# Numerical models of the formation of asteroid satellites in large impacts

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We have been investigating the properties of satellites and the morphology of size-frequency distributions (SFDs) resulting from a suite of 160 SPH/*N*-body simulations of impacts into 100-km diameter solid basalt parent asteroids (Durda et al. 2004, *Icarus* **170,** 243–257; Durda et al. 2007, *Icarus* **186,** 498–516). Because many asteroids have undergone a series of battering impacts that likely have left their interiors substantially fractured we have also re-mapped the matrix of solid target simulations using rubble-pile target objects.

Our simulations utilize a 3-dimensional smooth-particle hydrodynamics (SPH) code to model the impact between the colliding asteroids. The outcomes of the SPH models are handed off as the initial conditions for *N*-body simulations, which follow the trajectories of the ejecta fragments to search for the formation of satellite systems. Our results show that catastrophic and large-scale cratering collisions create numerous fragments whose trajectories can be changed by particle-particle interactions and by the reaccretion of material onto the remaining target body. Some impact debris can enter into orbit around the remaining target body, which is a gravitationally reaccreted rubble pile, to form a SMAshed Target Satellite (SMATS). Numerous smaller fragments escaping the largest remnant may have similar trajectories such that many become bound to one another, forming Escaping Ejecta Binaries (EEBs).

Our simulations so far seem to be able to produce satellite systems qualitatively similar to observed systems in the main asteroid belt. We find that impacts of 34-km diameter projectiles striking at 3 km $s^{-1}$ at impact angles of ~30° appear to be particularly efficient at producing relatively large satellites around the largest remnant as well as large numbers of modest-size binaries among their escaping ejecta.

For computational expediency, our simulations so far have treated the resulting collision fragments as spheres, such that our models miss the complex gravitational perturbations on impact debris near the largest remnant that are produced by realistic, irregular asteroid shapes. To address this we have now enhanced our existing simulations of satellite formation in large cratering impacts by conducting SPH simulations of impacts into realistic, irregularly-shaped targets and by computing the *N*-body phase of the simulations using a new version of pkdgrav that *preserves the irregular shapes of the reaccumulated largest remnants.* These simulation upgrades are ideally suited to investigating the details of formation scenarios for multiple, small satellites around irregular primaries.