SV VULPECULAE

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1. The variable star SV Vulpeculae[1] is of particular interest as a Cepheid with the unusually long period of 45.2 days. Three significant problems presented by this star are:

a. Whether a Cepheid of so long a period shows slight deviations from strict periodicity, or transitory fluctuations in the form of its light curve. The existing observational material is rather unsuitable for the detection of such irregularities, for which photoelectric observations are necessary.

b. Whether a progressive increase in period exists, as suggested by Kukarkin.[2]

c. The possibility of a phase shift between the photographic and visual light curves.

2. To investigate these last two points, the magnitude of SV Vulpeculae has been estimated on 595 plates taken in 1933–40 with the 3-inch Ross astrographic camera of the Warner and Swasey Observatory. Each plate was estimated at least twice; the probable error of a single observation is $\pm 0^m.055$. The adopted magnitudes on the International System for the comparison stars are given in Table I. The sequence depends on 7 double exposure plates of Field and Kapteyn Selected Area 64, and 4 double exposure plates of Field and North Polar Sequence. The probable error of a sequence magnitude is $\pm 0^m.02$.

TABLE I. COMPARISON STARS FOR SV VULPECULAE

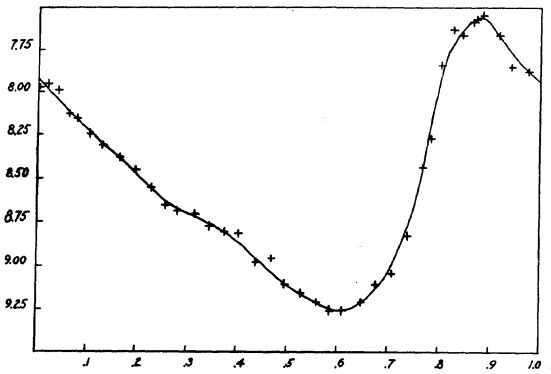
BD	m_{pg}
+26°3678	7.29
26 3704	8.35
27 3539	8.72
27 3530	9.20
26 3681	10.20

TABLE II. PHOTOGRAPHIC MEAN LIGHT CURVE OF SV VULPECULAE

φ	m_{pg}	n	φ	m_{pg}	n
P			P		
0.0030	7.98	24	0.5256	9.16	13
.0232	7.95	19	.5561	9.21	6
.0423	7.99	12	.5841	9.27	28
.0610	8.13	8	.6102	9.26	20
.0844	8.15	10	.6468	9.21	17
.1046	8.25	9	.6742	9.12	15
.1337	8.29	18	.7062	9.04	19
.1663	8.37	13	.7364	8.83	14
.1957	8.45	12	.7621	8.43	6
.2255	8.55	18	.7783	8.27	14
.2550	8.66	19	.8009	7.84	15
.2815	8.69	28	.8222	7.63	8
.3162	8.71	14	.8406	7.67	16
.3456	8.77	8	.8614	7.58	15
.3728	8.81	20	.8788	7.55	22
.4030	8.83	12	.9153	7.67	19
.4378	8.98	13	.9401	7.85	27
.4650	8.96	8	.9723	7.87	47
.4946	9.11	17			

3. The mean light curve of SV Vulpeculae during the years 1933–40 is defined by the normal points listed in Table II. Each normal place rests on a mean of 16 observations, and consequently has an internal probable error of $\pm 0^m.014$. The phases were calculated from the formula

$$\phi = (\text{J.D.} - 2427000)\,(45^d.1631)^{-1} \qquad (1)$$



THE MEAN LIGHT CURVE OF SV VULPECULAE

The characteristics of the mean light curve are Maximum = $7^m.55$, Minimum = $9^m.26$, Amplitude = $1^m.71$, $(M - m)/P = 0.265$. The form of the light curve is closely similar to that found by Gerasimovič[3] from Harvard plates of 1898–1922. It resembles those of T Monocerotis,[4] $P = 27^d.0$ and *l* Carinae,[5] $P = 35^d.5$, but is unlike the more nearly symmetrical curve of Y Comae Berenices,[6] $P = 43^d.4$. The last named star, which has been little observed, is perhaps not a Cepheid, but may be an analogue to Z Leonis.

4. The period of SV Vulpeculae was determined by two methods from the present material. From a plot of single observations, the 8 best maxima give a period and its probable error of $45^d.1631 \pm 0^d.0071$. Secondly, the period was determined from 25 epochs of passage through $8^m.00$ on the ascending branch of the light curve. For this purpose, the times of all observations on the linear part of the ascending branch were reduced to those of $8^m.00$ with the aid of the mean light curve. A least-squares solution from the 25 epochs gave the period and its probable error as $45^d.1535 \pm 0^d.0050$.

