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THE ANTALGOL VARIABLE ST OPHIUCHI (52.1907)

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ASTRONOMICAL SERIES

LAWS OBSERVATORY BULLETIN NO. 17

THE ANTALGOL VARIABLE ST OPHIUCHI (52.1907)

1900.0 R. A. $17^h\ 28^m\ 50^s$ Dec.—1° 0'.4[1]

The variability of ST Ophiuchi was discovered at Harvard from an examination of 31 photographs taken during the interval 1893-1904. Professor Pickering announced[2] that the light variation was of short duration, evidently about a day or a fraction thereof, and that the rise from minimum to maximum brightness through a range of at least one magnitude was very rapid. The photometric measures of the star made at the Laws Observatory on August 1, 5, and 14, 1908, indicated that it belonged to the antalgol class of variables, and that its period was approximately $0^d.45$. The resulting light curve showed a very steep ascending branch. These early results were announced by Professor Seares at the ninth annual meeting of the Astronomical and Astrophysical Society of America at Put-in-Bay, Ohio, August 25-28, 1908, and an abstract of his paper has been published.[3] The star was observed at Berlin during 1908, from May 26 to August 31, by Guthnick, who found the variation was of the antalgol type, and from the observations of four complete and two fragmentary maxima derived the elements:

$$\text{Max.} = \text{J. D. } 2418088.5066 + 0^d.450363E, \quad \text{G.M.T.}$$[4]

Guthnick considers the star a very abnormal case. From his observations he found an irregularity in the light curve near maximum and accounts for it by supposing a shallow algol minimum superposed upon a normal antalgol maximum. Assuming, then, that this anomalous condition is proved to exist, he offers suggestions concerning the theory of this class of variables. The observations made at the Laws Observatory throughout an interval of more than two years do not verify the existence of any unusual deviation from the ordinary type of antalgol variation.

On the 29 nights that the star has been measured at this observatory, a total of 293 observations have been made with the equalizing wedge photometer attached to the 7½-inch equatorial

[1] Position from A. N. vol. 175, p. 169.

[2] Harvard College Observatory Circ. No. 129; A. N. vol. 175, p. 169.

[3] Publications of the Astronomical and Astrophysical Society of America, vol. 1, p. 310.

[4] A. N. vol. 179, p. 181.

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TABLE I

OBSERVATIONS OF ST OPHIUCHI

Date	G.M.T.	Julian Day	Phase	Obs. Star	Readings	$b-a$	Δm	Mag.	O − C
1908, Aug. 1	15h 50m	2418155.660	+ 0d056	S, *a*	31.6 36.9	+0m50	+0m59	11m21	− 14
				S, *b*	36.1 37.3		+ 0.13	11.32	− 3
	58	.665	+ 0.061	H, *a*	25.1 29.3	0.48	+ 0.46	11.08	− 31
				H, *b*	29.5 29.5		0.00	11.19	− 20
	16 6	.671	+ 0.067	S, *a*	33.3 37.6	0.43	+ 0.47	11.09	− 34
				S, *b*	37.2 38.6		+ 0.14	11.33	− 10
	17 16	.719	+ 0.115	S, *a*	31.8 43.5	0.53	+ 1.29	11.91	+ 23
				S, *b*	36.6 42.1		+ 0.59	11.78	+ 10
	26	.726	+ 0.122	H, *a*	31.2 39.3	0.42	+ 0.88	11.50	− 22
				H, *b*	34.9 39.0		+ 0.43	11.62	− 10
	37	.734	+ 0.130	S, *a*	32.3 42.8	0.53	+ 1.16	11.78	+ 2
				S, *b*	37.1 42.2		+ 0.55	11.74	− 2
	18 24	.767	+ 0.163	S, *a*	33.8 46.8	0.41	+ 1.43	12.05	+ 8
				S, *b*	37.6 45.9		+ 0.92	12.11	+ 14
	32	.772	+ 0.168	H, *a*	30.9 40.4	0.47	+ 1.03	11.65	− 35
				H, *b*	35.1 40.7		+ 0.60	11.79	− 21
	42	.779	+ 0.175	S, *a*	32.3 44.6	0.58	+ 1.36	11.98	− 7
				S, *b*	37.6 44.4		+ 0.75	11.94	− 11
4	18 5	158.753	− 0.004	H, *a*	29.2 32.3	0.63	+ 0.35	10.97	+ 7
				H, *b*	34.8 32.3		− 0.28	10.91	+ 1
5	15 20	159.639	− 0.019	S, *b*	39.3 41.2		+ 0.21	11.40	+ 9
	24	.642	− 0.016	S, *b*	38.4 40.0		+ 0.17	11.36	+ 15
	28	.644	− 0.014	H, *b*	30.7 30.4		− 0.04	11.15	+ 1
	31	.646	− 0.012	H, *b*	30.3 28.9		− 0.15	11.04	− 5
	37	.651	− 0.007	S, *b*	38.1 36.5		− 0.17	11.02	+ 6
	42	.654	− 0.004	S, *b*	36.9 33.9		− 0.33	10.86	− 4
	48	.658	0.000	H, *a*	27.2 29.1	0.50	+ 0.21	10.83	+ 2
				H, *b*	31.7 29.7		− 0.22	10.97	− 12
	54	.662	+ 0.004	S, *a*	30.0 33.1	0.68	+ 0.35	10.97	+ 7
				S, *b*	36.1 33.3		− 0.31	10.88	− 2
	16 2	.668	+ 0.010	H, *a*	26.4 29.7	0.61	+ 0.37	10.99	+ 2
				H, *b*	31.8 30.3		− 0.18	11.01	+ 4
	10	.674	+ 0.016	S, *a*	31.5 35.3	0.59	+ 0.42	11.04	+ 1
				S, *b*	36.8 34.2		− 0.29	10.90	− 13
	17	.678	+ 0.020	H, *a*	26.9 30.6	0.52	+ 0.41	11.03	− 4
				H, *b*	31.6 30.9		− 0.08	11.11	+ 4
	24	.683	+ 0.025	S, *a*	30.9 35.9	0.68	+ 0.56	11.18	+ 7
				S, *b*	37.0 36.2		− 0.09	11.10	− 1

