DART and Hera missions at Didymoon

The NASA Double Asteroid Redirection Test (DART) will be the first mission to test a controlled deflection of a near-Earth asteroid, by impacting the moon of Didymos [1, 2]. The change in momentum caused by the impact can be expressed in terms of the multiplication factor \( \beta \) [3]. \( \Delta p = \frac{\Delta \vec{p}}{m} \), where \( m \) is the impactor mass and \( \vec{v} \) is the impactor velocity.

ESA’s Hera mission will arrive at Didymoon several years after the DART impact and will perform detailed measurements that will enable us to validate our numerical models.

Key measurements for model validation:
- Momentum enhancement, \( \beta \)
- Bulk density measurements
- Surface cohesion estimate
- Morphology and size of the DART crater
- Asteroid surface survey

We used iSALE to model the DART impact

The DART spacecraft was modelled using iSALE [4, 5], as a porous aluminium sphere, impacting a basalt target at 7 km/s. We considered three distinct target scenarios; for each, we systematically varied the target material properties and determined crater morphology and momentum transfer efficiency, \( \beta \).

References

Same deflection predicted for different target structures

We found that similar deflection (similar \( \beta \) values), can be achieved by impacting targets with very different material properties or structures. However, these impacts produce different crater morphologies. The Hera mission will acquire high-resolution images and measurements of the DART impact crater which will allow the asteroid’s near-surface properties and structure to be inferred and provide robust validation of impact simulations.

Conclusion: Hera measurements are vital for validation purposes

- Impacts into a homogeneous porous Didymoon produce \( 2 < \beta < 4 \). The crater size is mainly influenced by the target cohesion.
- Impacts into layered targets produce both amplification and reduction in \( \beta \). The crater morphology is dependent on the upper layer thickness.
- Impacts into targets with exponentially decreasing porosity produce an amplification in \( \beta \) only for sharp gradients, while the crater size remains unchanged.

REFERENCES