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LIGHT ELEMENTS AND ORBIT OF AR *AURIGAE*

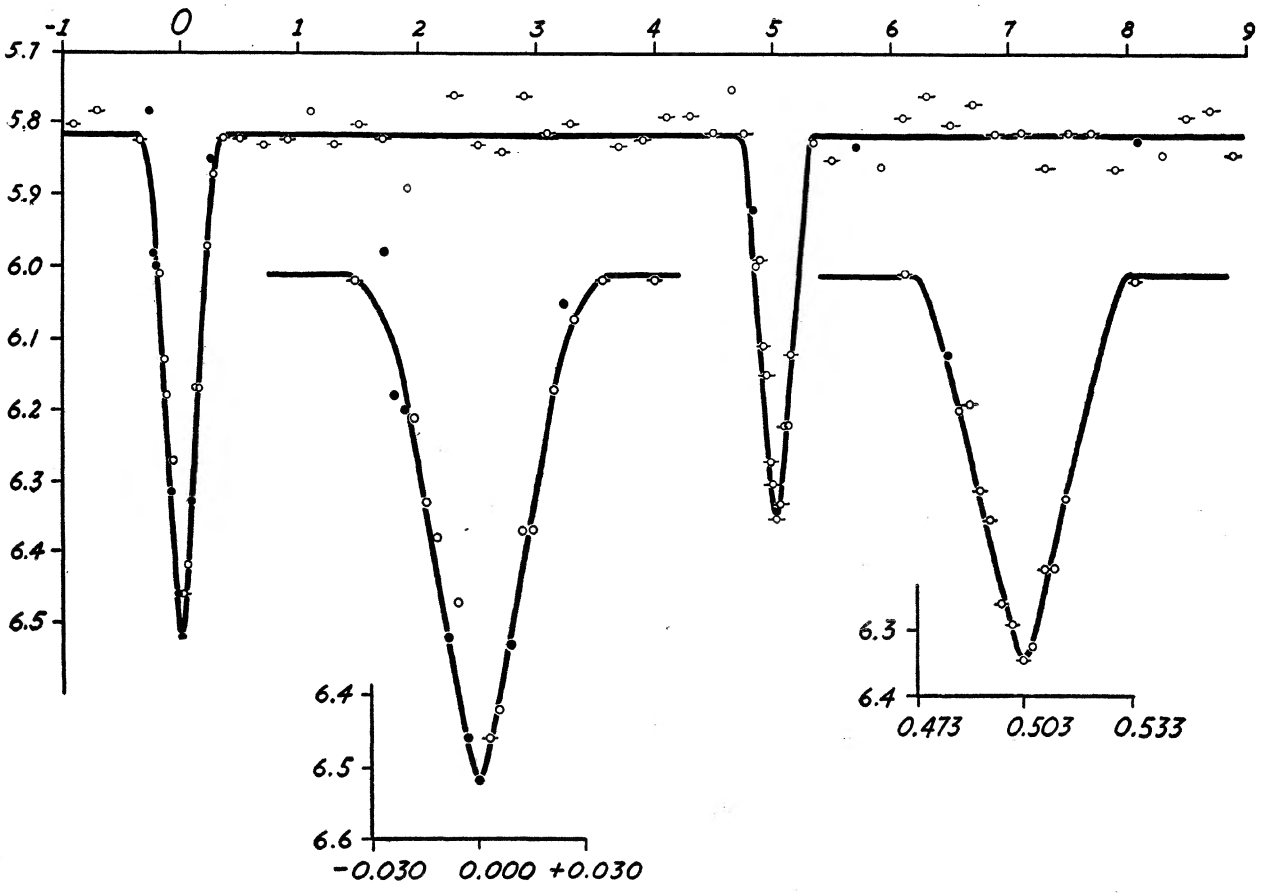
By J. J. NASSAU

In 1931, Pedersen and Steensgard[1] discovered the variablity of AR *Aurigae*, and later [2] published two sets of values for its light elements. Prager's Katalog for 1936 gives the light elements

$$2426742.434 + 2^d.067292E$$

for the star, with the indication that no secondary minimum has been observed.

From spectroscopic observations, Harper[3] reported that the period of variation is twice the above. In January 1936, Wyse[4] computed the spectroscopic orbit from



Mean Light Curve of AR *Aurigae*

● single observations o average of two -o- average of three or more observations

his own observations. His epoch agrees with that given by PRAGER; his period is twice as long.