Date	G.M.T.	Julian Day	Phase	Obs. Star	Readings	$b-a$	Δm	Mag.	O-C
1908, Aug. 5	16h 46m	2418159.699	+ 0d041	H, *a*	26.0 31.1	+0m46	+ 0m56	11m18	− 7
				H, *b*	30.2 31.8		+ 0.19	11.38	+ 13
	17 41	.737	+ 0.079	H, *a*	28.5 35.5	0.47	+ 0.78	11.40	− 10
				H, *b*	32.7 35.1		+ 0.26	11.45	− 5
	52	.744	+ 0.086	S, *b*	39.2 42.4		+ 0.37	11.56	+ 2
14	14 46	168.615	− 0.050	H, *a*	23.7 41.8	0.57	+ 1.98	12.60	+ 20
				H, *b*	29.0 41.0		+ 1.31	12.50	+ 10
	15 15	.635	− 0.030	H, *a*	25.5 37.2	0.52	+ 1.30	11.92	+ 8
				H, *b*	30.2 36.9		+ 0.75	11.94	+ 10
	36	.650	− 0.015	H, *a*	22.9 29.9	0.55	+ 0.75	11.37	+ 17
				H, *b*	28.1 29.6		+ 0.17	11.36	+ 16
	44	.656	− 0.009	H, *a*	25.6 27.8	0.45	+ 0.24	10.86	− 14
				H, *b*	29.7 27.5		− 0.25	10.94	− 6
	52	.661	− 0.004	H, *a*	23.4 25.7	0.61	+ 0.24	10.86	− 4
				H, *b*	29.1 25.2		− 0.43	10.76	− 14
	16 2	.668	+ 0.003	H, *a*	23.8 25.7	0.63	+ 0.20	10.82	− 6
				H, *b*	29.6 25.8		− 0.42	10.77	− 11
	8	.672	+ 0.007	H, *a*	23.1 26.2	0.58	+ 0.32	10.94	0
				H, *b*	28.5 26.0		− 0.28	10.91	− 3
	38	.693	+ 0.028	H, *a*	22.1 27.2	0.47	+ 0.54	11.16	+ 3
				H, *b*	26.5 26.4		− 0.02	11.17	+ 4
	17 18	.721	+ 0.056	H, *a*	26.1 33.9	0.61	+ 0.87	11.49	+ 14
				H, *b*	31.6 34.1		+ 0.28	11.47	+ 12
15	15 32	169.647	+ 0.081	H, *a*	27.6 35.1	0.57	+ 0.83	11.45	− 7
				H, *b*	32.7 34.9		+ 0.24	11.43	− 9
16	15 58	170.665	+ 0.199	H, *b*	31.3 40.2		+ 0.96	12.15	− 8
	16 40	.694	+ 0.228	H, *b*	32.9 43.9		+ 1.21	12.40	0
17	16 12	171.675	− 0.143	H, *a*	29.1 47.1	0.65	+ 1.99	12.61	+ 21
				H, *b*	34.9 47.1		+ 1.34	12.53	+ 13
22	14 32	176.606	− 0.167	H, *a*	26.0 41.9	0.47	+ 1.75	12.37	− 3
				H, *b*	30.3 42.0		+ 1.29	12.48	+ 8
	52	.619	− 0.154	H, *a*	35.8 53.0	0.46	+ 1.96	12.58	+ 18
				H, *b*	40.2 53.2		+ 1.53	12.72	+ 32
	15 31	.647	− 0.126	H, *a*	35.2 53.1	0.52	+ 2.04	12.66	+ 26
				H, *b*	40.1 52.8		+ 1.49	12.68	+ 28
	47	.658	− 0.115	H, *a*	37.6 55.1	0.53	+ 2.03	12.65	+ 25
				H, *b*	42.4 55.5		+ 1.55	12.74	+ 34
	16 3	.669	− 0.104	H, *a*	38.3 55.3	0.49	+ 1.99	12.61	+ 21
				H, *b*	42.7 55.1		+ 1.47	12.66	+ 26
	25	.684	− 0 089	H, *a*	35.6 53.0	0.48	+ 1.98	12.60	+ 20
				H, *b*	40.2 52.6		+ 1.45	12.64	+ 24

Date	G.M.T.	Julian Day	Phase	Obs. Star	Readings	$b-a$	Δm	Mag.	O − C
1908, Aug. 22	16h 42m	2418176.696	− 0d.077	H, *a*	31.7 50.7	+ 0m.63	+ 2m.13	12m.75	+ 35
				H, *b*	37.4 50.9		+ 1.53	12.72	+ 32
	58	.707	− 0.066	H, *a*	32.0 51.1	0.71	+ 2.14	12.76	+ 36
				H, *b*	38.6 51.8		+ 1.52	12.71	+ 31
24	15 39	178.652	+ 0.078	H, *a*	33.7 39.4	0.46	+ 0.60	11.22	− 28
				H, *b*	38.0 39.5		+ 0.16	11.35	− 15
	50	.660	+ 0.086	H, *a*	32.7 41.2	0.58	+ 0.91	11.53	− 1
				H, *b*	38.1 40.8		+ 0.29	11.48	− 6
27	14 19	181.597	− 0.130	H, *a*	27.4 43.1	0.70	+ 1.74	12.36	− 4
				H, *b*	33.6 42.5		+ 0.97	12.16	− 24
	33	.606	− 0.121	H, *a*	27.9 44.3	0.68	+ 1.81	12.43	+ 3
				H, *b*	34.0 44.3		+ 1.13	12.32	− 8
	15 0	.625	− 0.102	H, *a*	26.8 43.8	0.69	+ 1.88	12.50	+ 10
				H, *b*	33.0 44.1		+ 1.22	12.41	+ 1
	49	.659	− 0.068	H, *a*	29.4 45.3	0.55	+ 1.76	12.38	− 2
				H, *b*	34.3 45.2		+ 1.20	12.39	− 1
30	14 34	184.607	+ 0.177	H, *a*	27.2 42.5	0.68	+ 1.69	12.31	+ 24
				H, *b*	33.3 42.5		+ 1.01	12.20	+ 13
	43	.613	+ 0.183	H, *a*	26.5 43.1	0.67	+ 1.83	12.45	+ 34
				H, *b*	32.5 42.8		+ 1.13	12.32	+ 21
	15 16	.636	+ 0.206	H, *a*	30.3 46.1	0.54	+ 1.75	12.37	+ 9
				H, *b*	35.1 45.8		+ 1.18	12.37	+ 9
	43	.655	+ 0.225	H, *a*	28.8 44.8	0.60	+ 1.77	12.39	− 1
				H, *b*	34.2 45.1		+ 1.20	12.39	− 1
Sept. 1	13 56	186.581	− 0.101	H, *a*	25.5 42.8	0.62	+ 1.92	12.54	+ 14
				H, *b*	31.1 42.5		+ 1.26	12.45	+ 5
	14 18	.596	− 0.086	H, *a*	26.8 42.2	0.58	+ 1.69	12.31	− 9
				H, *b*	32.0 42.7		+ 1.17	12.36	− 4
	41	.612	− 0.070	H, *a*	27.7 43.1	0.56	+ 1.70	12.32	− 8
				H, *b*	32.7 43.0		+ 1.13	12.32	− 8
	15 4	.628	− 0.054	H, *a*	28.9 44.5	0.57	+ 1.72	12.34	− 6
				H, *b*	34.0 44.4		+ 1.14	12.33	− 7
	31	.647	− 0.035	H, *a*	28.2 44.0	0.64	+ 1.75	12.37	+ 22
				H, *b*	33.9 43.5		+ 1.06	12.25	+ 10
	58	.665	− 0.017	H, *a*	31.2 37.4	0.58	+ 0.69	11.31	+ 6
				H, *b*	36.4 37.2		+ 0.09	11.28	+ 3
	16 4	.669	− 0.013	H, *a*	30.8 35.0	0.55	+ 0.47	11.09	− 2
				H, *b*	35.7 35.5		− 0.02	11.17	+ 6
	7	.672	− 0.010	H, *a*	29.7 33.1	0.52	+ 0.38	11.00	− 5
				H, *b*	34.4 33.3		− 0.12	11.07	+ 2

