.1273
.3126	— .650	.1318
.3157	— .646	.1362
.3235	— .612	.1472
.3265	— .618	.1514
.3294	— .585	.1555

J. D. hel. —2435600	Δm	phase
d	m	P
82.2145	— .615	.3967
.2173	— .639	.4006
.2201	— .652	.4045
.2281	— .650	.4157
.2310	— .690	.4198
.2339	— .682	.4239
.2420	— .592	.4352
.2475	— .626	.4429
83.2198	— .579	.8065
.2227	— .507	.8105
.2256	— .494	.8146
.2271	— .523	.8166
.2342	— .526	.8267
.2370	— .545	.8306
.2398	— .536	.8346
.2478	— .547	.8457
.2506	— .571	.8497
.2541	— .563	.8546
.2578	— .558	.8598
85.2134	— .687	.6021
.2163	— .673	.6062
.2193	— .685	.6105
.2274	— .646	.6218
.2303	— .651	.6259
.2333	— .644	.6301
.2407	— .637	.6405
.2435	— .625	.6444
.2464	— .623	.6484
.2271	— .690	.0237
.2310	— .700	.0292
.2338	— .682	.0331
.2408	— .690	.0429
.2435	— .680	.0467
.2463	— .687	.0507
88.2184	— .514	.8162
.2210	— .504	.8199
.2237	— .511	.8237

J. D. hel. —2435600	Δm	phase
d	m	P
88.2314	— .537	.8344
.2341	— .537	.8382
.2369	— .547	.8421
.2448	— .514	.8532
.2476	— .562	.8571
.2509	— .571	.8617
89.2169	— .408	.2164
.2196	— .406	.2202
.2222	— .350	.2239
.2295	— .217	.2340
.2321	— .144	.2378
.2348	— .081	.2415
.2422	+ .089	.2519
.2450	+ .174	.2558
.2478	+ .258	.2598
.2549	+ .534	.2697
.2606	+ .750	.2778
.2672	+1.139	.2870
.2701	+1.122	.2910
.2730	+1.043	.2951
.2803	+ .639	.3054
.2832	+ .529	.3094
.2861	+ .400	.3134
.2926	+ .167	.3226
.2955	+ .101	.3267
.2986	+ .032	.3310
.3059	— .140	.3413
.3089	— .223	.3454
.3118	— .269	.3495
91.2182	— .676	.0229
.2211	— .669	.0270
.2240	— .689	.0310
.2314	— .679	.0414
.2343	— .683	.0454
.2375	— .687	.0499
.2734	— .673	.1003
.2767	— .673	.1049
.2801	— .669	.1097

TABLE 2

J. D. hel. —2435600	Δm	phase
d	m	P
24.3108	— .314	.1960
.3298	— .297	.2227
.3370	— .133	.2327
.3408	+ .281	.2381
.3618	+ .554	.2674
.3659	+ .712	.2732
.3702	+ .876	.2794
.3814	+1.283	.2950
.3853	+ .843	.3005
.3893	+ .656	.3061
.3936	+ .525	.3122
.4021	+ .275	.3240
.4058	+ .196	.3292
.4169	— .026	.3448
.4206	— .055	.3499
.4250	— .131	.3562
.4404	— .280	.3777
.4435	— .309	.3821
.4468	— .326	.3868
.4600	— .391	.4052
26.3702	— .453	.0839
.3733	— .473	.0884
.3763	— .453	.0926
.3831	— .453	.1020
.3860	— .438	.1062
27.3232	— .423	.4204
.3261	— .429	.4245
.3289	— .433	.4284
.3363	— .428	.4387
.3394	— .416	.4432
.3424	— .424	.4474
.3705	— .433	.4867
.3736	— .422	.4911
.3772	— .412	.4961
28.3888	— .410	.9147

J. D. hel. —2435600	Δm	phase
d	m	P
28.3931	— .405	.9207
.3971	— .410	.9264
29.3153	— .226	.2140
.3236	— .086	.2256
.3268	— .068	.2301
.3299	— .007	.2344
.3366	+ .132	.2438
.3402	+ .193	.2489
.3435	+ .238	.2535
.3505	+ .430	.2633
.3537	+ .546	.2679
.3572	+ .665	.2727
.3606	+ .799	.2775
.3643	+ .927	.2827
.3688	+ .990	.2891
.3727	+ .977	.2945
.3833	+ .590	.3094
.3868	+ .454	.3143
.3903	+ .355	.3192
.3985	+ .162	.3307
.4025	+ .091	.3363
.4060	+ .008	.3412
.4154	— .112	.3545
.4184	— .140	.3585
30.4015	— .305	.7372
.4049	— .284	.7420
.4082	— .256	.7466
.4160	— .230	.7576
.4193	— .247	.7622
.4228	— .226	.7671
.4307	— .217	.7782
.4341	— .178	.7830
.4377	— .173	.7880
34.2790	— .351	.1748

