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Impact simulations of the Double Asteroid Redirection Test (DART) - Results from the HERA Impact Simulation Group

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Keywords: *HERA, asteroid deflection, impact crater, numerical modelling, laboratory experiments*

ABSTRACT

The HERA mission is ESA's contribution to an international cooperation with NASA called Asteroid Impact Deflection Assessment (AIDA), to validate the "kinetic impactor" asteroid deflection technique. The moon of the Didymos asteroid will be impacted by NASA's DART mission in October 2022. The proposed HERA mission will be launched in 2023/24 and will characterise the binary system in detail, particularly the small moon and the crater produced by DART on its surface.

In the HERA impact simulation working group we conduct numerical modelling studies and laboratory experiments to improve predictions on the resulting crater morphology and morphometry, the ejection and deposition of material, and the momentum transfer. Previous studies have shown that the outcome of the kinetic impactor experiment depends to a large extent on the material properties (mainly porosity and strength) of the asteroid. Therefore, our study focuses on how varying these parameters over a realistic range affects the impact process. In addition, some uncertainties may arise from:
(i) differences in the numerical approach (e.g., ALE vs. SPH);
(ii) different material models (EoS, strength, fracturing);
(iii) user-specific differences in the set-up and analysis.

Comparisons against experiments and benchmarking of different state-of-the-art shock physics codes allows for a significant advance of our understanding of code related differences.

Our initial modelling results show generally a good agreement between the different codes, when comparable initial assumptions are made. The biggest uncertainty results from the limited knowledge of target properties. Within a reasonable range of parameters for strength or porosity, significant changes in crater size are expected. For instance, the volume of ejected material decreases with increasing strength and porosity. Furthermore, the ejection dynamics are affected such that (i) the ejection velocities decrease and (ii) ejection angles are shallower when the coefficient of friction increases. As a consequence, the transfer of momentum on the target decreases and consequently also the degree of orbital change due to the impact. An

increase of porosity from 20% to 50% causes a decrease by ~50% of the momentum carried in the ejecta from the small moon.

In conclusion, our joint modelling and experimental approach is important to provide estimates of the outcome of the DART impact experiment, and to correlate the observable constraints such as crater size and morphology with the target properties of Didymos' moon.

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