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COMMUNICATIONS FROM THE OBSERVATORY AT LEIDEN

The period and the photometric orbit of RW Tauri, by *L. Binnendijk*.

The observations.

Observations of the principal minimum of the eclipsing variable RW Tauri have been made at Leiden with the 32 cm refractor during the years 1928—1940 by Dr. H. VAN GENT, Dr. P. TH. OOSTERHOFF, Dr. A. J. WESSELINK and by the writer.

Eastman 40 plates of size 16 cm × 16 cm were used throughout. The spectral sensitivity of this brand has been investigated by WESSELINK [1]) and the effective wavelength of the present observations may be taken equal to μ·423.

These plates were intended primarily for the determination of accurate epochs of minimum, later also for obtaining a light curve of the whole minimum. As a consequence of the large photographic range (4^{m}·3) the exposure time was varied from 5 minutes at minimum to 40 seconds at maximum.

In addition to these plates, which were all taken without grating, I have taken several plates with grating for the purpose of obtaining an accurate scale of magnitudes. Also plates were taken with exposures with grating and without grating on the same plate, both having the same exposure time.

The measurements and their reduction.

The plates 1558 to 1860 and 2836 have been measured in the Schilt microphotometer by Mr. C. J. KOOREMAN, the others by the writer. Table 1 gives information concerning the variable and the comparison stars. The galvanometer readings were then converted into provisional magnitudes by means of a table similar to that given in *B.A.N.* No. 318. The magnitudes of the comparison stars were derived from the plates taken with grating. The zero point was obtained from plates containing both the region of RW Tauri and the Pleiades, of which the magnitudes given by HERTZSPRUNG [2]) were used. The definitive magnitudes of the mean of all exposures of the comparison stars are given in column 5 of Table 1. Between brackets the magnitudes derived from the Pleiades plates are given. The two scales agree satisfactorily. For each exposure the brightness of the variable was then determined in a graphical way by plotting the provisional magnitudes of the galvanometer readings against the magnitudes of the comparison stars just mentioned.

The results for each exposure are given in Table 2. The abbreviations used are v. G. = VAN GENT, Oo. = OOSTERHOFF, W. = WESSELINK, B. = BINNENDIJK.

The epochs of minimum and the period.

For the five minima for which both descending and ascending branches have been observed the

TABLE 1.

Star	B. D.	α (1855)	δ (1855)	m_{pg}	
RW Tauri	+ 27° 623	3h 55m 1s·2	+ 27° 45'·6	{ 8m·00 / 12·27	
a	27 618	3 53 21·6	27 43·8	8·30	[8m·34]
b	27 629	3 56 34·7	27 29·7	8·72	[8·78]
c	28 610	3 54 3·5	28 3·0	9·20	[9·18]
d	27 626	3 55 57·6	27 32·7	10·45	[10·42]
e	27 619	3 53 54·6	27 47·5	10·52	[10·41]
f		3 54 36·3	27 43·3	11·85	[11·78]
g		3 54 7·3	27 45·0	12·56	[12·58]

1) *B.A.N.* No. 294.
2) *D.K.D. Vidensk. Selsk. Skr.*, Afd. 8, R, IV, 4, Table 14; *A.N.* **199**, 247.

TABLE 2.

