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47.

LIGHT CURVES AND OTHER PHYSICAL OBSERVATIONS

233 ASTEROPE IN 1975

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ABSTRACT. Visual light curves indicate that minor planet 233 Asterope varies by 0.2 with a tentative period of 0.1952 days to 0.2178 days at the aspect presented in September 1975. Photoelectric measurements on October 3, 1975 give tentative photoelectric indices $V(1,0) = 8.6 \pm 0.2$, $B-V = 0.76$, $U-B = 0.25$, all at 5° phase angle, with tentative composition type U, diameter 100 ± 30 km.

Alain Porter and Derek Wallentine¹ pointed out that planet 233 Asterope would pass through the field of the AAVSO "d" chart for 2109-03 RR Aqr from August 29 to September 5, 1975, and urged observers to use this opportunity to determine the visual magnitude and investigate the previously unknown light curve.

Alain Porter obtained the first visual light curve on Aug. 29, 2^h30^m-4^h10^m UT with a 15 cm f/8 reflector. Arbitrary brightness steps were used since no comparison stars of known magnitude were in the same field. A distinct maximum was noted at 3^h25^m UT. Porter at once urged several other observers to obtain further light curves.

The next light curve was obtained visually Sept. 1, 3^h05^m-6^h55^m UT by Pilcher with a 35.4 cm Celestron at 98X. Asterope was then in the same field as RR Aqr and direct estimates using the 11.9 magnitude star and the closest 11.4 magnitude star on the AAVSO "d" chart were made. The magnitude varied irregularly between 11.6 and 11.7, interpreted by the observer as observational scatter, except for a single observation at 11^h38^m, at 6^h55^m UT, just before clouds halted observations. It is uncertain whether this final observation represents a genuine minimum or is spurious. With a B magnitude of 12.4 on that night, a value of $B-V = 0.7$ to 0.8 was established, very typical for most asteroids but of insufficient accuracy to establish a compositional class.

Porter and David Hough, South Plainfield, New Jersey, USA, also using a 15 cm f/8 telescope, obtained independent, overlapping, but conflicting light curves on Sept. 10. Both suggest a 4 to 5 hour rotation period assuming two maxima and two minima per cycle. But Porter obtained a maximum at 2^h10^m UT and a minimum at 3^h25^m UT, while Hough found a maximum at 3^h30^m UT and a minimum at 2^h30^m UT. Since there is no a priori reason for assuming that one of these light curves is more reliable than the other, we are forced to conclude that no usable information was obtained on the night of Sept. 10.

The next visual light curves were obtained Sept. 13 (4^h00^m-8^h20^m UT) and Sept. 14 (1^h45^m-7^h55^m UT) by

Pilcher, using arbitrary brightness steps since magnitudes were not available for the comparison stars. These light curves are both consistent with an approximate 5 hour period with 2 maxima and 2 minima. Minima were observed Sept. 13.212, Sept. 13.328, Sept. 14.097, Sept. 14.192, and Sept. 14.298, with maxima occurring Sept. 13.260, Sept. 14.135, and Sept. 14.242, all times ± 0.01 day.

Being the most comprehensive data set available, these timings of maxima and minima will be utilized in an effort to determine the period of rotation. Zero epoch is assigned the maximum of Sept. 13.260. It is unclear from inspection of the data whether the number of rotations between the maxima of Sept. 13.260 and 14.135 should be 3.5, 4.0, 4.5, or 5.0. A linear least squares analysis of all maxima and minima performed on the basis of all of these assumptions yields the following results for the period, time of zero epoch, and square of the sum of the residuals:

Epoch of Sept.	Time of		
14.135 maximum	Period	0 Epoch	$\Sigma(\text{residuals})^2$
3.5	0.2459	Sept. 13.269	$1283 \times 10^{-6} \text{ days}^2$
4.0	0.2178	13.267	$311 \times 10^{-6} \text{ days}^2$
4.5	0.1952	13.266	$352 \times 10^{-6} \text{ days}^2$
5.0	0.1769	13.265	$1009 \times 10^{-6} \text{ days}^2$

