

VISUAL SPECTROSCOPY OF ASTEROIDS AT SAN PEDRO MÁRTIR

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En este trabajo se presentan los resultados de la espectroscopía de baja resolución para tres asteroides Nysa y uno de la familia “Near-Earth”. Los espectros cubren el intervalo de longitud de onda entre 5000 y 10,000 Å y se obtuvieron en el telescopio de 2.1 m del Observatorio Astronómico Nacional en San Pedro Mártir. Aun con los límites importantes debidos al intervalo espectral abarcado, el análisis revela que dos de los asteroides de la familia Nysa, (2007) McCuskey y (3130) Hillary, son compatibles con un tipo F, mientras que el tercero, (3384) Daliya, pertenece al tipo S. Para (3908) Nyx, el asteroide de la clase “Near-Earth” (tipo “Amor”), se sugiere una clasificación taxonómica consistente con un tipo V. Por lo tanto, este objeto podría ser el resultado de un impacto con el asteroide Vesta.

ABSTRACT

We present low resolution reflectance spectra over the wavelength range 5000–10,000 Å for 4 asteroids (three belonging to the Nysa family and one Near-Earth asteroid) obtained at the Observatorio Astronómico Nacional at San Pedro Mártir (México) using the 2.1 m telescope. Though the limited wavelength range covered often makes a classification difficult, the analysis of the available data reveals that two asteroids of the Nysa family, (2007) McCuskey and (3130) Hillary, are probably of F-type and (3384) Daliya of S-type. Near-Earth asteroid (3908) Nyx (Amor asteroid) shows a spectrum, within the limits of our signal-to-noise ratio (S/N), consistent with a V-type taxonomic classification and may be a fragment excavated from Vesta by an impact.

Key Words: **MINOR PLANETS, ASTEROIDS — TECHNIQUES: SPECTROSCOPIC**

1. INTRODUCTION

The population of Earth-approaching asteroids has long eluded systematic study due to their small sizes and low brightness. Spectroscopic observations can help to determine the surface mineralogy of Near Earth Asteroids (NEAs). Investigations of asteroid compositions can identify potential parent bodies of specific meteorites or meteorite types or objects which have experienced similar evolutionary histories. Most meteorites are asteroidal fragments ejected from their parent bodies as a consequence of impacts, and channeled into chaotic dynamical

routes, associated with mean motion and secular resonances. The main problem is that approximately 73% of the meteorites that fall on Earth are classified as ordinary chondrites (consisting of grains of olivine and pyroxene thought to be only modestly altered during the formation process), which cannot be matched with the typical observed reflectance spectra of any common asteroid taxonomic type (Wetherill & Chapman 1988). The source of these bodies is still a matter of great debate. Numerical orbital dynamic simulations (Migliorini et al. 1998) show that many asteroids in the main belt are driven to

ward Mars-crossing orbits by numerous weak mean motion resonances; in addition, half of the Mars-crossing asteroids are injected in Earth-crossing orbits in less than 20 million years. Gladman et al. (1996) suggest that even ejecta from Mars may be consistent with the dynamical constraints imposed by the small Earth-approachers. There has been a persistent problem of finding a source body for the ordinary chondrites. Due to their dynamically short lifetimes (10–100 Myr), Near-Earth asteroids must be actively replenished (Wetherill 1985, 1988). It has been argued that S(IV)-type asteroids provide the only plausible source of parent bodies, with (3) Juno, (6) Hebe, and (7) Iris being the leading candidates (Gaffey et al. 1993; Broglia, Manara, & Farinella 1994; Migliorini et al. 1997a, 1997b).

The reflectance spectra of 3 Nysa family asteroids have been measured in order to investigate the mineralogical characterization of this family. These observations belong to a systematic campaign to study the peculiar Nysa family (Zappalà et al. 1995). We have some difficulty in assessing whether the Nysa family can be considered as a unique group or as the result of the merging of two independent families, because it is known that in the region of the belt surrounding the family, there is an unusual concentration of F-type asteroids, some of them are included into the list of nominal Nysa members, while some others apparently, do not belong to the family.

We carried out spectroscopic observations of Near-Earth asteroid (3908) Nyx and 3 Nysa asteroids family (2007) McCuskey, (3130) Hillary, and (3384) Daliya.

2. OBSERVATIONS AND DATA REDUCTIONS

Spectroscopic observations were performed at the San Pedro Mártir Observatory (México) using a 2.1 m telescope equipped with a Boller & Chivens spectrograph and a CCD-Tektronix TK-1024 AB detector at the f7.5 focus with a dispersion of 8 Å/pixel in the wavelength direction. The grating used was a 150 gr/mm with a dispersion of 326 Å/mm; also a GG 455 filter was used (blaze 3:26). The useful spectral range is about $4800 < \lambda < 10,000$ Å.

The slit width (2" and 2.5") has been chosen to minimize the consequences of atmospheric differential refraction and to reduce the loss of light at both ends of the spectrum. We observed in 1996 September 3–6, but only the first night was good for the observations.

