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Experimental Investigation of Regolith Adhesion in Low-Energy, Microgravity Interactions: Implications for Planetesimal Accretion

Stephanie Jarmak, Joshua Colwell, Julie Brisset, Adrienne Dove, Jeb Massaro

University of Central Florida, Florida, USA,

Abstract

Exploration and sample return missions to asteroids and other small, airless bodies involve low energy interactions with small (μm to cm-size) weakly-bound regolith particles. Additionally, particles in this size range collide at low relative velocities (< 1 m/s) in planetary ring systems and protoplanetary disks and tend to aggregate through non-gravitational interactions. Therefore, to characterize the processes that lead to planetesimal formation and to develop appropriate procedures for crewed and robotic missions to near Earth asteroids, the Moon and Mars, it is critical to obtain laboratory measurements of how μm to cm-size particles respond to low energy collisions in a microgravity environment. Our lab, the UCF Center for Microgravity Research, has conducted several flight-based experiments designed to investigate low-velocity impacts of cm-scale projectiles into simulated planetary regolith. Certain impact events occurring at speeds less than 40 cm/s resulted in mass transfer from the target regolith onto the projectile. To study this phenomenon with significantly reduced cost and time constraints we developed an experimental apparatus that makes use of a laboratory drop tower (free-fall time ~0.75 s) that allows us to simulate the rebound portion of these mass-transfer collision events. The apparatus consists of a rigid pulley mechanism controlled by a stepper motor that will provide us with precise control over the rebound velocity of a cm-size marble. With this method, we plan to increase the explored parameter space of microgravity collision events including projectile mass, material, and rebound velocity as well as regolith compaction, regolith grain type, and regolith size distribution. We present the preliminary results of our drop tower experiment along with a comparison to collision events carried out in our parabolic and suborbital flight experiments.