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Letter to the Editor

Search for rotational variation in the spectra of 253 Mathilde*

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Abstract. 253 Mathilde will be the next asteroid to be visited by a spacecraft (NEAR). Mathilde is an exceptional slow and complex rotator with a period of 17.4 days (Mottola et al., 1995). Binzel et al. (1996) have obtained the first spectrum of Mathilde in the visible range. To search for any variation on the asteroid surface, we have performed several observations in the visible range at the European Southern Observatory (ESO). The results show, combined with the spectrum of Binzel, that Mathilde's surface is homogeneous over almost half of its rotational period.
C type asteroids to which 253 Mathilde belongs, often show some absorption features due to acqueous alteration. Our spectroscopic surface analysis reveal featureless spectra.

Key words: asteroid spectroscopy

1. Introduction

The Near Earth Asteroid Rendezvous (NEAR) spacecraft was successfully launched on February 17, 1996 to its one year study of 433 Eros on 1999. On its way to Eros, on June 26, 1997, NEAR will flyby, within 1200 kilometers, 253 Mathilde. The primary instrument for the encounter will be the Multispectral Imager (MSI), but measurements of Mathilde's mass will also be made. MSI has a filter wheel containing seven color filters covering the wavelength range of 0.4 - 1.1 μm, and one clear filter for low-light imaging and optical navigation.
253 Mathilde will be the third asteroid ever visited by a spacecraft, after flyby encounters of asteroids 951 Gaspra and 243 Ida (plus Ida's satellite named Dactyl) by Galileo. With a diameter of 58 km (Tedesco, 1992), it will be also the substantially largest asteroid flybyed. But, most noticeably, Mathilde will be the first C type asteroid that we will have a close observation since Eros is a S type asteroid as well as the three Galileo targets.
C type asteroids are defined to have generally featureless, flat spectra in the visible, similar to the colors and spectra of carbonaceous chondrite meteorites. They are considered to be primitive asteroids, including more than 75% of known asteroids. Jones et al. (1990) established on the base of the study of the 3 μm feature on the spectra that two-third of C asteroids have hydrated silicate surfaces. the 3 μm absorption feature is the signature of the spectral absorptions of water and structural OH. Vilas (1994) found a strong correlation between the 3 μm feature and the 0.7 μm absorption feature atributed to $Fe^{2+} \rightarrow Fe^{3+}$ charge transfer in oxidized iron present in phyllosilicates. This feature is observed in the low-albedo asteroids. Vilas et al. (1994) found several other absorption features due to acqueous alteration at 0.43, 0.60-0.65, 0.80-0.90 μm attributed to charge tranfer transition in minerals which are products of anydreous silicates.

Binzel et al. (1996) were the first to do a spectroscopic reconnaissance of the asteroid Mathilde. Their spectrum does not show the 0.7 μm feature nor other features. However, Mathilde is an exceptionnal slow and tumbling rotator, with a period of 17.4 days, (Mottola et Al. 1995) which is the third longuest rotation period ever measured for an asteroid.
To monitor any variation of the surface color with the rotation and to detect any acqueous alteration features, we have performed observations of Mathilde spanning over three months.

2. Observations

Observations were performed at the European Southern Observatory (ESO, La Silla, Chile).
We used the 1.5 m telescope equipped with a Boller & Chivens spectrograph and a type Loral CCD (2048$\times$2048 pixels) as a detector. The grating used was a 225 gr/mm with a dispersion of 330 Å/mm in the first order. The CCD has a 15 μm square pixel, yielding a dispersion of 5 Å/pixel in the wavelength direction. The useful spectral range covered is about 0.48$< \lambda <$0.92 μm

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* Based on observations carried out at the European Southern Observatory (ESO), La Silla.

Table 1. Observational circumstances of 253 Mathilde.

STARTING TIME [UT]	INT. TIME [s]	r [AU]	Δ [AU]	PHASE ANGLE [°]	m_v	SOLAR ANALOG	S' [%/10^3Å]
1996 Mar 26 08:23:38	300	2.818	2.036	14.9	14.8	HD 76151	2.9±0.1
1996 Mar 27 07:43:08	480	2.815	2.023	14.6	14.8	HD 144585	3.0±0.2
1996 Mai 21 03:08:26	420	2.668	1.695	7.6	14.0	HD 144585	2.8±0.2
1996 Mai 22 04:14:41	360	2.665	1.697	8.0	14.0	HD 144585	2.1±0.1

