PHOTOMETRIC PROPERTIES OF 12753 POVENMIRE

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Main-belt asteroid 12753 Povenmire has been observed for several years at the Hereford Arizona Observatory. A phase coefficient of 26 ± 2 mmag/degree is used to estimate albedo $p_V = 0.28 \pm 0.08$, which leads to a size of 5.7 ± 0.8 km. A rotation period of 17.5752 ± 0.0008 hours replaces an earlier published value.

Asteroid 12753 Povenmire (1993 HE) was discovered by Eugene and Carolyn Shoemaker, and named in honor of Hal and Katie Povenmire. It is located in the Main Belt Zone II (2.6 AU) with a high inclination (15 degrees) and high eccentricity (0.15). These orbital properties are associated with the Eunomia family. If true, then it would be an old asteroid (2.5 billion years), highly reddened and having an S taxonomy.

A previously reported period of 12.85 hours (Gary, 2004) was based on observations during the "faint" opposition of 2003, when V-mag was 17.6. Background stars required image subtraction before photometry readings could be made. This challenge accounts for the construction of a marginally significant phase-folded rotation light curve with an incorrect period. Reported V-R and R-Ic colors were also of poor quality. This publication corrects mistakes in the earlier publication and reports results from the "bright" opposition of 2010 used to estimate the asteroid's albedo and size.

Observations

Asteroid 12753 was ~1.4 AU from Earth between 2010 May 14 and June 20. Its magnitude was predicted to range from 16.0 to 16.7 during that time. A Meade 0.35-m fork-mounted Schmidt-Cassegrain telescope was used with an SBIG ST-10 XME CCD camera. Hereford Arizona Observatory (MPC code G95) is located at 1417 meter altitude near Sierra Vista, AZ. Control of the telescope, dome, focuser and camera was accomplished using *MaxIm DL* and 30-meter cabling in buried conduit. Image analysis was done with *MaxIm DL* and an *Excel* spreadsheet designed for photometry (see Gary, 2014, for spreadsheet details). All observations were made with an r' band filter and were calibrated using APASS magnitudes found in the UCAC4 catalog. CCD transformation corrections were determined using a plot of reference star instrumental magnitude minus true (APASS) magnitude versus star color (B-V). This assured that each lightcurve segment was calibrated with an accuracy estimated to be ~ 10 mmag.

Sample Lightcurves

Since the goal for this observing project was to estimate the asteroid's size using its phase function, it was necessary to establish rotation period well enough to know when to observe one of the rotation maxima on several dates. Figure 1 shows a phase-folded overlay of lightcurve segments from 11 observing dates in 2010, from which an accurate rotation period was determined: 17.5752 ± 0.0008 hours.

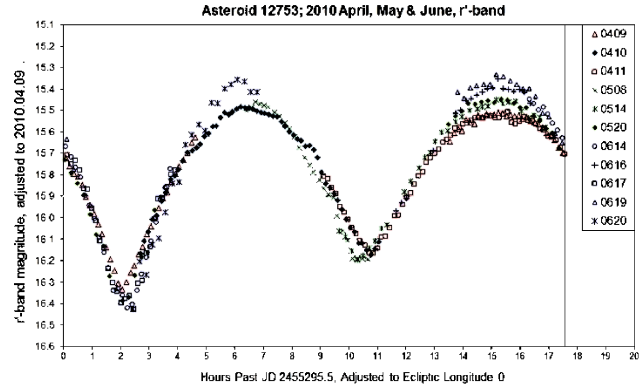

Figure 1. Phase-folded lightcurve for 2010 observations using a period of 17.5752 hours. All magnitudes have been adjusted to an ephemeris magnitude for April 9 using G = 0.15.

The minima exhibit a significant brightness difference and the maxima also vary some. Since there were more data for the second maximum, it was chosen for use in deriving a phase function.