Date	G.M.T.	Julian Day	Phase	Obs. Star	Readings	$b-a$	Δm	Mag.	O-C
1908, Sept. 1	$16^h\ 10^m$	2418186.674	$-0^d.008$	H, *a*	30.0 33.0	$+0^m.58$	$+0^m.34$	$10^m.96$	− 3
				H, *b*	35.2 32.8		− 0.26	10.93	− 6
	14	.676	− 0.006	H, *a*	30.7 32.6	0.51	+ 0.22	10.84	− 10
				H, *b*	35.3 32.6		− 0.29	10.90	− 4
	19	.680	− 0.002	H, *a*	30.6 32.2	0.49	+ 0.18	10.80	− 8
				H, *b*	35.0 31.7		− 0.37	10.82	− 6
	23	.683	+ 0.001	H, *a*	30.1 32.5	0.54	+ 0.27	10.89	+ 3
				H, *b*	34.9 32.4		− 0.28	10.91	+ 5
	28	.686	+ 0.004	H, *a*	29.9 33.0	0.60	+ 0.35	10.97	+ 7
				H, *b*	35.3 32.6		− 0.29	10.90	0
	34	.690	+ 0.008	H, *a*	31.4 33.8	0.46	+ 0.27	10.89	− 6
				H, *b*	35.5 33.4		− 0.24	10.95	0
	58	.707	+ 0.025	H, *a*	32.1 35.8	0.54	+ 0.41	11.03	− 8
				H, *b*	37.0 35.8		− 0.13	11.06	− 5
	17 4	.711	+ 0.029	H, *a*	32.9 36.6	0.54	+ 0.41	11.03	− 11
				H, *b*	37.9 36.4		− 0.16	11.03	− 11
2	15 44	187.656	+ 0.073	Sh, *a*	26.1 36.6	0.77	+ 1.17	11.79	+ 32
				Sh, *b*	33.0 36.5		+ 0.38	11.57	+ 10
	54	.662	+ 0.079	Sh, *a*	26.5 37.3	0.90	+ 1.19	11.81	+ 31
				Sh, *b*	34.6 36.9		+ 0.25	11.44	− 6
1909, July 14	16 36	502.692	− 0.139	Sh, *a*	27.5 38.7	0.69	+ 1.23	11.85	− 55
				Sh, *b*	33.6 40.7		+ 0.76	11.95	− 45
	46	.699	− 0.132	H, *a*	18.0 35.5	0.59	+ 1.92	12.54	+ 14
				H, *b*	23.4 36.2		+ 1.40	12.59	+ 19
15	15 37	503.651	− 0.080	H, *a*	14.9 30.9	0.64	+ 1.80	12.42	+ 2
				H, *b*	20.1 29.8		+ 1.04	12.23	− 17
	48	.658	− 0.073	H, *a*	15.9 33.1	0.66	+ 1.91	12.53	+ 13
				H, *b*	21.6 33.4		+ 1.28	12.47	+ 7
	16 54	.704	− 0.027	H, *a*	19.8 29.2	0.52	+ 1.00	11.62	− 4
				H, *b*	24.8 29.0		+ 0.46	11.65	− 1
	17 21	.723	− 0.008	H, *a*	21.5 26.3	0.44	+ 0.51	11.13	+ 14
				H, *b*	25.6 26.0		+ 0.04	11.23	+ 24
	43	.738	+ 0.007	H, *a*	21.4 26.0	0.48	+ 0.49	11.11	+ 17
				H, *b*	25.9 26.2		+ 0.03	11.22	+ 28
	18 19	.763	+ 0.032	H, *a*	22.2 28.5	0.59	+ 0.67	11.29	+ 12
				H, *b*	27.7 28.7		+ 0.11	11.30	+ 13
16	15 58	504.665	+ 0.033	H, *a*	36.7 40.7	0.46	+ 0.42	11.04	− 14
				H, *b*	41.1 40.2		− 0.10	11.09	− 9
	16 32	.689	+ 0.057	H, *a*	34.8 41.9	0.54	+ 0.77	11.39	+ 3
				H, *b*	39.9 41.9		+ 0.23	11.42	+ 6

