

Micrometers Regolith Grain Size Properties Inferred by Laboratory Infrared Observation and their Implication for Planetary Protection

Giovanni Poggiali⁽¹⁾, A. Alberini⁽¹⁾, J. Beccarelli⁽²⁾, A. Wargnier^(3,4), J. R. Brucato⁽¹⁾, M. Pajola⁽²⁾, A. Lucchetti⁽²⁾, T. Fornaro⁽¹⁾, A. Meneghin⁽¹⁾

⁽¹⁾ *INAF-Astrophysical Observatory of Arcetri, 50125 Firenze, Italy*

⁽²⁾ *INAF-Astronomical Observatory of Padova, 35122 Padova, Italy*

⁽³⁾ *LIRA-Observatoire de Paris, 92195 Meudon, France*

⁽⁴⁾ *LATMOS, Guyancourt, France*

Keywords: *Hera, Didymos-Dimorphos, Laboratory, Infrared, Grain size*

The successful demonstration of NASA DART mission success in testing the kinetic impact as a planetary defense technique will be enhanced even more by the scientific observations of the upcoming ESA Hera mission. The spacecraft, launched on October 2024, and now on his way to the Didymos-Dimorphos binary asteroid system, will understand in detail the effect of the DART impact and the outcome of the first planetary defense mission ever. Moreover, en route to its target, the Hera spacecraft will perform in March a close fly-by of Mars and its moon Deimos increasing the scientific outcome of the mission.

In the study of laboratory analogs of mission targets, the grain size is a critical factor for understanding regolith, dust and fragmented rocks covering solid planetary surfaces such as asteroids. Its presence affects key physical properties that are crucial for interpreting remote sensing observation, such as: albedo, thermal conductivity, surface roughness, and spectroscopic properties. Since our understanding of complex samples with varying grain sizes remains incomplete, we conducted several laboratory experiments to deepen our knowledge on the topic. Our analog sample preparation benefits of a new protocol we developed to effectively select grains to hyperfine size, cleaning bigger grains from small grain size contaminations, and mix several components with different grain sizes, assuring homogenization while preserving the initial grain size distribution. This study investigates a wide spectral range from near-infrared (NIR) to mid-infrared (MIR) to support a large number of instruments on board the Hera spacecraft.

One of the most intriguing findings is the observed shift in slope trends caused by the addition of dark material. Specifically, we observed an inversion between reddening and bluing effects, depending on both the composition of the mixture and the grain size of the components. Additionally, we examined several key features, including the hydration band at 2.7 μm , the Reststrahlen band and the Transparency feature.

This study highlights the importance of laboratory measurements on planetary rocky analogs in bridging the gap between the physical properties of these materials and remote sensing data obtained from ground-based telescopes, space telescopes, or spacecraft missions. Indeed, silicate asteroids, like Didymos, are known for their rocky composition, and they are a fascinating focus of space exploration, providing insights into the primordial materials that shaped our Solar System. Moreover, as asteroids in general, should be monitored for the possible threat posed to terrestrial life in the event of an Earth impact and our results will be useful also for the upcoming Apophis close approach in 2029.