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Rotationally Resolved Spectroscopy of (20000) Varuna in the near-Infrared

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Abstract

We present a new study of the surface composition of (20000) Varuna. This study is based on near-infrared spectroscopic observations made with the 3.58 m Telescopio Nazionale Galileo (TNG), at the Roque de Los Muchachos Observatory, Canary Islands (Spain).

1. Introduction

(20000) Varuna (thereafter Varuna) a medium-size, fairly bright trans-Neptunian object (TNO), provides a rare opportunity to investigate the retention and migration of volatile ices. Because of its mass and estimated surface temperature, Varuna is not expected to have retained its original inventory of ices (Levi & Podolak, 2009; Schaller & Brown, 2007). However, the existence of patches of different albedo on the surface of icy objects imply that the equilibrium temperature is not constant on the surface and processes of sublimation, on the hottest areas, and recondensation, on the coolest, can take place (e.g Pluto, Stern et al. 1997). Surface heterogeneity has been detected on several TNOs, and Centaurs (a population os small bodies related to TNOs), it can be caused by a variety of reasons e.g. collisions, volatile migration and cryovolcanism. Two near-infrared spectra of Varuna are available in the literature, and both are different suggesting differences in composition on the surface. Licandro et al. (2001) show evidence of the presence of water ice while the spectrum presented in Barkume et al. (2008) is not compatible with the presence of this ice (Fig 1).

Here we present observations of Varuna during two consecutive nights covering a whole rotational period ($\sim$ 6.3 hrs) and study the surface composition of this interesting TNO.

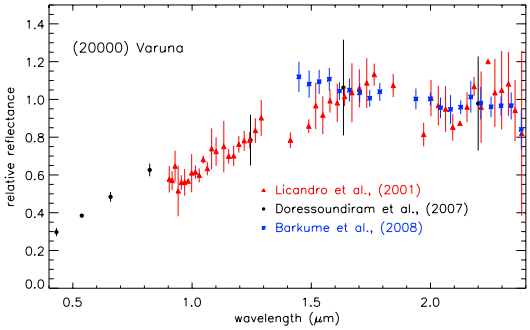

Figure 1: Spectra in the NIR and photometry (BVRIJHK) available in the literature. There are discrepancies between the two NIR spectra, which suggests that the surface of Varuna could be heterogeneous to some extent.

2. Observations and results

We observed Varuna on January 08^{th} and 09^{th}, 2011 with NICS, a near-infrared spectrometer attached to the TNG (0.8-2.5 μm), using the low-resolution grism AMICI. Several solar analogues were observed during the nights at different airmass. The spectra of the object were dividing by the spectra of the solar analogs, then averaged and normalized to unity around 1.6 μm to obtain the relative reflectance. We combine the data into four averaged spectra each of them covering a fourth of the rotation. The four spectra don't show significative variation, suggesting that the surface of Varuna is homogeneous. All the spectra show an absorption band at 2.0 μm due to water ice in accordance to what was detected by Licandro et al. (2001). None of the spectra are similar to that of Barkume et al. (2008), this is featureless within the SNR of the data and shows a blue slope between 1.5 and 2.4 μm. Finally we averaged all the spectra and fit some scattering models (Shkuratov et al. 1999) to study the surface

composition of Varuna. We find that its composition is compatible with a surface covered by a mantle of silicates with a certain amount of water ice and complex organics. No other material is detected on the surface of Varuna (e.g N_2, CH_4,CH_3OH) at least within the signal to noise ratio (SNR) of our data.

3. Conclusions

The analysis of rotationally resolved spectroscopy in the NIR of TNO (20000) Varuna suggests that the surface of Varuna is homogeneous, no dramatic changes of temperature are expected along its surface due to the presence of patches of different composition. Our models suggest that this medium-size TNO is covered by a mantle of silicates, water ice and complex organic materials. We do not detect any volatile (other than water ice) on the surface of this TNO but based on the SNR of our data we cannot discard the presence of some methane or other volatile hydrocarbons whose footprints could be hidden in the noise. Though it is not expected based on models of retention of volatiles, more data are needed to confirm the existence of volatiles on the surface of (20000) Varuna.

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