J. D. 242....	Phase	m_{pg}
Plate 1354 (taken by v. G.)		
d	P	m
5261·3356	·2112	12·15
·3391	·2125	12·13
·3425	·2137	12·11
·3460	·2150	12·17
·3494	·2162	12·24
·3529	·2175	12·14
·3564	·2187	12·10
·3598	·2200	11·74
·3633	·2212	11·34
·3668	·2225	11·00
·3702	·2237	10·68
·3737	·2250	10·47
·3772	·2262	10·27
·3806	·2275	10·02
·3841	·2287	9·85
·3875	·2300	9·64
·3910	·2312	9·59
·3945	·2325	9·56
·3979	·2337	9·40
·4014	·2350	9·26
·4049	·2362	9·21
·4083	·2375	9·06
Plate 1558 (taken by Oo.)		
d	P	m
5535·3980	·1930	10·54
·4014	·1943	10·76
·4049	·1955	11·02
·4083	·1968	11·39
·4118	·1980	11·81
·4153	·1993	12·22
·4187	·2005	12·20
·4223	·2018	12·17
·4257	·2030	12·14
·4291	·2043	12·23
·4326	·2055	12·34
·4360	·2068	12·24
·4395	·2080	12·31
·4430	·2093	12·18
·4464	·2105	12·18
·4499	·2118	12·20
·4534	·2130	12·16
·4568	·2143	12·23
·4603	·2155	12·14
·4637	·2168	12·20
·4672	·2180	12·23
·4707	·2193	12·12
·4741	·2205	11·87
·4776	·2218	11·46
·4811	·2230	11·06
·4845	·2243	10·81
·4880	·2255	10·53
·4914	·2268	10·26
·4949	·2280	10·10
·4984	·2293	9·96
·5018	·2305	9·80
·5053	·2318	9·68
·5088	·2330	9·56
Plate 1760 (taken by Oo.)		
d	P	m
5856·5706	·1894	9·96
·5741	·1906	10·12
·5775	·1919	10·27
·5810	·1931	10·53
·5845	·1944	10·81
·5879	·1956	11·06
·5914	·1969	11·44
·5949	·1981	11·90
Plate 1808 (taken by Oo.)		
d	P	m
5881·4838	·1872	9·68
·4873	·1884	9·78
·4908	·1897	9·92
·4942	·1909	10·09
·4977	·1922	10·24
·5011	·1934	10·50
·5046	·1947	10·71
·5081	·1959	11·06
·5115	·1972	11·42
·5150	·1984	11·79
·5185	·1997	12·21
·5219	·2009	12·29
·5254	·2022	12·28
·5288	·2034	12·32
·5323	·2047	12·36
·5358	·2059	12·42
·5392	·2072	12·37
·5427	·2084	12·42
Plate 1809 (taken by Oo.)		
d	P	m
5881·5496	·2109	12·32
·5531	·2122	12·42
·5566	·2134	12·42
·5600	·2147	12·37
·5635	·2159	12·37
·5669	·2172	12·42
·5704	·2184	12·31
·5739	·2197	12·23
·5773	·2209	11·77
·5808	·2222	11·38
·5843	·2234	11·00
·5877	·2247	10·71
·5912	·2259	10·44
·5946	·2272	10·21
·5981	·2284	10·02
·6016	·2297	9·84
·6050	·2309	9·73
·6085	·2322	9·62
·6120	·2334	9·47
·6154	·2347	9·40
Plate 1822 (taken by Oo.)		
d	P	m
5892·5551	·1857	9·62
·5585	·1870	9·73
·5620	·1882	9·80
·5654	·1895	9·94
·5689	·1907	10·12
·5724	·1920	10·29
·5758	·1932	10·50
·5793	·1945	10·68
·5828	·1957	11·00
Plate 1846 (taken by Oo.)		
d	P	m
5964·5710	·1954	10·79
·5744	·1966	11·15
·5779	·1979	11·52
·5814	·1991	11·90
·5848	·2004	12·00
Plate 1860 (taken by Oo.)		
d	P	m
5967·3203	·1883	9·71
·3237	·1896	9·86
·3272	·1908	9·97
·3307	·1921	10·17
·3341	·1933	10·39
Plate 2328 (taken by W.)		
d	P	m
6648·4698	·1958	10·95
·4733	·1970	11·15
·4767	·1983	11·60
·4802	·1995	12·03
·4836	·2008	12·23
·4871	·2020	12·29
Plate 2329 (taken by W.)		
d	P	m
6648·4940	·2045	12·21
·4975	·2058	12·30
·5010	·2071	12·30
·5044	·2083	12·18
·5079	·2096	12·18
·5113	·2108	12·19
Plate 2330 (taken by W.)		
d	P	m
6648·5217	·2146	12·16
·5252	·2158	12·11
·5287	·2171	12·29
·5321	·2183	12·15
·5356	·2196	12·12
·5390	·2208	11·96
Plate 2331 (taken by W.)		
d	P	m
6648·5460	·2233	11·04
·5494	·2246	10·67
·5529	·2258	10·53
·5564	·2271	10·28
·5598	·2283	10·11
·5633	·2296	9·90
Plate 2836 (taken by W.)		
d	P	m
7415·4210	·1919	10·23
·4228	·1925	10·43
·4245	·1931	10·55
·4262	·1938	10·68
·4280	·1944	10·75
·4297	·1950	10·86
·4332	·1963	11·15
·4349	·1969	11·39
·4366	·1975	11·50
·4383	·1981	11·72
·4401	·1988	11·96
·4418	·1994	12·03
·4435	·2000	12·09
·4453	·2006	12·19
·4470	·2013	12·23
·4487	·2019	12·17
·4505	·2025	12·22
·4522	·2031	12·25
·4539	·2038	12·23
·4557	·2044	12·27
·4574	·2050	12·25
·4591	·2056	12·29
·4609	·2063	12·31
·4626	·2069	12·24
·4643	·2075	12·26
·4660	·2081	12·28
·4678	·2088	12·22
·4695	·2094	12·34
·4712	·2100	12·31
·4730	·2106	12·31
·4747	·2113	12·36
·4764	·2119	12·38
·4782	·2125	12·35
Plate 2836 (*continued*)		
d	P	m
7415·4799	·2131	12·33
·4816	·2138	12·30
·4834	·2144	12·34
·4851	·2150	12·27
·4868	·2156	12·31
·4886	·2163	12·28
·4903	·2169	12·35
·4920	·2175	12·25
·4938	·2181	12·31
·4955	·2188	12·30
·4972	·2194	12·31
·4989	·2200	12·16
·5007	·2206	11·93
·5024	·2213	11·72
·5041	·2219	11·51
·5059	·2225	11·30
·5076	·2231	11·08
·5093	·2238	10·97
·5111	·2244	10·81
·5128	·2250	10·71
·5145	·2256	10·51
·5163	·2263	10·36
·5180	·2269	10·33
·5197	·2275	10·16
·5215	·2281	10·04
·5232	·2288	10·00
Plate 5106 (taken by B.)		
d	P	m
9558·5407	·2121	12·25
·5445	·2134	12·19
·5483	·2148	12·23
·5521	·2162	12·21
·5559	·2176	12·23
·5597	·2189	12·13
·5635	·2203	12·04
·5673	·2217	11·48
·5711	·2231	11·09
·5749	·2244	10·76
·5787	·2258	10·45
·5826	·2272	10·19
Plate 5167 (taken by B.)		
d	P	m
9630·4328	·1770	8·89
·4335	·1773	8·95
·4342	·1775	8·93
·4349	·1778	9·00
·4356	·1780	8·94
·4363	·1783	8·99
·4370	·1785	8·97
·4377	·1788	9·01
·4383	·1790	9·02
·4390	·1793	9·02
·4397	·1795	9·01
·4404	·1798	9·15
·4411	·1800	9·07
·4418	·1803	9·15
·4425	·1805	9·13
·4432	·1808	9·19
·4439	·1810	9·16
·4446	·1813	9·13
·4453	·1815	9·16
·4460	·1818	9·21
·4467	·1820	9·25
·4474	·1823	9·27
·4480	·1825	9·37
·4487	·1828	9·31
·4494	·1830	9·27
·4501	·1833	9·28

TABLE 2 (*continued*).

Plate 5187 (taken by B.)

J. D. 242....	Phase	m_{pg}
d	P	m
9633·2367	·1897	9·93
·2377	·1900	10·01
·2387	·1904	10·02
·2398	·1908	10·03
·2408	·1912	10·13
·2424	·1917	10·19
·2445	·1925	10·31
·2465	·1932	10·50
·2486	·1940	10·59
·2507	·1947	10·71
·2528	·1955	10·95
·2548	·1962	11·18
·2578	·1973	11·47
·2616	·1987	12·04
·2654	·2000	12·31
·2692	·2014	12·31
·2734	·2029	12·26
·2775	·2044	12·37
·2813	·2058	12·31
·2851	·2072	12·29
·2890	·2085	12·38
·2928	·2099	12·40
·2966	·2113	12·33
·3004	·2127	12·35

Plate 5188 (taken by B.)

J. D. 242....	Phase	m_{pg}
d	P	m
9633·3177	·2189	12·24
·3215	·2203	12·06
·3253	·2217	11·48
·3291	·2231	11·10
·3329	·2244	10·60
·3367	·2258	10·34
·3397	·2269	10·23
·3418	·2276	10·09
·3438	·2284	10·03
·3459	·2291	9·94
·3480	·2299	9·86
·3501	·2306	9·80
·3522	·2314	9·72
·3537	·2319	9·65
·3548	·2323	9·58
·3558	·2327	9·53
·3568	·2331	9·51
·3579	·2334	9·51
·3589	·2338	9·50
·3599	·2342	9·49
·3610	·2346	9·42
·3620	·2349	9·43
·3631	·2353	9·36
·3641	·2357	9·35
·3651	·2361	9·33
·3662	·2364	9·24

Plate 5189 (taken by B.)

J. D. 242....	Phase	m_{pg}
d	P	m
9633·3737	·2391	9·08
·3751	·2396	9·00
·3765	·2401	8·98
·3778	·2406	9·00
·3792	·2411	8·93
·3806	·2416	8·87
·3820	·2421	8·89
·3834	·2426	8·81
·3848	·2431	8·80
·3862	·2436	8·82
·3875	·2441	8·74
·3889	·2446	8·77
·3903	·2451	8·74

Plate 5189 (*continued*)

J. D. 242....	Phase	m_{pg}
d	P	m
9633·3917	·2456	8·69
·3931	·2461	8·70
·3945	·2466	8·69
·3958	·2471	8·68
·3972	·2476	8·59
·3986	·2481	8·62
·4000	·2486	8·59
·4014	·2491	8·57
·4028	·2496	8·62
·4042	·2501	8·59
·4055	·2506	8·60

Plate 5243 (taken by B.)

