Laboratory measurements of initial launch velocities of electrostatically lofted dust on airless planetary bodies
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Regolith dust particles on airless bodies are charged by solar wind and solar ultraviolet (UV) radiation. These dust particles may become mobilized, lofted, and transported due to the resulting electrostatic force. To explain the charging mechanism behind this lofting, the patched charge model was developed and supported by experiments. In the model, substantial negative charge builds up on the surface of microcavities in the regolith due to emission and reabsorption of secondary or photoelectrons in the microcavity. The electrostatic repulsive force these negatively charged particles eventually overcome gravity and inter-particle cohesive forces, resulting in the mobilization and lofting of dust particles.

In this paper, we report findings on the initial launch velocities of irregularly shaped, micron sized dust particles. Lunar Highland Type (LHT) simulant dust particles were sifted to be <38 microns in diameter, loosely packed into a crater 1 cm in diameter and 0.2 cm deep and set in a vacuum chamber. On airless bodies near 1 AU, photoelectrons dominate the fluxes of charged particles at the surface. In this experiment, the dust was bombarded with a 120-eV electron beam to generate secondary electrons to best simulate the role of photoelectrons in the microcavity charging process on airless bodies. In addition to irregularly sized dust particles, silica microspheres 20 and 40 microns in diameter were also tested to provide a comparison to the irregularly shaped LHT simulant. The lofted dust was observed with a high-speed camera at 5300 frames per second (fps).

It is shown that irregularly shaped dust particles of similar size were lofted with a wide distribution of launch velocities, indicating a large variation in the inter-particle cohesive forces. The maximum velocity is shown to be inversely proportional to the particle radius, a relationship which was predicted by a theoretical model based on patched charge model and conservation of energy. Furthermore, it is shown that irregularly sized dust particles were lofted with much higher speeds than the silica microspheres. These measurements provide some insight into the launch velocities of regolith particles on small airless bodies. The maximum velocity for a particle of 15 microns in radius was found to be ~0.7 m/s. These laboratory results are helpful for understanding the observations of regolith on the Moon and asteroids Itokawa, Ryugu, and Bennu.