magnitudes from each other. One minimum in particular exhibited an extra increase of ~0.13 magnitudes between the early-August and mid-September data. This may be a real effect due to the change in geometry during the intervening 7-8 weeks between observations as noted in the table, and the shape of the asteroid.

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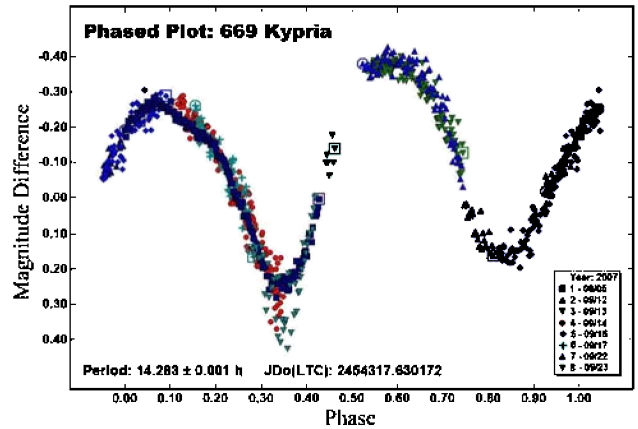

349 DEMBOWSKA: A MINOR STUDY OF ITS SHAPE AND PARAMETERS

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Photometry of asteroid 349 Dembowska was obtained at a high-latitude aspect, yielding a synodic rotational period of 4.7029 ± 0.0054 h. Lightcurve inversion, performed with the new observations combined with archival photometry, yields an asymmetric elongated ellipsoid as the dominant shape solution. The absolute magnitude and phase coefficient for 349 Dembowska were determined using archival photometry to be $M_v = 6.14 \pm 0.07$ and $\beta_v = 0.022 \pm 0.004$ mag/degree. We estimate Dembowska's diameter (143 km) by adopting a simple formalism to interpret the object's thermal emission and we demonstrate that the spectral energy distribution from the *Two Micron All Sky Survey* and the *Sloan Digital Sky Survey* can be used to reveal the known signature of olivine and pyroxene absorption near 1μm.

Located just prior to the prominent 7:3 resonance with Jupiter, 349 Dembowska is among the larger asteroids in the main belt with an estimated diameter of ~140 km (Tedesco 1989) and is classified as an R-type asteroid from the presence of strong absorption bands of olivine and pyroxene with little or no metals (Gaffey et al. 1993). In this study, observations taken during an epoch of high-latitude viewing were used to deduce the asteroid's rotational period and phased lightcurve parameters. Our photometry was supplemented by archival observations in order to model the asteroid's shape and determine its intrinsic brightness. We also examine the asteroid's spectral energy distribution using data from the *Sloan Digital Sky Survey* (SDSS), the *Two Micron All Sky Survey* (2MASS), and the *Infrared Astronomical Satellite* (IRAS), enabling us to investigate the object's spectral composition and size.

Lightcurve. 349 Dembowska has been well monitored during its passage through ecliptic longitudes of 60°-70° and 230°-240° (Abell & Gaffey 2000, see references therein). The lightcurve exhibits bimodal structure with two maxima and minima separated by nearly 0.4 magnitude. However, during ecliptic longitudes of 150°-160° and 330°-360°, the brightness profile transitions to display only one peak per orbital period and a significant decrease in amplitude is noted. The evolution in the lightcurve morphology may be consistent with a transformation from a near-equatorial viewing perspective to one of high latitude. The need for precision photometry at high latitude inspired this study.

The asteroid was observed on four nights in March 2003 from the Burke-Gaffney Observatory at Saint Mary's University in downtown Halifax, Nova Scotia, Canada. The observatory houses a 0.4m Cassegrain reflector and is equipped with an SBIG ST-8 CCD camera. All images were obtained unfiltered, which allowed a high signal-to-noise ratio during this particular epoch (ecliptic longitude ~155°). Pre-processing and differential photometry were performed using Cyanogen's MaximDL and Mirametrics Mira Pro. The asteroid's motion necessitated different reference stars on each night. Consequently, the data needed to be standardized in magnitude space before a period search could ensue.

A period search was then initiated after removal of spurious data obtained through clouds or during twilight. The period analysis was carried out using Peranso (Vanmunster 2007), which incorporates the FALC algorithm (Harris et al. 1989). A synodic period of 4.7029 ± 0.0054 h was found. Figure 1 shows the data phased to that period. Our result is consistent with, although less precise than, that of Zappala et al. (1979) who obtained a period of 4.70117 ± 0.00007 h. The lightcurve has an amplitude of ~0.1 magnitude, and displays one maximum and minimum per orbital period. There is an obvious plateau that bridges the extrema; this imposed valuable constraints during modeling.