J. D. hel. —2435600	Δm	phase
d	m	P
36.2553	— .413	.9462
.2588	— .413	.9512
.2623	— .437	.9562
.2703	— .433	.9673
.2738	— .461	.9721
.2771	— .440	.9769
.3244	— .445	.0431
.3276	— .458	.0477
.3310	— .451	.0524
.3389	— .451	.0635
.3421	— .458	.0679
.3453	— .435	.0724
.3529	— .431	.0831
.3562	— .438	.0878
.3593	— .438	.0921
.3724	— .428	.1105
.3755	— .428	.1149
.3789	— .431	.1195
37.3414	— .402	.4694
.3445	— .402	.4737
.3475	— .405	.4779
.3547	— .437	.4880
.3576	— .427	.4921
.3606	— .451	.4962
38.3562	— .400	.8924
.3593	— .425	.8968
.3623	— .452	.9010
.3707	— .443	.9128
.3739	— .520	.9172
.3771	— .431	.9217
39.2866	— .283	.1972
.2898	— .270	.2017
.2929	— .235	.2061
.3015	— .162	.2180
.3045	— .109	.2223

J. D. hel. —2435600	Δm	phase
d	m	P
39.3075	— .109	.2265
.3153	+ .028	.2374
.3183	+ .098	.2416
.3212	+ .166	.2457
.3350	+ .482	.2650
.3379	+ .638	.2692
.3408	+ .753	.2732
.3477	+ .971	.2828
.3506	+1.114	.2870
.3536	+1.054	.2912
.3606	+ .844	.3009
.3635	+ .648	.3050
.3665	+ .581	.3092
.3766	+ .314	.3234
.3802	+ .221	.3285
.3831	+ .148	.3324
.3900	+ .024	.3421
.3929	— .017	.3462
.3958	— .062	.3503
.4029	— .187	.3602
.4060	— .187	.3645
.4090	— .238	.3688
.4158	— .279	.3784
.4190	— .302	.3828
.4220	— .298	.3871
.4293	— .267	.3972
.4324	— .352	.4016
.4356	— .389	.4062
40.3254	— .405	.6539
.3286	— .423	.6584
.3316	— .420	.6626
.3389	— .388	.6728
.3420	— .384	.6772
.3453	— .380	.6819
.3527	— .377	.6922
.3556	— .395	.6963
.3588	— .366	.7008

TABLE 2 (*continued*)

J. D. hel. —2435600	Δ*m*	phase
d	m	P
40.3883	— .286	.7421
.3912	— .297	.7463
.3941	— .270	.7503
.4014	— .224	.7605
.4044	— .233	.7646
.4074	— .229	.7688
.4148	— .216	.7792
.4179	— .168	.7836
.4206	— .203	.7875
.4346	— .216	.8071
.4374	— .241	.8110
.4404	— .237	.8153
.4474	— .261	.8249
.4503	— .261	.8291
.4532	— .270	.8332
.4604	— .286	.8432
.4633	— .309	.8473
.4662	— .309	.8513
.4730	— .309	.8608
.4757	— .317	.8647
41.3038	— .458	.0259
.3070	— .441	.0304
.3100	— .420	.0347
.3178	— .434	.0456
.3211	— .434	.0502
.3241	— .430	.0545
.3312	— .454	.0644
.3342	— .441	.0686
.3373	— .451	.0729
.3445	— .448	.0830
.3476	— .437	.0873
.3506	— .441	.0916
.3614	— .437	.1067
.3643	— .437	.1108
.3672	— .410	.1149
.4014	— .399	.1629
.4044	— .402	.1671
.4073	— .410	.1711
.4142	— .385	.1808
.4173	— .363	.1852
.4203	— .355	.1894
42.2225	+ .468	.3143
.2258	+ .392	.3189
.2290	+ .328	.3235
.2363	+ .106	.3337
.2396	+ .075	.3382
.2426	+ .010	.3425
.2502	— .086	.3532
.2533	— .120	.3574
.2562	— .163	.3616
.2686	— .266	.3790
.2716	— .278	.3831
.2747	— .311	.3875
.2827	— .355	.3988
.2857	— .349	.4029
.2887	— .371	.4071
.2991	— .394	.4217
.3028	— .411	.4269
.3103	— .390	.4374
.3132	— .383	.4415
.3162	— .397	.4457
.3232	— .411	.4556
.3262	— .415	.4597
.3292	— .401	.4639
.3415	— .460	.4812
.3444	— .439	.4852
.3474	— .453	.4894
.3545	— .446	.4994
.3574	— .457	.5035
.3603	— .460	.5076
.4339	— .446	.6107
.4370	— .443	.6151
.4400	— .429	.6194
.4474	— .422	.6298
.4506	— .426	.6342
.4537	— .422	.6385
.4610	— .411	.6488
.4642	— .394	.6533
.4674	— .411	.6577