J. D. 242....	Phase	m_{pg}
d	P	m
9641·4946	·1721	8·76
·4960	·1726	8·79
·4974	·1731	8·77
·4988	·1736	8·78
·5001	·1741	8·80
·5015	·1746	8·83
·5029	·1751	8·83
·5043	·1756	8·84
·5057	·1761	8·95
·5071	·1766	8·93
·5084	·1771	8·99
·5098	·1776	8·99
·5112	·1781	9·03
·5126	·1786	9·01
·5140	·1791	9·10
·5154	·1796	9·08
·5168	·1801	9·11
·5181	·1806	9·09
·5195	·1811	9·19
·5209	·1816	9·20
·5223	·1821	9·26
·5237	·1826	9·27
·5251	·1831	9·29
·5265	·1836	9·35
·5278	·1841	9·41
·5292	·1846	9·41

Plate 5244 (taken by B.)

J. D. 242....	Phase	m_{pg}
d	P	m
9641·5364	·1872	9·72
·5378	·1877	9·71
·5391	·1882	9·80
·5405	·1887	9·84
·5419	·1892	9·88
·5433	·1897	9·93
·5447	·1902	10·04
·5467	·1909	10·06
·5491	·1918	10·18
·5515	·1927	10·33
·5539	·1936	10·50
·5563	·1944	10·69

Plate 5266 (taken by B.)

J. D. 242....	Phase	m_{pg}
d	P	m
9669·3386	·2284	10·09
·3417	·2295	9·93
·3448	·2307	9·71
·3479	·2318	9·63
·3510	·2329	9·48
·3542	·2340	9·39
·3573	·2352	9·31
·3604	·2363	9·22

Plate 5402 (taken by B.)

J. D. 242....	Phase	m_{pg}
d	P	m
9903·5005	·7995	8·06
·5033	·8006	8·05
·5061	·8016	8·04
·5088	·8025	8·02
·5116	·8035	8·01
·5144	·8046	8·02
·5171	·8055	8·03
·5199	·8065	7·97
·5227	·8076	7·99
·5255	·8086	8·02
·5282	·8095	7·98
·5310	·8106	7·98
·5338	·8116	8·03
·5366	·8126	7·97
·5393	·8136	7·95
·5421	·8146	7·96
·5449	·8156	8·00
·5476	·8166	8·00
·5504	·8176	7·96
·5532	·8186	7·96

Plate 5405 (taken by B.)

J. D. 242....	Phase	m_{pg}
d	P	m
9904·5020	·1612	8·36
·5048	·1623	8·34
·5076	·1633	8·35
·5103	·1642	8·40
·5131	·1653	8·45
·5159	·1663	8·45
·5187	·1673	8·48
·5214	·1683	8·50
·5242	·1693	8·54
·5270	·1703	8·63
·5297	·1713	8·65
·5325	·1723	8·68
·5353	·1733	8·70
·5381	·1743	8·79
·5408	·1753	8·83
·5436	·1763	8·83
·5464	·1773	8·91
·5491	·1783	8·98
·5519	·1793	9·01
·5547	·1803	9·11
·5574	·1813	9·20
·5602	·1823	9·25

Plate 5415 (taken by B.)

J. D. 242....	Phase	m_{pg}
d	P	m
9915·5966	·1682	8·48
·5977	·1686	8·42
·5987	·1690	8·57
·5998	·1694	8·45
·6008	·1697	8·54
·6018	·1701	8·48
·6029	·1705	8·65
·6039	·1709	8·51
·6050	·1713	8·52
·6060	·1716	8·56
·6070	·1720	8·66
·6081	·1724	8·60
·6091	·1727	8·63
·6102	·1731	8·66
·6112	·1735	8·68
·6122	·1739	8·70
·6133	·1743	8·71
·6143	·1746	8·74
·6153	·1750	8·71
·6164	·1754	8·71
·6174	·1757	8·75

Plate 5415 (*continued*)

J. D. 242....	Phase	m_{pg}
d	P	m
9915·6185	·1761	8·79
·6195	·1765	8·88
·6205	·1769	8·77
·6216	·1773	8·90
·6226	·1776	8·91
·6237	·1780	8·96

Plate 5418 (taken by B.)

J. D. 242....	Phase	m_{pg}
d	P	m
9918·6066	·2553	8·45
·6073	·2556	8·35
·6080	·2558	8·40
·6087	·2561	8·37
·6094	·2563	8·27
·6101	·2566	8·24
·6108	·2569	8·32
·6115	·2571	8·26
·6121	·2573	8·32
·6128	·2576	8·32
·6135	·2578	8·36
·6142	·2581	8·24
·6149	·2583	8·36
·6156	·2586	8·16
·6163	·2588	8·16
·6170	·2591	8·16
·6177	·2594	8·20

Plate 5419 (taken by B.)

J. D. 242....	Phase	m_{pg}
d	P	m
9918·6399	·2674	8·06
·6410	·2678	8·06
·6420	·2681	8·06
·6430	·2685	8·00
·6441	·2689	8·02

Plate 5435 (taken by B.)

J. D. 242....	Phase	m_{pg}
d	P	m
9929·3687	·1422	8·05
·3694	·1425	8·12
·3701	·1427	8·07
·3708	·1430	8·05
·3715	·1432	8·04
·3722	·1435	8·14
·3729	·1437	8·10
·3736	·1440	8·16
·3743	·1442	8·03
·3750	·1445	8·05
·3756	·1447	8·11
·3763	·1450	8·05
·3770	·1452	8·11
·3777	·1455	8·13
·3784	·1457	8·04
·3791	·1460	8·13
·3798	·1462	8·16
·3805	·1465	8·08
·3812	·1467	8·09
·3819	·1470	8·02
·3826	·1472	8·05
·3833	·1475	8·07
·3840	·1477	8·17
·3846	·1480	8·02
·3853	·1482	8·05
·3860	·1485	8·08
·3867	·1488	8·11

Plate 5436 (taken by B.)

J. D. 242....	Phase	m_{pg}
d	P	m
9929·3930	·1510	8·16
·3936	·1512	8·18

TABLE 2 (*continued*).

J. D. 242....	Phase	m_{pg}
Plate 5436 (*continued*)		
d	P	m
9929·3943	·1515	8·16
·3950	·1517	8·21
·3957	·1520	8·20
·3964	·1522	8·23
·3971	·1525	8·18
·3978	·1527	8·24
·3985	·1530	8·20
·3992	·1532	8·27
·3999	·1535	8·20
·4006	·1537	8·15
·4013	·1540	8·12
·4020	·1542	8·16
·4027	·1545	8·12
·4034	·1547	8·18
·4040	·1550	8·09
·4047	·1552	8·20
·4054	·1555	8·17
·4061	·1557	8·19
·4068	·1560	8·16
·4075	·1562	8·20
·4089	·1567	8·21

J. D. 242....	Phase	m_{pg}
Plate 5436 (*continued*)		
d	P	m
9929·4096	·1570	8·22
·4110	·1575	8·32
·4117	·1577	8·24
·4123	·1580	8·20
·4130	·1582	8·26
Plate 5437 (taken by B.)		
d	P	m
9929·4262	·1630	8·26
·4269	·1632	8·33
·4276	·1635	8·35
·4283	·1637	8·36
·4290	·1640	8·30
·4297	·1642	8·29
·4304	·1645	8·40
·4311	·1647	8·30
·4317	·1650	8·36
·4324	·1652	8·35
·4331	·1655	8·43
·4338	·1657	8·39
·4345	·1660	8·43