These periods may be compared with the value $45^d.1715 \pm 0^d.0040$ for mean epoch 1927 found by Nielsen from all visual estimates, and with the periods $45^d.146$ and $45^d.160$ for mean epoch 1913, found by Gerasimovič from maxima and minima respectively. The suspected progressive increase in period is therefore not acceptable.

5. Nielsen[7] has derived epochs of maximum by Hertzsprung's method from all series of observations up to 1937. The epoch of maximum has been determined from the present

mean light curve by NIELSEN's procedure to be J.D. 2428077.68. In his notation, $n = 595$, $k = 0.61$, $\epsilon_1 = \pm 0^m.082$, $\mu = \pm 0^P.0007$. From this epoch, and from the photographic epochs of GERASIMOVIČ and NASSAU-TOWSON as determined by NIELSEN, a least-squares solution gives the elements

$$\text{Max.} = 2424916.53 + 45.1617 \cdot E \qquad (2)$$
$$\pm .13 \quad \pm .0016 \quad \text{(p.e.)}$$

On comparison with NIELSEN's elements

$$\text{Max.} = 2424917.05 + 45^d.1715 \cdot E \qquad (3)$$
$$\pm .08 \quad \pm .0040 \quad \text{(p.e.)}$$

found from visual observations, it is seen that the photographic epoch precedes the visual by $0^P.012 \pm 0^P.003$. This value is independent of any errors in the periods, because of the fortunate coincidence of the midtimes of the photographic and the visual observations. The existence of this color equation is rendered more probable by the general agreement with the results from ζ Geminorum. For the latter NIELSEN[8] found that the photographic and photoelectric maximum preceded the visual maximum by $0^P.023 \pm 0^P.004$. HALL[9] showed that the maximum at λ 7400 followed the visual maximum by $0^P.024$.

6. NIELSEN's elements fail to represent the present normal maximum, for which $O - C = -1^d.37$ for $E = +70$. Fresh elements have therefore been determined for SV Vulpeculae. Since NIELSEN's period and the period given by (2) are independent, their weighted mean may be taken, forming elements (5):

$$M = 2424917.05 + 45^d.1630 \cdot E + \phi(\lambda) \qquad (5)$$
$$\pm .08 \quad \pm .0015 \quad \text{(p.e.)}$$

where $\phi(\lambda)$ is $0^d.00$ for visual and $-0^d.52 \pm 0^d.15$ for photographic observations.

It is well to calculate in addition new elements, using photographic and visual epochs indiscriminately. Assigning equal weights to the normal epochs listed in Table 3, elements (6) were obtained by a least-squares solution:

$$M = 2424916.91 + 45^d.1636 \cdot E \qquad (6)$$
$$\pm .09 \quad \pm .0019 \quad \text{(p.e.)}$$

Table III shows the representation of the normal maxima by NIELSEN's elements, elements (5), and (6) as $(O - C)_1$, $(O - C)_2$, and $(O - C)_3$ respectively. The first ten epochs were determined by NIELSEN by HERTZSPRUNG's method, and are taken directly from his paper.[7]

TABLE III. REPRESENTATION OF NORMAL MAXIMA OF SV VULPECULAE

No.	Observer	n	E	J. D. Max. (observed)	$(O-C)_I$	$(O-C)_2$	$(O-C)_3$
					d	d	d
1	Gerasimovič	669 pg	-111	2419903.52	+0.51	+0.08	-0.23
2	Leiner	202 vis	- 29	2423606.82	-0.26	-0.51	-0.35
3	Nielsen	231 vis	- 17	4148.90	-0.23	-0.38	-0.23
4	Zacharov	389 vis	- 15	4239.44	-0.04	-0.17	-0.02
5	Beyer	409 vis	- 3	4782.04	+0.51	+0.48	+0.62
6	Leiner	246 vis	+ 2	5007.83	+0.43	+0.45	+0.59
7	Ahnert	319 vis	+ 4	5097.64	-0.09	-0.06	+0.08
8	Nassau-Towson	144 pg	+ 25	6045.82	-0.52	+0.21	-0.18
9	Kukarkin	139 vis	+ 30	6271.83	-0.36	-0.11	+0.01
10	Nielsen	278 vis	+ 32	6362.56	+0.02	+0.26	+0.41
11	Nassau-Ashbrook	595 pg	+ 70	8077.68	-1.38	-0.16	-0.68
				Σv^2	3.14	1.03	1.63

Summary: A sequence for SV Vulpeculae has been determined on the International System. The mean light curve has been obtained from 595 new photographic observations. There is reason for believing that the photographic light curve precedes the visual by about a half a day. New elements have been determined with (5) and without (6) consideration of this color equation.

REFERENCES

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