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Spectroscopic Observations of (65803) Didymos with VLT/X-Shooter

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We present spectroscopic observations of the binary near-Earth asteroid (65803) Didymos supporting the upcoming NASA DART and ESA Hera missions, which form the first space-based planetary defence collaboration. Reconnaissance efforts are ongoing, attempting to determine the target's physical properties. (65803) Didymos comprises (780 ± 30)m Didymos and (150 ± 30)m Dimorphos [1]. The first optical spectroscopic observations suggested that Didymos is an Xk-type in Bus-DeMeo taxonomy [2], although, subsequent observations indicated an S-type classification [3] with prominent features from olivines and pyroxenes around $\lambda \approx 1\ \mu m$ and $\lambda \approx 2\ \mu m$ respectively [4]. Recent observations with WHT/ACAM [5] indicated a shallow 1-μm band, suggesting deficiency in silicates. Inconsistencies exist between previously reported reflectance spectra of Didymos, in particular, their optical slopes and 1-μm band-depths.

Observations of Didymos were performed at an excellent seeing of ≈ 0.6" at $\lambda = 0.5\ \mu m$ on the night of 6th April 2019[1] using the intermediate resolution X-Shooter [6] at the ESO 8.2m VLT/UT2. Didymos had visible magnitude V ≈ 20.7. The data reduction methodology builds upon previous software developed to robustly obtain spectra of faint targets [7]. Our processing adds optimal extraction routines [8], to further increase the S/N.

The combined spectrum of Didymos is shown in Figure 1. As anticipated, Didymos shows a $\lambda \approx 1\ \mu m$ silicate absorption indicative of silicate asteroids. Our X-Shooter spectrum has an excellent match

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[1] Observing campaign ESO 0103.C-0224

with the ACAM data at the optical part of the spectrum. The 1-μm band may also exhibit splitting associated with cooler olivine surfaces [9], although it would not be expected given the heliocentric distance of Didymos. Preliminary optical slope measurements between 0.5 and 0.7 μm, were performed and defined as BR_{Slope}. We report a mean value of BR_{Slope} = (10.9 ± 1.0)% per 0.1 μm, higher than (8.5 ± 0.9)% per 0.1 μm from the ACAM data but confirming the red optical slope of the spectrum. Based on our spectrum, an S-type classification is apparent as our near infrared data show both 1-μm and 2-μm bands in agreement with previous observations [3]. A complete analysis of the 2-μm band is not deemed possible at this stage due to extremely low signal beyond 1.80 μm. We will present a taxonomic and mineralogical analysis of the data, including an investigation of any possible longitudinal variations in composition.

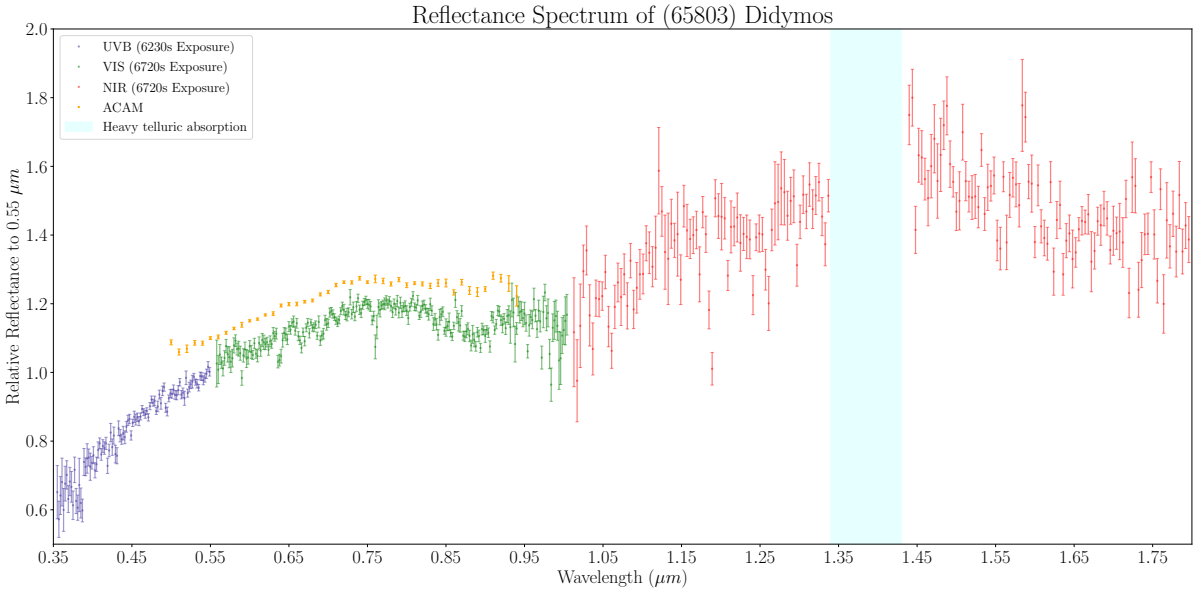

Figure 1: The combined VLT reflectance spectrum of Didymos between 0.35 and 1.80 μm, normalised to unity at λ = 0.55 μm. Data from the UVB, VIS and NIR arms of X-Shooter have been scaled via linear regression, assuming reflectance curve continuity between arms and linearity at arm border regions. The spectrum is robustly binned to bin sizes of $\Delta\lambda$ = 0.002 μm and $\Delta\lambda$ = 0.004 μm in the UVB/VIS and NIR arms respectively. The ACAM data [5] is plotted for reference, shifted +0.1 in reflectance for clarity.

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