J. D. 242....	Phase	m_{pg}
Plate 5437 (*continued*)		
d	P	m
9929·4352	·1662	8·48
·4359	·1665	8·45
·4366	·1667	8·45
·4373	·1670	8·40
·4380	·1672	8·42
·4387	·1675	8·44
·4394	·1677	8·51
·4401	·1680	8·46
·4407	·1683	8·48
·4414	·1685	8·48
Plate 5514 (taken by B.)		
d	P	m
9998·5702	·1354	7·89
·5709	·1356	7·91
·5716	·1359	7·99
·5723	·1361	7·92
·5730	·1364	8·10
·5736	·1366	8·09
·5743	·1369	8·15
·5750	·1371	8·08

J. D. 242....	Phase	m_{pg}
Plate 5514 (*continued*)		
d	P	m
9998·5757	·1374	8·11
·5764	·1376	7·99
·5771	·1379	7·89
·5778	·1381	7·91
·5785	·1384	8·02
·5792	·1386	7·99
·5799	·1389	7·98
·5806	·1391	7·96
·5813	·1394	7·92
·5820	·1396	8·00
·5827	·1399	8·01
·5833	·1401	8·01
·5840	·1404	8·04
·5847	·1406	7·99
·5854	·1409	8·02
·5861	·1411	7·96
·5868	·1414	8·02
·5875	·1416	8·05
·5882	·1419	8·01
·5889	·1421	8·04
·5896	·1424	8·01

epochs were determined by the method described by HERTZSPRUNG [1]). For the determination of the epoch in the case only one of the two branches was observed the following procedure was followed: From the five minima just mentioned a provisional "reflected" light curve was made. The determination of the epoch of minimum was then made by shifting in time the mean light curve with respect to the observed branch in such a way that the sum of the squares of the differences of the magnitudes between the two curves became minimum. These epochs are given in column 2 of Table 3.

TABLE 3.

Observer	J. D. H. M. A. T. Gr. — 2420000	E_1	Weight	O — C	E
	d			d	
VAN GENT	5261·3281	0	4	— ·0026	+ 2912
OOSTERHOFF	5535·4431	99	7	— 5	+ 3011
,,	5856·6253	215	4	— 9	+ 3127
,,	5881·5460	224	10	+ 5	+ 3136
,,	5892·6202	228	2	— 6	+ 3140
,,	5964·6115	254	3	+ 15	+ 3166
,,	5967·3804	255	1	+ 16	+ 3167
WESSELINK	6648·5090	501	6	+ 14	+ 3413
,,	7415·4702	778	9	+ 5	+ 3690
BINNENDIJK	9558·5338	1552	4	+ 5	+ 4464
,,	9630·5225	1578	1	— 1	+ 4490
,,	9633·2908	1579	10	— 6	+ 4491
,,	9641·5975	1582	2	— 3	+ 4494
,,	9669·2854	1592	1	— 6	+ 4504

A. A. NIJLAND collected 80, 4 and 23 epochs of minimum resp. in *B.A.N.* No. 6 [2]), p. 26, *B.A.N.* No. 58, p. 131 and *B.A.N.* No. 217, p. 118. The following minima (Table 4) not included in the list of NIJLAND I found in:

A.N. **220**, 182
A.N. **246**, 287
A.N. **267**, 323
Hamb. Mitt. No. 11, 192
Journal B.A.A. **35**, 59
A.A. c. Vol. **1**, 148
A.A. c. Vol. **3**, 96
Circ. de Cracovie No. 19
Warsaw Circ. No. 16, 7
Harv. Circ. No. 104

For all the epochs observed residuals from the following elements were computed and means were taken:

$$\text{Min.} = 2417198^{d}\cdot421 + 2^{d}\cdot76885\ E.$$

In Table 5 and Figure 1 mean values of O — C are given as a function of the number of epochs elapsed since, which show the variation of the period from the years 1900 until 1940.

Dots represent means of the visual observations, crosses means of the photographic ones. The open dot on the left-hand side of the figure is very uncertain.

It is seen that the Leiden observations fall on the straight recent part of the curve in Figure 1. There-

[1]) *B.A.N.* No. 147, p. 179.

[2]) *B.A.N.* No. 6,
p. 25, line 4 from bottom: for 2417198d·442 read 2417198d·419,
p. 26, E = + 255, column 5, for ·882 read ·482,
E = + 272, column 3, for 7915·552 read 7951·552,
p. 27, E = + 1861, column 1, read E = 1865.

TABLE 4 (earlier observations).

Observer	Minimum	E	Observer	Minimum	E
HARVARD	2409913·560	— 2631	PAGACZEWSKI	2425945·231	+ 3159
,,	2410284·567	— 2497	LAUSE	6039·3681	+ 3193
,,	0954·642	— 2255	JOHNSON [2]	6338·3988	+ 3301
,,	5993·942	— 435	FESTA	6676·196	+ 3423
,,	6043·765	— 417	ROSENHAGEN	6684·500	+ 3426
,,	6439·731	— 274	FESTA	6684·512	+ 3426
,,	6860·598	— 122	,,	6695·568	+ 3430
GRAFF	7115·335 [1]	— 30	ROSENHAGEN	6695·579	+ 3430
RYVES	7591·587	+ 142	FESTA	6698·347	+ 3431
BROOK	7594·385	+ 143	,,	6712·187	+ 3436
,,	7907·229	+ 256	ROSENHAGEN	6712·201	+ 3436
RYVES	7976·456	+ 281	FESTA	6720·498	+ 3439
,,	8001·413	+ 290	,,	6734·340	+ 3444
BROOK	8383·506	+ 428	,,	6745·420	+ 3448
,,	8624·382	+ 515	ROSENHAGEN	6745·423	+ 3448
GRAFF	8962·213	+ 637	FESTA	6767·566	+ 3456
,,	9798·401	+ 939	,,	6781·420 [1]	+ 3461
,,	9820·565	+ 947	,,	6792·496	+ 3465
,,	9823·328	+ 948	,,	6806·332	+ 3470
,,	2420169·440	+ 1073	PIOTROWSKI	7343·4814	+ 3664
,,	2290·388	+ 1839	,,	7429·3136	+ 3695
,,	2362·375	+ 1865	,,	7692·3505	+ 3790
,,	2622·643	+ 1959	,,	7714·5011	+ 3798
,,	2628·184	+ 1961	,,	7728·3464	+ 3803
,,	2733·397	+ 1999	,,	7739·4209	+ 3807
,,	2744·467	+ 2003	,,	7753·2636	+ 3812
,,	2747·242	+ 2004	GADOMSKI	8124·2859	+ 3946
,,	2783·236	+ 2017	PIOTROWSKI	8135·3629	+ 3950
GADOMSKI	3353·6097	+ 2223	LAUSE	8459·3166	+ 4067
,,	3503·1270	+ 2277	PIOTROWSKI	8484·2327	+ 4076
GRAFF	3835·382 [1]	+ 2397	,,	8592·2169	+ 4115
GADOMSKI	4026·4361	+ 2466	LAUSE	8902·3270	+ 4227

fore these observations have been used for the determination of a linear ephemeris for the purpose of extrapolation in the nearest future.