Phase Function and Albedo

Figure 2 is a plot of r'-mag measurements that have been adjusted to the standard 1 AU for sun/asteroid and Earth/asteroid distances.

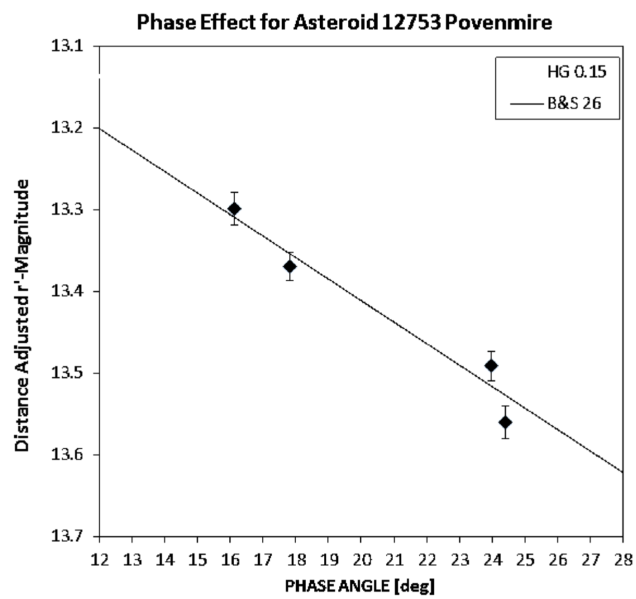

Figure 2. r' magnitudes, adjusted to standard distance, for 4 dates in 2010, with two model fits: 1) HG (G=0.15) and 2) linear B&S model with slope = 26.3 ± 1.4 mmag/degree.

Two model solutions are shown: an H-G model with the common default $G = 0.15$, and a straight line fit.

Belskaya and Schevchenko (2000), hereafter B&S, analyzed 33 well-studied main belt asteroids using a 3-term phase effect model first introduced by Schevchenko (1996, 1997):

$$V(\alpha) = Vo + b \times \alpha - a/(1+\alpha) \qquad (1)$$

where $V(\alpha)$ is V-mag at phase angle α, Vo is V-mag at zero phase, b is phase coefficient (a slope term) fitted to $V(\alpha)$ measurements and a is an "opposition effect" (OE) amplitude term. B&S found that there was a strong correlation between the phase coefficient b

and albedo, and also an inverted U-shape relationship between the OE amplitude term *a* and albedo. Their equation relating phase coefficient *b* and V-mag albedo at zero phase, p_V, is:

$$b = 0.013(2) - 0.024(2) * \log(p_V) \qquad (2)$$

where *b* has units of mag/degree and p_V is a fraction. (Hereafter I will use the term "albedo" to be the same as p_V.) When 26.3 ± 1.4 mmag/degree is substituted for *b* in the above equation, this gives albedo = 0.28 ± 0.08/0.07.

Zero Phase Brightness and Size

Since we don't have information for phase angles close to zero, we don't know the size of the "opposition effect." Fortunately, B&S also investigated the relation between OE and albedo. For an albedo of 0.28, they find that the OE term *a* ~ 0.35 ± 0.04 magnitude. Using the B&S phase function equation and adopting their suggested OE value, a chi-square fit is achieved that is better than the H-G fit with *G* = 0.15 (delta chi-square =17), as illustrated in Figure 3.