Date	G.M.T.	Julian Day	Phase	Obs. Star	Readings	$b-a$	Δm	Mag.	O - C
1909, July 16	17h 8m	2418504.714	+ 0d.082	H, *a*	36.3 44.2	+0m.58	+0m.87	11m.49	− 3
				H, *b*	41.7 44.7		+ 0.35	11.54	+ 2
17	14 47	505.616	+ 0.083	H, *a*	31.2 40.4	0.64	+ 1.00	11.62	+ 10
				H, *b*	36.9 40.4		+ 0.36	11.55	+ 3
	56	.622	+ 0.089	H, *a*	30.8 38.2	0.66	+ 0.81	11.43	− 12
				H, *b*	36.7 37.7		+ 0.10	11.29	− 26
	15 11	.633	+ 0.100	H, *a*	33.4 41.1	0.60	+ 0.83	11.45	− 17
				H, *b*	39.0 41.0		+ 0.22	11.41	− 21
	21	.640	+ 0.107	H, *a*	33.5 41.6	0.50	+ 0.87	11.49	− 16
				H, *b*	38.2 41.5		+ 0.36	11.55	− 10
	19 58	.832	+ 0.299	H, *a*	38.2 52.1	0.67	+ 1.60	12.22	− 18
				H, *b*	44.2 52.2		+ 0.94	12.13	− 27
19	15 14	507.635	− 0.151	H, *a*	26.8 42.7	0.57	+ 1.75	12.37	− 3
				H, *b*	31.9 42.9		+ 1.21	12.40	0
	24	.642	− 0.144	Sh, *a*	35.9 48.8	0.36	+ 1.43	12.05	− 35
				Sh, *b*	39.5 48.0		+ 0.95	12.14	− 26
	54	.662	− 0.124	H, *a*	30.5 46.3	0.51	+ 1.74	12.36	− 4
				H, *b*	35.1 46.0		+ 1.20	12.39	− 1
	16 3	.669	− 0.117	Sh, *a*	36.6 51.5	0.44	+ 1.68	12.30	− 10
				Sh, *b*	40.8 51.2		+ 1.21	12.40	0
	31	.688	− 0.098	H, *a*	34.0 47.6	0.39	+ 1.50	12.12	− 28
				H, *b*	37.6 47.4		+ 1.08	12.27	− 13
	42	.696	− 0.090	H, *a*	32.5 46.8	0.49	+ 1.58	12.20	− 20
				H, *b*	36.9 46.8		+ 1.09	12.28	− 12
	52	.703	− 0.083	H, *a*	33.7 49.1	0.51	+ 1.70	12.32	− 8
				H, *b*	38.5 49.2		+ 1.21	12.40	0
	17 2	.710	− 0.076	H, *a*	33.1 48.1	0.55	+ 1.65	12.27	− 13
				H, *b*	38.2 48.3		+ 1.13	12.32	− 8
	26	.726	− 0.060	H, *a*	33.1 48.6	0.54	+ 1.71	12.33	− 7
				H, *b*	38.1 48.6		+ 1.17	12.36	− 4
	39	.735	− 0.051	H, *a*	31.8 48.6	0.59	+ 1.85	12.47	+ 7
				H, *b*	37.2 48.7		+ 1.27	12.46	+ 6
	49	.742	− 0.044	H, *a*	32.7 49.0	0.55	+ 1.80	12.42	+ 2
				H, *b*	37.8 48.8		+ 1.23	12 42	+ 2
20	15 6	508.629	− 0.057	H, *a*	28.6 46.4	0.55	+ 1.96	12.58	+ 18
				H, *b*	33.5 46.8		+ 1.46	12.65	+ 25
	18	.638	− 0.048	H, *a*	27.0 46.4	0.68	+ 2.14	12.76	+ 36
				H, *b*	33.1 46.6		+ 1.49	12.68	+ 28
	31	.646	− 0.040	H, *a*	28.6 44.5	0.63	+ 1.75	12.37	+ 5
				H, *b*	34.3 44.4		+ 1.11	12.30	− 2

Date	G.M.T.	Julian Day	Phase	Obs. Star	Readings		$b-a$	Δm	Mag.	O − C
1909, July 20	$15^h\ 43^m$	2418508.655	− 0.031	H, *a*	29.1	44.0	+0.51	+ 1.65	12.27	+ 37
				H, *b*	33.6	43.6		+ 1.10	12.29	+ 39
	56	.664	− 0.022	H, *a*	30.6	38.4	0.65	+ 0.85	11.47	+ 7
				H, *b*	36.5	38.1		+ 0.17	11.36	− 4
	16 5	.670	− 0.016	H, *a*	29.3	34.1	0.65	+ 0.54	11.16	− 5
				H, *b*	35.1	34.1		− 0.11	11.08	− 13
	10	.674	− 0.012	H, *b*	34.4	34.2		− 0.02	11.17	+ 8
	14	.676	− 0.010	H, *b*	35.2	34.5		− 0.08	11.11	+ 7
Oct. 2	13 32	582.564	+ 0.013	Sh, *a*	30.6	34.7	0.65	+ 0.46	11.08	+ 8
				Sh, *b*	36.5	35.8		− 0.07	11.12	+ 12
	41	.570	+ 0.019	Sh, *a*	29.8	35.1	0.79	+ 0.59	11.21	+ 15
				Sh, *b*	36.9	35.1		− 0.20	10.99	− 7
	14 2	.585	+ 0.034	Sh, *a*	30.4	35.5	0.72	+ 0.58	11.20	+ 1
				Sh, *b*	36.8	35.6		− 0.13	11.06	− 13
3	13 33	583.565	+ 0.113	Sh, *a*	31.6	42.6	0.57	+ 1.21	11.83	+ 15
				Sh, *b*	36.7	43.0		+ 0.69	11.88	+ 20
1910, July 26	18 12	879.758	− 0.025	Sh, *b*	44.2	46.4		+ 0.24	11.43	− 7
	18	.762	− 0.021	Sh, *b*	42.5	44.1		+ 0.18	11.37	+ 1
	25	.767	− 0.016	Sh, *b*	44.1	43.7		− 0.04	11.15	− 6
	29	.770	− 0.013	Sh, *b*	41.7	41.2		− 0.06	11.13	+ 3
	34	.774	− 0.009	Sh, *b*	42.4	41.0		− 0.17	11.02	+ 2
	44	.781	− 0.001	Sh, *b*	44.4	41.9		− 0.28	10.91	+ 5
	53	.787	+ 0.004	Sh, *b*	43.7	39.9		− 0.44	10.75	− 15
	58	.790	+ 0.007	Sh, *b*	43.6	39.8		− 0.44	10.75	− 19
	19 12	.800	+ 0.017	Sh, *b*	44.8	43.7		− 0.12	11.07	+ 3
	25	.809	+ 0.026	Sh, *b*	46.0	45.6		− 0.04	11.05	− 7
27	15 41	880.653	− 0.031	Sh, *b*	43.4	45.5		+ 0.24	11.43	− 47
	48	.658	− 0.026	Sh, *b*	43.0	44.6		+ 0 18	11.37	− 22
	59	.666	− 0.018	Sh, *b*	43.8	44.1		+ 0.03	11.22	+ 5
	16 5	.670	− 0.014	Sh, *b*	43.4	42.7		− 0.08	11.11	− 3
	10	.674	− 0.010	Sh, *b*	43.7	42.2		− 0.18	11.01	− 3
	19	.680	− 0.004	Sh, *b*	44.7	42.3		− 0.27	10.92	+ 2
	26	.685	+ 0.001	Sh, *b*	48.3	44.8		− 0.39	10.80	− 6
	31	.688	+ 0.004	Sh, *b*	49.8	46.7		− 0.36	10.83	− 7
	40	.694	+ 0.010	Sh, *b*	46.4	44.0		− 0.26	10.93	− 4
	17 27	.727	+ 0.043	Sh, *b*	45.5	46.5		+ 0.10	11.29	+ 2
Sept. 11	15 28	926.644	+ 0.019	Sh, *a*	42.8	45.9		+ 0.34	10.96	− 10
16	13 49	931.576	− 0.003	Sh, *a*	43.0	45.4		+ 0.26	10.88	0
	52	.578	− 0.001	Sh, *a*	43.6	45.7		+ 0.23	10.85	− 1
	57	.581	+ 0.002	Sh, *a*	42.7	46.4	0.81	+ 0.41	11.03	+ 16
				Sh, *b*	49.8	46.4		− 0.40	10.79	− 8