Weights were assigned which depend on the number of observations and on the slope of that part of the light curve which is covered by the observations (column 4 of Table 3). The resulting ephemeris is:

$$\text{Min.} = 2427415^{d}{\cdot}4697 + 2^{d}{\cdot}7688162\ (E_1 - 778)$$
$$\pm 3 \qquad \pm 5 \quad \text{(m.e.)}$$

The light curve and the orbit.

For the determination of a final light curve only the observations made at Leiden were used. The phases have been computed with the formula:

$$\text{phase} = (\text{J. D. H. M.A.T. Grw.} - 2420000) \times {}^{d-1}{\cdot}36116518$$

[1]) Misprint in *A.N.* No. 5268, Bd **220**, 182.

[2]) Estimated by E. HERTZSPRUNG; unpublished.

On the assumption that the light curve is symmetrical the observations were then arranged according to phase counted from the middle of the minimum and normal values of ten or twenty observations were computed. Table 6 and Figure 2 give the mean "reflected" light curve. Now the magnitudes of each plate used for the derivation of the epochs were compared with this mean light curve. For two plates (1354 and 1846) the systematic deviations are considerable, namely ${}^{m}{\cdot}13$.

The material was too small to separate the night error from the plate error. I found for the mean of the plates of Table 3:

$$(\text{mean night error})^2 + (\text{mean plate error})^2 = {}^{m2}{\cdot}003771.$$

The mean error of one normal value, consisting of 20 exposures, is found to be $\pm\,{}^{m}{\cdot}017$.

The night errors have no influence on the epochs if the whole minimum is observed. A new calculation of the period from the five completely observed minima only gave a result in accordance within the mean error with the value derived above.

For the calculation of the orbit the formulae of H. N. RUSSELL [1]) have been used. If a solution for uniform

TABLE 5.

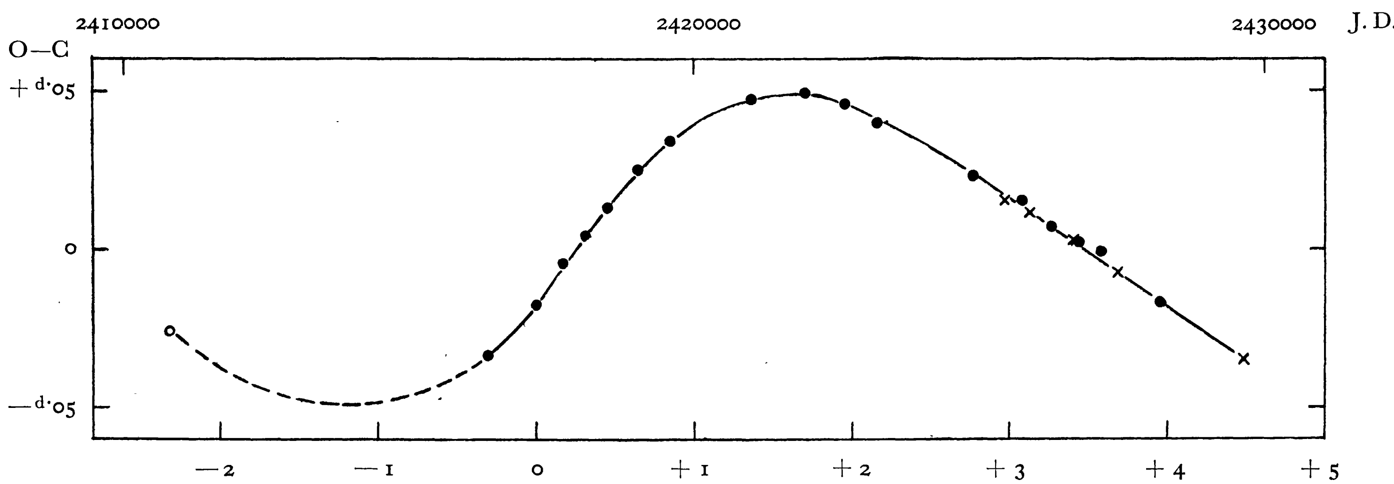
n	O — C	E
	d	
4	— ·026	— 2325
10	— 34	— 306
10	— 18	0
10	— 5	+ 170
10	+ 4	315
10	+ 13	453
10	+ 25	654
10	+ 34	852
10	+ 47	1370
10	+ 49	1704
10	+ 46	1953
10	+ 40	2162
10	+ 23	2777
ph. 2	+ 15	2975
10	+ 15	3085
ph. 5	+ 11	3140
10	+ 7	3269
ph. 1	+ 3	3413
9	+ 2	3436
9	— 1	3583
ph. 1	— 8	3690
9	— 17	3956
ph. 5	— 35	4486

1) *Ap. J.* **35**, 315 (1912).

TABLE 6.

Phase from minimum	Mean brightness	*n*
P	m	
·0011	12·28	20
·0031	12·29	20
·0051	12·27	20
·0072	12·25	20
·0086	12·24	10
·0095	12·15	10
·0104	12·07	10
·0112	11·87	10
·0120	11·52	10
·0128	11·29	10
·0136	11·06	10
·0143	10·85	10
·0155	10·63	20
·0169	10·37	20
·0183	10·12	20
·0196	9·96	20
·0216	9·73	20
·0242	9·48	20
·0267	9·28	20
·0291	9·10	20
·0313	8·97	20
·0334	8·83	20
·0360	8·72	20
·0389	8·59	20
·0422	8·46	20
·0459	8·34	20
·0504	8·24	20
·0563	8·17	20
·0619	8·08	20
·0669	8·05	20
·0717	8·00	20

FIGURE 1.



Abscissae are thousands of periods, ordinates are O—C's in days.
● = means of visual observations, × = means of the Leiden photographic observations.

discs is made, we have, as known, for a circular orbit the following formula:

$$\left(\frac{\delta}{r_1}\right)^2 = \frac{\cos^2 i}{r_1^2} + \frac{\sin^2 i}{r_1^2} \sin^2\theta = f^2(k,\alpha) \qquad (1)$$

where: δ = projected distance between the centres of the two stars
r_1 = radius of the large star
$r_2 = kr_1$ = radius of the small star
θ = the orbital longitude counted from mid-eclipse
i = inclination of the orbit
α = the fraction of the smaller disc, obscured by the larger one.

The tables of E. HETZER [1]) and M. WEND [2]), giving $\frac{\delta}{r_1} = f(k, \alpha)$ and $\alpha = F\left(k, \frac{\delta}{r_1}\right)$ have been used.

All normal points and therefore $m - m_{max}$ have the same weight if they contain the same number of observations. Every normal point gives rise to an equation of condition of the form $u = A + Bt$. The weights of u are estimated now by calculating the value of u for $m - m_{max}$ and for $m - m_{max} \pm {}^m\!\cdot 10$, using the provisional value $k = \cdot 68$. Then the weights of u are taken proportional with $(\Delta u)^{-2}$.

Table 7 gives the normal points used for the least squares solutions and the residuals in magnitudes for different adopted values of k. The mean deviations for a single normal are calculated from the expression $\sqrt{\frac{1}{20} \Sigma (O - C)^2}$. As seen in Figure 3 the best representation of the light curve is obtained for $k = \cdot 681$. The mean deviation of $\pm {}^m\!\cdot 024$ corresponding with the value of $k = \cdot 681$ is of the same order as the mean error of $\pm {}^m\!\cdot 017$ for a single normal point.

