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Exploring the near-UV for primitive asteroids using ground-based observations, space telescopes, a survey-like catalog, and following up with Gaia

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Primitive asteroids (PAs) are characterized by dark surfaces (albedo < 10%) dominated by carbon compounds. Their reflectance spectra are similar to those of carbonaceous chondrites (CCs), the most pristine meteorites in our records, abundant in hydrated minerals and organics. Studying these life-forming materials in PAs and CCs is important to answer how water and life appeared on Earth.

PAs present rather featureless spectra in visible and near-infrared wavelengths (from 0.5 to 2.5 microns). The most diagnostic and reliable region to study hydrated mineralogies and organics is the 3 microns region. However, observing at those wavelengths is extremely complicated using ground-based telescopes due to Earth's atmosphere, and so, the 3-microns feature can only be appropriately studied using space telescopes (e.g. AKARI). Another feature in visible wavelengths around 0.7 μm, thus accessible from the Earth, is related to the Fe2+ Fe3+ iron transition in hydrated mineralogies (Vilas 1994, Fornasier et al. 2014, Morate et al. 2016). However, this band is shallow. Hiroi et al (1998) have proposed a correlation between the 3 microns band and the UV absorption based on the meteorite spectra.

In our work, we aim to explore the near UV (NUV hereafter) behavior of PAs and try to relate it with the main characteristics in the visible (0.7 micron band and slope). To accomplish this objective we have observed and explored spectral data for more than a hundred primitive asteroids with different taxonomies using the 3.58-m Telescopio Nazionale Galileo and the 2.54-m Isaac Newton Telescope located at the Roque de Los Muchachos Observatory. All the spectra go down to ~0.35 microns (near-UV or NUV). The ground-based reflectance spectroscopy in NUV needs special cautions such as airmass, and solar analogs (Tatsumi et al. accepted). In addition, we have explored the Hubble Space Telescope archive thanks to the Archival Research Visitor Program from ESA, finding also some primitive asteroids observed at UV. We also selected ~100 PAs from the MoOJA catalog (Morate et al. 2021), that have 5 filters between 0.35 and 0.55 microns and other 7 from 0.55 to 1 microns. This set of filters allows us to obtain information about how strong is the NUV absorption, to characterize the 0.7-micron band, and to compute several spectral slopes.

Results: we have found a correlation of 77% between the difference of spectral slopes between 0.4 - 0.55 microns and 0.55-0.7 microns (associated with the absorption in the UV) and the difference of spectral slopes between 0.55 - 0.7 microns and 0.7-0.9 microns (associated with iron transition at 0.7 microns), see Figure 1. Therefore, this drop in reflectance in the NUV can be used as a proxy for the phyllosilicates to measure the hydration degree of asteroids. Moreover, there are Fe-rich and Mg-rich phases among phyllosilicates, which reflect the amount of water present during their formation. On other hand, we have found a way to describe the beginning of the NUV drop, and among different taxonomies, there is a difference in the wavelength statistically significant, see Figure 2.

Gaia DR3 will provide thousands of low-resolution slit-less spectra of asteroids in the range of 0.35 - 0.90 microns before the meeting. This will constitute the largest dataset of asteroid spectra down to the NUV and we are going to also present how the thousands of asteroid spectra look like in our spectral slope space.