Date	G.M.T.	Julian Day	Phase	Obs. Star	Readings	$b-a$	Δm	Mag.	O-C
1910, Sept. 16	14h 1m	2418931.584	+0d.005	Sh, *a*	43.3 47.2		+0m.43	11m.05	+14
	5	.587	+0.008	Sh, *b*	50.3 47.7		−0.32	10.87	−8
	10	.590	+0.011	Sh, *a*	44.6 48.2		+0.39	11.01	+3
				Sh, *b*	50.9 48.4	+0m.73	−0.31	10.88	−10
	17	.595	+0.016	Sh, *a*	43.1 48.0		+0.54	11.16	+13
	23	.599	+0.020	Sh, *a*	43.7 48.6	0.68	+0.54	11.16	+11
				Sh, *b*	49.7 48.4		−0.16	11.03	−4
	28	.603	+0.024	Sh, *a*	44.5 50.1		+0.64	11.26	+16
	47	.616	+0.037	Sh, *a*	43.9 51.5	0.87	+0.88	11.50	+28
				Sh, *b*	51.4 51.8		+0.05	11.24	+2
	15 36	.650	+0.071	Sh, *a*	44.8 55.7		+1.30	11.92	+46
17	13 19	932.555	+0.075	Sh, *a*	44.6 55.3		+1.28	11.90	+42
27	13 5	942.545	−0.294	Sh, *a*	40.2 52.5	0.56	+1.44	12.06	+13
				Sh, *b*	45.1 52.3		+0.86	12.05	+12
	14	.551	−0.288	Sh, *b*	46.2 55.1		+1.08	12.27	+30
	24	.558	−0.281	Sh, *a*	42.4 52.6	0.48	+1.19	11.81	−20
				Sh, *b*	46.7 52.8		+0.74	11.93	−8
	32	.564	−0.275	Sh, *b*	47.6 53.4		+0.71	11.90	−15
	56	.581	−0.258	Sh, *a*	43.7 54 7	0.47	+1.30	11.92	−25
				Sh, *b*	48.0 54.8		+0.85	12.04	−13
	14 27	.602	−0.237	Sh, *b*	48.2 54.9		+0.84	12.03	+31
29	13 8	944.547	−0.093	Sh, *a*	42.1 56.4	0.54	+1.70	12.32	−8
				Sh, *b*	46.9 56.0		+1.11	12.30	−10
	25	.559	−0.081	Sh, *a*	42.7 54.4	0.47	+1.39	12.01	−39
				Sh, *b*	46.9 54.9		+0.98	12.17	−23
	34	.565	−0.075	Sh, *a*	41.8 54.7	0.66	+1.52	12.14	−26
				Sh, *b*	47.7 55.3		+0.94	12.13	−27
	43	.572	−0.068	Sh, *b*	48.1 54.9		+0.85	12.04	−36
	48	.575	−0.065	Sh, *b*	48.8 55.4		+0.82	12.01	−39
	14 0	.583	−0.057	Sh, *b*	49.0 54.2		+0.65	11.84	−56
	4	.586	−0.054	Sh, *b*	47.9 54.4		+0.81	12.00	−40
	21	.598	−0.042	Sh, *b*	48.1 55.3		+0.90	12.09	−26
	37	.609	−0.031	Sh, *b*	48.8 53.8		+0.62	11.81	−9
	41	.612	−0.028	Sh, *b*	48.2 52.2		+0.50	11.69	−3
	44	.614	−0.026	Sh, *b*	48.0 50.7		+0.33	11.52	−5
	49	.617	−0.023	Sh, *b*	48.8 51.1		+0.28	11.47	+2
	53	.620	−0.020	Sh, *b*	46.9 47.5		+0.07	11.26	−8
	15 0	.625	−0.015	Sh, *b*	47.5 46.9		−0.07	11.12	−4
	6	.629	−0.011	Sh, *b*	48.1 46.8		−0.14	11.05	−2
	12	.633	−0.007	Sh, *b*	48.6 45.8		−0.31	10.88	−8
	15	.635	−0.005	Sh, *b*	48.4 45.1		−0.37	10.82	−9

