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The Study of Planet Formation and Asteroid Surfaces Using a CubeSat Laboratory

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How did planets begin to form? What are the surface properties of asteroids? These are two fundamental questions of planetary science. Even though these questions seem to fall into different realms of study, they have a commonality in that they both involve granular particles (powders, gravels, frosts) interacting in a low-gravity environment. The early planet formation process begins when millimeter-sized particles collide and stick to each other, presumably due to electrostatics. This process is effective at creating objects about a centimeter in size; however, electrostatics and gravity are too weak to create larger objects. Therefore, a critical area of study is to understand how the dust in the early solar system was able to grow to kilometer-sized planetesimals. These questions are related to the surfaces of asteroids, that are covered by regolith in a micro-gravity environment. For scientific understanding and for future space missions to asteroids, it is essential that we understand certain physical parameters that govern the behavior of regolith on these bodies. For example, quantifying the angle of repose (i.e. the critical angle beyond which granular material will flow) and determining its dependence (if any) on local gravity will be necessary to design landing apparatus for future missions. To study the early planet formation process and to understand the surface properties of asteroids, we are developing a low-cost CubeSat mission called the Asteroid Origins Satellite (AOSAT), for launch readiness in 2016. AOSAT is a 3U format, 10 cm x 10 cm x 34 cm, with a mass of 4 kg. Of its three chambers, the central chamber will house the spacecraft electronics while the two outer chambers will contain gravel-to-sand-sized meteorite material. The meteorite material was chosen to be as representative as possible to the particles in the early solar system and to the regolith on the surfaces of asteroids; gravels and sands were chosen to facilitate visual analysis. When in orbit, the weightless environment will allow the meteorite fragments to interact in a manner similar to what happens in the early planet formation process. To study the surface properties of asteroids, AOSAT will spin about its maximum moment of inertia axis thus creating artificial gravity in the end chambers. A spin of one revolution a second will create artificial gravity that is representative of the gravity on the surfaces of asteroids about a kilometer in size. High-resolution cameras will record the interactions and an on-board algorithm will package the relevant data for transmission. AOSAT will acquire high-quality data (visual and acoustic) that will help us better understand how planets form and to help characterize the surface properties of asteroids.