J. D. hel. —2435600	Δ*m*	phase
d	m	P
43.3051	— .262	.8261
.3081	— .275	.8366
.3112	— .262	.8410
.3182	— .318	.8508
.3211	— .322	.8549
.3241	— .322	.8592
.3305	— .341	.8681
.3334	— .352	.8721
.3364	— .345	.8763
44.3608	+ .588	.3129
.3638	+ .485	.3171
.3670	+ .355	.3216
.3745	+ .157	.3321
.3776	+ .157	.3365
56.2709	— .486	.0150
.2741	— .466	.0194
.2796	— .458	.0233
.2992	— .451	.0547
.3022	— .463	.0588
.3052	— .436	.0630
.3142	— .444	.0756
.3171	— .440	.0798
.3199	— .440	.0837
.4158	— .166	.2182
.4187	— .113	.2222
.4216	+ .068	.2262
57.2585	— .345	.3999
.2614	— .397	.4039
.2642	— .424	.4079
.2709	— .409	.4173
.2739	— .395	.4214
.2766	— .416	.4253
.2904	— .436	.4447
.2933	— .433	.4486
.2960	— .413	.4525
.3034	— .398	.4628
.3063	— .398	.4670
.3091	— .410	.4709
.3158	— .418	.4803
.3188	— .398	.4845
.3217	— .422	.4886
.3594	— .432	.5414
.3625	— .471	.5457
60.3127	— .412	.6829
.3155	— .376	.6869
.3183	— .371	.6907
.3486	— .304	.7332
.3517	— .334	.7376
.3554	— .325	.7428
.3621	— .215	.7522
.3650	— .247	.7563
64.2741	+ .050	.2382
.2772	+ .129	.2425
.2801	+ .197	.2465
.2872	+ .371	.2566
.2903	+ .462	.2609
.2933	+ .490	.2651
.3006	+ .791	.2753
.3036	+ .877	.2795
.3165	+ .945	.2976
.3197	+ .822	.3021
.3232	+ .650	.3071
.3308	+ .418	.3176
.3344	+ .377	.3228
.3376	+ .245	.3271
.3451	+ .109	.3377
.3482	+ .016	.3420
.3511	— .035	.3461
67.2225	— .267	.3728
.2258	— .288	.3774
.2290	— .342	.3819
.2390	— .378	.3959
.2425	— .393	.4008
.2455	— .418	.4050
.2541	— .415	.4171
.2571	— .404	.4213

J. D. hel. —2435600	Δ*m*	phase
d	m	P
67.2601	— .411	.4256
.2683	— .438	.4371
.2712	— .410	.4411
.2740	— .430	.4450
68.3724	— .430	.9854
.3755	— .457	.9897
.3784	— .452	.9937
.3861	— .404	.0045
.3893	— .404	.0090
.3922	— .421	.0131
69.2151	— .405	.1671
.2181	— .402	.1713
.2210	— .411	.1753
.2286	— .343	.1861
.2315	— .288	.1901
.2344	— .290	.1942
.2417	— .261	.2044
.2445	— .228	.2083
.2473	— .193	.2122
.2563	— .071	.2248
.2590	— .043	.2286
.2617	+ .009	.2325
.2690	+ .124	.2427
.2719	+ .171	.2468
.2748	+ .228	.2508
.2818	+ .454	.2606
.2846	+ .551	.2646
.2874	+ .571	.2686
.2945	+ .863	.2784
.2974	+ .929	.2825
.3002	+1.018	.2864
.3070	+1.029	.2960
.3100	+ .837	.3002
.3130	+ .749	.3043
.3196	+ .486	.3137
.3227	+ .412	.3180
.3256	+ .347	.3221
.3333	+ .140	.3328
.3361	+ .100	.3368
.3392	+ .047	.3411
.3463	— .073	.3511
.3492	— .108	.3552
.3522	— .147	.3593
.3598	— .234	.3699
.3627	— .272	.3741
.3655	— .290	.3781
.3754	— .350	.3919
.3784	— .362	.3961
.3813	— .370	.4001
.3883	— .354	.4099
.3910	— .389	.4138
.3938	— .374	.4177
72.3378	— .430	.5462
.3408	— .444	.5503
.3438	— .436	.5546
.3510	— .460	.5648
.3541	— .437	.5690
.3572	— .440	.5735
.3827	— .449	.6091
.3856	— .436	.6132
.3886	— .456	.6174
81.2328	— .419	.0199
.2356	— .419	.0239
.2384	— .436	.0279
.2464	— .432	.0390
.2494	— .432	.0432
.2521	— .436	.0471
.2600	— .432	.0582
.2628	— .436	.0621
.2658	— .419	.0663
.2783	— .444	.0838
.2812	— .423	.0879
.2842	— .414	.0921
.2922	— .432	.1033
.2973	— .436	.1104
.3002	— .397	.1145
.3078	— .423	.1252
.3109	— .401	.1295

J. D. hel. —2435600	Δ*m*	phase
d	m	P
81.3143	— .379	.1342
.3220	— .388	.1451
.3250	— .374	.1493
.3279	— .379	.1534
82.2130	— .372	.3946
.2159	— .362	.3987
.2186	— .406	.4025
.2266	— .425	.4136
.2295	— .429	.4177
.2325	— .434	.4219
.2406	— .357	.4332
.2433	— .367	.4371
.2461	— .362	.4410
83.2184	— .142	.8045
.2213	— .174	.8085
.2241	— .201	.8124
.2327	— .242	.8245
.2356	— .217	.8286
.2384	— .235	.8326
.2463	— .268	.8437
.2492	— .300	.8477
.2521	— .306	.8518
.2563	— .322	.8577
85.2114	— .409	.5994
.2147	— .387	.6040
.2178	— .400	.6083
.2258	— .387	.6196
.2288	— .367	.6238
.2319	— .409	.6280
.2392	— .402	.6383
.2421	— .412	.6424
.2449	— .402	.6463
86.2296	— .436	.0272
.2324	— .459	.0311
.2351	— .428	.0350
.2422	— .440	.0448
.2449	— .424	.0486
.2477	— .444	.0526
88.2172	— .254	.8145
.2197	— .236	.8180
.2223	— .232	.8217
.2300	— .281	.8324
.2327	— .254	.8363
.2355	— .281	.8402
.2435	— .312	.8514
.2461	— .282	.8551
.2494	— .312	.8597
89.2155	— .254	.2144
.2182	— .195	.2183
.2209	— .195	.2220
.2280	— .036	.2320
.2308	+ .040	.2359
.2334	+ .066	.2396
.2408	+ .193	.2500
.2436	+ .283	.2539
.2464	+ .381	.2578
.2533	+ .501	.2674
.2591	+ .730	.2757
.2658	+1.065	.2849
.2687	+1.094	.2890
.2716	+1.058	.2931
.2789	+ .782	.3034
.2817	+ .713	.3073
.2846	+ .547	.3114
.2913	+ .386	.3207
.2940	+ .264	.3246
.2972	+ .214	.3290
.3045	+ .058	.3393
.3075	+ .007	.3434
.3103	— .023	.3474
91.2168	— .452	.0210
.2196	— .452	.0249
.2225	— .458	.0290
.2299	— .470	.0394
.2328	— .449	.0434
.2359	— .461	.0478
.2718	— .393	.0980
.2750	— .404	.1026
.2783	— .410	.1072

