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A preliminary assessment of asteroid shapes produced by impact disruption and re-creation: Application to the AIDA target.

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In order to understand the origin of the 65803 Didymos, the target of the Asteroid Impact and Deflection Assessment mission, and gain insights on the origin and evolution of the asteroid's162173 Ryugu and 101955 Bennu, we investigate systematically the shapes of all re-accumulated fragments produced by the catastrophic disruption of a parent body that is 1 km in diameter or larger. These new fragments eventually become new asteroids of the size that current sample-return missions plan to explore. We choose a range of impact conditions by varying the parent bodies' strength, size and porosity, and the velocity and size of the projectile. Impact conditions range from near the catastrophic threshold, usually designated by Q*, where half of the target's mass escapes, to far greater values above this threshold. Our numerical investigations of the catastrophic disruption, which are undertaken using an SPH hydrocode, include a model of fragmentation for porous materials. The gravitationally dominated phase of reaccumulation of our asteroids is computed using the N-body code pkdgrav. At sufficiently slow impact speeds in the N-body model, particles are permitted to stick, forming irregular, competent pieces that can gather into non-idealized rubble piles as a result of re-accumulation. Shape and spin information of re-accumulated bodies are thus preserved. Due to numerical expense, this first study uses what we call a hard-sphere model, rather than a soft-sphere spring and dashpot model. This latter model is more commonly used in granular flow simulations for which detailed treatment of the multicontact physics is needed, which is not the case here, and comes at the expense of much smaller timesteps. With the hard-sphere model, there are three supported collision outcomes for bonded aggregates: sticking on contact (to grow the aggregate); bouncing (computed for these generally non-central impacts); and fragmentation (wherein the particles involved become detached from their respective aggregates and proceed to bounce as rigid spheres, possibly releasing more particles). We adjusted the strength of the forming aggregates to the measured strength of materials in the lab, scaled to the aggregate size, by using strength size scaling rules. In the future we expect to compare our hard-sphere models to a few soft-sphere for reasonable granular materials to best characterize differences between the two approaches, if any. Our results indicate that while 25143 Itokawa-like potato-shaped asteroids are typically the outcome of disruption, often more spherical or "top-shaped" asteroids can also be produced. Our results confirm what others have already noted, namely that a "top-shaped" or diamond shaped asteroid is not necessarily the result of the formation of YORP spin-up. Other criteria besides just shape need to be developed to determine whether or not the evolution of an asteroid and its surface geology have been dominated by YORP-related processes or by impact-derived re-accretion.