Date	G.M.T.	Julian Day	Phase	Obs. Star	Readings	$b-a$	Δm	Mag.	O − C
1910, Sept. 30	$12^h\ 52^m$	2418945.536	$-0^d.005$	Sh, *a*	41.1 45.3		$+0^m.48$	$11^m.10$	+ 19
	56	.539	− 0.002	Sh, *a*	39.9 43.4		+ 0.40	11.02	+ 14
	13 0	.542	+ 0.001	Sh, *b*	47.0 44.6		− 0.26	10.93	+ 7
	4	.544	+ 0.003	Sh, *b*	46.4 44.5		− 0.21	10.98	+ 9
	7	.547	+ 0.006	Sh, *a*	41.9 44.6		+ 0.31	10.93	0
	14	.551	+ 0.010	Sh, *a*	41.5 44.6		+ 0.36	10.98	0
				Sh, *b*	46.3 44.9	$+0^m.54$	− 0.15	11.04	+ 6
	20	.556	+ 0.015	Sh, *b*	48.1 46.9		− 0.13	11.06	+ 4
	27	.560	+ 0.019	Sh, *a*	43.0 47.0		+ 0.44	11.06	0
				Sh, *b*	46.9 47.2	0.43	+ 0.03	11.22	+ 16
	15 2	.626	+ 0.085	Sh, *a*	40.8 50.0		+ 1.06	11.68	+ 15
				Sh, *b*	45.8 50.2	0.57	+ 0.51	11.70	+ 17

each observation consisting of four settings upon the variable and four upon the comparison star so arranged as to minimize the effects of changes in the transparency of the atmosphere and in the brightness of the artificial star. In addition, on five nights the star was observed when no measures were made because the condition of the sky was such that the variable, then in minimum, was too faint for satisfactory measurements. When in minimum it is but little more than visible under favorable conditions, and on six of the 29 nights was not measurable some of the times the field was looked up. It is fainter than the twelfth magnitude during one-half of the period and the measures then made are affected by much larger errors than those made during the brighter part of the interval.

The measures were made by three different observers. Professor Seares secured 23 observations on the nights of August 1, and 5, 1908. Observations made by Mr. Haynes extend from August 1, 1908, to July 20, 1909, and are 174 in number. The remainder were obtained by me, nearly all of which were made after October 2, 1909. The entire observing interval extends from August 1, 1908, to September 30, 1910.

The observational data and certain parts of the reduction are in Table I. The general arrangement of this table follows closely that of tables of observations in former Bulletins. The phase values refer to the nearest geocentric maximum given by the final elements, and are positive for decreasing light. The initial of the observer and the comparison star used are in column five. The measured magnitude of the variable at the time of every observation is in column nine and is secured by applying to the adopted magnitudes of the comparison stars the Δm of column eight which is derived from the wedge readings.

The comparison star *a* is BD.$-0°3313$, $9^m.5$. Its magnitude was determined by reference to a star of the *Potsdam Durchmusterung*, *s* = BD.$+0°3709$, $6^m.8$. The Potsdam magnitude of the

star *s* is $6^m.88$. The mean of six concordant observations on three different nights gave $3^m.74$ for the difference *a*—*s*, and, as the relative positions of the two stars at the times of observation made corrections for differential absorption unnecessary, the value $10^m.62$ was adopted as the

TABLE II

EPOCHS OF OBSERVED MAXIMA

E	Obs. Geoc. Epochs	Red. to Sun	Obs. Helioc. Epochs	O – C
0	8159^d.658	+ 0^d.003	8159^d.661	0^d.000
20	8168.666	+ 0.003	8168.669	+0.001
60	8186.681	+ 0.001	8186.682	—0.001
764	8503.736	+ 0.005	8503.741	+0.004
775	8508.688	+ 0.004	8508.692	+0.001
1599	8879.785	+ 0.004	8879.789	—0.002
1601	8880.684	+ 0.004	8880.688	0.000
1714	8931.575	0.000	8931.575	—0.004
1743	8944.639	— 0.001	8944.638	—0.001
1745	8945.544	— 0.001	8945.543	+0.003

TABLE III

REDUCTION TO THE SUN

Date	Red.	Date	Red.	Date	Red.
Jan. 0	— 0^d.0050	Apr. 30	+ 0^d.0040	Aug. 28	+ 0^d.0016
10	46	May 10	45	Sep. 7	+ 0.0007
20	41	20	50	17	— 0.0002
30	35	30	53	27	11
Feb. 9	28	June 9	54	Oct. 7	20
19	19	19	54	17	28
Mar. 1	10	29	52	27	35
11	— 0.0001	July 9	49	Nov. 6	42
21	+ 0.0008	19	45	16	46
31	17	29	39	26	50
Apr. 10	25	Aug. 8	32	Dec. 6	52
20	33	18	24	16	52
30	+ 0.0040	28	+ 0.0016	26	— 0.0051

magnitude of *a* to be used in the reductions. The similar comparison of *a* with two BD. stars which are included in the *Revised Harvard Photometry* gave the values $10^m.63$ and $10^m.77$, respectively. Guthnick also used *a* for his comparisons and by reference to several Harvard stars found its

brightness to be $10^m.68$. The comparison star *b* follows the variable about $0^m.8$, and is 8′ north. The observed values of the magnitude difference *b*—*a* are in column seven of Table I. The mean of the 115 values there given is $+0^m.57$, with a probable error of $\pm 0^m.006$. The probable error of a single observation on *b*—*a* is $\pm 0^m.066$. In order to detect if possible any variation in the magnitudes of either of the comparison stars, the residuals referred to the mean value were plotted

TABLE IV

NORMAL PLACES

No.	Phase	Mag.	No. Obs.	O-C	No.	Phase	Mag.	No. Obs.	O-C
1	−0.081	12.26	6	−14	25	+0.022	11.09	7	0
2	−0.076	12.39	6	−1	26	+0.027	11.11	6	−1
3	−0.070	12.40	6	0	27	+0.034	11.22	8	+2
4	−0.066	12.38	4	−2	28	+0.042	11.28	3	+3
5	−0.058	12.29	6	−11	29	+0.057	11.32	8	−4
6	−0.052	12.45	6	+5	30	+0.068	11.45	3	+1
7	−0.046	12.44	7	+4	31	+0.076	11.52	7	+4
8	−0.033	12.30	4	+22	32	+0.081	11.54	8	+3
9	−0.030	11.84	4	0	33	+0.087	11.52	7	−3
10	−0.026	11.51	6	−6	34	+0.107	11.60	6	−4
11	−0.022	11.38	5	−2	35	+0.118	11.70	4	0
12	−0.017	11.28	6	+3	36	+0.130	11.76	2	0
13	−0.014	11.19	8	+4	37	+0.163	12.00	7	+3
14	−0.013	11.10	6	−1	38	+0.174	12.01	7	−3
15	−0.009	11.02	8	0	39	+0.188	12.18	4	+4
16	−0.006	10.92	6	−1	40	+0.206	12.23	4	−5
17	−0.004	10.93	11	+3	41	+0.226	12.39	3	−1
18	−0.001	10.86	6	0	42	+0.294	12.41	8	+1
19	+0.002	10.86	8	−1	43	+0.310	12.28	8	−12
20	+0.004	10.94	8	+4	44	+0.322	12.46	4	+6
21	+0.007	10.94	8	0	45	+0.331	12.45	8	+5
22	+0.010	10.99	5	+2	46	+0.349	12.45	8	+5
23	+0.014	11.03	7	+1	47	+0.360	12.38	8	−2
24	+0.019	11.08	8	+2					

with respect to the time, but no unusual deviation from constancy was found. In like manner the residuals for the individual observers were examined and, although the average residual was rather large, no systematic corrections were considered necessary or advisable. Therefore, the adopted value of the brightness of *b* for the entire series is $11^m.19$.

