Simulating NASA DART impact: Insights into the interior of asteroid Dimorphos

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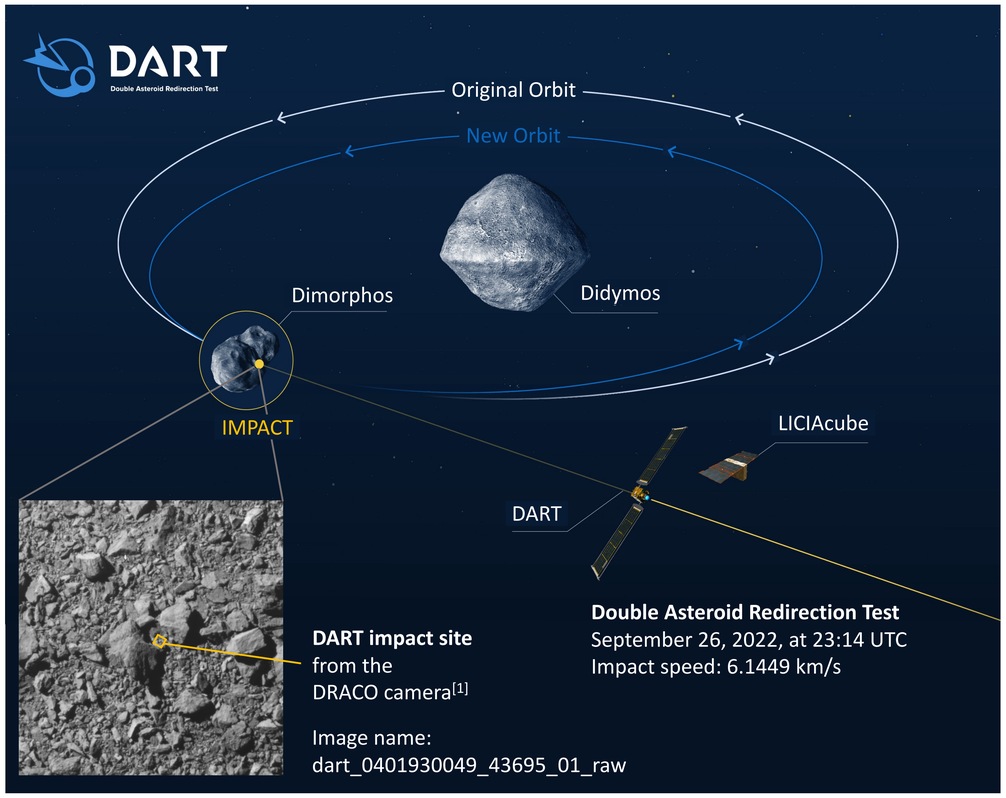
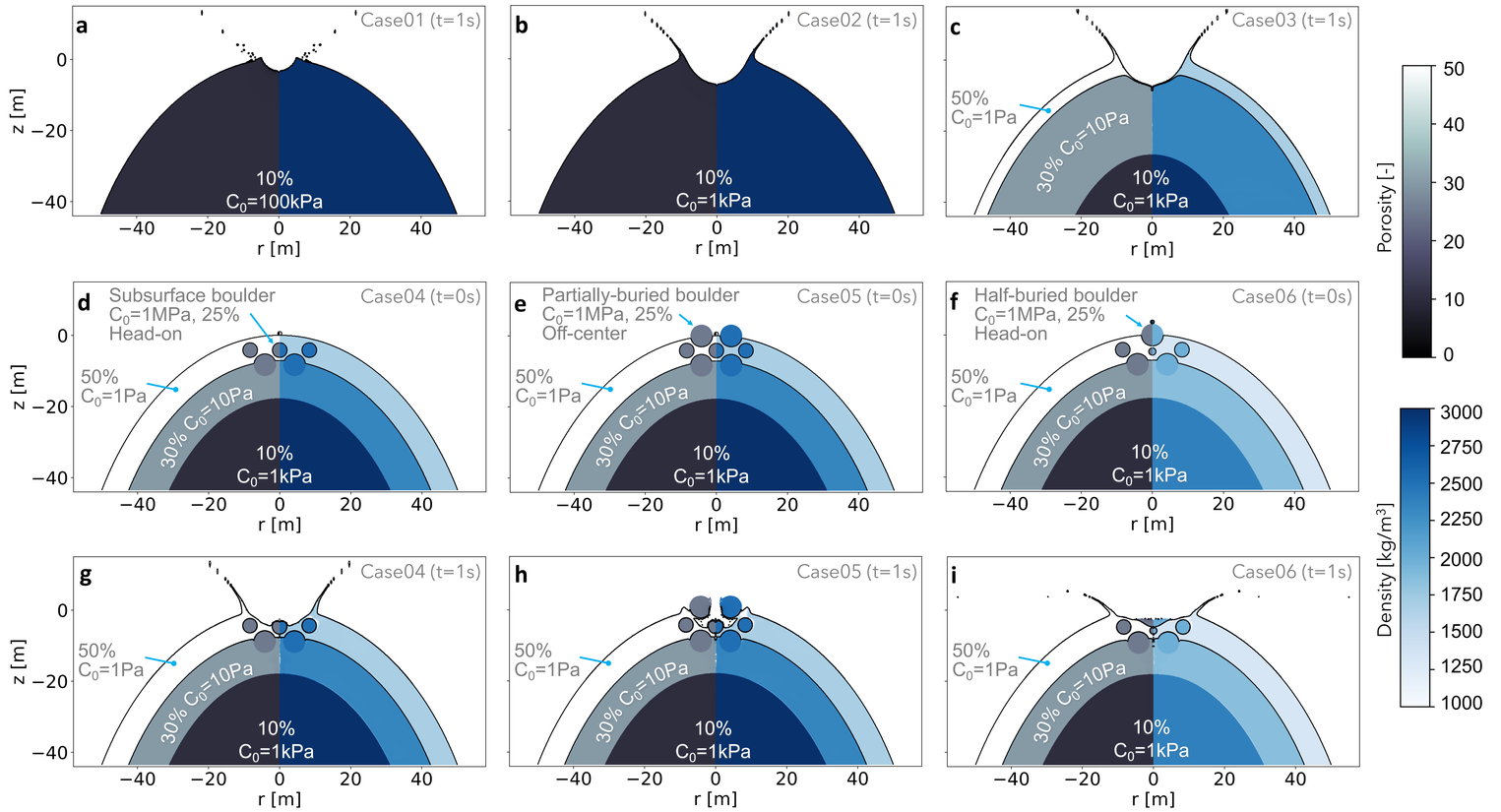


