Hypervelocity impact simulations of DART on asteroid Dimorphos: Impact-generated porosity and gravity anomalies

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EUROPLANET SCIENCE CONGRESS EPSC2022

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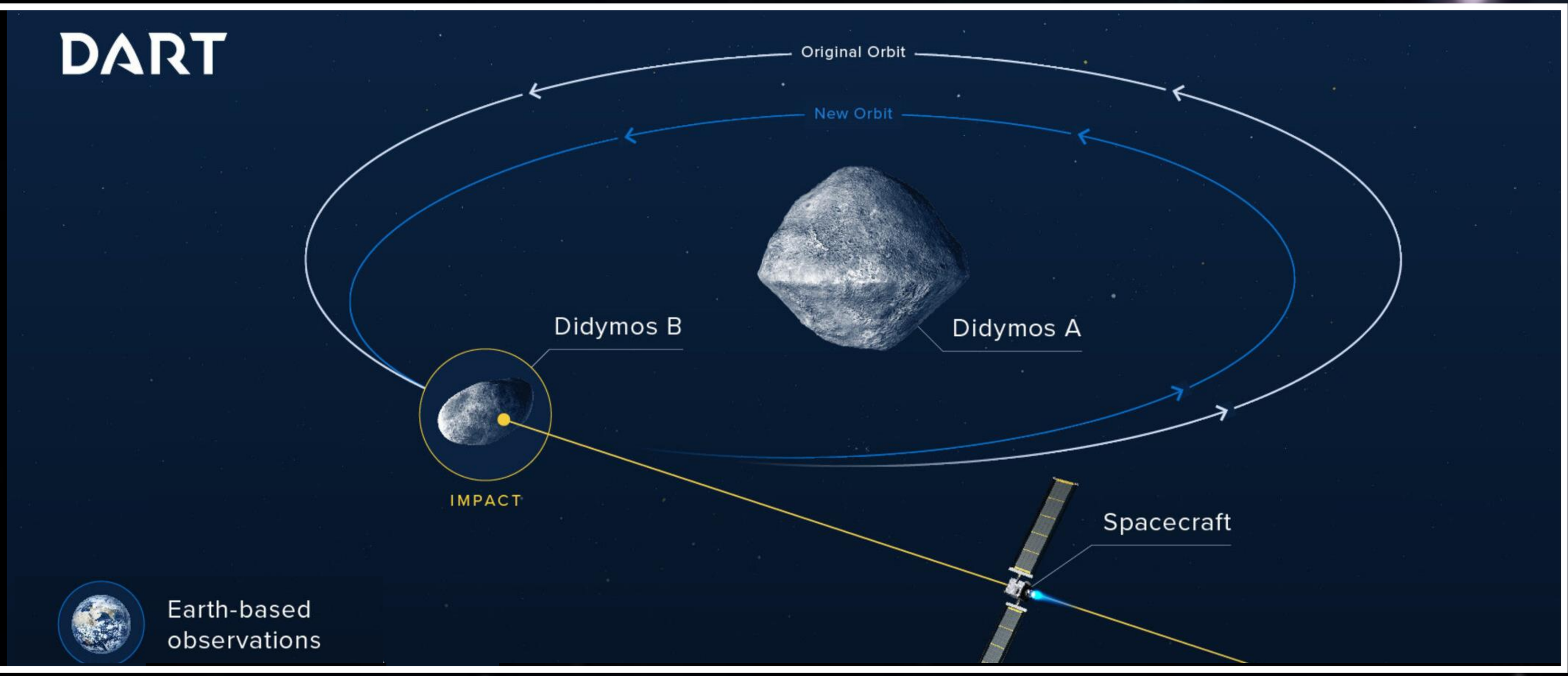
Background

- Impact processes are ubiquitous in the solar system, as one of the fundamental mechanisms driving the evolution of asteroids and comets [1].
- From small meteorites to gigantic Moon-forming collisions [2], impact cratering holds key insights pointing out the dynamic history of our solar system from 4.5 billion years ago.
- Planetary defense missions have steeply advanced in characterizing Near-Earth Objects (NEO), such as NASA's upcoming DART mission [3], scheduled for September 26, 2022. It will deflect the orbit of Dimorphos through a kinetic impactor.
- A few years after the DART impact, the Hera mission by European Space Agency (ESA) [4] will rigorously portray the consequences of the collision, from cratering to exploring the interior and dynamics.
- Previous numerical efforts have reported several factors [5] that can affect the Dimorphos' response, from target layering to strength [6] and projectile obliquity [7].