Table 3

Mean light-curve (blue measurements)

Δm	mean phase	weight	rectified intensity $\mathfrak{J}''$	$(O-C)_m$ rectification	$(O-C)_m$ separate solution	$(O-C)_m$ combined solution	Δm	mean phase	weight	rectified intensity $\mathfrak{J}''$	$(O-C)_m$ rectification	$(O-C)_m$ separate solution	$(O-C)_m$ combined solution
+ .966	.0072	39	.2473		+.0023	+.0189	— .461	.4911	20	.9199		+.0216	—.0017
+ .741	.0131	39	.3036		—.0043	—.0007	— .498	.5100	21	.9516		—.0145	—.0367
+ .485	.0211	40	.3843		—.0034	—.0074	— .510	.5317	23	.9580		—.0025	—.0192
+ .303	.0282	41	.4538		+.0046	—.0029	— .525	.5436	20	.9670		—.0007	—.0138
+ .174	.0335	38	.5099		—.0014	—.0109	— .530	.5478	20	.9694		+.0007	—.0114
+ .088	.0380	38	.5509		+.0051	—.0035	— .531	.5542	20	.9676		+.0087	—.0015
— .055	.0448	37	.6269		—.0152	—.0236	— .556	.5665	50	.9835		+.0012	—.0057
— .117	.0492	41	.6625		—.0068	—.0144	— .592	.5896	51	1.0013		—.0052	—.0074
— .194	.0544	40	.7095		—.0079	—.0160	— .662	.6597	50	.9912	+.0096		
— .273	.0597	39	.7607		—.0172	—.0250	— .664	.7000	48	.9934	+.0072		
— .348	.0675	38	.8115		—.0033	—.0106	— .675	.7318	53	.9942	+.0063		
— .403	.0730	42	.8505		—.0034	—.0104	— .683	.7391	52	1.0009	—.0010		
— .483	.0825	50	.9100		—.0034	—.0107	— .686	.7500	53	1.0030	—.0032		
— .525	.0917	47	.9401		+.0109	+.0082	— .684	.7565	50	1.0016	—.0017		
— .559	.1009	50	.9633		+.0266	+.0201	— .684	.7623	50	1.0020	—.0022		
— .602	.1112	52	.9946	+.0059			— .672	.7731	50	.9926	+.0081		
— .617	.1170	52	1.0039	—.0042			— .664	.7865	52	.9886	+.0125		
— .617	.1286	49	.9951	+.0053			— .655	.7947	48	.9835	+.0182		
— .631	.1342	47	1.0038	—.0041			— .665	.8037	52	.9963	+.0040		
— .647	.1447	52	1.0111	—.0119			— .673	.8177	50	1.0110	—.0118		
— .647	.1539	52	1.0045	—.0049			— .661	.8283	48	1.0057	—.0062		
— .656	.1641	51	1.0060	—.0065			— .617	.8737	50	.9971	+.0032		
— .658	.1820	51	.9967	+.0036			— .493	.9111	50	.9149		+.0282	+.0209
— .680	.1968	54	1.0099	—.0106			— .375	.9290	41	.8306		+.0010	—.0063
— .685	.2102	51	1.0100	—.0107			— .282	.9360	38	.7656		+.0194	+.0120
— .691	.2863	50	1.0138	—.0149			— .246	.9401	39	.7419		+.0071	—.0005
— .658	.3286	47	1.0031	—.0034			— .152	.9490	41	.6835		—.0198	—.0278
— .634	.3476	45	.9937	+.0068			— .086	.9520	39	.6439		+.0002	—.0082
— .620	.3662	48	.9943	+.0062			+ .043	.9600	40	.5738		—.0094	—.0179
— .627	.3956	48	1.0236		—.0252	—.0257	+ .186	.9673	38	.5047		—.0164	—.0250
— .565	.4480	22	.9997		—.0287	—.0394	+ .369	.9743	40	.4271		—.0026	—.0089
— .548	.4558	21	.9878		—.0237	—.0362	+ .555	.9800	39	.3604		+.0239	+.0181
— .513	.4659	21	.9598		—.0026	—.0187	+ .772	.9874	38	.2953		—.0067	—.0023
— .492	.4768	20	.9442		+.0046	—.0151	+1.006	.9937	39	.2383		+.0005	+.0141
							+1.102	.9992	39	.2179		—.0005	+.0214