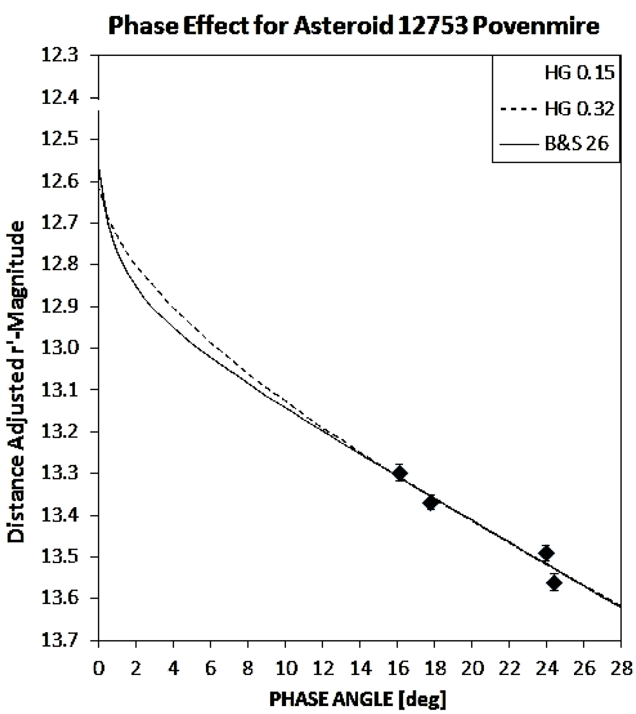

Figure 3. Phase function measurements for "second maximum" fitted with 3 models: 1) H-G (*G* = 0.15); 2) H-G (*G* = 0.32); and 3) B&S model with slope = 26 mmag/degree.

The phase curve measurements were fitted using the phase effect model of Eq. 1 with the OE amplitude term *a* = 0.35. The slope and intercept terms, *b* and V_0, were adjusted until chi-square was minimized. As expected, *b* = 26.3 ± 1.4 mmag/degree; the zero phase intercept (not really V_0, since the observations were made with an r'-band filter) produced a solution r'-mag at zero phase of 12.89 ± 0.03. For an asteroid with B-V = +0.78 ± 0.08 and V-R = +0.60 (measured during the 2006 opposition), converting r'-mag to V-mag can be accomplished by adding 0.30 ± 0.10 to r'-mag. In addition, a correction of +0.35 ± 0.07 magnitude is required for the fact that the "second maximum" is on average that much brighter than the rotation average. A total correction to the zero phase r'-mag brightness for the second maximum is therefore 0.65 ± 0.13. The phase curve measurements therefore correspond to a rotation-averaged V-mag, or V_0 = 13.26 ± 0.13 for the H-G (*G* = 0.32) model and 13.22 ± 0.13 for the B&S model. Forcing *G* = 0.15 for the H-G model would lead to V_0 ~ 13.1. All of these values are greater than the archive value of *H* = 12.7. I adopt V_0 = 13.2 ± 0.2.

The asteroid's size can now be calculated using the standard equation:

$$D\,[\text{km}] = (1329 / \sqrt{\text{albedo}}) \times 10^{(-0.2H)} \qquad (3)$$

where albedo is a fraction. Setting $H = V_0$ = 13.2 ± 0.2 yields a diameter of 5.7 ± 0.8 km.

The NEOWISE database lists a diameter and geometric albedo of 7.4 ± 0.1 km and 0.32 ± 0.04. The diameter is based on measured thermal IR flux and an assumed bond albedo used to calculate a disk-average brightness temperature. The Lightcurve Database (LCDB; Warner *et al.*, 2009) lists a diameter of 8.36 km (based on *H* = 12.7 and albedo = 0.21).

Conclusion

Asteroid 12753 rotates with a period of 17.5752 ± 0.0008 hours. The phase coefficient was used to derive an albedo of 0.28 ± 0.08. This albedo allows the opposition effect to be an estimated 0.35 mag. The phase effect measurements can be fit using either an H-G model yielding *H* ~ 13.3, or a Shevchenko model with phase coefficient = 26 ± 2 mmag/degree that yields a zero-phase V ~ 13.2. The albedo and zero-phase magnitude were used to calculate a diameter of 5.7 ± 0.8 km. Two lines of evidence support the S-type taxonomy classification for 12753 Povenmire, its orbit and albedo. Additional confirmation will require measurements for a wider range of phases and over a wider range of wavelengths.

References

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