The large residuals seem to rule out the first and last of these possibilities, but the other two seem equally likely. Since not even the epochs of Sept. 13 and 14 can be unambiguously linked, it is hopeless to link the epochs of these two dates with any other observed maximum or minimum. We must conclude that rotation periods of 0.2178 days (= 5 hours 13 minutes) and 0.1952 days (= 4 hours 41 minutes) are both consistent with all currently available data.

The final reported light curve was obtained by Derek Wallentine using an 11 cm f/10 reflector and visual estimates using arbitrary brightness steps, Sept. 26.224 to Sept. 26.316. A well-defined maximum appears at Sept. 26.245. Another narrower maximum at Sept. 26.287 was observed. We are inclined to view the second maximum as spurious, since it would imply a period of 0.084 days, shorter than that of any other known asteroid, and inconsistent with all other data.

The final observations of the 1975 apparition were made by Edward F. Tedesco, New Mexico State University, with a UBV photoelectric photometer attached to a 61 cm telescope. Equipment problems plus the necessity of meeting other commitments permitted observations for only 20 minutes. The identification is therefore uncertain, as no confirming observations were possible on subsequent nights. The following results must therefore be regarded as tentative.

Data obtained indicate that

$V = 12.07$, $B-V = 0.78$, $U-B = 0.29$, $r = 2.396$, $\Delta = 1.658$ AU, phase angle = 19.9° . Assuming the same phase coefficient and color phase coefficients as 110 Lydia (which has similar UB colors) the following are obtained:

$V(1,0) = 8.63$, colors reduced to 5° phase are $B-V = 0.76$ and $U-B = 0.25$.

Given these colors and V magnitude we find that $B(1,0) = 9.4 \pm 0.2$, the uncertainty being due to the observed amplitude. This is in reasonable agreement with the Ephemerides of Minor Planets value of $g = 9.6$. This agreement together with the fact that the colors are those of a typical U type asteroid give some confidence that the object observed was indeed 233 Asterope. Using the corrected colors deduced above we find that 233 Asterope lies about half way between 16 Psyche and 624 Hektor on a $B-V - U-B$ plot. Using data from Chapman, Morrison, and Zellner², we estimate that the albedo of 233 Asterope lies between about .04 and .10. With this range in values for the albedo and assuming that $V(1,0)$ lies between 8.4 and 8.8, we calculate that the diameter is likely to be between 70km and 130km.

Assuming the identification to be correct, we have the following:

$$\begin{aligned} V(1,0) &= 8.6 \pm 0.2 \\ B-V &= 0.76 \\ U-B &= 0.25 \quad \text{at } 5^\circ \text{ phase} \\ \text{Type} &= U \\ \text{Diameter} &= 100 \pm 30 \text{ km} \end{aligned}$$

The summary of observed maxima and minima in the light curve is given below in the hope that future observations can permit the epochs to be uniquely determined and extend the interval of observations. A indicates that the observation is extremely uncertain.

Event	UT 1975	light time	α 1950	δ	r	Δ	β
Max	Aug 29.142	11 ^h 9	21 ^h 15 ^m -2 ^o 47'		2.406	1.429	7 ^o 8
min	Sep 1.288	11.9	21 13 -3 05		2.405	1.439	9.0
Max	10.090	12.3	21 08 -4 01		2.401	1.476	12.2
min	10.142:						
min	Sep 10.104:						
Max	10.146:						
min	13.212	12.5	21 07 -4 20		2.400	1.498	13.4
Max	13.260						
min	Sep 13.328:						
min	14.097	12.5	21 06 -4 27		2.400	1.504	13.7
Max	14.135						
min	14.192						
Max	Sep 14.242						
min	14.298						
Max	26.245	13.2	21 04 -5 34		2.398	1.594	17.6
Max	26.287:						

Note: In the above summary α and δ stand for right ascension and declination respectively, of course; r is the planet-Sun distance in AU, Δ is the planet-Earth distance in AU, and β is the phase angle.