Table 4

Mean light-curve (yellow measurements)

Δm	mean phase	weight	rectified intensity $\mathfrak{J}''$	$(O-C)_m$ rectification	$(O-C)_m$ separate solution	$(O-C)_m$ combined solution	Δm	mean phase	weight	rectified intensity $\mathfrak{J}''$	$(O-C)_m$ rectification	$(O-C)_m$ separate solution	$(O-C)_m$ combined solution
+1.018	.0040	21	.2896		+.0007	—.0064	— .266	.5469	19	.9074		+.0137	+.0299
+ .808	.0125	20	.3487		+.0032	+.0056	— .302	.5585	19	.9347		+.0067	+.0202
+ .621	.0185	19	.4120		—.0234	—.0177	— .359	.5856	50	.9748		+.0063	+.0134
+ .461	.0254	18	.4757		—.0258	—.0159	— .411	.6370	52	.9988	+.0013		
+ .380	.0302	21	.5116		—.0111	+.0026	— .436	.6721	48	1.0070	—.0076		
+ .342	.0346	20	.5289		+.0320	+.0490	— .440	.7096	51	1.0001	—.0001		
+ .163	.0420	20	.6209		—.0252	—.0056	— .450	.7344	50	1.0060	—.0065		
+ .099	.0469	22	.6569		—.0181	+.0039	— .440	.7458	52	.9964	+.0039		
+ .026	.0520	23	.7006		—.0229	+.0002	— .442	.7566	48	.9981	+.0021		
— .041	.0584	21	.7429		—.0135	+.0109	— .441	.7639	51	.9981	+.0021		
— .105	.0656	19	.7861		—.0030	+.0227	— .446	.7733	52	1.0041	—.0044		
— .166	.0714	21	.8286		—.0090	+.0166	— .446	.7817	53	1.0056	—.0060		
— .257	.0827	20	.8961		—.0112	+.0131	— .442	.7932	53	1.0044	—.0048		
— .291	.0902	22	.9210		+.0032	+.0262	— .439	.7994	51	1.0035	—.0038		
— .300	.1002	52	.9242		+.0465	+.0658	— .437	.8089	45	1.0052	—.0056		
— .385	.1174	51	.9909	+.0100			— .428	.8204	47	1.0007	—.0008		
— .412	.1315	50	1.0085	—.0092			— .416	.8315	52	.9945	+.0060		
— .416	.1428	50	1.0063	—.0068			— .396	.8714	53	.9951	+.0053		
— .413	.1551	52	.9977	+.0025			— .365	.8938	50	.9786		+.0026	+.0172
— .406	.1756	49	.9820	+.0199			— .268	.9110	22	.9028		+.0164	+.0398
— .435	.1961	47	1.0014	—.0015			— .206	.9233	18	.8578		—.0082	+.0171
— .434	.2075	52	.9967	+.0036			— .150	.9306	22	.8175		—.0146	+.0106
— .433	.2781	50	.9914	+.0094			— .081	.9354	20	.7688		+.0080	+.0340
— .427	.3287	51	.9994	+.0007			— .041	.9406	20	.7427		—.0068	+.0180
— .412	.3580	51	.9981	+.0021			+ .072	.9499	20	.6728		—.0075	+.0151
— .382	.3973	21	.9886		+.0069	+.0104	+ .160	.9556	20	.6220		+.0012	+.0226
— .290	.4519	21	.9271		—.0081	+.0078	+ .274	.9635	19	.5621		—.0095	+.0075
— .240	.4690	19	.8888		—.0032	+.0167	+ .483	.9732	20	.4663		+.0165	+.0274
— .206	.4870	21	.8637		—.0142	+.0097	+ .568	.9786	19	.4325		—.0182	—.0115
— .201	.5127	21	.8594		—.0088	+.0154	+ .812	.9871	21	.3473		+.0076	+.0100
— .247	.5341	19	.8945		—.0015	+.0174	+1.003	.9949	22	.2932		—.0086	—.0100

Computation of the elements of the system.

The first author is responsible for this section. In the first part of this section the blue and yellow light-curves were treated separately and independently of each other. In the second part both light-curves were combined to give a single solution postulating that the geometrical elements should be the same.

An analysis of the light-curves between the minima (i.e. $-1.0 < \cos 2\theta < 0$) gives the following representations:

$$\text{blue:}\quad {}^{l_v}/{}_{l_c} = \underset{\pm .0062}{1.7655} + \underset{\pm .0068}{.0096} \cos\theta - \underset{\pm .0086 \text{ m.e.}}{.1096} \cos 2\theta \qquad (1)$$

$$\text{yellow:}\quad {}^{l_v}/{}_{l_c} = \underset{\pm .0045}{1.4491} - \underset{\pm .0048}{.0063} \cos\theta - \underset{\pm .0062 \text{ m.e.}}{.0562} \cos 2\theta \qquad (2)$$

It appeared from these formulae that the coefficient due to reflection is negligible and that it even has the wrong sign in the first formula. In view of this a new representation formula was made for the blue light-curve without the cos θ-term. This gave:

$$\text{blue:}\quad {}^{l_v}/{}_{l_c} = \underset{\pm .0061}{1.7685} - \underset{\pm .0087 \text{ m.e.}}{.1069} \cos 2\theta \qquad (3)$$

The mean deviation for an observation of unit weight from the representations (3) and (2) are $\pm^{m}.058$ and $\pm^{m}.047$ for blue and yellow respectively.

