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INFLUENCE OF POROSITY ON IMPULSIVE ASTEROID MITIGATION SCENARIOS

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ABSTRACT

The morphological and mechanical properties of asteroids play a significant role in determining the response to impulsive-deflection strategies for potentially hazardous objects on paths towards Earth. The wide variation in composition, material state and structure of asteroids constitute a significant barrier to understand their response to impulsive loading. The role of porosity and strength of fractured and gravitationally consolidated "rubble pile" asteroids to a standoff explosion or high-velocity impact are investigated for nominally spherical objects considered for the 2015 PDC hypothetical asteroid-impact scenario [1]. The interplay between micro- and macro-scale porosity and material strength are compared between these two different scenarios. Scaling laws between strength and porosity are known for several terrestrial rock types (e.g. sandstone, limestone) and are considered here in the absence of detailed knowledge of an asteroid's material composition.

Impulsive loading of loosely consolidated "rubble pile" asteroids has been considered in [2], with the individual boulders treated as rigid bodies. Recently, [3] investigated the effects of micro- and macroporosity on the β factor in simulations of asteroid impacts.

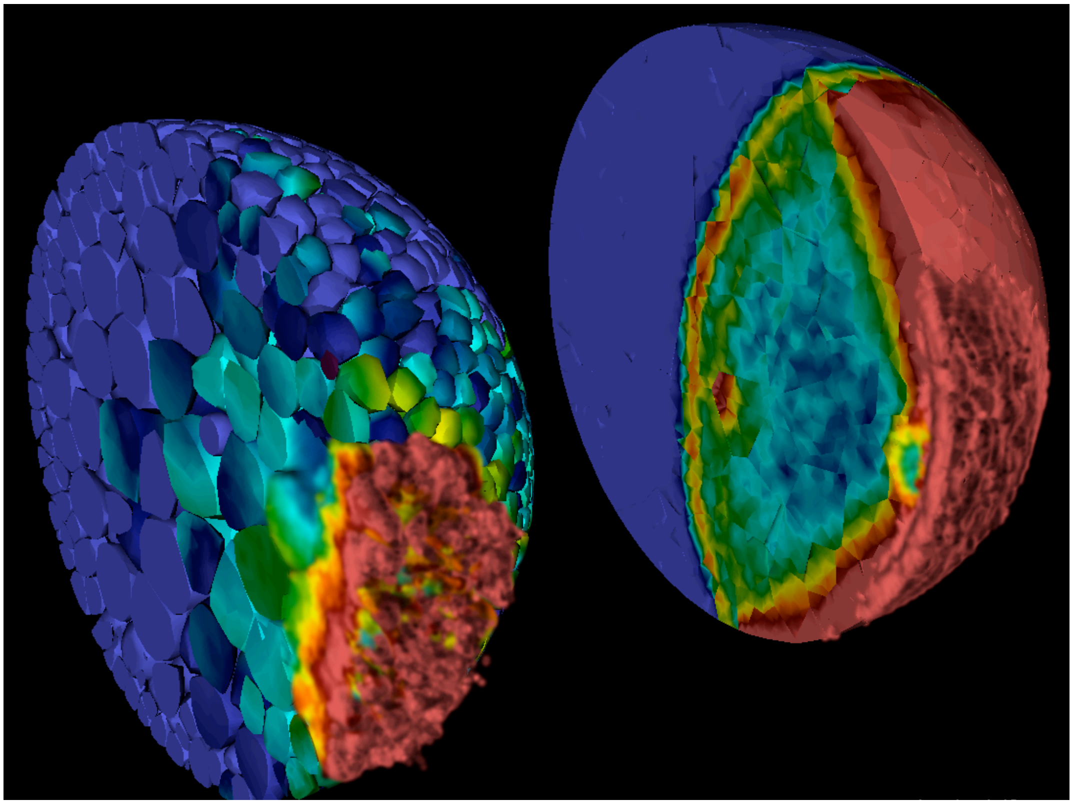

Figure 1 – Sectioned view of standoff-explosion results comparing the response of a nominally 500-m-diameter gravitational aggregate (left) and fractured consolidated body (right) at times t = 0.9 s and t = 7.1 s respectively. The color variation shows the velocity magnitude ranging from 0 - 1 m/s.

The role of micro- and macroporosity will be presented for impulsive loading including standoff nuclear explosions. The response of different asteroid structures largely depends on where the porosity resides. In Fig. 1, a sectioned view of a “rubble pile” and fractured consolidated asteroid are subjected to the same standoff explosion where 5 kt was coupled to the outermost layer of the finite element mesh using Geodyn-L. Fig. 1 elucidates the large difference in wave propagation depending on the internal structure. The “rubble pile” asteroid transmits information through the material via contacting boulders with small contact patches, while the fractured consolidated body is much more efficient at propagating waves. There is almost an order of magnitude difference in time when the impulse has propagated halfway across the simulated asteroid (0.9 s compared to 7.1 s). It is also clear that the impulse is influenced by the internal structure of the asteroid, that can affect the dispersion velocity of the individual pieces once the initial impulse has passed through the entire body. Tracking the statistical motion of resultant pieces is important for deflection or disruption assessments, and will also be addressed.

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[1] http://neo.jpl.nasa.gov/pdc15/. The 2015 PDC Hypothetical Asteroid Impact Scenario.

[2] Korycansky DG, Plesko CS. Acta Astronaut 2012;73:10.

[3] Jutzi M, Michel P. Icarus 2014;229:247.

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