REGOLITH STRATIFICATION AND MIGRATION IN AN ASTEROID-LIKE ENVIRONMENT.

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Introduction: Knowledge of the particle size distributions and layer depths of regolith on the surface of small, airless bodies such as asteroids and moons is crucial to the success of science and exploration missions, as it will clarify choices for appropriate landing and exploration sites, as well as the design requirements for exploration and ISRU hardware. Understanding the evolution of particle size distrbutions in regolith layers also aides with interpretation of ground-based and remote-sensing observations of the regolith-covered surfaces of airless bodies.

Strata-1 was designed to study the mixing and segregation dynamics of regolith on small bodies by utilizing the low-gravity vibrational environment on the International Space Station (ISS). Here we present the results of an alaysis of a subset of data from the Strata-1 experiment, which operated aboard the ISS from April 2016 – May 2017. We discuss the observed particle motion and redistribution, and how it was affected by a variety of vibrational environments.

Experiment Description: Strata-1 was designed as a passive experiment that could operate autonomously aboard the ISS, which provides a microgravity and vibrational environment similar to that at the surface of asteroids (nominal gravity levels on the order of 10^{-6} *g* and vibration over a wide spectrum that can simulate everything from seismic vibrations to the effects of landed vehicles). We utilized imaging capabilities to observe the behavior of different layers of regolith simulant in this environment over the entire duration of the experiment stay on the ISS. The experiment consists of 4 polycarbonate tubes, each filled with a regolith simulant and evacuated prior to flight. Images were taken periodically throughout the duration of the experiment, and local acceleration data was provided via an ISS SAMS accelerometer mounted on the experiment.

Figure 1. Strata-1 experiment tubes prior to flight, with the regolith simulant (left) and the angular shards (right) sorted into distinct particles sizes prior to loading.

For this initial experiment, we used two classes of simulants: two realistic small-body surface simulants, and two simplified silicate glass simulants. These materials were chosen to span a range of granular complexity for both realism and to enable comparison with numerical models. The materials were sorted into three size ranges, with particles about 1mm, 5mm, and 10mm in diameter for the glass simulant tubes. The regolith simulant tubes contained smaller size fractions, as well.

Data Analysis: We first compare the particle size distributions in the experiment tubes containing spherical glass beads and aspherical glass shards, which are more easily tracked visually and can be treated in numerical simulations. We are developing an image processing procedure (Fig. 2) that takes advantage of the (preselected) colors of the angular shards to easily separate the different particles sizes, splitting by the RGB components of the image. After processing a batch of images, we will evaluate how the particle size distrubtion changes as a function of time by mapping the motion of each set of particles. While we are looking at an external view of the particle column, as opposed to a true cross-sectional view, we are still able to identify overall trends in the data and particle size distrubtion.

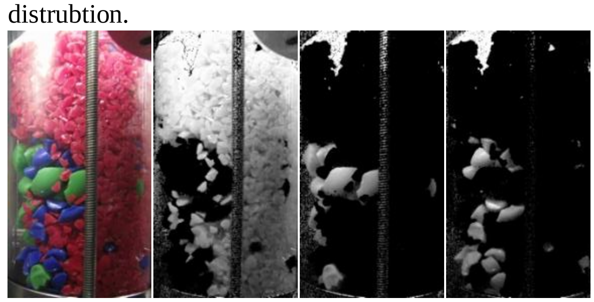

Figure 2. Single processed image from the Strata experiment. (Left) The figure has been cropped and aligned, then split in to (from left to right) red, green, and blue channels to highlight the specific particles.

Results: Although the experiment was passive, we observe a large variation in the particle size distribution over time, and can identify significant events that perturb the system. In particular, we are identifying when major changes occur in the structure of the regolith, and attempt to correlate these with identifiable events in the SAMS acceleration data. By comparing these datasets, we can assess the effect of both the magnitude and vibration frequency of the accelerations on the regolith particle size distributions. Overall, we observe a significant amount of motion and restructuring of the regolith within the tubes over the duration of the experiment.

References: [1] M. Fries, et al. (2016) in LPSC 47 2799. [2] M. Fries, et al. (2018) Acta Astronautica 142 (87-94).