Small Gravity Geophysics Inside a Cubesat Centrifuge

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Considerable research attention is paid to the zero-G environment of space, but equally important and more fundamentally baffling is the microgravity environment relevant to comets, asteroids, planetesimals and small moons. Understanding such environments is vital to understanding planet formation and evolution, and to overcoming the technological hurdles of small body exploration. The gravity field around a small planetary body is measurable and constant, but less than one percent the gravity of Earth. For reference the surface gravity of a 1 km asteroid is about 0.0001 G. Astronauts would feel 'weightless' in such environments, yet at the end of the day, all of their belongings would be on the floor. Do melted planetesimals differentiate into an iron core and a rocky mantle, or is their gravity and internal pressure too weak? At what size does gravity overcome surface tension and other forces? Do landslides occur on small granular asteroids? Evidently, but with ground movements of only a few cm/s is the physics the same as on the Moon and on Earth? Does the Brazil Nut Effect segregate an asteroid's components by size? In a separate abstract (Chandra et al.) we describe our ongoing development of AOSAT-1, which is a 3U CubeSat centrifuge spinning at ~1 rpm to attain the equivalent gravity of a 100 m diameter asteroid; its experimental chamber is designed to conduct experiments into meteorite regolith. Here we describe several additional concept payloads, representing relatively small modifications to AOSAT-1, for use in mitigating the risks of more costly missions (testing lander and sampler designs), accelerating the development of instrument or method prototypes, advancing capabilities in microgravity operations, developing novel technologies of in-situ resource extraction, and exploring the behavior of material properties and mixed liquid dynamics in space. We emphasize environments where access to non-human-tended environments is a priority, either for cost or schedule, or because the experiments may be hazardous to astronauts. We emphasizing experiments that will function with limited control from the ground, and with limited power and availability of consumables.