NEAR PHOTOMETRY OF C-TYPE ASTEROID 253 MATHILDE. Beth Ellen Clark, *Center for Radiophysics and Space Research, Cornell University, Ithaca NY 14853, beth@astrosun.tn.cornell.edu*, J. Veverka, P. Helfenstein, P. Thomas, J. Bell III, J. Joseph, A. Harch, B. Carcich, *Center for Radiophysics and Space Research, Cornell University, Ithaca NY 14853*, M. Robinson, *Northwestern University, Evanston IL 60208*, S. Murchie, A. Cheng, N. Izenberg, *Johns Hopkins University, Applied Physics Laboratory, Laurel MD 20723*, L. McFadden, *University of Maryland, Department of Astronomy, College Park MD 20817*, C. Chapman, W. Merline, *Southwest Reseach Institute, Boulder CO 80302*, M. Malin, *Malin Space Science Systems Inc., San Diego CA 92191*.

INTRODUCTION

NEAR's Multispectral Imager (MSI) recorded over 300 images (at 0.45, 0.55, 0.70, 0.76, 0.90, 0.95, 1.00 and 1.05 μm) of asteroid 253 Mathilde during a flyby on June 27, 1997 [1]. Monochromatic images were acquired at 0.70 μm at solar phase angles of 40-60, 90, and 136 degrees. These data, combined with previous telescopic observations at lower phase angles (1-16 degrees) [2] were used to derive a photometric model for Mathilde. The photometric properties of Mathilde were then compared to those of similar small bodies. We find: 1) Mathilde has a geometric albedo of 0.041 $\pm$0.003 at 0.55 μm, making it the darkest object yet observed by spacecraft. 2) Mathilde is remarkably homogeneous in albedo across the surface. 3) As a whole, Mathilde is more backscattering than Phobos, and Mathilde's surface may be rougher.

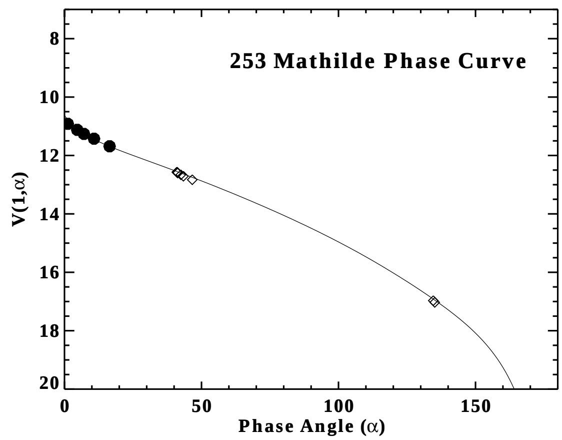

Figure 1: The phase function of Mathilde as determined by the best fit model Hapke parameters (solid line) is compared to the ground-based data from Mottola et al. 1995 (filled circles), and to the NEAR whole-disk 0.70 μm data (diamonds). The Mottola et al. data have been scaled by +0.45 magnitudes to be consistent with the Hapke fit of the NEAR data.

PREVIOUS WORK

Prior to the NEAR flyby, several ground-based reconnaisance studies were performed to characterize 253 Mathilde. The ground-based photometric data, published by Mottola et al. [2] consist of five whole-disk observations taken at 0.56 μm at phase angles from 1.21 to 16.47. The ground-based visual wavelength spectroscopic data of Mathilde, published by Binzel et al. [3] consist of CCD spectra from 0.43 to 0.92 μm. Infrared observations at five wavelengths were obtained by Rivkin et al. [4]. Also available are the IRAS (Infrared Astronomical Satellite) measurements published by Tedesco [5]. Taken together, these data indicated that Mathilde was dark, most closely resembled C-type asteroids, and showed no evidence of the presence of hydrated minerals.

Table 1: Nominal Hapke Parameters†

	$\bar{\omega}_o$	h	B_o	$g1$	$g2$	f	$\bar{\theta}$
Mathilde	0.04	0.06	3.04	-0.27	0.66	0.25	29
Phobos	0.07	0.06	4.00	-0.20	0.66	0.13	22
Deimos	0.08	0.07	1.65	-0.29	-	-	16
Gaspra	0.36	0.06	1.63	-0.18	-	-	29
Ida	0.22	0.02	1.53	-0.33	-	-	18
Moon	0.28	0.16	1.00	-0.24	0.64	0.44	27

†Note that these parameters were derived for slightly different wavelengths (in μm): Mathilde - 0.55, Phobos and Deimos - 0.54, Gaspra and Ida - 0.56, and the Moon - 0.56.

Table 2: Basic Photometric Quantities

	Geometric Albedo p	**Phase Integral** q	**Spherical Albedo** $A=pq$
Mathilde	0.041	0.276	0.011
Phobos	0.071	0.300	0.021

PHOTOMETRIC FUNCTION

All 20 images used for this analysis were obtained through the clear filter at 0.70 μm and were radiometrically calibrated using MSICAL software [6]. The numerical shape model developed for Mathilde by Thomas et al. [7] provides the radius of the satellite surface every 3 degrees in latitude and longitude. The shape model was used to extract the incidence, emission, and phase angle of each illuminated pixel. The viewing geometry values estimated for each pixel were used in conjunction with the corresponding calibrated reflectance values to fit a photometric function to the data.

We used a seven term form of the Hapke photometric function [8,9,10] with a two-term Henyey-Greenstein single particle phase function. The fitting routine, from Helfenstein et al. [11,12], simultaneously fits disk-resolved and whole-disk data with a combination of grid and gradient searches to minimize the RMS residual between the theoretical and observed reflectance values. Shown in Table 1 are the nominal Hapke parameters obtained from the Mathilde imaging data. These values were derived for 0.70 μm but have been scaled to 0.55 μm for comparison with other planetary surfaces. (Actually, to within the precision shown in the table, the values do not vary between 0.70 and 0.55 μm.) Figure 1 illustrates the model fit to the data as a function of the phase angle of observation (using only the whole-disk data).

GLOBAL PHOTOMETRIC PROPERTIES

Based on the Hapke parameters in Table 1 the calculated global photometric properties of Mathilde are compared with those of Phobos in Table 2. The slightly lower value of the phase integral q for Mathilde indicates that this asteroid is more backscattering than Phobos.

THE ALBEDO OF MATHILDE

Telescopic measurements of Mathilde's brightness combined with the Thomas et al. size estimate (52.8 km $\pm$2.6) yield a geometric albedo for Mathilde of 0.050 $\pm$0.004 in the V-band [2,5,7]. The value we have determined from the Hapke photometric fit is 0.041 $\pm$0.003 at 0.55 μm.

COMPARISON WITH OTHER OBJECTS

On Phobos, a body whose geometric albedo is 0.071 $\pm$0.012 [13], normal reflectance (r_n) values range from 0.06 to 0.10, and have been shown to be uncorrelated with crater-centers and terminators [13]. On Mathilde, a body whose geometric albedo is 0.041 $\pm$0.003, typical r_n values range from 0.022 to 0.044.

SUMMARY

1) Mathilde has a geometric albedo of 0.041 $\pm$0.003 at 0.55 μm. This is very low on the scale of Solar System materials, and makes Mathilde the darkest object yet observed by spacecraft. In comparison, Phobos has a geometric albedo of 0.071 $\pm$0.012 at 0.54 μm.

2) Mathilde is remarkably homogeneous in brightness across the surface.

3) The best fit Hapke parameters indicate that as a whole, Mathilde is more backscattering than Phobos, and Mathilde's surface roughness ($\bar{\theta}$) may be greater.

REFERENCES

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