The period was determined by a consideration of ten maxima. The magnitudes of the variable taken from Table I in the neighborhood of these maxima were plotted and curves were

drawn that seemed best to represent the light change. The geocentric times of maxima were read from the curves and are in the second column of Table II. On account of the relatively low latitude of the star, correction for the equation of light was necessary. The reduction to the sun in column three of Table II was taken from Table III which was computed for this star by means of the formula:

$$Helioc.\ Time - Geoc.\ Time = -497^{s}8\ R\ cos\ B\ cos\ (\lambda_{\odot} - \lambda),$$

where B and λ are the latitude and longitude of the variable, $\lambda_{\odot}$ is the longitude of the sun, and R is

TABLE V

ORDINATES OF THE MEAN LIGHT-CURVE. PHASE FROM MAXIMUM

Phase	Mag.	Phase	Mag.	Phase	Mag.	Phase	Mag.
— 0.048	12.40	+ 0.020	11.07	+ 0.088	11.55	+ 0.156	11.92
0.044	12.40	0.024	11.10	0.092	11.57	0.160	11.95
0.040	12.32	0.028	11.13	0.096	11.59	0.164	11.98
0.036	12.20	0.032	11.17	0.100	11.62	0.168	12.00
0.032	11.95	0.036	11.21	0.104	11.64	0.172	12.03
0.028	11.72	0.040	11.24	0.108	11.65	0.176	12.06
0.024	11.49	0.044	11.27	0.112	11.67	0.180	12.08
0.020	11.34	0.048	11.30	0.116	11.69	0.184	12.12
0.016	11.21	0.052	11.33	0.120	11.71	0.188	12.14
0.012	11.09	0.056	11.35	0.124	11.73	0.192	12.17
0.008	10.99	0.060	11.38	0.128	11.75	0.196	12.20
— 0.004	10.90	0.064	11.41	0.132	11.77	0.200	12.24
0.000	10.85	0.068	11.44	0.136	11.80	0.204	12.27
+ 0.004	10.90	0.072	11.47	0.140	11.82	0.208	12.30
0.008	10.95	0.076	11.49	0.144	11.85	0.212	12.34
0.012	10.99	0.080	11.51	0.148	11.87	0.216	12.37
+ 0.016	11.03	+ 0.084	11.53	+ 0.152	11.90	+ 0.220	12.40

the radius vector of the earth's orbit. The heliocentric times of observed maxima thus derived were given weights ranging from unity to eight, according to the completeness and consistency of the corresponding observations, and a least square solution of the ten equations resulted in the following heliocentric elements:

$$Max. = J.\ D.\ 2418159.661 + 0^{d}.4503604E,\quad G.\ M.\ T.$$

The probable error of the period is ±3 in the last decimal place as written above. The observations of Guthnick were not used in deriving these elements, as the slight extension of the interval,

which would be obtained by including his work in this investigation, would not offset the uncertainty arising from a combination of the two different systems of observing. Neither could the Harvard photographs be used to improve the period, in this case, however, because the interval separating the dates of the photographs and of the photometric observations was too long to permit a definite determination of the epoch. The Julian date and Greenwich mean time of the maximum corresponding to the initial epoch of Guthnick's published elements was computed from the above formula and found to be J. D. 2418088.504, G. M. T. The difference of $0^d.003$ is consistent with the residuals in the last column of Table II. The range of variation determined at the Laws Observatory is $0^m.3$ greater than that observed at Berlin.

To construct the mean light curve the final elements were used to compute epochs of maxima for the entire interval of observations. These epochs were reduced to the center of the earth and

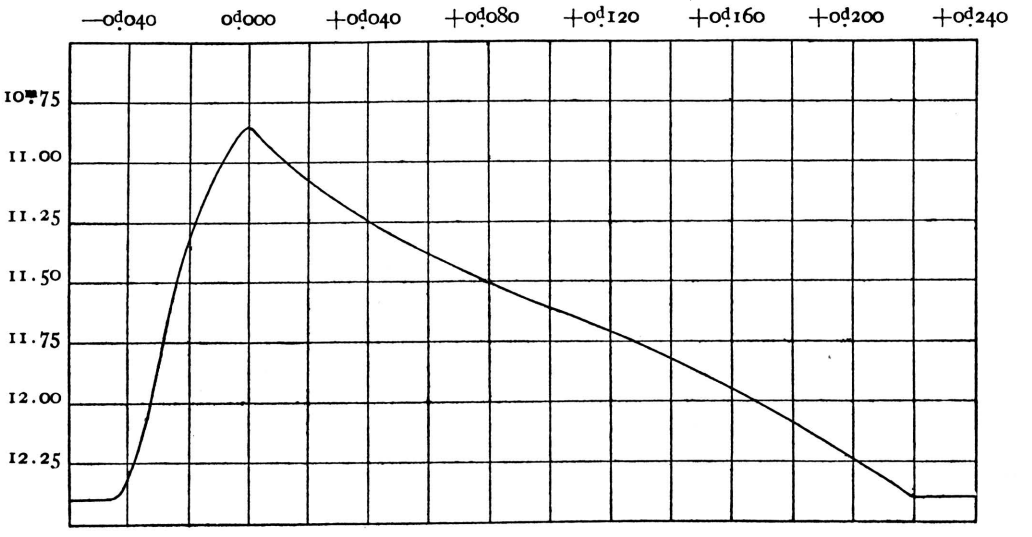

Figure 1. Light Curve for ST Ophiuchi

the phase values in column four of Table I were formed. The observations during changing light were then arranged in order of phase and were combined to form the 47 normal places of Table IV. The mean magnitudes corresponding to the mean phases of these normal places are in columns three and eight, and the number of observations of the respective groups is in columns four and nine of this table. The normal places were plotted and the mean light curve drawn. The residuals in columns five and ten, expressed in hundredths of a magnitude, are referred to this curve. The character of the variation is shown by Figure 1, and in the ordinates of the mean light curve given in Table V for every four-thousandth of a day during changing light. The range is from $12^m.40$ to $10^m.85$, the star at maximum being two tenths of a magnitude fainter than *a*. The ascent from minimum to maximum takes less than sixty-five minutes. For the descent a little more than five hours is required. The light is in constant minimum brightness for $0^d.186$, about two-fifths of the

period. The curve is quite sharp at maximum, but an examination of the residuals of the descending branch in the table of normal places failed to reveal any trace of the irregularity that Guthnick claims to have discovered.