The observations used in the determination of the photographic light curve in this paper were made at the Warner and Swasey Observatory with the 3-inch Ross astrographic. The plates were taken at the focus and the star images measured with the thermoelectric photometer. The majority of the plates were made with an exposure of two minutes. Our observations clearly show that the "odd" and "even" minima differ in depth, thus establishing the 4-day period as the correct one, even though the duration of the eclipse is only a little more than one quarter day.

Table I gives the data for the three comparison stars used. The last column shows the adopted magnitudes which were made by direct comparison with the North Polar Sequence and are expressed on the International scale.

Table II gives the complete set of observations. PRAGER'S epoch, which happens to refer to a primary minimum, with two of our primary minima, yields a period in very good agreement with the double period. The secondary minimum, however, is not exactly at the middle phase.

The description of the light variation of the star is given in Table III. Both eclipses appear to be partial. As the light between eclipses seems to remain constant, the effects of reflection and ellipticity were not considered.

Uniform Solution. A satisfactory representation of the primary minimum was secured with the value of

$$\chi\,(k, \alpha_{op}, \tfrac{1}{4}) = 2.145.$$

For the secondary,

$$\chi\,(k, \alpha_{os}, \tfrac{1}{4}) = 2.105.$$

The values of k, α_{op} and α_{os} were obtained from these and the equation,

$$\frac{1-\lambda_1}{\alpha_{op}} + \frac{1-\lambda_2}{k^2\alpha_{os}} = 1.$$

The results shown in Table IV were obtained from the primary minimum and are approximate as no effort was made to obtain the eccentricity of the orbit. WYSE does not give the eccentricity but assumes it to be zero.

The data of Table V were obtained from the above photometric results and WYSE'S data, The values of the masses of the stars given by him seem to be erroneous[5] apparently due to a slight arithmetical error. They were recomputed from his own values of K_1 and K_2.

I am indebted to Mr. R. F. BOYER for taking and measuring the first 84 plates, and to MRS. NASSAU for measuring most of the rest.

REFERENCES

1. BZ *13*, 70, 1931.
2. BZ *13*, 72, 1931; BZ *14*, 71, 1932.
3. *J. Can. R. A. S.*, *29*, 413, 1935.
4. *Publ. A. S. P.*, *48*, 25, 1936.
5. *Publ. A. S. R.*, *48*, 131, 1936.

TABLE I.

Star	B. D.	H. D.	Pg. M. (H.D.)	Spectral type (H. D.)	Pg. M.
a	+33° 1013	34578	5.30	A5p	5.16
b	+33° 1010	34499	6.66	A5	6.49
c	+33° 0991	34201	7.7	A3	7.03

TABLE II

No.	H. C. J. T.	Pg. M.	No.	H. C. J. T.	Pg. M.	No.	H. C. J. T.	Pg. M.	No.	H. C. J. T.	Pg. M.
1	7449.556	5.74	15	7489.574	5.80	29	7559.623	5.81	43	7726.771	5.83
2	449.578	5.83	16	503.611	5.78	30	560.577	5.85	44	726.805	5.77
3	458.697	5.76	17	527.610	5.79	31	560.597	5.81	45	727.788	5.75
4	458.723	5.83	18	530.602	5.73	32	561.582	5.83	46	746.754	5.78
5	459.625	5.75	19	530.624	5.75	33	561.603	5.82	47	746.786	5.82
6	459.651	5.75	20	536.593	5.90	34	562.589	5.83	48	757.757	5.83
7	461.602	5.73	21	536.619	5.91	35	564.608	5.79	49	774.745	5.81
8	474.618	5.78	22	537.571	5.75	36	565.592	5.81	50	774.774	5.84
9	474.650	5.86	23	537.593	5.84	37	565.613	5.81	51	802.529	5.82
10	482.656	5.80	24	545.583	5.80	38	712.756	5.81	52	802.542	5.74
11	483.606	5.82	25	557.592	5.73	39	719.724	5.82	53	802.561	5.81
12	485.587	5.82	26	558.581	5.73	40	721.812	5.77	54	802.580	5.78
13	486.522	5.78	27	558.601	5.85	41	722.751	5.79	55	802.599	5.79
14	486.543	5.78	28	559.596	5.81	42	724.781	5.82	56	802.623	5.74

