3. There is some evidence of a rhythmic arrangement of the stars, which makes their co-ordinates multiples of some unit interval.

[*Note added Jan. 29.*—On reading the proof it was felt that perhaps the best condition to look for was that the short axis should be perpendicular to the direction of motion. Making trial, the co-ordinate $Z_1 - 0.3Y_1$ divides Table II. into two well-separated groups (omitting only star 20); and the inclination to the motion is now 70° . The co-ordinate $Z_1 + 0.2X_1$ gives for Table III. a very flat cluster, except for stars 12 and 14, and the inclination is sensibly 90° . It was also noticed that the range in ζ in Table I. would have been further reduced if the rotation round the axis of y had been taken as 11° instead of 15° .]

*Note on Changes in the Period and Light-curve of the Cluster
Variable SW Andromedæ. By Harlow Shapley.*

1. Non-uniformity of period, similar to that of the star Bailey No. 33 in Messier 5 discussed by Professor Turner in *Monthly Notices*, 1920 May, p. 640, appears also to be a property of the isolated cluster variable SW Andromedæ for which observations and light elements are published by Martin and Plummer in *Monthly Notices*, 1919 Dec., p. 212. The elements given by Martin and Plummer,

$$\text{Max.} = \text{J.D. } 2422\ 227.411 + 0.441848\ \text{E},$$

are based upon a series of observations extending over three months in 1919 and an earlier epoch of maximum. The almost identical provisional period by Seares,*

$$\text{Max.} = \text{J.D. } 2418\ 132.805 + 0.44185\ \text{E},$$

is based upon observations on six nights by Seares and Haynes in 1908 July. Both of these periods fit their respective series of observations extremely well; but apparently other values would also represent the observed maxima within the irregularities now found to exist (cf. section 6, and fig. 1).

2. In 1908 August observations † by Haynes showed that the published period was incorrect in the fourth decimal place (or had changed); and my observations † at the Laws Observatory fourteen months later indicated that the maxima were probably falling one whole period later than the predicted times. My observations at Princeton in 1913–14 gave maxima deviating from two to five hours from the times predicted by Seares' provisional elements, and they also showed an oscillation in the time of rise from minimum to maximum light.‡

* *Laws Observatory Bulletin*, No. 16, 1908 Aug. 3.

† Unpublished. See Table II. below.

‡ *Publications of the American Astronomical Society*, 3, 16, 1914.

In view of the importance, for considerations of the sources of stellar radiation, of changes in the periods and light-curves of cluster and Cepheid variables, the available data on SW Andromedæ are briefly presented below, although they do not approach in completeness or homogeneity the material derived by Barnard* for the variable Bailey No. 33 in Messier 5.

3. Table I. contains the Princeton observations, made with a polarising photometer attached to the 23-inch refractor. B.D. + 28°53' was used as comparison star; its photographic magnitude is 10.42 according to Martin and Plummer.

TABLE I.
Princeton Observations of SW Andromedæ.

Date.	J.D., G.H.M.T.	<i>v-a.</i>	Date.	J.D., G.H.M.T.	<i>v-a.</i>	Date.	J.D., G.H.M.T.	<i>v-a.</i>
1913	2420000+		1913	2420000+		1913	2420000+	
Oct. 31	072.468	+0.90	Nov. 4	076.580	+0.27	Dec. 5	107.559	+0.12
	.476	0.82		.587	0.26		.570	0.08
	.483	0.98		.594	0.00			
	.491	0.87		.601	0.01	Dec. 13	115.486	0.71
	.504	0.90		.616	-0.16		.494	0.45
	.512	0.97		.625	+0.04		.502	0.28
	.522	0.96					.512	0.12
	.535	1.01	Nov. 6	078.458	0.29		.520	0.06
	.542	0.94		.466	0.42		.528	0.04
	.550	1.04		.472	0.42		.536	0.12
				.480	0.49		.542	0.06
Nov. 1	073.527	0.13		.487	0.50			
	.534	0.09		.530	0.65	1914		
	.542	0.26		.538	0.68	Feb. 9	173.469	0.15
	.550	0.33					.477	-0.04
	.557	0.14	Nov. 11	083.453	0.69		.523	+0.28
	.569	0.17		.462	0.71		.537	0.28
	.576	0.32		.471	0.81			
	.582	0.35				Feb. 12	176.530	0.54
	.590	0.29	Nov. 24	096.446	1.02		.548	0.25
	.596	0.48		.459	0.75			
	.622	0.47		.471	0.56	Feb. 16	180.520	0.19
				.478	0.39		.528	0.03
Nov. 4	076.530	0.92		.528	0.01		.538	-0.13
	.537	0.97					.549	+0.03
	.544	0.87	Dec. 5	107.524	0.72			
	.552	0.86		.532	0.51	Feb. 24	188.482	0.25
	.562	0.69		.540	0.40		.492	-0.09
	.570	0.48		.550	0.21		.502	+0.01