Shape. The asteroid's surface profile was modeled using MPO LCInvert, a GUI package based on the photometric inversion techniques of Kaasalainen & Torppa (2001). For the inversion process our own observations were supplemented by a number of other studies (Table 1) summarized in digitized form in the Asteroid Photometric Catalog (Lagerkvist et al. 2001). A period search was carried out in LCInvert using the entire data set. The result was a sidereal period of 4.701207 ± 0.000058 h, which was adopted for the inversion. The uncertainty is merely the dispersion among the top five solutions with the lowest χ^2 statistic.

A single shape (Fig. 2) consistently emerged among the solutions and can be described as an asymmetric elongated ellipsoid (the canonical potato shape), which generally agrees with the structure of 349 Dembowska as suggested by Torppa et al. (2003). The model fits compare satisfactorily to the observations (Fig 3). However, we were unable to identify a unique pole orientation confidently. Additional observations, especially absolute photometry, should help resolve the ambiguities. Lastly, we note that Abell & Gaffey (2000) have suggested that 349 Dembowska could exhibit albedo variation.

Diameter & Albedo: Veeder & Walker (1995) cite several measurements of the asteroid's diameter and geometric albedo that were derived from IRAS data by adopting a standard thermal model. A weighted mean and weighted standard deviation of their results yields a diameter of 139 ± 9 km and geometric albedo of 0.36 ± 0.05. Alternatively, we decided to assess how parameters determined from a simpler formalism would compare. For a blackbody, the emitted surface flux, $f(s, \nu)$, at a specific frequency is related to the Planck function, $I(\nu,T)$ by: $f(s, \nu) = \pi\, I(\nu,T)$. For a spherical geometry, the total flux measured at a distance d from a source of radius R is given by: $f(s) = \pi\, I(\nu,T)\ (R/d)^2$. A temperature of ~210 K and diameter of ~143 km produced the best fit to the IRAS photometry (Fig. 4). During the fitting process, however, the flux densities produced by the above equation were not convolved with the IRAS filter transmission functions. Testing indicates that the resulting uncertainties are of order ~1-10%, nonetheless, the diameter is in general agreement with the value derived from the more robust standard thermal model.

Spectral Energy Distribution: A profile of the asteroid's spectral energy distribution (SED) was created by using photometry from IRAS (Veeder & Walker 1995), 2MASS (Sykes et al. 2001), and SDSS (Krisciunas et al. 1998). The available observations enabled a broad sampling of the spectrum from the far-infrared to the ultraviolet. To homogenize the set, the data were reduced to unity Sun-Earth distance. The SED (Fig. 5) highlights both the reflected and reradiated regimes along with a prominent absorption feature near 1μm, denoting the likely presence of olivine and pyroxene (Hiroi & Sasaki 2001; Gaffey & McCord 1978). The presence of such minerals may explain the asteroid's high albedo and could place important constraints on the body's formation history since olivine and pyroxene may be found in the mantle of differentiated objects. Lastly, we note the usefulness of the all-sky surveys in determining the spectral composition of minor bodies, which may be of added importance when studying lesser-known objects.

Absolute Magnitude & Phase Coefficient: When an asteroid is not observed at opposition, the flux received is diminished because of fractional illumination and shadowing (for fluxes reduced to unit distance). The effect can be described by a phase function diagram (Fig. 6) from which the absolute magnitude (Mv) and phase coefficient (βv) of the asteroid are determined. In the case of 349 Dembowska, the parameters were derived from the combined data sets of Zappala et al. (1979), Weidenschilling et al. (1987), and di Martino et al. (1987). A linear least squares fit to data with phase angles between 10° and 20°, thus avoiding the oppositional surge, found Mv=6.14±0.07 and βv = 0.022 ± 0.004 mag/degree. That is consistent with the results of Zappala et al. (1979), confirming that 349 Dembowska is among the brighter asteroids in the main belt.