No.	H. C. J. T.	Pg. M.	No.	H. C. J. T.	Pg. M.	No.	H. C. J. T.	Pg. M.	No.	H. C. J. T.	Pg. M.
57	7802.647	5.79	107	8075.809	6.07	157	8115.817	5.86	207	8206.579	5.77
58	805.589	5.83	108	75.822	6.25	158	127.621	5.85	208	214.542	5.81
59	805.623	5.74	109	75.846	6.22	159	127.738	5.76	209	214.569	5.75
60	807.551	5.74	110	75.870	6.20	160	127.754	5.80	210	214.584	5.78
61	807.582	5.84	111	83.781	5.80	161	127.772	5.84	211	214.615	5.71
62	833.613	5.77	112	83.823	5.79	162	131.529	5.84	212	214.645	5.85
63	833.648	5.79	113	83.867	5.87	163	31.563	6.00	213	218.538	6.25
64	840.666	5.77	114	83.897	5.76	164	31.570	6.00	214	219.551	5.88
65	857.605	5.81	115	87.912	5.84	165	31.584	6.10	215	219.579	5.82
66	865.583	5.73	116	88.793	5.92	166	31.591	6.04	216	220.505	6.10
67	866.608	5.76	117	89.768	5.88	167	31.602	6.18	217	.510	6.14
68	867.612	5.88	118	89.779	5.80	168	31.609	6.18	218	.513	6.19
69	867.638	5.82	119	89.903	5.84	169	31.623	6.23	219	.516	6.07
70	870.676	5.76	120	92.773	5.90	170	31.630	6.32	220	.518	6.11
71	870.711	5.92	121	92.830	5.74	171	31.648	6.52	221	.521	6.19
72	884.629	5.90	122	92.848	5.77	172	31.666	6.42	222	.524	6.18
73	885 549	5.79	123	94.687	5.88	173	31.669	6.45	223	.526	6.22
74	889.556	5.79	124	94.696	5.93	174	31.684	6.42	224	.529	6.19
75	889.593	5.83	125	94.714	5.82	175	31.691	6.33	225	.532	6.29
76	890.630	5.86	126	95.719	5.84	176	131.704	6.12	226	220.534	6.29
77	917.611	5.79	127	95.727	5.83	177	31.735	5.90	227	.536	6.20
78	918.612	5.86	128	95.755	5.80	178	33.723	6.38	228	.539	6.34
79	919.579	5.77	129	95.813	5.80	179	33.745	6.27	229	.541	6.30
80	919.609	5.86	130	101.607	5.92	180	33.777	5.98	230	.543	6.19
81	930.593	5.83	131	101.626	5.82	181	65.711	5.74	231	.546	6.29
82	931.611	5.85	132	101.646	5.81	182	65.763	5.78	232	.549	6.23
83	933.600	5.83	133	101.664	5.81	183	65.783	5.77	233	.551	6.34
84	941.608	5.78	134	101.674	5.76	184	67.729	5.86	234	.554	6.34
85	8051.827	5.80	135	101.705	5.79	185	67.762	5.92	235	.557	6.36
86	53.760	5.89	136	101.727	5.87	186	67.804	5.86	236	.560	6.38
87	64.797	5.78	137	101.787	5.79	187	67.820	5.84	237	.562	6.32
88	65.811	5.84	138	106.690	5.80	188	82.506	5.73	238	.565	6.32
89	67.766	5.85	139	106.724	5.86	189	82.519	5.78	239	.568	6.27
90	67.793	5.83	140	106.747	5.98	190	82.545	5.87	240	.575	6.29
91	68.765	5.83	141	106.768	6.01	191	88.712	5.85	241	.580	6.20
92	69.776	5.85	142	106.788	6.21	192	88.729	5.82	242	.585	6.22
93	69.797	5.77	143	106.810	6.32	193	88.846	5.90	243	227.543	5.82
94	69.818	5.89	144	106.830	6.46	194	91.490	5.84	244	.559	5.96
95	69.839	5.81	145	106.856	6.51	195	91.511	5.77	245	229.589	5.79
96	69.860	5.85	146	106.872	6.42	196	91.653	6.14	246	231.563	5.74
97	69.881	5.76	147	106.891	6.21	197	91.853	5.82	247	.581	5.80
98	70.662	5.92	148	106.913	6.10	198	92.500	5.78	248	235.639	5.84
99	70.681	5.82	149	106.935	6.03	199	92.527	5.80	249	.654	5.86
100	70.704	5.82	150	113.700	5.86	200	92.652	5.75	250	237.552	5.77
101	70.723	5.83	151	113.756	5.80	201	92.709	5.79	251	237.583	5.80
102	70.758	5.81	152	113.794	5.70	202	92.725	5.79	252	.596	5.80
103	70.773	5.90	153	114.767	5.78	203	92.796	5.81	253	238.547	5.74
104	70.823	5.77	154	114.787	5.83	204	92.813	5.96	254	.568	5.88
105	70.868	5.78	155	114.796	5.78	205	8204.504	5.83	255	.583	5.71
106	75.781	5.92	156	115.795	5.80	206	206.559	5.75	256	247.615	6.00