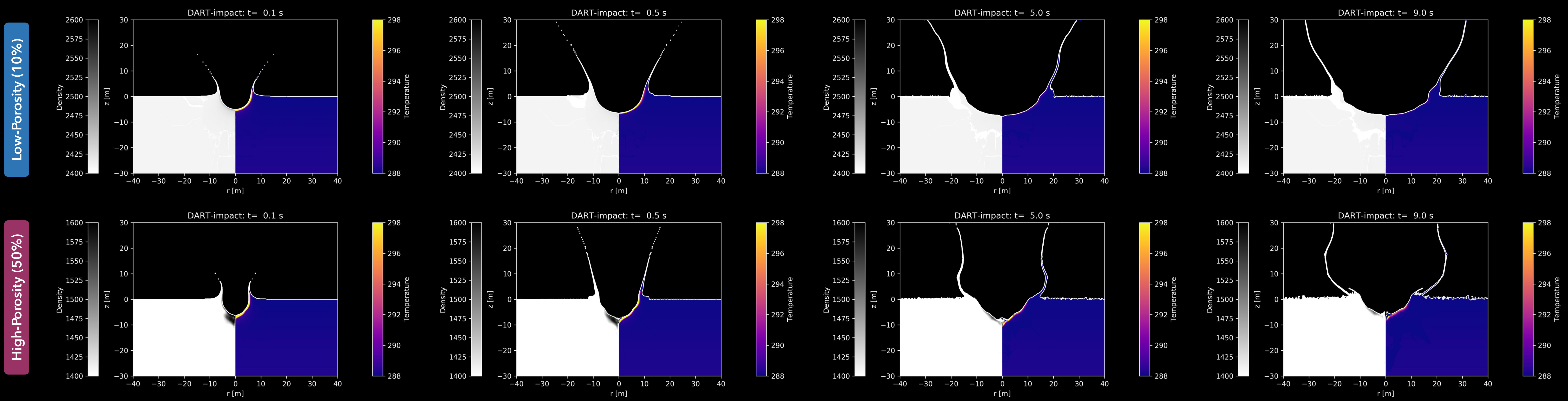
Method & Assumptions

- We use the iSALE2D shock physics code [8-10], assuming gravity-dominated impact into a low cohesion target, Dimorphos (cohesion, Y_0 = 100 Pa).
- For the porosity-compaction routine, the ε-α model of (Wunnemann et al., 2006) [10] is utilized.
- To model the pore-space alteration due to dilatancy, we use the model of Collins (2014) [11], which has been applied in different impact events on the Mesozoic Earth, Mars, and the Moon.
- In our simulations, the DART impactor (solid aluminum sphere with 650 kg mass) hits Dimormos in a vertical trajectory with a speed of 6.5 km/s, based on Raducan et al. [7].

