PHOTOMETRY OF DAMOCLOID ASTEROID 2006 BZ8

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Photometry of the Damocloid asteroid 2006 BZ8 was obtained on two nights in 2006 February with the University of Arizona Kuiper 1.54-m telescope. Lightcurve analysis yielded a rotation period of 5.960 ± 0.003 h and amplitude of 0.35 magnitudes. An analysis of photometry reported by the Catalina Sky Survey, Mount Lemmon Survey. and Siding Spring Survey to the Minor Planet Center found a steep phase function slope of β_V = 0.054 ± 0.008 which is consistent with 2006 BZ8 being a very low albedo object.

Asteroid 2006 BZ8 was discovered by the Catalina Sky Survey with the 0.68-m Catalina Schmidt on 2006 January 23. It resides in a comet-like orbit with semi-major axis of 9.61 AU, eccentricity of 0.80, inclination of 165°, and orbital period of 29.8 years. Perihelion occurred on 2006 July 2 at a heliocentric distance of 1.90 AU. The object displayed no cometary activity in observations taken with the 2.5-m Isaac Newton Telescope (Snodgrass et al., 2008). This object is classified as a Centaur in the JPL Small-Body Database and Warner et al. (2009). Jewitt (2005) and Morais and Namouni (2013) classify it as a Damocloid, an inactive Halley-family or long-period comet. Currently, 2006 BZ8 is in a long-lived (~15000 yr) 2:5J resonance with Jupiter and near the 1:1S resonance with Saturn (Morais and Namouni, 2013).

Lightcurve Observations and Analysis

CCD photometric lightcurve observations of 2006 BZ8 were acquired on 2006 February 22 and 25 with the University of Arizona Kuiper 1.54-m telescope and the Montreal4K imager (better known as the "Mont4K"). The Mont4K consists of a Fairchild CCD486 4096x4097 detector with 15 µm pixels. Images were binned 3x3 yielding an effective plate scale of 0.45 arc seconds per pixel.

Data reduction included the standard procedure of zero subtraction and use of flat field images produced from the data and twilight images. All data reduction was done within the IRAF IMRED package. Lightcurve photometry was conducted with a Harris R filter. Multiple stars from Landolt (1992) were observed at various air masses from 1.1 to 2.0 air masses in the filter. The asteroid was observed between air masses of 1.03 and 1.83 during the two nights. Zero points and extinction coefficients were calculated for each night of observation. All photometric observations of the standard stars and asteroids were measured with the IRAF DIGIPHOT package. Variable circular apertures of 2 times the measured FWHM of each image were used, which allowed compensating for variable seeing conditions. Sky background was measured with a circular ring aperture of radius 20 pixels and width of 5 pixels. The sky aperture was centered on the position of the measured source. Petr Pravec's Asteroid Lightcurve (ALC) software (version 0.96) was used for lightcurve period determination.

The observations on 2006 February 22 consist of 62 measurements taken over a span of 6.8 hours. The object was at a heliocentric distance of 2.37 AU, geocentric distance of 1.40 AU, and phase angle of 5.8°. The observations on 2006 February 25 consist of 41 measurements taken over a span of 4.2 hours. On that date, the object was at a heliocentric distance of 2.35 AU, geocentric distance of 1.37 AU, and phase angle of 4.8°. The photometry conducted on these two nights yielded a rotation period of 5.960 ± 0.003 h and amplitude of 0.35 magnitudes (Figure 1).

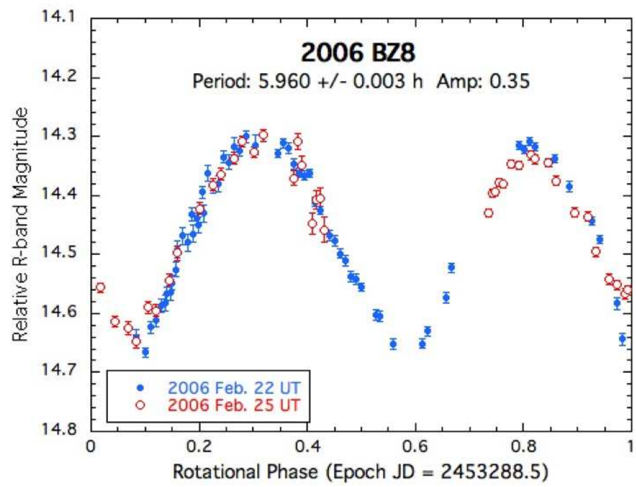

Figure 1 - Phased lightcurve for 2006 BZ8.

Phase Function Observations and Analysis

Determining the relationship between the brightness of an asteroid and the observed phase angle allows an estimate of the absolute magnitude (*H*) or brightness of the object at zero degrees phase angle. The relationship between brightness and phase angle is determined by normalizing the observed apparent magnitude of the comet to a heliocentric and geocentric distance of 1 AU. The phase function can be modeled a number of ways. In this paper, our observations are modeled by a linear least squares fit and by the H-G photometric system derived by Bowell et al. (1989) for airless bodies.