The ellipticity coefficients were computed with RUSSELL and MERRILL's formulae [2]). Taking for a preliminary evaluation $x = .6$ and .8 for yellow and blue respectively, we arrived at:

$$z^b = +.0712 \pm .0107 \text{ and } z^y = +.0594 \pm .0063$$

Rectification was then made by RUSSELL and MERRILL's method using the following formulae:

$$\text{blue:} \begin{cases} \mathfrak{I}'' = \dfrac{{}^{l_v}/{}_{l_c}}{1.7685 - .1069 \cos\theta} \\ \sin^2\Theta = \dfrac{\sin^2\theta}{1 - .0712 \cos^2\theta} \end{cases} \qquad (4)$$

$$\text{yellow:} \begin{cases} \mathfrak{I}'' = \dfrac{{}^{l_v}/{}_{l_c} + .0054 + .0063 \cos\theta + .0018 \cos 2\theta}{1.4545 - .0544 \cos 2\theta} \\ \sin^2\Theta = \dfrac{\sin^2\theta}{1 - .0594 \cos^2\theta} \end{cases} \qquad (5)$$

In the latter formulae the assumption was made that the secondary component was an F8-type star, which follows from the difference in colour index of the eclipsing system at both minima, when the primary component is assumed to be an ordinary B8 star.

The rectified intensities $\mathfrak{I}''$ are given in column 4 of Tables 3 and 4, while column 5 of both tables gives the magnitude deviations from formulae (3) and (2) respectively.

The geometrical and physical elements of the eclipsing system were computed with the well-known formula (using RUSSELL and MERRILL's notations):

$$\frac{\cos^2 i_r}{a_g^2} + \frac{\sin^2 i_r}{a_g^2} \sin^2\theta = (1 + kp)^2 \qquad (6)$$

The normal points are weighted thus, that the errors are the same in magnitude scale. The final elements were derived by IRWIN's method of differential corrections [1]). Apart from RUSSELL and MERRILL's tables [3]) intensive use has also been made of TSESEVICH's tables [4]).

As any preliminary estimate of the elements by nomographic methods [5]) failed on account of too small a value of χ (0.8), much attention was paid to the intermediary stage of the computations. During this stage large difficulties arise with respect to the darkening coefficient of the primary component, (i.e. the component eclipsed at primary minimum). All tentative solutions point to a uniform intensity distribution ($x = 0$) for this component. Even then large systematic errors cannot be removed. The secondary minimum is too shallow and not well enough observed to give a reliable determination of the limb darkening of the secondary component. The final solutions were made with the assumption of a uniform intensity distribution for the primary component and a value for the limb darkening coefficient $x = .8$

1) *Ap. J.* **106**, 380, 1947.

2) *Princeton Contribution* No 26, 1952.

3) *Princeton Contribution* No. 23, 1950.

4) *Bull. Astron. U.S.S.R.* **45**, 1938 and **50**, 1940.

5) RUSSELL and MERRILL, *Princeton Contribution* No. 24, 1953.

and $x = .6$ for the secondary component for blue and yellow respectively. The latter values were taken in concordance with MÜNCH and CHANDRASEKHAR'S tabulated values for an F8-type star [1]).

It soon became clear during the earlier stages of the computations that the primary minimum should be a transit, which means that the brighter (and probably the heavier) component is also the larger.

In Table 5 the final elements of the solutions from the independently treated light-curves are given. The errors given here result from the final least-squares solutions and therefore are only a measure of the determinability of the solutions. The errors between parentheses are the errors of the elements in question if these elements were also included in the least-squares solution. The residuals $(O - C)_m$, i.e. the observed normal magnitudes minus the theoretically derived magnitudes based on these solutions, are given in column 6 of Tables 3 and 4.

From Table 5 it can be seen that the two light-curves give only concordant values for the ratio of the radii k and the apparent inclination i_r. The other two geometric elements a_g and a_s differ considerably for the blue and yellow curves. As there is no reason at all that this difference should be real, a combined solution is made from both light-curves, postulating that a_g, a_s and i_r should be the same. In this solution we have also inserted theoretical values for z^b and z^y:

$$(z^b)_c = .0577$$
$$(z^y)_c = .0691$$

These values will be discussed in the next section. The adjustment of z^b and z^y was made in the final stage by the differential method. The differential coefficients were computed in the same way as those for the other quantities in IRWIN'S method [2]). We have here

$$\frac{\partial(O-C)_{\mathfrak{J}''}}{\partial z} = -L\frac{\partial f}{\partial z} = -L\tau\frac{\partial \alpha}{\partial z} = -L\tau\frac{\partial \alpha}{\partial p}\frac{\partial p}{\partial z}$$

Differentiating (6) to z we get, remembering that $\sin^2\Theta = \dfrac{\sin^2\theta}{1 - z\cos^2\theta}$:

$$\frac{\partial p}{\partial z} = \frac{\sin^2 i_r \sin^4\Theta \operatorname{ctg}^2\theta}{2a_g a_s(1+kp)}$$

Thus
$$\frac{\partial(O-C)_{\mathfrak{J}''}}{\partial z} = -L\tau\frac{\partial\alpha}{\partial p}\frac{\sin^2 i_r \sin^4\Theta \operatorname{ctg}^2\theta}{2a_g a_s(1+kp)}$$