The residuals in the last column of Table I are referred to the mean light curve and are expressed in hundredths of a magnitude. The investigation of them, made for the purpose of showing any differences between odd and even maxima, gave negative results. The average residuals for the different parts of the curve are

Light.	No. Obs'ns.	Av. Resid.
Increasing	72	$0^m.09$
Decreasing	132	0.11
Constant	89	0.17
Changing	204	0.10

The relative sizes during changing and constant light result from the difficulty of making measures during the extremely faint minima. A single abnormal series of measures made during minimum light on the night of August 22, 1908, contributes largely to the magnitude of the average residuals.

The average systematic deviations for the individual observers are

	No. Obs'ns.	Av. Syst. Dev.
Seares	23	$+0^m.001$
Haynes	174	+ 0.021
Shapley	96	− 0.030
All	293	+ 0.003

All the observations on the variable late in the year when the field was low and difficult were made by me. This accounts for my large systematic deviation, for, by excluding the observations made when the field was extremely low, the resulting errors are normal.

Columbia, Missouri, 1911, April 2. *Harlow Shapley.*

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NEW ELEMENTS FOR RW CAMELOPARDALIS

BD.+58°663,8m8, 1855.0 R.A.$3^h42^m31^s5$ Dec.+58° 13′.2
1900.0 46 9 21.6

The variability of this star was detected by Miss Leavitt at the Harvard College Observatory through the inspection of a plate made at Cambridge, February 8, 1904.[1] By making a comparison of the plate with four others of the same field, the period was estimated to be short and the photographic range to be from the ninth to the tenth magnitude. From observations made at Dombaas, Norway, in 1907, Enebo concluded that the period was about 16^d and that the range was at least 1m.2.[2] In 1908 he published 57 observations of the star in the second volume of his *Beobachtungen Veränderlicher Sterne* and derived the following approximate elements:

$$\text{Max.} = 1907 \text{ Oct. } 8 = 2417857^d + 16^d.4E, \text{ G.M.T.}$$

The range of light variation indicated by these observations was less than half a magnitude 8m.48 — 8m.93.

The star has been observed intermittently at the Laws Observatory since the announcement of its discovery in 1907. Nearly 150 observations have been made, the earlier ones by Mr. Haynes and the later ones by me. The Zöllner-Müller photometer was used by Mr. Haynes for the first two sets of measures attributed to him in the accompanying table. The wedge photometer was used for all other measures. The comparison stars are a = BD. + 58°672, 8m.2, and b = BD. + 58°676, 8m.6. The magnitude of a in the A.G. catalogue is 8.5. It is f in the series of comparison stars used at Dombaas, and its A.G. magnitude was adopted by Enebo in determining the limits of variation.

For the investigation of the value of the period, all the observed magnitudes were plotted with respect to the time. Very few maxima or minima were sufficiently observed for a satisfactory reduction, but it was found that a certain part of the descending branch of the light curve was well represented for a number of widely separated epochs. The times during decreasing light for which $v - a = +0^m.35$ were read off from the graphs and are entered in column two of Table VI. Four of the times were obtained from graphs made of Enebo's observations. The first and last epochs observed here were used for a first determination of the period. The resulting preliminary elements are:

$$\text{Desc. Br. } v - a = +0^m.35 = \text{J.D. } 2417862.7 + 16^d.409E, \text{ G.M.T.}$$

To improve the values of initial epoch and period, the weighted residuals in column four of the

[1] Harvard College Observatory Circ. No. 127; A. N. vol. 175, p. 93.

[2] A. N. vol. 176, p. 374.

table, which are referred to the preliminary elements, were used to form eleven equations of condition, the solution of which gave for the revised elements:

$$\text{Desc. Br. } v - a = +0^{m}.35 = \text{J.D. } 2417863.3 + 16^{d}.402E, \text{ G.M.T.}$$

The sum of the squares of the residuals were reduced by this treatment from 6.04 to 2.92. The new set of residuals is in column five. The probable error of the initial epoch is $\pm 0^{d}.1$, and of the period, $\pm 0^{d}.004$. By plotting all the observations, referred to a common phase value, a mean

TABLE VI

EPOCHS FOR WHICH $v - a = +0^{m}.35$, DECREASING LIGHT

Epoch	Observed G.M.T.	Wt.	O − C	O − C_1	Observer
0	2417862^{d}.2	1	−0^{d}.5	−1^{d}.1	Enebo
0	7862.7	1	0.0	−0.6	Haynes
3	7912.6	1	+0.7	+0.1	Enebo
5	7945.4	1	+0.7	+0.1	"
5	7945.8	1	+1.1	+0.5	Haynes
8	7994.9	1	+0.9	+0.4	"
9	8011.0	2	+0.6	+0.1	"
10	8027.8	1	+1.0	+0.5	Enebo
20	8192.1	1	+1.2	+0.7	Haynes
32	8387.8	1	0.0	−0.4	Shapley
76	9109.8	2	0.0	−0.1	"

light curve was obtained that indicates the maximum precedes by $5^{d}.9$ the time for which $v - a = +0^{m}.35$ on the descending branch. Applying this value to the above elements, we have finally:

$$\text{Max.} = \text{J.D. } 2417857.4 + 16^{d}.402E, \text{ G.M.T.}$$

Except in the matter of depth, the curve given by Enebo accurately represents the light change.[1] The variation is continuous, and maxima and minima are about equally sharp. For increasing light $6^{d}.8$ are required. At maximum the variable is $0^{m}.04$ brighter than a, and at minimum is $0^{m}.66$ fainter.

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[1] Beobachtungen Veränderlicher Sterne, vol. 2, p. 56.

Columbia, Missouri, 1911, April 24. *Harlow Shapley.*

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