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The X-Shooter spectrum of (136199) Eris

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Abstract

We observe Eris, one of the largest trans-Neptunian objects, in the $300 - 2480$ nm range with X-Shooter, the first second-generation instrument for the ESO-Very Large Telescope, and compare the newly obtained spectra with those available in the literature.

The large spectra coverage and high resolving power ($\lambda/\Delta\lambda \simeq 5000$) of X-Shooter allow us to study absorption features due to CH_4 and search for other ices' absorptions. We measure the positions and depth of CH_4 absorption features and compare them with those of reflectance of pure methane ice obtained from the optical constants of this ice at 30 K to study shifts in their positions.

We do not directly detect absorption bands due to N_2 or CO ices in the spectra. Nevertheless, the measured wavelength shifts of the CH_4 absorption features points to a dilution of this ice in another one on the surface of Eris and the presence of pure CH_4 spatially segregated. The comparison of the centers and shapes of these bands with previous works suggest that the surface is heterogeneous.

Discussion

Visible and near-infrared spectroscopy of minor bodies bring a wealth of information: absorption bands of silicates and ices, and has been widely used for the study of trans-Neptunian objects [3]. Nevertheless, uncertainties arise due to several technical issues, for instance the use of different stars as solar analogues, combining information of different instruments, or the rotation of the object.

Instruments such as X-Shooter allow us to avoid some of these issues. X-Shooter is able to record spectra from $300 - 2480$ nm, nominally, at once with high resolving power and efficiency. At the time of its Science Verification we proposed to test its capabilities by observing the well known trans-Neptunian object (136199) Eris, which shows absorption features in most of the spectral range covered by X-Shooter [8, 4].

Different works have measured wavelength shifts of the centers of several absorption features on the spectra of Eris [8, 1, 9, 11]. This could be explained by the dilution of CH_4 in other ice. We explore this possibility using the X-Shooter spectrum as well as some of the data already available in the literature [8, 6, 2, 1, 7, 9]. We also search for for other ices, which might be present on Eris surface, in particular N_2 and CO [10].

The resulting spectrum is shown in Fig. 1. The spectrum shows clear absorption features over most of the spectral range covered by X-Shooter. We analyze the complete set of spectra in a homogeneous way, and measure the wavelength shifts of selected absorption features, by comparing the spectra with synthetic CH_4 spectra at 30 K.

We see two overall behaviours: *(i)* there is no clear relationship between wavelength and wavelength shift unless a wide spectral range is used, reinforcing the need of X-Shooter-like instrument for the study of minor bodies, *(ii)* the same absorption feature does not behave equally among different spectra, indicating surface heterogeneity (Fig. 2).

We do not detect absorption features due to N_2 nor to CO ices, which were expected by comparison with Pluto and from volatile loss models [10]. Nevertheless, the absorption bands of CH_4 indicate its dilution in other ice, likely N_2 or N_2:CO, as well a mix of different phases of CH_4 [5].

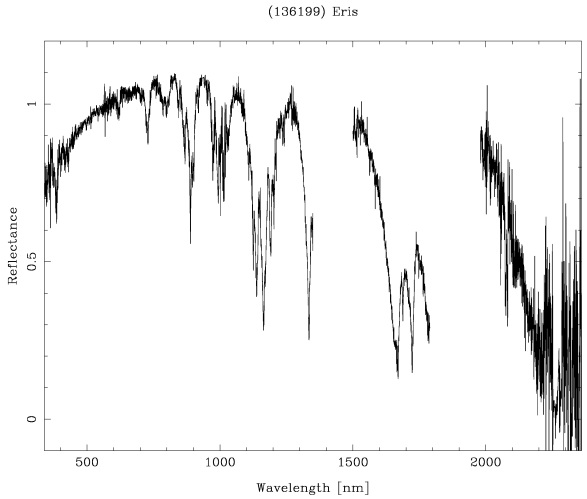

Figure 1: Eris spectrum obtained with X-Shooter. The spectrum was arbitrarily normalized to unity at 600 nm. Note that we removed parts with strong atmospheric absorption.

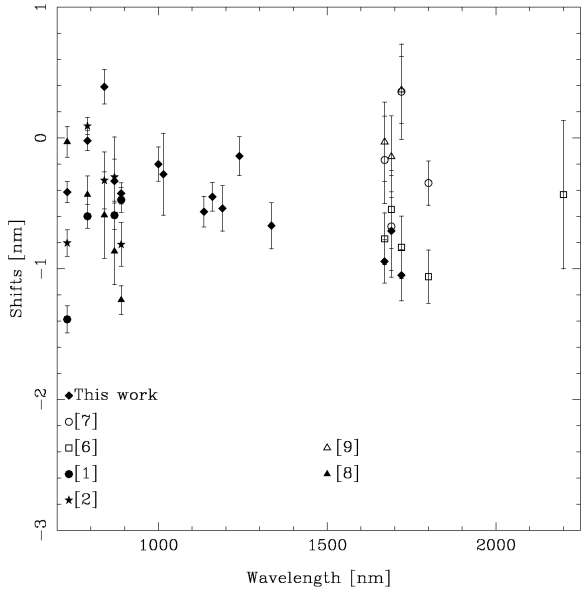

Figure 2: Wavelength shifts for the spectra analyzed in this work *vs.* wavelength.

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