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Multi-wavelength study of activated asteroid (596) Scheila.

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Abstract

(596) Scheila is a large primitive asteroid observed with a comet-like apearence last December. We present near-infrared spectra (0.8-2.4 μm) obtained at different rotational phases, covering a whole rotation period of the object after the ejection event, a spectrum in the 2.2-4.0 μm region obtained in 2007, and mid-infrared photometry measured by WISE in Feb. 2010. We show that the surface is homogeneous, and corresponds to a dark (diameter D=113.3km, albedo at 3.4μm $p_{3.4}$=0.068) primitive D-type asteroid. We also find that the best meteorite analogs are carbonaceous chondrites, in particular those of the CM sub-group.

1. Introduction

Asteroid (596) Scheila (hereafter Scheila) is a large primitive body (D=113.3 km) that has been observed with a comet-like apearence [4]. Its visual geometric albedo is p_V=0.038±0.004 [7] and its spectral class is T-type [1], or P-, D-type [8] .

In this paper we present a multi-wavelength study of Scheila (from visible to mid-infrared) in order to study its surface properties and obtain more information about its origin and possible mechanisms underlying the observed activity.

2. Observations

Spectra of Scheila, covering the 0.8-2.4μm spectral region, were obtained during 5 different nights (see Table 1) using the low resolution prism mode of the camera/spectrograph NICS at the 3.56m Telescopio Nazionale Galileo (TNG, “Roque de los Muchachos" Observatory, Canary Islands, Spain), and the low-resolution prism mode of the camera/spectrograph SpeX at the 3m NASA Infrared Telescope Facility (IRTF, Mauna Kea Observatory, Hawaii, USA). All spectra are featureless and look very similar, with similar spectral slopes, thus we conclude that the surface is homogeneous.

Table 1: Date, time and telescope used to obtain each near-infrared spectrum, the computed rotational phase ph and infrared slope S_I.

Date	UT	tel.	ph	S_I'
Dec. 27, 2010	10:58	IRTF	0.69	2.3±0.05
Dec. 27, 2010	14:35	IRTF	0.92	2.4±0.05
Dec. 27, 2010	15:02	IRTF	0.95	2.2±0.05
Jan. 07, 2011	02:56	TNG	0.81	2.2±0.05
Jan. 08, 2011	06:22	TNG	0.54	2.2±0.05
Jan. 09, 2011	06:50	TNG	0.08	2.2±0.05
Jan. 10, 2011	01:53	TNG	0.28	2.3±0.05
Jan. 10, 2011	07:02	TNG	0.60	2.0±0.05

Scheila was also observed using NASA's IRTF on 2.45 June 2007 UT, with SpeX spectrograph/imager in the Long Cross-dispersed (LXD) mode to record spectra from 1.95 to 4.0 μm, with a spectral resolution $\lambda/\Delta\lambda \sim 800$.

In Fig. 1 we present the average normalized reflectance in the 0.8-2.4μm region together with IRTF 2-4μm spectrum and the visible spectrum from [1].

3 Mid-infrared photometry.

Scheila was observed by the NASA *Wide-field Infrared Survey Explorer* (WISE) on Feb. 15.2-16.3 and Nov. 10.9 to 12.1 UT, 2010. Photometry with four filters, centered at 3.4, 4.6, 11.6 and 22.1μm respectively are reported in the WISE Preliminary Data Release

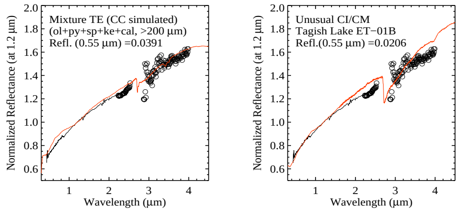

Figure 1: 0.5-4.0 μm reflectance spectrum of (596) Scheila, normalized at 0.55 μm together with two of the spectral analogues found in the RELAB database.

[1] only for the February observations, from which we derived mean fluxes of 8.0652e-16±7.0e-18, 1.5757e-15±8.7e-18, 5.8029e-14±5.2e-17, 4.2233e-14±3.5e-17 $W/m^2/\mu$m. The flux at 12.0 and 22.0 μm is dominated by thermal emission, at 3.4 μm is almost pure reflected light and at 4.6 μm both, thermal emission and reflected light are significant. Using the NEATM [3] model we derive a diameter D=113.38±0.08km, a beaming parameter η=0.724±0.001 (very similar to the canonical 0.756 value) and a geometric albedo (assuming G=0.15) at 3.4μm $p_{3.4}$=0.068±0.001 (see Fig. 2). Considering that, from Scheila's normalized spectrum, the reflectance at 3.4μm is 2.0 times that at 0.55μm, the geometric albedo is p_V=0.034. On the other hand, using the size obtained and Scheila's absolute magnitude[2] H_V=8.9 we obtain a very similar value, p_V=0.038. Both values are in agreement with the albedo reported by [7].

4 Discussion and Conclusions

The spectrum of Scheila shown in Fig. 1 is featureless and has a red spectral slope. The spectral slope parameter in the near-infrared S'_I in %/1000Å is presented in Table 1. The mean S'_I=2.22%/1000Å, for spectra normalized at 1.6 μm. The slope of the visible spectrum obtained from [1], normalized at 0.6μm is S'_V=6.0%/1000Å. The low albedo and the spectral slope together suggest that Scheila can be spectrally classified as a primitive D- type [2]. Different than the other activated asteroids with known spectra that are B-type [5].

We also searched for the best spectral analogs for Scheila among the 15.000 reflectance spectra of meteorites and terrestrial minerals available in the RELAB public database [6], using a χ^2 minimization method. Candidates with the lowest χ^2 value are then visually inspected, and a second selection is done taking into account the absolute reflectance of the comparison spectra, the obtained absolute reflectance of Scheila scaling by the derived albedo, and the center position of absorption bands. Following this procedure we find that best meteorite analogs are carbonaceous chondrites, in particular the CM sub-group (e.g. see Fig. 1), supporting that Scheila is composed of very primitive materials.

[1] http://wise2.ipac.caltech.edu/docs/release/prelim/index.html
[2] JPL Small-Body Database Browser, http://ssd.jpl.nasa.gov/

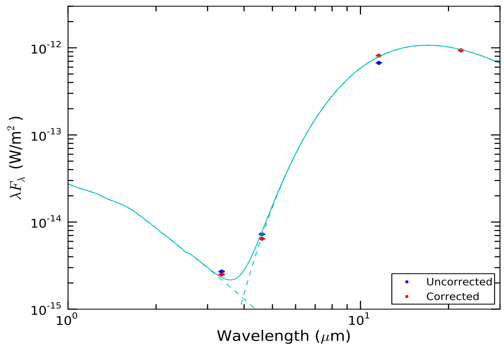

Figure 2: Best-fit using NEATM for Scheila's fluxes measured by WISE. Fluxes corrected by color are in red.

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