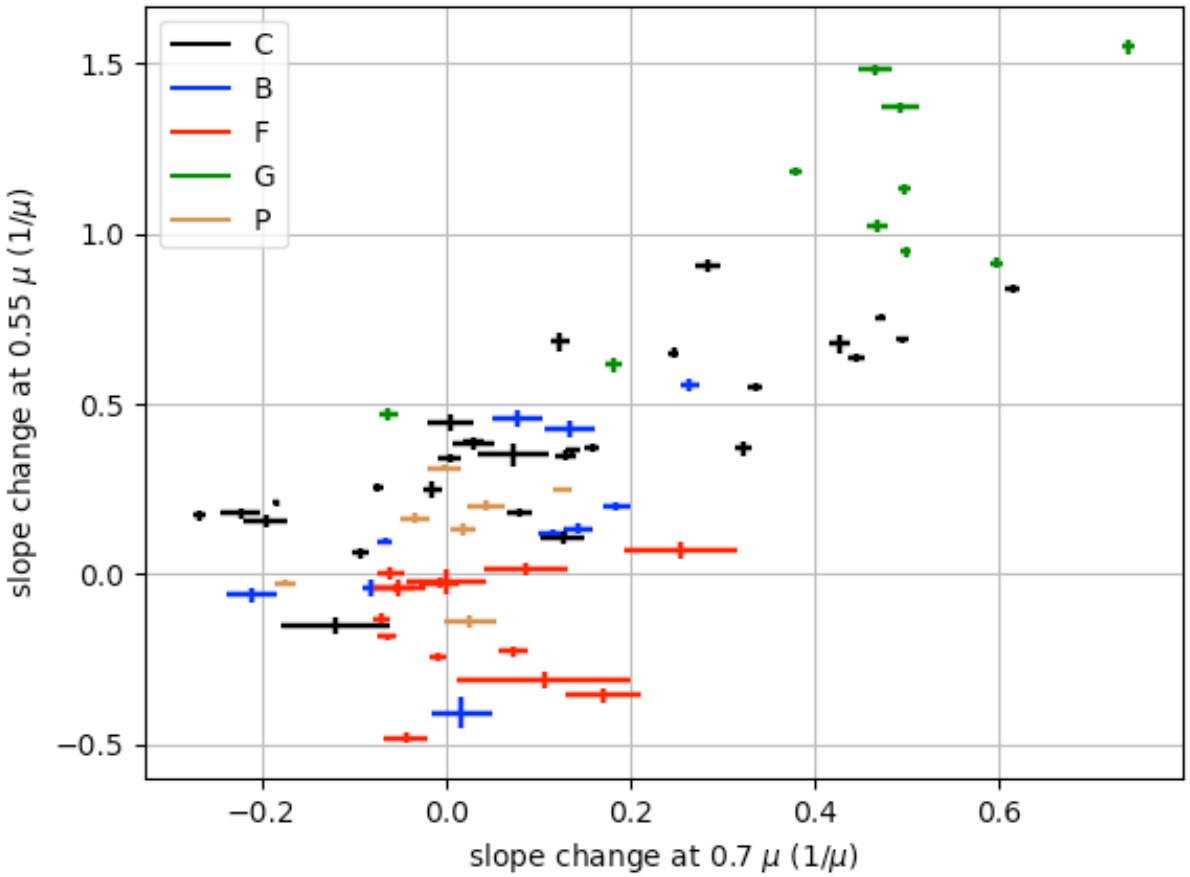

Figure 1. Slope change at 0.55 microns (computed as slope between 0.39 and 0.55 microns minus slope between 0.55 and 0.7) versus slope change at 0.7 microns (computed as slope between 0.55 and 0.7 minus slope between 0.7 and 0.9). The Pearson correlation coeficient between both variables is 0.77.

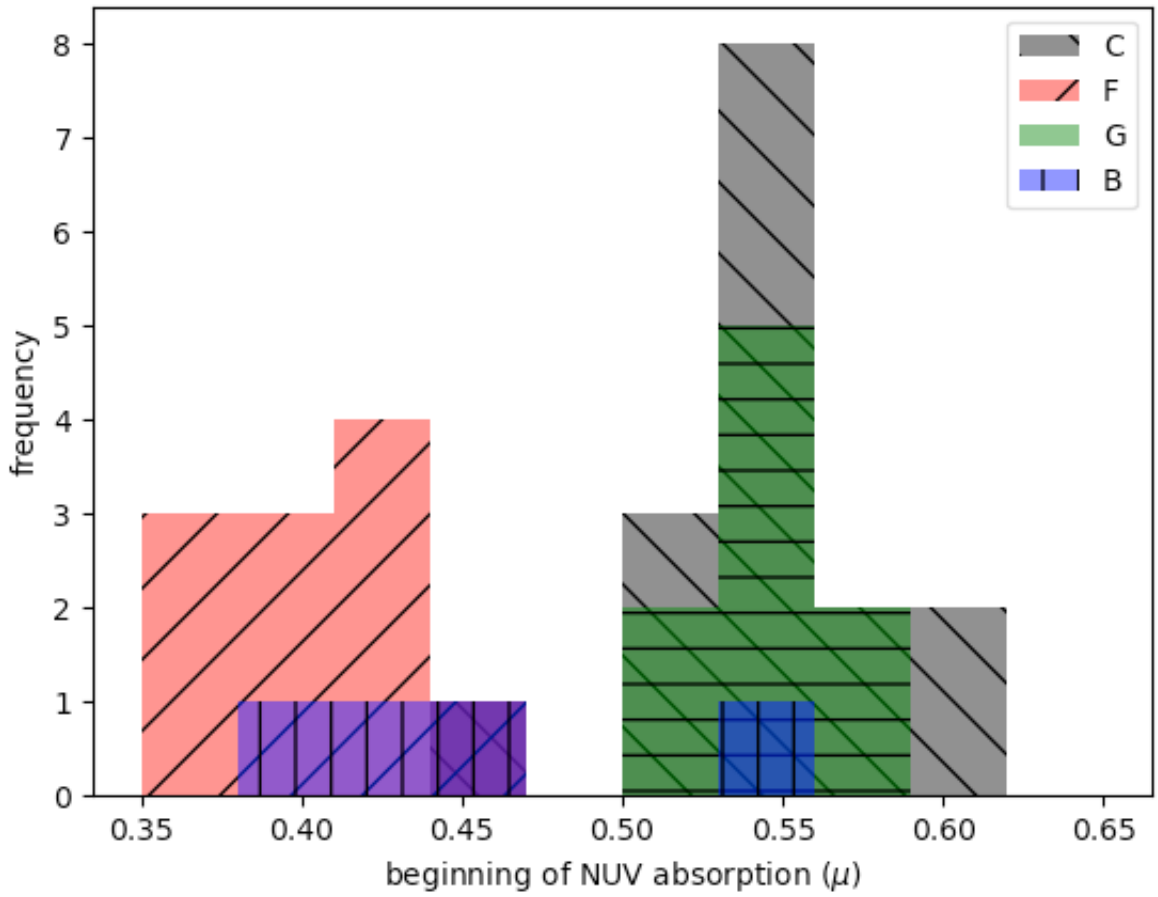

Figure 2. Histogram for the wavelength where the drop in reflectance downwards UV wavelengths begins for C, B, G and F taxonomies. We can see 2 main groups: one around 0.4 microns composed by F and B types and the other around 0.55 containing mainly C and G types.

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