According to IRWIN [3]) we also have:

$$\frac{\partial(O-C)_{\mathfrak{J}''}}{\partial(\cos^2 i_r)} = -L\tau\frac{\partial\alpha}{\partial p}\frac{\cos^2\Theta}{2a_g a_s(1+kp)}$$

We can thus write:

$$\frac{\partial(O-C)_{\mathfrak{J}''}}{\partial z} = \frac{\sin^2 i_r}{1-z}\,.\,\sin^2\Theta\,.\,\frac{\partial(O-C)_{\mathfrak{J}''}}{\partial(\cos^2 i_r)} \quad (7)$$

TABLE 5
Geometrical and physical elements of RR Trianguli Australis

element:	separate solutions		combined solution	
	blue	yellow	blue	yellow
a_g	.3361 ± .0015	.3548 ± .0025	.3416 ± .0016	
r_g	.3299	.3494	.3360	
a_s	.3072 ± .0018	.3258 ± .0027	.3125 ± .0018	
r_s	.3016	.3209	.3074	
k	.9140	.9183	.9148	
$\cos^2 i_r$	.00077 ± .00024	.00026 ± .00059	.00081 ± .00028	
$\cos^2 j$	.00072	.00024	.00076	
$\cos^2 i$	.00069	.00023	.00072	
p_0	− 1.0037	− 1.0396	− 1.0020	
L_g	.9363 ± .0066	.8422 ± .0079	.9160 ± .0069	.8609 ± .0061
L_s	.0637	.1578	.0840	.1391
x_g	.00 [± .14]	.00 [± .19]	.20 [± .13]	.00 [± .17]
x_s	.8 [± 2.8]	.6 [± 1.5]	.8 [± 2.8]	.6 [± 1.5]
J_s/J_g	.0814	.2222	.1096	.1931
z	.0712 ± .0107	.0594 ± .0063	.0577 [± .023]	.0691 [± .023]
$1 - \mathfrak{J}''_{pr.}$	.7822	.7102	.7778	.7205
$1 - \mathfrak{J}''_{sec.}$	.0637	.1578	.0840	.1391
mean deviation observation of unit weight	± $.079^m$	± $.086^m$	± $.112^m$	

[1]) *Harvard Circular* No. 453, 1949.
[2]) *Ap. J.* **106**, 380, 1947.
[3]) *L.c.*

The last formula is valid for a transit as well as for an occultation.

First a combined solution was tried in which z^b and z^y appeared as free variables. Although the systematic differences vanished for the greater part, this solution gave too absurd values ($z \approx .5$) for both parameters. So in the final combined solution the theoretical values for z^b and z^y mentioned above were inserted. The magnitude differences $(O - C)_m$ for this solution, which is given in column 4 of Table 5, showed a large systematic trend, as can be seen from column 7 of Tables 3 and 4.

Discussion

a. Ellipticity:

The ellipticity coefficients z^b and z^y which were derived from the rectification constants in formulae (2) and (3) can only be interpreted as photometric means over both components. With regard to the elements derived in Table 5, the true values of z_g and z_s (which must be the same for both light-curves) may differ considerably from each other. In view of this the values of a_g and a_s in Table 5, for the derivation of which only equal ellipticity for both components was allowed, lose their true meaning. If however we define r by:

$$r^2 = ab = a^2 \sqrt{1 - z \operatorname{cosec}^2 j} \qquad (8)$$

we may consider r as a more representative measure for the dimension of the component. We have also given the values of r for the different solutions in Table 5.

In order to compute theoretical values for z_g and z_s and to compare these with the observations, we had to adopt a model of the eclipsing system. Although no spectroscopic observations are available except for a classification of the spectral type of the main component, there is still a possibility to estimate the mass ratio $\frac{m_s}{m_g}$ of the components. On the one hand we have the indication from the colour difference, which was mentioned before, and the ratio of the surface brightness, that the secondary component is a late F-type star, on the other hand we have the rather large values of k, r_g and r_s from Table 5. If the primary is an ordinary B8 star, the secondary must be a subgiant, and we may reasonably assume that we are dealing with a semi-detached system. If this is so, the secondary component fills completely its lobe of the inner contact surface[1]), and its dimension will be directly correlated with the mass ratio $\frac{m_s}{m_g}$. It should be remarked that in any case this assumption forms a limiting case and that by adopting it we get a lower limit of $\frac{m_s}{m_g}$. As we will see later, the assumption is not in contradiction with the observed ellipticity coefficients. In Table 6 we have given the dimensions of the smaller component of a semi-detached system as a function of the mass ratio $\frac{m_s}{m_g}$. The values were taken from KUIPER and Miss JOHNSON's article[2]), where we have set β_s for b_1 and γ_s for c_1, and where we have introduced

$$\alpha_s = \tfrac{6}{7}\, a_1' + \tfrac{1}{7}\, a_1'' . \qquad (9)$$

TABLE 6

Dimensions of the secondary components in semi-detached systems.

m_s/m_g	α_s	β_s	γ_s	ρ_s
$^2/_3$	.3823	.3376	.3227	.3593
$^1/_2$	.3574	.3129	.2998	.3344
$^2/_5$	.3386	.2945	.2825	.3158
$^1/_3$	.3237	.2801	.2689	.3011
$^1/_4$	.3010	.2583	.2482	.2788

Expression (9) seemed to be a convenient approximation of the apparent longer equatorial axis of the component, and is derived by postulating $\pi\alpha_s\gamma_s$ to be equal to the area of the projection on the x-z plane. We have approximated this area by numerical integration.