Effects of the DART-scale impact on Dimorphos depending on the asteroid interior and boulder positioning



Background

- In recent years, asteroid missions have made major advancements in characterizing the Near-Earth Objects (NEOs), from JAXA's Hayabusa2 sample-return mission on asteroid Ryugu to NASA's recent DART space mission that performed the first kinetic deflection on asteroid Dimorphos **[1]**.
- The upcoming Hera mission by the European Space Agency (ESA) will characterize the DART impact during a rendezvous with Dimorphos in 2026 **[2]**.
- Meanwhile, numerical simulations have studied the potential impact cratering and ejecta plume outcomes in response to the DART-scale impactor **[3]**.

Method

- To explore what lies underneath the surface of asteroid Dimorphos, various interior scenarios are tested here through the iSALE-2D shock physics modeling **[4-6]**.
- The simulation set-up is based on the latest material and mechanical parameters documented in detail for the impactor and target asteroid **[7-8]**.
- The modeling process is iterated for homogeneous and heterogeneous interiors. The tested range of strength and porosity values are between 1 Pa – 1 kPa and 10 – 50%, respectively.

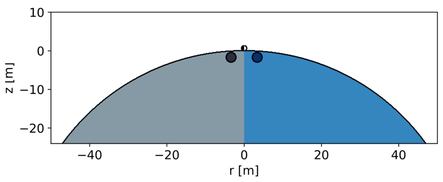
Results

- Impact simulations are depicted at t=1s post-impact in terms of porosity and density fields, showing that the crater size and the morphology highly rely on the asteroid strength.
- Results show the crucial role of boulder positioning and subsurface layering in shaping crater morphology.
- When a half-buried boulder the size of Atabaque **[9]** is positioned off-center, it results in substantially deeper craters. This stems from the impact on weak and high porosity regolith, in contrast to those formed from head-on collisions with a boulder.

Perspectives and future work

- The impact crater continues to collapse for several seconds after impact in the case of rubble-pile asteroids **[8]**, thus the impact crater can be even larger for rubble-pile asteroids with lower strength.
- The next step will involve those interiors, specifically, weak asteroids (Y_0=1-100 Pa) with a homogeneous or heterogeneous composition.
- Crater formation will be examined over extended timeframes, to explore plausible interior heterogeneities **[10]** using available telescopic ejecta observations following the DART impact.

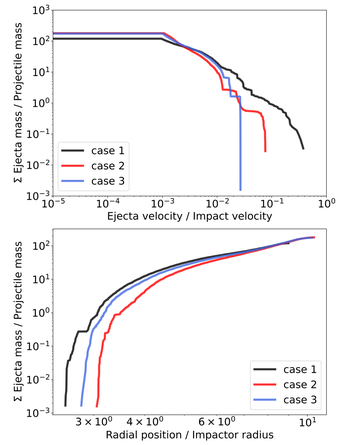
Effects of the boulder representation in the 2D axisymmetric impact simulations:



Comparison at t=0.5s post-impact

case 1: Boulder with radial offset (circular ring)
case 2: case1 + increased boulder porosity
case 3: case1 + decreased boulder density

#	Crater diameter	Crater depth	β momentum enhancement
case 1	13.1 m	6.81 m	1.47
case 2	14.2 m	6.58 m	1.34
case 3	14.2 m	6.65 m	1.37



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