Figure 4 gives the relation between k and r_1, and Figure 5 between k and i.

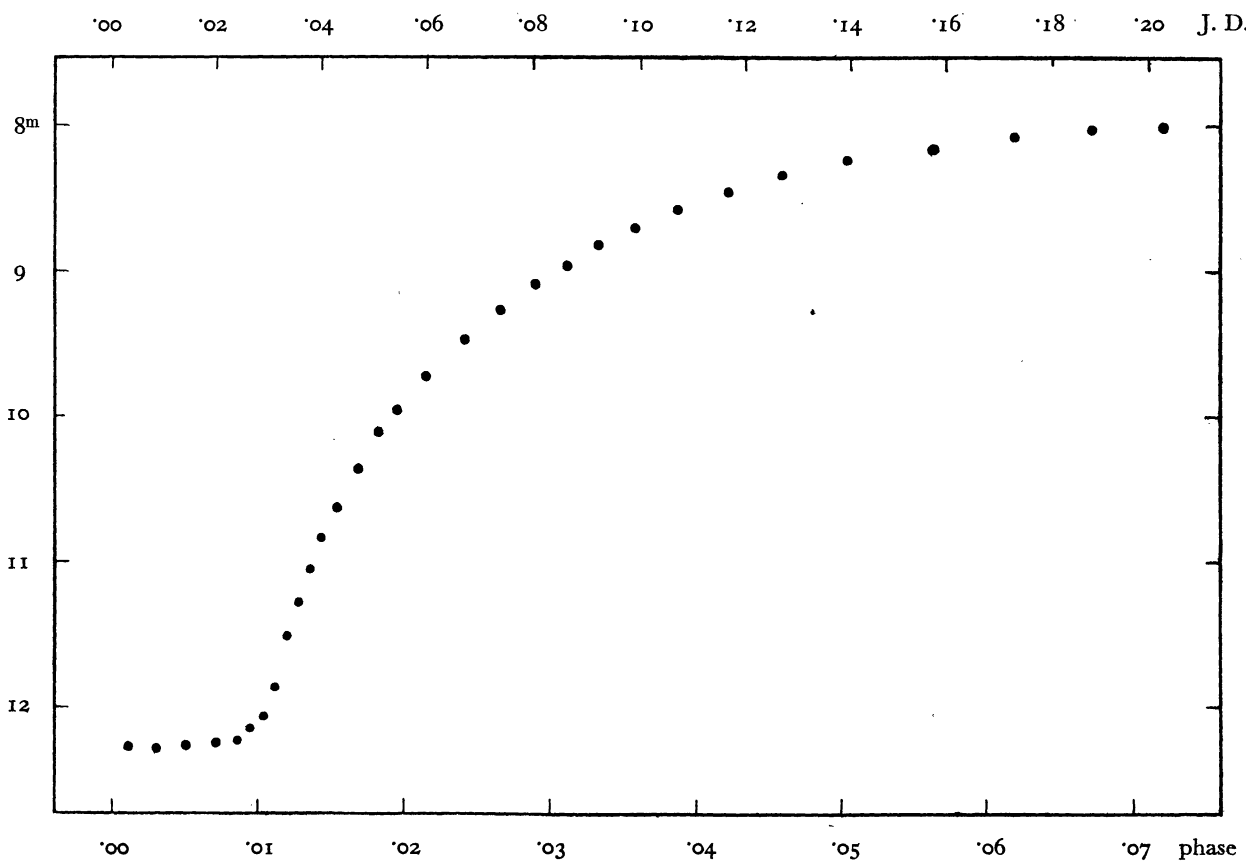
The final values are given in Table 8, where the distance between the centres of the two stars is taken as unit of length. The mean error of k has been determined by the method of PANNEKOEK and Miss VAN DIEN [1]).

The influence of a scale error was investigated in the following way. The above calculations were repeated, but now the scale was ·95 times the former. Table 9 and the dotted lines in the Figures 3, 4 and

[1]) *Beitrag zu* H. N. RUSSELL'*s Methode*, Diss. Leipzig (1931).
[2]) *Eine Tafel zur Theorie der Bedeckungsveränderlichen*, Diss. Leipzig (1931).

[1]) *B.A.N.* No. 297 (1937).

FIGURE 2.



Mean "reflected" light curve of minimum.

TABLE 7.

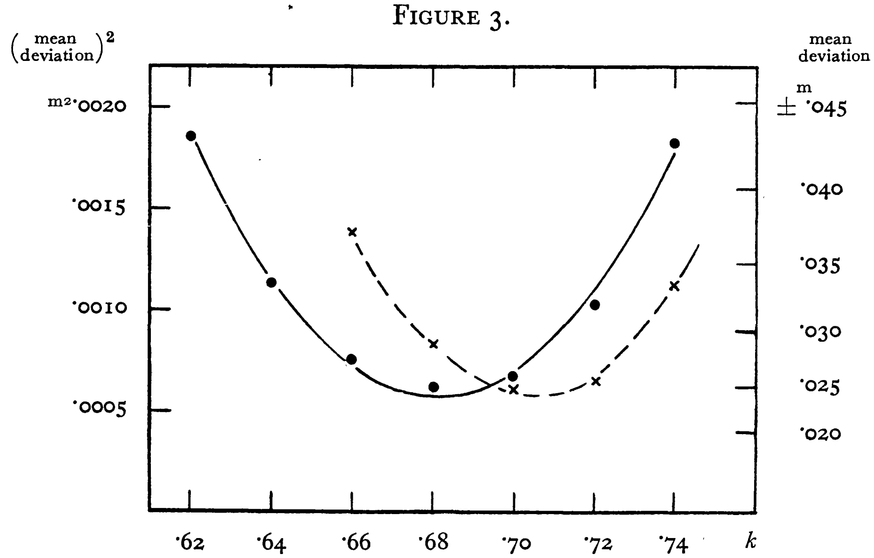
Phase	$m - m_{max}$	k = ·62	·64	·66	·68	·70	·72	·74
p	m	m	m	m	m	m	m	m
·0104	4·07	+ ·03	+ ·02	+ ·01	− ·01	− ·04	− ·05	− ·08
·0112	3·87	+ 8	+ 7	+ 7	+ 6	+ 5	+ 3	+ 2
·0120	3·52	0	0	0	0	0	+ 1	+ 1
·0128	3·29	− 1	− 1	+ 1	+ 1	+ 2	+ 3	+ 4
·0136	3·06	− 4	− 3	− 2	− 1	+ 1	+ 2	+ 3
·0143	2·85	− 7	− 6	− 5	− 4	− 2	− 1	+ 1
·0155	2·63	− 4	− 2	− 1	+ 1	+ 2	+ 4	+ 5
·0169	2·37	− 4	− 3	− 2	0	+ 1	+ 3	+ 4
·0183	2·12	− 6	− 4	− 3	− 2	− 1	0	+ 2
·0196	1·96	− 3	− 2	− 1	0	+ 1	+ 2	+ 3
·0216	1·73	− 1	− 1	0	+ 1	+ 1	+ 2	+ 3
·0242	1·48	+ 1	+ 1	+ 1	+ 2	+ 2	+ 2	+ 3
·0267	1·28	+ 2	+ 2	+ 2	+ 2	+ 2	+ 2	+ 2
·0291	1·10	+ 2	+ 1	+ 1	+ 1	0	0	0
·0313	·97	+ 3	+ 2	+ 2	+ 1	0	0	+ 1
·0334	·83	0	0	− 1	− 2	− 3	− 4	− 4
·0360	·72	+ 3	+ 2	+ 1	0	− 1	− 2	− 3
·0389	·59	+ 2	+ 1	0	− 1	− 3	− 4	− 5
·0422	·46	+ 2	0	− 1	− 2	− 4	− 5	− 6
·0459	·34	+ 3	0	− 1	− 3	− 4	− 6	− 7
·0504	·24	+ 3	+ 2	+ 1	− 1	− 3	− 4	− 6
·0563	·17	+ 8	+ 7	+ 5	+ 4	+ 2	+ 1	− 1
·0619	·08	+ 6	+ 5	+ 4	+ 4	+ 2	0	− 1
mean deviation		± ·043	± ·034	± ·027	± ·025	± ·026	± ·032	± ·043