Defining $\rho_s = \sqrt{\alpha_s \beta_s}$ and equating $\rho_s = r_s$, we find from Table 5 for the blue and yellow solutions respectively:

$$\left(\frac{m_s}{m_g}\right)^b = .34 \text{ and } \left(\frac{m_s}{m_g}\right)^y = .43$$

In the following we have taken as a convenient mean value

$$\frac{m_s}{m_g} = .40$$

With this value of the mass ratio we proceed with computing the dimensions of the primary component. For this aim we have evaluated for several equipotential surfaces the corresponding values of α_g, β_g, γ_g and ρ_g, all of them similarly defined as for the secondary component. In Table 7 these values are given as a function of the (negative) potential Ω, which characterizes the equipotential surface. Again equating $\rho_g = r_g = .3360$, which is a weighted mean of the blue and the yellow values, we find the surface potential of the primary component $\Omega_g = -2.52$.

[1]) KUIPER, *Ap. J.* **93**, 133, 1941; KOPAL, *Jodrell Bank Ann.* **1**, 37, 1945.

[2]) *Ap. J.* **123**, 90, 1956.

TABLE 7

Dimensions of some equipotential surfaces of the primary lobe of an eclipsing system with a mass ratio $m_s/m_g = .40$

Ω	α_g	β_g	γ_g	ρ_g
− 2.30	.3833	.3716	.3589	.3774
− 2.40	.3615	.3523	.3420	.3569
− 2.50	.3425	.3351	.3266	.3388
− 2.60	.3255	.3195	.3124	.3225

We are now able to compute the theoretical values of the ellipticity coefficients; we have:

$$\zeta_i = \left(1 - \frac{\beta_i^2}{\alpha_i^2}\right) \sin^2 j \; . \; . \; . \; . \; . \quad (i = g, s) \qquad (10)$$

and
$$\begin{cases} \zeta^b = L_g^b \zeta_g + L_s^b \zeta_s \\ \zeta^y = L_g^y \zeta_g + L_s^y \zeta_s \end{cases} \qquad (11)$$

Doing this, we find: $\zeta^b = .0577$ and $\zeta^y = .0691$, values which we have used above. Comparison with the observed values z^b and z^y shows that they are not in contradiction with the latter, when the errors of these are taken into account.

It should be remarked that, owing to the large values of L_g^b and L_g^y, ζ^b and ζ^y are rather insensible to a variation in the mass ratio $\frac{m_s}{m_g}$, so we can safely insert these values in our final combined solution.

b. Reflection effect:

The reflection coefficient $\frac{A_1}{A_0}$ in formulae (1) and (2) can also be compared with a theoretical value. The theoretical expression for this coefficient is given by RUSSELL and MERRILL [1]) and may be written as:

$$\left(\frac{A_1}{A_0}\right)_c = -.40\left(L_g t_s^2 \frac{E_s}{E_g} - L_s t_g^2 \frac{E_g}{E_s}\right) \sin i. \qquad (12)$$

Taking $t^2 = \beta\gamma$ and inserting the elements found in our final combined solution we find, with the assumption of the earlier mentioned spectral types:

$$\left(\frac{A_1}{A_0}\right)_c^b = -.025 \text{ and } \left(\frac{A_1}{A_0}\right)_c^y = -.033 ,$$

which differ considerably from the observed values + .0054 and − .0043 respectively. No explanation can be found for this discrepancy.

[1]) *Princeton Contr.* No. 26, 1952.

c. General discussion:

Apart from the unexpectedly small observed value of the reflection effect, there remain two other unsatisfactory results from the solutions. The first is the limb darkening coefficient of the brighter component, which turned out to be extremely low for a B8 star. The second is the large difference between the blue and the yellow solutions, which cannot be removed unless large systematic deviations from the observed magnitudes should be accepted, as is shown in column 7 of Tables 3 and 4. As to how far the three effects are correlated with each other remains an unanswered guess. One could think that surrounding gas clouds may have distorted the light-curves, so that treated in the orthodox manner they give false results. However, the light-curves showed no asymmetric terms, which must be expected if surrounding gas clouds were present.

An other weak point in the computations is the assumption of equal ellipticity of the components. If the system really is a semi-detached system as we assumed above, this condition is far from fulfilled, as can be seen from Tables 6 and 7 and formula (10). Although KOPAL [2]) has given a precept how to act in such cases, the indicated way is very laborious, and the author regrets not to find the necessary time for it. So we have to conclude with this rather unsatisfactory picture of the system.

Regarding the mass ratio, it should be remarked that only spectroscopic observations can give more information about it. The author feels that, owing to the large difference in surface brightness of the components, it will be very hard to get a secondary spectrum on the plates, even at the moment of primary minimum where the contribution of the brighter component will be about 16% of the total light. For further discussion, however, it will be of importance to know whether the assumed spectral type of the secondary component (F8) and the mass ratio (which according to Table 6 and r_s for the combined solution should be equal to $\frac{m_s}{m_g} = .36$) are concordant with any spectroscopic observations.

[2]) *Harvard Monographs* **8**, 1950.