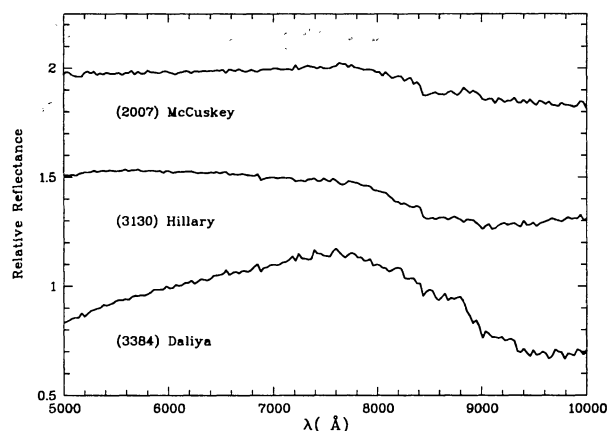


Fig. 1. Reflectance spectra curves for asteroids (2007) McCuskey, (3130) Hillary, and (3384) Daliya.

The observational circumstances are listed in Table 1.

Column 1 gives the observed object; column 2 the date of observations; column 3 and 4 RA and DEC of the object; column 5 and 6 Sun and Earth distance; column 7 phase angle, and the last column the visual apparent magnitude.

The spectral data reduction was performed using the ESO-MIDAS package and taking much care to ensure a proper calibration of the spectra. The bias level of each night was determined through an average of the many bias images taken at night. This averaged bias was then subtracted from each frame

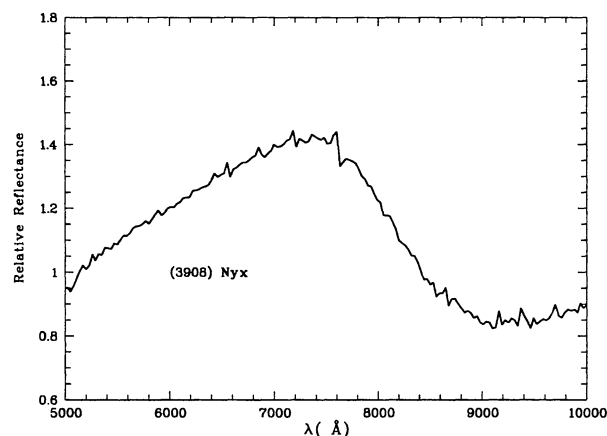


Fig. 2. Reflectance spectrum curve for asteroid (3908) Nyx.

TABLE 1
OBSERVING CONDITIONS

Number and Name	UT 1996 Sep.	α_{2000} (h m s)	δ_{2000} ($^{\circ}$ ' ")	R AU	Δ AU	Phase	m_V
(2007) McCuskey	4.39375	00 47 39	+03 42 01	2.641	1.723	11.3	15.8
(3130) Hillary	4.35278	22 58 28	-13 48 51	1.982	0.977	3.4	14.5
(3384) Daliya	4.30555	22 34 32	-10 53 06	2.085	1.079	2.8	15.7
(3908) Nyx	4.23333	20 54 11	-03 25 56	1.174	0.186	25.2	15.2

and pixel-to-pixel variations were removed by dividing the resulting image by a normalized medium flat field. The MIDAS “long” context was used to sum the pixel values within a specified aperture and to subtract the background level. Wavelength calibration was performed several times during each night using a He-*Ar* lamp, and spectra were corrected for airmasses by using the mean extinction curve of San Pedro Mártir (Buzzoni 1994).

This correction was checked by comparing the same analog star taken at different air mass and the differences were negligible. Since each analog was observed several times we also reduced each asteroid spectrum with the solar analog taken at the same air mass (or as near as possible). Again no difference could be observed, which confirms the quality of the data. Two solar analog, 16 Cyg B, and HD 191854 (Hardorp 1978) were observed to compute reflectivities, since these are solar analogs which closely match the spectra of the Sun. The ratios between the spectra of the two solar analogs for the night of September 3th show no substantial variation. The influence of different solar analogs on the resulting spectra has also been checked, showing negligible differences. The obtained reflectance spectra are normalized at 7000 Å.

3. RESULTS

Asteroids of Nysa family The spectra of (2007) McCuskey and (3130) Hillary are similar, therefore, this confirms their membership to the same group (Figure 1). These spectra are representative of subgroup of objects of the Nysa family belonging to the F taxonomic class. This conclusion can be also obtained by comparing the spectral reflectance curve of these two asteroids with those (in particular asteroids 2391, 4026, 3485, 3228, 3064, 1076) shown in Cellino (2000) and in Xu et al. 1995. Concerning asteroid (3384) Daliya, its spectrum (Fig. 1) shows a curve similar to S-type objects (Cellino et al. 2000)

and therefore, is a representative of the subgroup of the Nysa family belonging to S taxonomic class. In any case it is also possible that (3384) Daliya may be an interloper of the Nysa family (Zappalà et al. 1995).

Asteroid (3908) Nyx This near-Earth asteroid, classified as V-Type by Tholen & Barucci (1989), has been spectroscopically studied by McFadden, Tholen, & Veeder (1989) and Luu & Jewitt (1990). Our spectrum (Figure 2) confirms the strong absorption feature centered at about 9500 Å. The similarity between the spectrum of 3908 Nyx and those of objects belonging to the Vesta Family (Binzel & Xu 1993) suggests that also this asteroid is a chip of a Vesta-like parent body (Cruikshank et al. 1991).

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