The Kuiper observations were too few and do not sufficiently sample phase angle space to properly derive phase function parameters. The Minor Planet Center (MPC) publishes additional photometric data as part of their database of astrometric positions. As described in Hergenrother et al. (2013), data submitted to the MPC can be of variable quality so only data taken by the Catalina Sky Survey telescopes (Catalina Sky Survey proper [MPC code 703], Mount Lemmon Survey [G96], and the Siding Spring

Number	Name	2006 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
	2006 BZ8	02/22-02/25	103	5.8,4.8	159	9	5.960	0.003	0.35	0.02	CEN

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984). Grp is the asteroid family/group (Warner *et al.*, 2009). CEN = Centaur

Survey [E12]). These surveys use no filter resulting in a loss of color information, though all of their fields are calibrated against solar-type stars. As a result, their photometry is internally consistent and is acceptable for assessing the brightness changes due to phase angle. All data was reported in V- and R-band magnitudes. R-band data were transformed to V using a V-R color index of +0.4.

The dataset for 2006 BZ8 consists of V- and R-band magnitude measurements made between 2006 January 23 UT and 2007 October 8 UT covering phase angles from 5.9° to 22.9°. The data show a consistent linear trend of decreasing brightness with increasing phase angle. A scatter of about 1 magnitude or less is present at all observed phase angles. A linear fit to the Catalina data yields H_V = 14.17 ± 0.13 and a phase slope (β_V) of 0.054 ± 0.008 magnitude per degree of phase angle. Solving within the H-G system for all phase angles produces values of H_V = 13.82 ± 0.15 and G_V = –0.12 ± 0.10. The phase function photometry and both phase function solutions are shown in Figure 2.

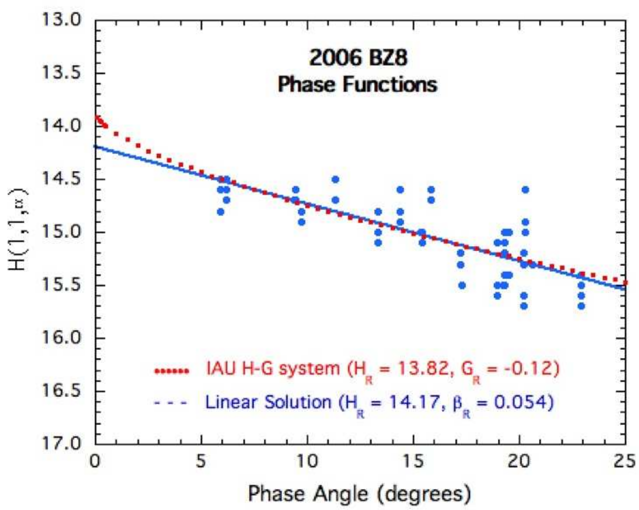

Figure 2 - Linear and IAU H-G phase functions for 2006 BZ8.

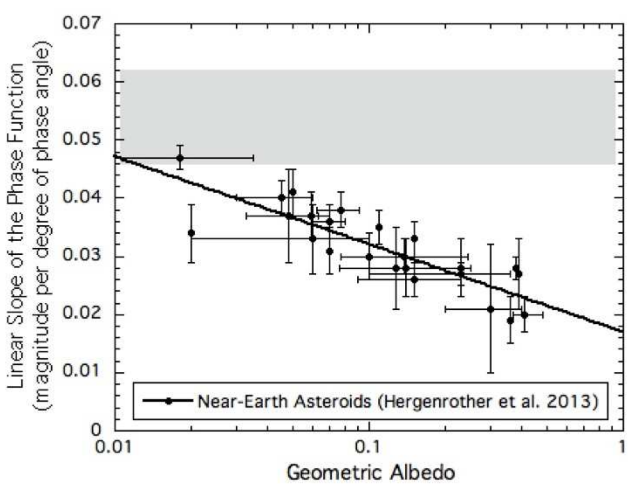

Figure 3 - Relationship between the slope of the phase function and albedo for near-Earth asteroids. The grey area covers the range of phase function slope measured for 2006 BZ8. NEA data is from Hergenrother et al. (2013).

The slope of the linear part of the phase function is directly correlated with albedo (Belskaya and Shevchenko, 2000; Hergenrother et al., 2013). A linear slope of 0.054 ± 0.008 magnitude per degree of phase angle suggests a very dark albedo. The slope corresponds to an albedo of $0.020^{+0.022}_{-0.010}$ according to the Belskaya and Shevchenko (2000) analysis of main-belt asteroids. Figure 3 presents the phase function slope to albedo relationship for near-Earth asteroids as analyzed in Hergenrother et al. (2013). The grey area covers the range of phase angle slopes determined for 2006 BZ8. The slope range is consistent with that of a very dark object.

An estimate of the effective diameter of 2006 BZ8 can be made by combing the extreme values for its absolute magnitude and albedo (Harris, 1997). An H of 13.67 and albedo of 0.01 yields a diameter of 24.5 km. At the other extreme, an absolute magnitude of 14.30 and albedo of 0.042 yields a diameter of 9.0 km.

Acknowledgements

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