No.	H. C. J. T.	Pg. M.	No.	H. C. J. T.	Pg. M.	No.	H. C. J. T.	Pg. M.	No.	H. C. J. T.	Pg. M.
257	8247.631	5.80	270	8253.585	6.14	283	8253.622	6.32	296	8253.685	6.18
258	.649	5.77	271	.586	6.03	284	.627	6.40	297	265.603	5.94
259	249.625	5.72	272	.590	6.07	285	.632	6.40	298	267.573	5.70
260	.666	5.90	273	.597	6.07	286	.635	6.44	299	.601	5.80
261	.673	5.86	274	.600	6.15	287	.639	6.32	300	.626	5.88
262	251.670	6.01	275	.602	6.24	288	.643	6.39	301	267.636	5.86
263	.689	5.89	276	.604	6.13	289	.649	6.42	302	271.579	5.73
264	253.549	5.92	277	.607	6.23	290	.652	6.32	303	.613	5.79
265	.562	5.98	278	.609	6.26	291	.657	6.21	304	272.560	5.74
266	.565	6.02	279	.611	6.30	292	.661	6.29	305	.578	5.85
267	.572	5.96	280	.613	6.34	293	.665	6.20	306	.602	5.77
268	.579	6.09	281	.618	6.26	294	.670	6.30	307	273.556	5.80
269	.583	6.12	282	.620	6.28	295	.679	6.19	308	.565	5.80

TABLE III

DESCRIPTION AND LIGHT VARIATION OF AR *Aurigae*

B. D.	+33°1002(17 Aur.)
α (1900)	$5^h\ 11.8^m$
δ (1900)	33° 39′
Spectral Class	B9
Maximum	5.81^m
Principal minimum	6.52^m
Secondary minimum	6.35^m
Occurrence of secondary minimum	0.503
Epoch at principal minimum	J. D. 2428106.846
Period	4.134581 days

TABLE IV

Ratio of radii, k	0.919
Greatest loss at primary minimum, α_{op}	0.943
Greatest loss at secondary minimum, α_{os}	0.912
$1-\lambda_1$	0.476
$1-\lambda_2$	0.384
Inclination of orbit, i	88.8°
Radius of large star in terms of radius of relative orbit, r_1	0.110
Radius of small star, r_2	0.101
Light of small star, L_2	0.505
Light of large star, L_1	0.495
Ratio of surface brightness $J_b \div J_f$	1.21
Computed duration of eclipse at primary	6^h42^m
Computed duration of eclipse at secondary	6^h28^m
Nature of eclipse: Partial with small star eclipsed at primary minimum.	

TABLE V

Radius of primary orbit	6.10×10^6 Km
Radius of secondary orbit	6.60×10^6 Km
Distance of stars (centers)	12.70×10^6 Km
Radius of larger star	1.40×10^6 Km
Radius of smaller star	1.28×10^6 Km
Mass of larger star	2.29 ⊙
Mass of smaller star	2.48 ⊙
Density of larger star	0.40
Density of smaller star	0.56

Warner and Swasey Observatory,
Case School of Applied Science,
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TABLE FOR THE SOLUTION OF KEPLER'S EQUATION

BY GLEN H. DRAPER

Tables for the solution of Kepler's equation may be based upon the following relations:

$$M = E - e \sin E = E - B, \quad (1)$$

$$M_o = E_o - e \sin E_o = E_o - B_o, \text{ or} \quad (2)$$

$$M_o/e = E_o/e - \sin E_o = E_o/e - B_o/e, \text{ and} \quad (3)$$

$$E = E_o + \Delta, \text{ where} \quad (4)$$

$$\Delta = (M - M_o)/\{(1 - B_o') + \Delta \cdot B_o'' + \Delta^2 B_o'''\} \text{ or} \quad (5)$$

$$= (M/e - M_o/e)/\{(1/e - B_o'/e) + \Delta \cdot B_o''/e + \Delta^2 B_o'''/e\} \quad (6)$$

Δ is the interpolated factor which would give M from a table of M_o. The convergence is very rapid, never requiring more than three divisions to give an accuracy of $\pm 0.°0000002$ in the value of E for any value of $e < 1$.

If a few values of E are desired the values are found