* *Publications of the American Astronomical Society*, 4, 76, 1919.

Table II. contains a list of all maxima clearly deducible from the observations. In general they are not accurately determined beyond the second decimal place. The first six maxima were published by Seares (*loc. cit.*). All times are heliocentric, and reduced to Greenwich. The four times of maximum given without observational detail by Yendell in *Astronomical Journal*, 29, 99, 1916, are not used, for though contemporary with the Princeton work they disagree widely; in fact, they agree excellently with the predicted times from Seares' provisional elements which were then used in Hartwig's ephemeris for the prediction of maxima.

The residuals in Table II., $O - C_1$ and $O - C_2$, in thousandths of a day, are computed from elements (1) and (2) below; the letters in the fourth column designate the observers, Haynes, Seares, Shapley, and Martin and Plummer.

TABLE II.

Observed Maxima of SW Andromedæ.

Observed Maximum.	Wt.	$O - C_1$.	$O - C_2$.	Obs.	Observed Maximum.	Wt.	$O - C_1$.	$O - C_2$.	Obs.
2418132.802	3	- 6	+ 8	H	2420076.612	4	- 19	- 13	Sh
133.685	1	- 7	+ 7	H	096.513	2	- 16	- 10	Sh
147.828	4	- 14	0	S & H	107.577	2	- 7	- 1	Sh
148.703	3	- 23	- 9	S & H	115.530	3	- 13	- 7	Sh
150.921	3	- 16	- 2	H	173.477	3	+ 8	+ 14	Sh
151.810	2	- 11	+ 2	S & H	180.537	4	- 7	- 1	Sh
171.726	2	+ 7	+ 20	H	188.500	2	- 3	+ 3	Sh
175.681	3	- 18	- 5	H	2227.412	2	+ 17	+ 15	M & P
586.585	2	+ 101	+ 113	Sh	2258.347	4	- 1	- 3	M & P
617.528	2	+ 91	+ 103	Sh					

4. For the derivation of a mean period, the observations are grouped by twos and threes in Table III. A least squares solution gives the following heliocentric elements and probable errors:

$$\text{Max.} = \text{J.D. } 2420076.631 (\pm 0.008) + 0.4421801 E (\pm 0.0000024) \quad (1)$$

The residuals $O - C_1$ in Tables II. and III. are unsatisfactory.

Omitting the 1909 observations from the solution, we derive:

$$\text{Max.} = \text{J.D. } 2420076.625 (\pm 0.002) + 0.4421818 E (\pm 0.0000005) \quad (2)$$

TABLE III.

Mean Maxima used in Solution.

Date.	Maximum.	Wt.	E.	$O - C_1$.	$O - C_2$.
1908 July 10	2418133.686	4	- 4394	- 5	+ 8
25	148.708	7	- 4360	- 18	- 4
28	151.807	5	- 4353	- 14	- 1
Aug. 21	175.691	5	- 4299	- 8	+ 5
1909 Nov. 6	617.533	4	- 3300	+ 96	(+ 108)
1913 Nov. 4	2420076.613	6	0	- 18	- 12
Dec. 13	115.533	5	+ 88	- 10	- 4
1914 Feb. 16	180.543	9	+ 235	- 1	+ 5
1919 Oct. 26	2422258.353	6	+ 4864	+ 5	+ 3

5. Although the period differs in the fourth decimal place from the values given by Seares, and by Martin and Plummer, the elements (2) represent all the maxima, except two, with an average deviation of less than ten minutes, and are probably the best for future prediction. A uniform mean period might be

FIG. 1.—Visual observations of SW Andromedæ. *Above*: Maxima of 1909 Oct. 6 and Nov. 6, by Shapley. *Below*: Ascending branch of the maxima of 1908 July 24, 25, 27, 28, Aug. 17, 21 (in order), by Seares and Haynes. The broken line is the mean curve.