5 give the results. In Table 8 the last column represents the influence of x % difference in the magnitude scale. For small magnitude intervals the change is supposed to be linear.

The system consists of a small bright star (spectrum A0) and a large darker star. If we suppose the temperature of the small bright star to be $T_2 = 10700°$ [1]) with the formula of PLANCK for black bodies a temperature $T_1 = 4350°$ for the large star is found, which corresponds with the spectrum K0.

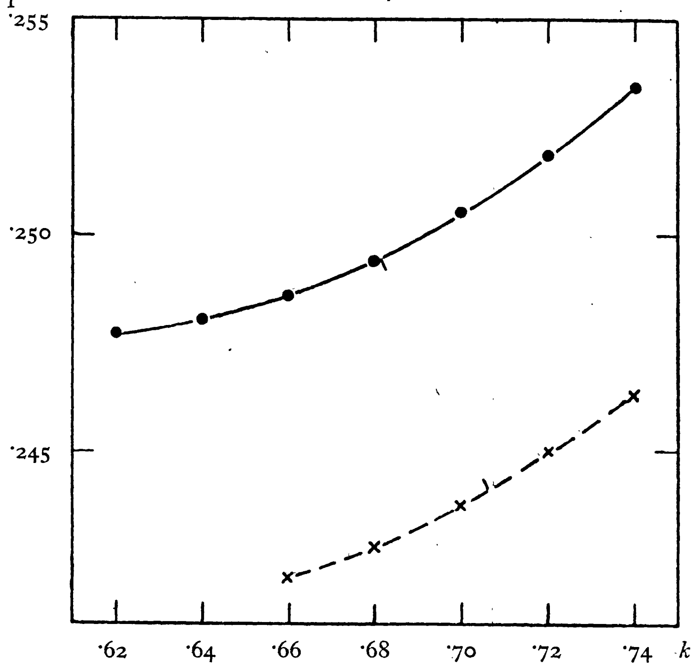
[1]) KUIPER, *Ap. J.* **88**, 429 (1938).

FIGURE 3.



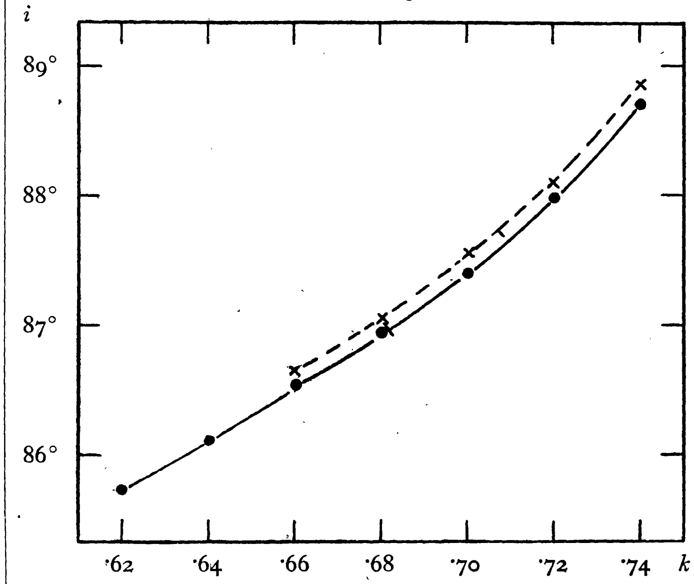
Relations of the mean deviation to the ratio of radii.

FIGURE 4.



Relations of the radius of the large star to the ratio of radii.

FIGURE 5.



Relations of the inclination to the ratio of radii.

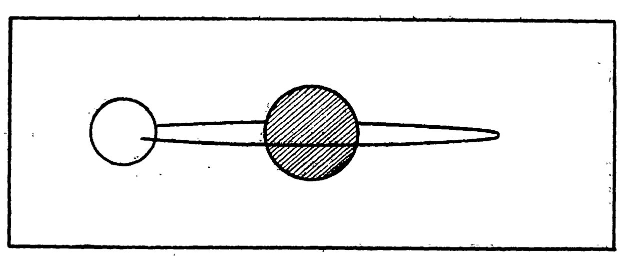
TABLE 8.

Epoch of principal minimum			$2427415^d\cdot4697 \pm \cdot0003$	
Period			$2^d\cdot7688162 \pm \cdot0000005$	
Magnitude range	Δm	=	4·27	— ·0427 x
Ratio of the radii	k	=	·681 ± ·009	+ ·005 x
Radius of the larger star	r_1	=	·2495	— ·0011 x
Radius of the smaller star	r_2	=	·170	+ ·0005 x
Inclination	i	=	86°·95	+ °·15 x
Luminosity of the larger star	l_1	=	·0196	+ ·0008 x
Luminosity of the smaller star	l_2	=	·9804	— ·0008 x
Ratio of the surface brightnesses	J_1/J_2	=	·0093 ± ·0003	+ ·0008 x

The duration of the whole minimum is 9·0 hours. Theoretically the depth of the secondary minimum is ᵐ·01, therefore too small to be observed at the wavelength of the present observations.

The depth of the secondary minimum at a wavelength of μ·7 may be expected to be about ᵐ·06. It would therefore be relatively easy to determine its phase by means of a photoelectric photometer sensitive in the red.

FIGURE 6.



The system RW Tauri.

TABLE 9.