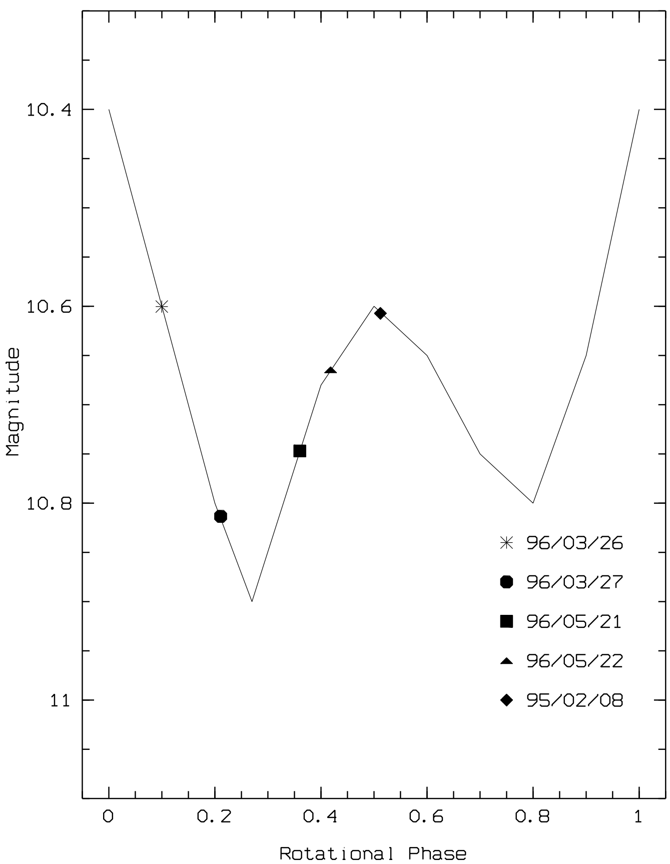

Fig. 1. schematic lightcurve of 253 Mathilde with a period of 17.406 days (obtained from Mottola et al. 1995). Our four observations and the one of Binzel are reported on the curve. Note that the integration times (see tab. 1) are negligeable compared to the period of rotation. The surface of Mathilde is spectroscopically surveyed over almost half a period.

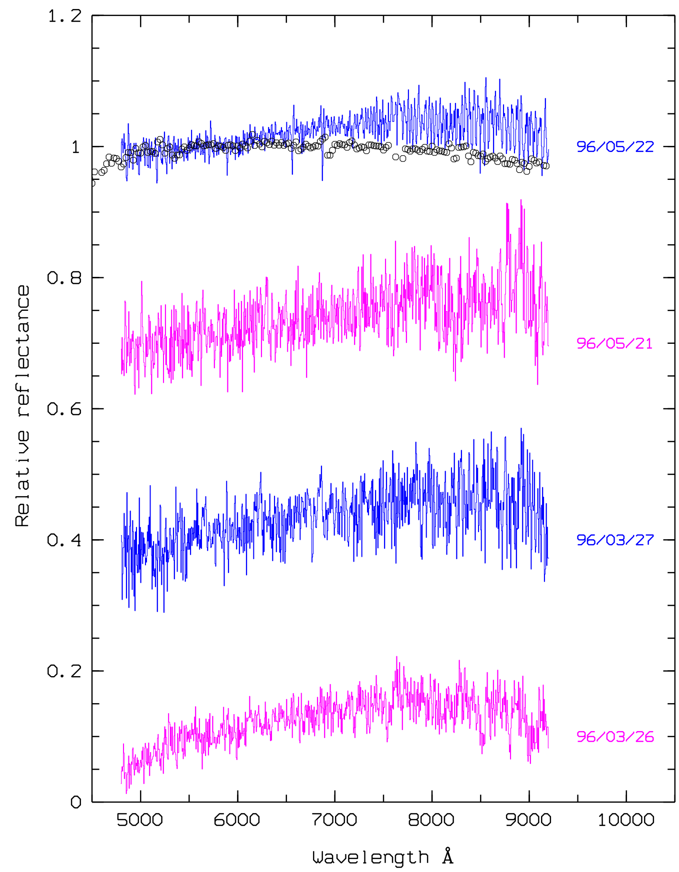

Fig. 2. Reflectance spectra of 253 Mathilde observed at various dates. The spectrum of Binzel et al. (1996) is reported for comparison (open circle). It can be seen that it is similar to our spectra, taking into account the noise. All the spectra have been normalized to unity at 5500 Å and have been offset vertically for clarity.

with an instrumental FWHM of 10 Å.

The observation procedure and the data reduction techniques are the same as described in Doressoundiram et al (1997). In Tab. 1 we report the circumstances of the observations.

3. Results and discussion

On the basis of the photometric measurements reported by Mottola et al. (1995), our observations monitored different locations of the asteroid surface. We have represented the corresponding locations on a schematized lightcurve of Mathilde (fig. 1). We have also reported the observation of Binzel et al. (1996). Finally, with these 5 observations, we are able to analyse the surface of Mathilde over roughly half rotational period.

The four spectra of Mathilde are presented in Fig. 2. They all look very similar and show a slightly red spectrum with respect to the solar one. We have computed the reflectivity gradient S' following the same procedure used by Luu and Jewitt (1990). The values of S' are reported in tab. 1. As expected, the slopes have very close values around 2-3%/10^3 Å, in the spectral range 5000÷8000 Å. The values are tight together within 1%/10^3 Å. This difference is not significant and comparable with the incertitude on the reflectivity gradient. This incertitude, estimated by many authors (Luu and Jewitt, 1990) is introduced by the use of different solar analogs. For comparison, the spectrum of Binzel et al. (1996) is reproduced at the top of fig. 2. We notice that this spectrum is comparable, in the blue part with our spectra, but differ slighly in the red part. Nevertheless, this small discrepency should be included in the noise. So, based on our four spectra and the one of Binzel, 253 Mathilde seems to be homogeneous over 7 days of its rotational period.

Our four spectra appears to be featureless in this wavelength range. However, the slow rotation of Mathilde indicates that these spectra only sample part of Mathilde's surface.

C-type asteroids have been generally linked to some type of carbonaceous chondrites. We have tentatively search for plausible meteorites analog among the carbonaceous chondrites of the Gaffey's meteorite collection (Gaffey 1976). But as Binzel et al. (1996), we confirm that these meteorites do not spectrally match our Mathilde's spectra. The latter authors found better meteorite analogs to be anomalous CI chondrite or black chondrites. This comparison was even confirmed by Rivkin et al. (1996) on the basis of near-IR observations.

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