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adopted except for the observations made in 1909, but there appears to be no reason to doubt their testimony of a change. They are given in Table IV., and plotted in the upper part of fig. 1 as an illustration of diversity in shape of maxima a month apart. Better illustrations of the variations in shape of the maxima of such stars are given in *Mount Wilson Contributions*, Nos. 104 and 112, for XX Cygni and RR Lyræ.

TABLE IV.
Observations of SW Andromedæ in 1909.

Date.	Time.	Δ_m
	d	
Oct. 6	2418586.561	0.54
	.568	0.42
	.572	0.28
	.586	0.12
	.618	0.46
	.682	0.72
Nov. 6	2418617.512	0.48
	.524	0.36
	.536	0.31
	.542	0.36
	.551	0.37
	.567	0.50
	.609	0.62
	.741	0.56

6. But, in addition to the slow change of period found above, there appears to be good evidence of a short-period or irregular oscillation in the time of maximum. This irregularity is best shown, however, not in the maximum light itself, but in the more accurately measured rise to maximum light. To illustrate the peculiarity, to which I have frequently called attention for other cluster variables,* the individual observations by Seares and Haynes, which have been placed at my disposal, are plotted for the rising branch of the curve in the lower part of fig. 1 for six maxima (third to eighth, inclusive, of Table II.).

The deviations from the mean curve (broken line) considerably exceed the possible systematic errors. Obviously a strictly uniform period cannot satisfy the observations, even over an interval of less than four weeks.

7. A similar oscillation in the time of rise to maximum light has been found and illustrated for the cluster variable RR Lyræ.† Its period also has a slow variation in a cycle of possibly sixteen

* *Mount Wilson Contrib.*, No. 92, 1914; 104, 1915; 112, 1916; 159, 1918.

† *Publications of the American Astronomical Society*, 3, 16, 1914; *Mount Wilson Contrib.*, No. 112, fig. 4, 1916.

years. If in these stars the cycle of the slow variation is proportional to the period itself, then the indication of a secular decrease in the period of δ Cephei, discussed by Eddington* and Hertzsprung,† may be only one phase of a cyclic phenomenon with a period of one or two centuries, rather than a suggestion of the measurable decay of Cepheid variation.

Mount Wilson Observatory:
1920 September.

Note on the Cluster N.G.C. 6633. By W. J. Luyten.

(Communicated by the Astronomer Royal.)

During the summer of 1920 a few plates were taken of the star cluster *N.G.C. 6633* for the purpose of measuring the positions of its stars, and, by comparing with older measures, deriving proper motions in the cluster itself, if possible.

Four plates were obtained, each with three exposures of about two minutes on Ilford Empress plates. In the case of two of the plates a diffraction grating was placed in front of the objective in order to get rid of a magnitude equation in the measures. A réseau was printed on the plates in the usual way, and they were measured in the Greenwich astrographic micrometer.

One plate was chosen as standard and the others reduced to it by means of linear corrections $ax + by + c$ and $dx + cy + f$. All the plates having been obtained on or near the meridian, and the corrections for second order terms of refraction and aberration therefore being very small (well under $0''.01$), no correction for these has been applied. For this reduction all the stars measured on each plate were used, and the mean of the final values taken; from the deviations of this mean the mean error was computed, and found to be equal to $0''.030$ in R.A. and $0''.032$ in Dec.

The final values thus obtained are tabulated below; the first two columns give the number and magnitude according to Valentiner (*Beob.*, Mannheim, iii.); the third and seventh columns the X and Y in réseau intervals of the 26-inch refractor, one unit roughly corresponding to $151''$.

To see whether there is any proper motion in the cluster itself, these results were compared with Nijland's measures on photographic plates (*Inaug. Dissert.*, Utrecht). To his co-ordinates (pp. 95-96) were applied his corrections for refraction, and the results converted into rectangular co-ordinates on the 26-inch scale. The X and Y thus obtained were corrected for difference in scale (it was tacitly assumed that the cluster had not sensibly altered its distance from us in the time between the two observations), orientation, and zero-point, the values of the six constants

* *Observatory*, 42, 338, 1919.

† *Astronomische Nachrichten*, 210, 17, 1919.