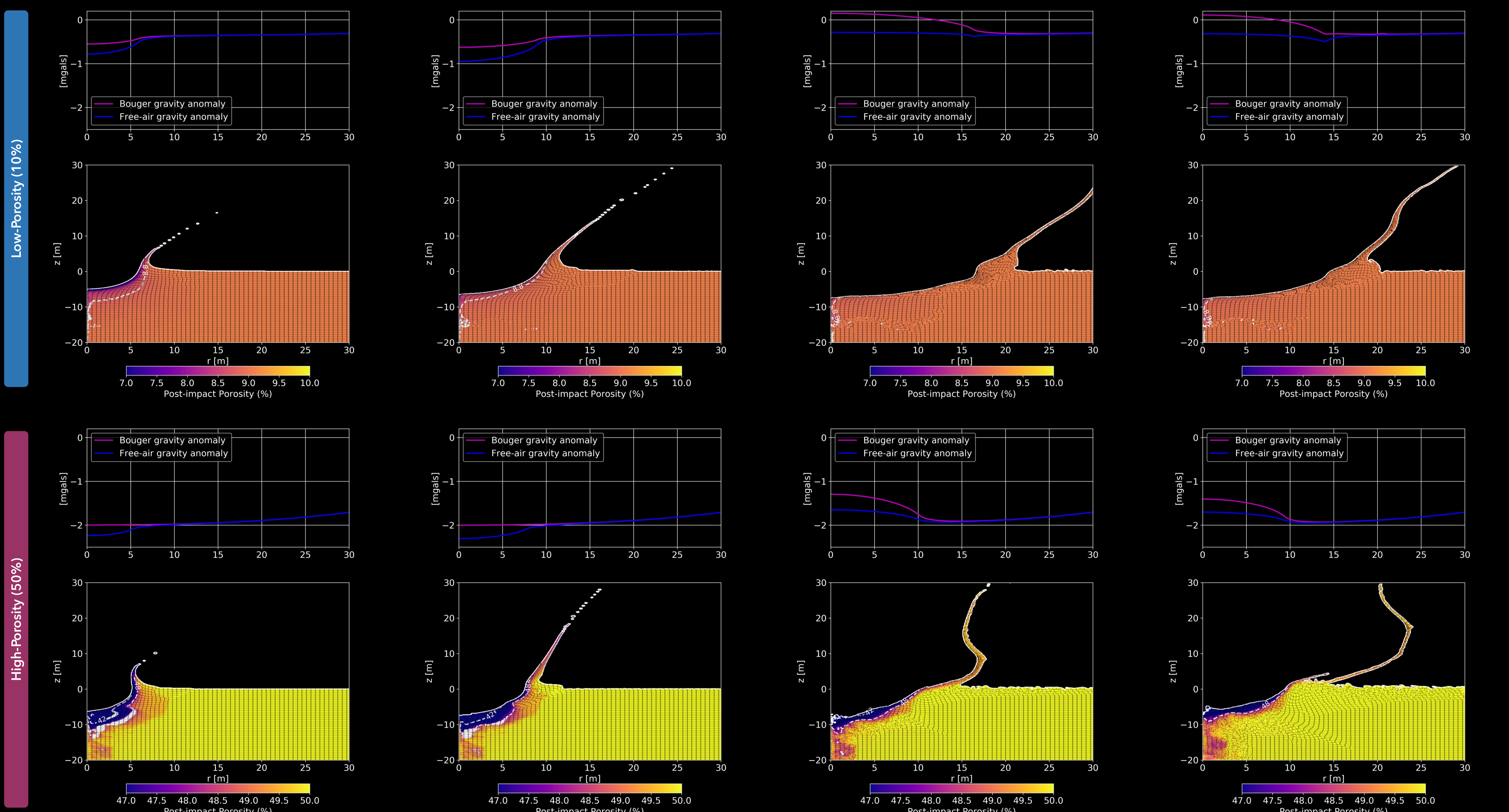
Highlights

- In the present study, after verifying our results using recent impactor/target constraints [5-7], we further explored the likely consequences of DART impact.
- Here we showcase the impact-induced porosity alteration and gravity signatures (free-air and Bouguer anomalies) in two target scenarios: low and high porosity Dimorphos.
- Our simulations show that pre-impact porosity can significantly influence gravity signatures during the crater excavation, leading to an anomaly up to ~0.5 mGal (10% of Dimorphos' gravity).
- In contrast to low porosity targets where the crater porosity recovers to pre-impact levels, high porosity targets would undergo a persistent change in the target porosity.

Results: Post-impact density and temperature evolution on low (10%) and high (50%) porosity target, Dimorphos



Results: Post-impact porosity and gravity signatures under gravity-dominated impact regime (cohesion, Y_0 = 100 Pa)



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