Phase	$m - m_{\max}$	$k = {\cdot}66$	·68	·70	·72	·74
P	m	m	m	m	m	m
·0104	3·87	+ ·03	+ ·01	·00	— ·02	— ·05
·0112	3·68	+ 8	+ 7	+ 6	+ 6	+ 4
·0120	3·34	— 1	0	0	0	0
·0128	3·13	+ 1	+ 1	+ 2	+ 3	+ 4
·0136	2·91	— 2	— 1	0	+ 1	+ 3
·0143	2·71	— 6	— 4	— 3	— 1	0
·0155	2·50	— 2	— 1	+ 1	+ 2	+ 4
·0169	2·25	— 3	— 2	— 1	+ 1	+ 2
·0183	2·01	— 5	— 4	— 3	— 1	0
·0196	1·86	— 3	— 2	— 1	0	+ 1
·0216	1·64	— 1	— 1	0	0	+ 1
·0242	1·41	+ 1	+ 1	+ 2	+ 2	+ 2
·0267	1·22	+ 2	+ 2	+ 2	+ 2	+ 2
·0291	1·05	+ 2	+ 1	+ 1	0	0
·0313	·92	+ 2	+ 1	+ 1	0	— 1
·0334	·79	0	— 1	— 2	— 3	— 5
·0360	·68	+ 2	+ 1	0	— 2	— 3
·0389	·56	+ 1	0	— 1	— 2	— 4
·0422	·44	+ 1	0	— 2	— 3	— 4
·0459	·32	0	— 1	— 3	— 4	— 6
·0504	·23	+ 3	+ 1	— 1	— 2	— 4
·0563	·16	+ 7	+ 6	+ 4	+ 3	+ 1
·0619	·08	+ 6	+ 5	+ 4	+ 3	+ 1
mean deviation		± ·037	± ·029	± ·025	± ·026	± ·034

Differential method of determining the constants of the system by means of least squares.

The magnitudes may be considered as a function of the constants of the system: k, r_1, i, the phase and the luminosities, or as a function of A, B, k, the phase and the luminosities, where

$$A = \frac{\cos^2 i}{r_1^2}, \quad B = \frac{\sin^2 i}{r_1^2}.$$

The ratio of the luminosities is known sufficiently well and we do not intend to determine a correction. We then have for a given normal:

$$m\ (A + dA,\ B + dB,\ k + dk) = m\ (A,\ B,\ k) + \frac{\partial m}{\partial A} dA + \frac{\partial m}{\partial B} dB + \frac{\partial m}{\partial k} dk \qquad (2)$$

when terms only of the first order in dA, dB, dk are considered. When the elements of the system corresponding to our solution for $k = {\cdot}68$ of the foregoing section are taken as initial values, we have the conditional equations:

$$\frac{\partial m}{\partial A} dA + \frac{\partial m}{\partial B} dB + \frac{\partial m}{\partial k} dk = (\text{O}-\text{C})_{k = {\cdot}68} \qquad (3)$$

where the right-hand members are the values given in the sixth column of Table 7. The values of A and B correspond with $k = {\cdot}68$.

For each normal the derivatives $\frac{\partial \alpha}{\partial A}$, $\frac{\partial \alpha}{\partial B}$ and $\frac{\partial \alpha}{\partial k}$ were calculated in the following way. We write the formula (1) as:

$$\left(\frac{\delta}{r_1}\right)^2 = A + B \sin^2 \theta = f^2\ (k,\ \alpha) \qquad (4)$$

B and k being taken constant, the equation

$$f^2\ (k,\ \alpha) + dA = f^2\ (k,\ \alpha + d\alpha)$$

gives $\frac{\partial \alpha}{\partial A}$. Keeping A and k constant we get a similar equation for $\frac{\partial \alpha}{\partial B}$, which is simply $\frac{\partial \alpha}{\partial B} = \sin^2 \theta \frac{\partial \alpha}{\partial A}$. Taking A and B constant we find

$$f\ (k,\ \alpha) = f\ (k + dk,\ \alpha + d\alpha)$$

which gives $\frac{\partial \alpha}{\partial k}$. Now $\frac{\partial m}{\partial A}$, $\frac{\partial m}{\partial B}$ and $\frac{\partial m}{\partial k}$ are found by multiplying $\frac{\partial \alpha}{\partial A}$, $\frac{\partial \alpha}{\partial B}$ and $\frac{\partial \alpha}{\partial k}$ with

$$\frac{dm}{d\alpha} = {\cdot}4 \ln 10 \frac{1 - l_{\min}}{l} = 1{\cdot}0857 \frac{l_2}{l}$$

In order to derive the mean errors of all three quantities k, r_1, i, we transform the equations of condition (3) as follows:

We introduce

$$\left\{ \begin{array}{l} x = \frac{1}{r_1^2} = A + B \\ y = \ln \mathrm{tg}^2\, i = \ln \frac{B}{A} \end{array} \right. \qquad (5)$$

Hence:

$$\left\{ \begin{array}{l} dA = \frac{A}{A+B}\, dx - \frac{AB}{A+B}\, dy \\ dB = \frac{B}{A+B}\, dx + \frac{AB}{A+B}\, dy \end{array} \right.$$

Substituting these in our equations of condition (3) we arrive at a new set of equations of condition:

$$a\ dx + b\ dy + c\ dk = (\mathrm{O-C}) \quad k = \cdot 68 \qquad (6)$$

where

$$\left\{ \begin{array}{l} a = \dfrac{A \frac{\partial m}{\partial A} + B \frac{\partial m}{\partial B}}{A + B} \\ b = \dfrac{AB}{A+B} \left(\frac{\partial m}{\partial B} - \frac{\partial m}{\partial A} \right) \\ c = \dfrac{\partial m}{\partial k} \end{array} \right.$$

Table 10 gives the values a, b, and c for each normal value. The weight has been taken proportional to the number of exposures contained in a normal and is equal to ½ for the first six and 1 for the remaining equations of condition.

The normal equations are:

$$+ \ \cdot 16816\, dx - \cdot 60773\, dy + 10\cdot 20912\, dk = - \cdot 00424$$
$$- \ \cdot 60773\, dx + 2\cdot 69448\, dy - 45\cdot 02717\, dk = + \cdot 02086$$
$$+ \ 10\cdot 20912\, dx - 45\cdot 02717\, dy + 758\cdot 14159\, dk = - \cdot 28882$$

The resulting corrections and their mean errors are:

$$dx = \cdot 00 \pm \cdot 12$$
$$dy = + \cdot 18 \pm \cdot 15$$
$$dk = + \cdot 010 \pm \cdot 009$$

TABLE 10.

Phase	a	b	c
P			
·0104	− ·138	+ ·887	− 15·532
·0112	·182	1·064	16·074
·0120	·178	·940	14·952
·0128	·164	·794	13·061
·0136	·154	·686	11·467
·0143	·143	·587	10·174
·0155	·128	·466	8·353
·0169	·114	·365	6·771
·0183	·104	·291	5·505
·0196	·096	·241	4·608
·0216	·084	·179	3·545
·0242	·076	·131	2·542
·0267	·070	·100	1·855
·0291	·065	·079	1·369
·0313	·060	·064	1·006
·0334	·057	·055	·745
·0360	·054	·044	·455
·0389	·050	·035	− ·223
·0422	·046	·027	+ ·016
·0459	·042	·021	·157
·0504	·039	·016	·302
·0563	·033	·011	·403
·0619	− ·024	+ ·006	+ ·390

The corresponding corrections in r_1 and i are:

$$dr_1 = \cdot 00 \pm \cdot 0009$$
$$di = + 0^\circ\!\cdot 28 \pm 0^\circ\!\cdot 23$$

We thus have as final set of elements the values in Table 11.

TABLE 11.

k =	·690	± ·009
r_1 =	·2495	± ·0009
r_2 =	·172	± ·004
i =	87°·21	±°·23
J_1/J_2 =	·0095	± ·0003

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ERRATA,

See page 176, note 2.