Analytical and Numerical Modeling of Asteroid Collisional Evolution: Recent Results

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Analytical Studies

We have extended the frequently cited work of Dohnanyi (1969) and subsequent authors, who analytically modeled a size-dependent collisional cascade for the case where material strength (per unit mass or volume) is independent of size. Dohnanyi found that the steady-state size distribution of such a population has a slope of -3.5 (incremental). It has been shown by numerous authors that over the size range of the asteroid belt, material strength is, in fact, a size dependent property. Small bodies decrease in strength with increasing size, due to the presence of larger primary flaws, and larger bodies increase in strength with increasing size, due to gravitational compression and reaccumulation. When strength varies with size, the slope of the size distribution differs from the Dohnanyi value of -3.5, and the transition between the small- and large-body strength regimes leads to `waves' in the size distribution. We have developed an analytical model which includes size-dependent strength (O'Brien and Greenberg, *Icarus* 2003). From this model, we have derived simple analytical relationships which relate the slope of the steady-state asteroid size distribution to the slope of the strength vs. size law, and which describe the amplitude and wavelength of the waves caused by the transition between strength regimes. We will discuss these results and their implications.

Numerical Studies

In order to study the collisional evolution of the asteroid belt in full detail, and to take non-collisional effects into account, numerical modeling is required. We have modified our numerical collisional evolution model to include the non-collisional removal of bodies by size-dependent radiation forces such as the Yarkovsky effect. Such a model must be able to fit a number of constraints, such as the observed main-belt size distribution and the observed NEA population (which consists of bodies removed from the main belt), the lifetimes of meter-scale bodies (as inferred from the cosmic ray exposure ages of meteorites), estimates of the strength of asteroids from analytical and numerical models and laboratory experiments, and the number of families in the current main belt. Furthermore, the non-collisional removal rates we assume must be consistent with current estimates of the removal rate of bodies from the main belt. We are able to achieve a good fit to all of these constraints with our model. We find that a brief, intense phase of collisional evolution could have occurred in the primordial main belt, and may have significantly influenced the current size distribution. We will present our most recent results, and discuss their implications for the collisional and dynamical evolution of the main belt and for the relation between the NEA and main-belt populations.