These results are sufficiently encouraging that 233 Asterope should be given high priority for further work. The chief deficiency lies in the low accuracy of the visual timings and the short light curves. Even for observations on two consecutive nights it is not possible to uniquely link the epochs. Longer light curves, preferably all night and on consecutive nights, will be required to correct this deficiency. An opportunity to do this for Asterope will be presented in December 1976 when the planet may be well above the horizon for 9 to 10 hours. At present we have no information about the orientation of the pole of rotation, and therefore the amplitude of the light curve at the next opposition is unknown. Observations at that time will be especially welcome.

For future work on this and other asteroids we urge observers to obtain light curves as long as possible on a given night, and on consecutive nights when possible, in order to link the epochs reliably from one night to the next. Only if this is done can an accurate period of rotation be obtained.

REFERENCES

1. PORTER, A., and WALLENTINE, D., Opportunities for Visual Photometry of Selected Minor Planets, Minor Planet Bulletin 3, 19-20 (1975 July-September)
2. CHAPMAN, C., MORRISON, D., and ZELLNER, B., Surface Properties of Asteroids: A Synthesis of Polarimetry, Radiometry, and Spectrophotometry, Icarus 25, 104-130 (1975)

MINOR PLANET ROTATIONS REPORTED IN 1975

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ABSTRACT. Observations submitted to the A.L.P.O. Minor Planets Section Photometry Co-ordinators during 1975 are examined for signs of rotational variation. Positive and encouraging results are obtained for 233 Asterope and 270 Anahita, the latter evidencing a retrograde rotation.

A total of 49 observations of 15 asteroids by 10 observers was reported in 1975 and late 1974 distributed as follows:

Observer:	RB	DH	BH	KK	PK	EM	FP	AP	KS	DW	Asteroid
Asteroid											Total
12 Victoria								3			3
13 Egeria								1			1
16 Psyche		1			1						2
20 Massalia								3			3
93 Minerva										2	2
113 Amalthea		1	1	2							4
127 Johanna							1				1
164 Eva								1			1
200 Dynamene		1									1
233 Asterope		1					4	4		4	13
236 Honoria				1							1
270 Anahita								3		3	6
409 Aspasia										2	2
433 Eros	1					1		2	1	3	8
444 Gytis	1										1
Observer											
Total:	2	4	1	3	1	1	5	17	1	14	49

Key to Observers

RB = Ray Bryant, Grinda, California. 20cm reflector.
DH = David Hough, South Plainfield, New Jersey. 15 cm reflector.
BH = Ben Hudgens, Clinton, Mississippi. 25cm reflector.
KK = Ken Kelly, Las Cruces, New Mexico. 36cm Celestron.
PK = Phil Kirby, Springfield, Ohio. 15cm refractor.
EM = Ernst Mayer, Barberton, Ohio.
FP = Frederick Pilcher, Jacksonville, Illinois. 36cm Celestron.
AP = Alain Porter, Narragansett, Rhode Island. 15cm reflector & 10cm refractor.
KS = Karl Simmons, Jacksonville, Florida.
DW = Derek Wallentine, Albuquerque, New Mexico. 11cm reflector, 7x35mm binoculars (on Eros)

As the table shows, many "observed" planets were given only cursory inspection. It is hoped that as interest in the program increases fewer objects will attract the attention of only one observer. Simultaneous and consecutive night observations do much toward establishing the accuracy of a curve, or confirming negative observations.

Results of Observations

12 Victoria

Three short light curves made by Porter (1975 Oct. 28, Nov. 1, and 2-3) cannot be reconciled with the accepted period of 8h39^m2, but observational scatter may