Acknowledgements

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TABLE 1
PHOTOMETRIC STUDIES USED IN THE INVERSION

Study	Date	# Datapoints	Weight
Zappala et al. (1979)	March 11th, 1965	45	1
Zappala et al. (1979)	April 1st, 1965	56	1
Zappala et al. (1979)	April 24th, 1965	50	2
Zappala et al. (1979)	May 6th, 1965	57	1
Zappala et al. (1979)	May 9th, 1965	43	1
Zappala et al. (1979)	May 21st, 1965	61	1
Zappala et al. (1979)	June 3rd, 1965	48	1
Zappala et al. (1979)	June 18th, 1965	59	1
Haupt (1980)	December 31st, 1977	70	2
Weidenschilling et al. (1987)	April 9th, 1984	30	1
Authors	March 10th, 2004	18	1
Authors	March 16th, 2004	93	1
Authors	March 24th, 2004	130	2
Authors	March 28th, 2004	163	2

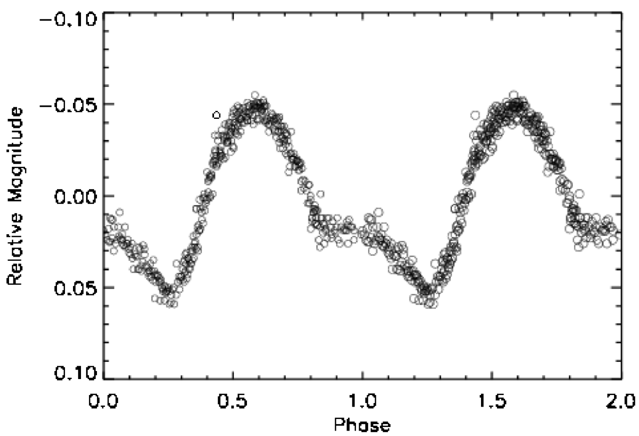

Fig. 1. The lightcurve of 349 Dembowska phased with a rotation period of 4.7029 ± 0.0054 h.

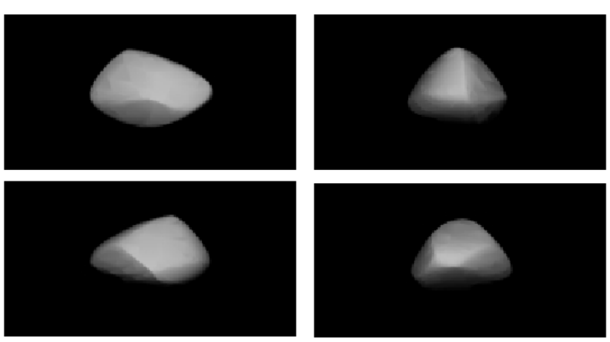

Fig. 2. Shape model of 349 Dembowska. The rotation axis is oriented vertically with Z = 0°, 90° (top row), 180°, and 270° (bottom row).

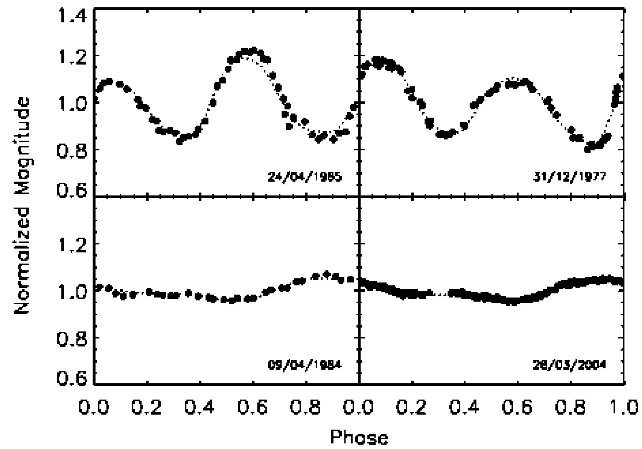

Fig. 3. A sample of photometric observations (filled circles) compared to synthetic light-curves (dotted line). Our photometry of the low amplitude phase is presented in the lower right panel.

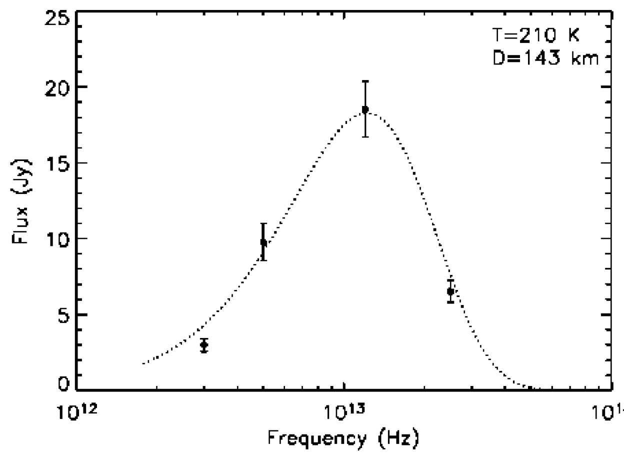

Fig. 4. A temperature of ~210 K and a diameter of ~143 km produce the minimum χ^2 statistic when fitting a modified Planck function to the asteroid's thermal emission (IRAS photometry).

