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○ **NEO Characterization**

Investigating the effect of aggregate parameters on the macro-scale properties of rubble-rile asteroids

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Asteroids with sizes below a few km are mostly believed to be loose aggregates bound together primarily by self-gravity, known as rubble-piles. Historically, rubble-pile asteroids have been treated as essentially cohesionless aggregates. Recent evidence from high-resolution spacecraft in-situ observations (e.g. Hayabusa2 and OSIRIS-REx missions) show very low values for cohesion on the surface and in the body [1]. However, the physical nature and intensity of inter-particle interaction forces remain unclear, therefore, their effect on the macroscopic properties is not well understood. For example, the mechanical properties of rubble-pile regolith and individual constituents (microscopic or particle-scale properties) could be different between its surface and subsurface layers, possibly influencing the aggregates response to natural or artificial impacts and high spin rates [e.g. 2].

In this study, we investigate how the variation of particle-scale properties affect the macroscopic behavior of rubble-pile asteroids by simulating layered rubble-piles using GRAINS [e.g. 3, 4]. GRAINS is an N-body Discrete Element Method (DEM) code designed for simulating the behavior of granular materials in rubble-pile asteroids and can model individual particles as irregular shapes instead of spheres. Following [5], we model a layered rubble-pile asteroid (see Fig. 1) where the microscopic properties of the surface layer and the core are characterized by distinct mechanical parameters (such as cohesion, friction, and density). We vary those mechanical parameters, analyze the resulting stability of the aggregate, calculate macroscopic properties (such as their tensile strength), and compare these results with observations and experimental findings [e.g. 1, 6].

Understanding the mechanical properties and evolution of rubble-pile asteroids is crucial for both their scientific and technological exploitation, including the effective design of planetary defense strategies. The approach proposed here offers predictive insights and characterization of layered rubble-pile asteroids and provides a framework for interpreting in-situ observations, including upcoming Hera-related investigations on the post-DART state of the Didymos binary.

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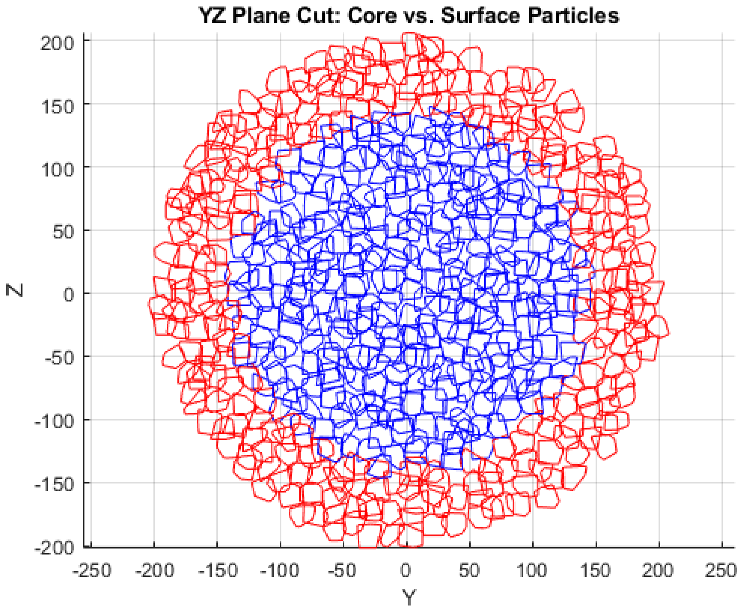

Figure 1: Representation in one plane of the layered rubble-pile asteroid with irregular/non-spherical shaped particles. The different colors represent the core (blue) and the surface layer (red).

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