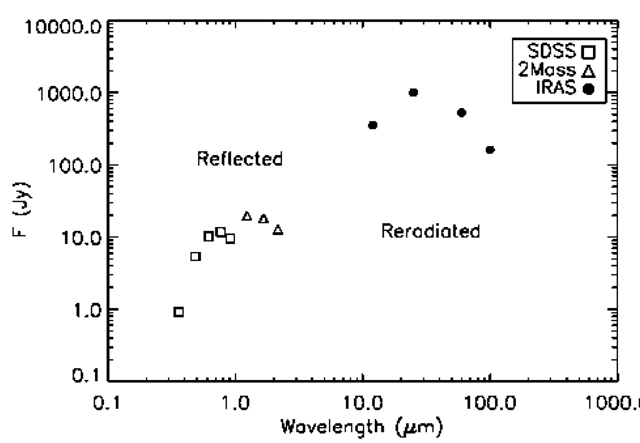

Fig. 5. The spectral energy distribution for 349 Dembowska established from SDSS, 2MASS, and IRAS data. Both the regimes of reflected and reradiated energy are distinctly visible, along with a likely absorption feature near 1μm (olivine & pyroxene).

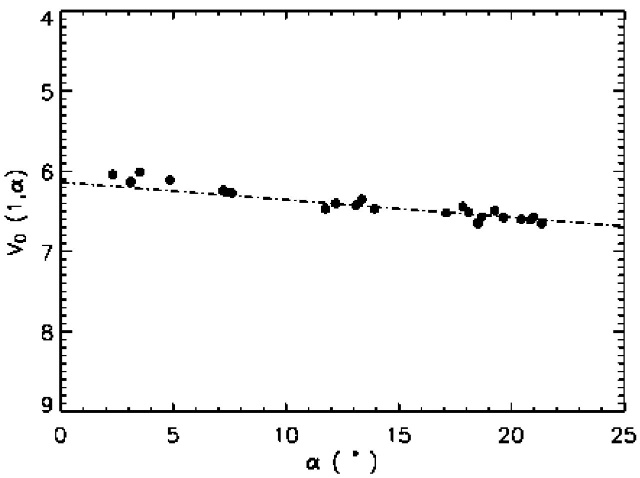

Fig. 6. The phase function for 349 Dembowska compiled from archival photometry. A linear least squares fit to data with phase angles between 10° and 20° gives an absolute magnitude of 6.14 ± 0.07 and a phase coefficient of 0.022 ± 0.004 mag/degree.

CALL FOR OBSERVATIONS

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Observers who have made visual, photographic, or CCD measurements of positions of minor planets in calendar 2007 are encouraged to report them to this author on or before April 1, 2008. This will be the deadline for receipt of reports which can be included in the "General Report of Position Observations for 2007," to be published in *MPB* Vol. 35, No. 3.

LIGHTCURVE PHOTOMETRY OPPORTUNITIES: APRIL-MAY 2008

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We present here four lists of "targets of opportunity" for the period 2008 April-June. The first list is those asteroids reaching a favorable apparition during this season, are <15m at brightest, and have either no or poorly constrained lightcurve parameters. By "favorable" we mean the asteroid is unusually brighter than at other times and, in many cases, may not be so for many years. The goal for these asteroids is to find a well-determined rotation rate. Don't hesitate to solicit help from other observers at widely spread longitudes should the initial findings show that a single station may not be able to finish the job.

The Low Phase Angle list includes asteroids that reach very low phase angles. Getting accurate, calibrated measurements (usually V band) at or very near the day of opposition can provide important information for those studying the "opposition effect", which is when objects near opposition brighten more than simple geometry would predict.

The third list contains those asteroids needing only a small number of lightcurves to allow shape and spin axis modeling. Some asteroids have been on the list for some time, so work on them is strongly encouraged so that models can be completed. For modeling work, absolute photometry is strongly recommended, meaning that data, not differential magnitudes but absolute values, put onto a standard system such as Johnson V. If this is neither possible nor practical, accurate relative photometry is also permissible. This is where all differential values are against a calibrated zero point that is not necessarily on a standard system.

When working any asteroid, keep in mind that the best results for shape and spin axis modeling come when lightcurves are obtained over a large range of phase angles within an apparition. If at all possible, try to get lightcurves not only close to opposition, but before and after, e.g., when the phase angle is 15° or more. This can be difficult at times but the extra effort can and will pay off.

The fourth list gives a brief ephemeris for planned radar targets. Supporting optical observations made to determine the lightcurve's period, amplitude, and shape are needed to supplement the radar data. Reducing to standard magnitudes is not required but high precision work, 0.01-0.03mag, usually is. *The*