

LABORATORY MEASUREMENTS OF INITIAL CONDITIONS OF ELECTROSTATICALLY LOFTED REGOLITH DUST. X. Wang^{1,2}, N. Hood^{1,2}, A. Carroll^{1,2}, R. Mike^{1,2}, H. -W. Hsu^{1,2} and M. Horányi^{1,2}, ¹Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, Colorado 80303 (first author email address: xu.wang@colorado.edu), ²NASA/SSSERVI's Institute for Modeling Plasma, Atmospheres and Cosmic Dust, Boulder, Colorado 80303.

Introduction: Electrostatic dust transport has been suggested to explain a number of unusual observations across airless planetary bodies from the lunar horizon glow to dust ponds on asteroid Eros to radial spokes in Saturn's rings [1]. Recent laboratory studies have greatly advanced our understanding of the dust charging and lofting mechanisms [1,2]. An experiment validated "patched charge model" explains that emitted photo and/or secondary electrons can be reabsorbed inside microcavities formed between dust particles, resulting in large negative charges on the surrounding particles that repel each other to become lofted or mobilized.

The charge in microcavities can be estimated using the following equation

$$Q \approx -0.5C(\eta T_{ee}/e) \quad (1)$$

where $C = 4\pi\epsilon_0 a$ is the capacitance of a dust particle with radius a , η is an empirical factor between 4 and 8 based on the laboratory measurements, T_{ee} is the emitted electron temperature in eV. $\eta T_{ee}/e$ shows the surface potential of the dust particle with respect to the ambient plasma.

The knowledge of initial launch conditions of charged dust particles is critical for understanding their electrostatic dynamics and subsequent effects on surface processes of airless bodies.

Initial Conditions of Electrostatically Lofted Dust: We have performed a series of laboratory experiments to characterize the initial conditions of lofted dust. We used both lunar and Mars simulants with a size range between 10 and 100 μm in diameter. Dust particles were exposed to ultraviolet (UV, 7.2 eV) or beam electrons (up to 120 eV). Here we report the current measurements of the charge, size, velocity and rate, as well as their interrelationships.

1) Charge. All lofted dust particles are charged negatively, even under UV radiation [2]. It is generally expected that dust particles are charged positively due to photoelectrons emitted from the dust surface. Our experiments, however, showed opposite results that are in agreement with the patched charge model, as described above. The magnitude of the measured charge is on the order of 10^{-14} C for 40 μm diameter particles, which is also in agreement with the predicted values from the patched charge model [2].

2) Size. The lofted dust shows a wide size range from 10 to 100s μm in diameter [1]. In addition to single-sized particles, aggregates (clumps held by the

cohesive force between particles) are lofted as well with the size up to 140 μm . In contrast, single sized particles 70 μm in diameter do not move under the same charging conditions. The high-porosity of aggregates enhances the total charge per the patched charge model.

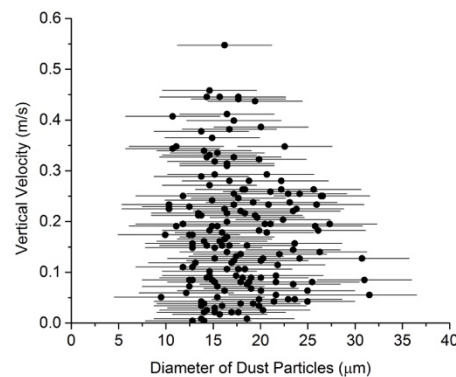


Fig. 1 Initial launch velocity as a function of dust size.

3) Velocity. For dust particles of 10s μm in diameter, the vertical launch speed is on the order of 1 m/s [1]. The preliminary results from a new experiment show that smaller particles are lofted with a higher speed (Fig. 1). It also shows that the velocity spreads a wide range for the same sized particles, which is likely attributed to the large variations in the cohesive force between irregular shaped particles.

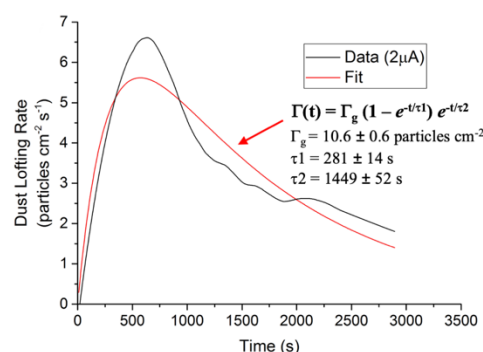


Fig. 2 Dust lofting rate over time with the simulated charging conditions at 1AU.

4) Rate. Our recent experiment [3] shows that the lofting process is time-dependent, which begins relatively fast and then slows down as time progresses (Fig.

2). The slow-down is likely due to the refilling or removal of microcavities as a result of dust movement, reducing the microcavity charging effects. Figure 2 shows that the transient rate may reach ~ 5 particles $\text{cm}^{-2} \text{s}^{-1}$ that is fast enough to supply the lunar horizon glow event. The slow-down indicates that the average rate over the geological timescale remains low.

Summary and Discussion: Laboratory experiments were performed to measure initial conditions of electrostatically lofted dust, including the charge, size, velocity and rate, as well as their interrelationships. These results are critical for future studies to understand the dynamics of charged dust across airless bodies in the Solar System and to ultimately explain the space observations that have been puzzling scientists for decades.

References: [1] X. Wang, J. Schwan, H.-W. Hsu, E. Grün, and M. Horányi (2016), GRL, 43, 6103–6110. [2] J. Schwan, X. Wang, H.-W. Hsu, E. Grün, and M. Horányi (2017), GRL, 44, 3059–3065. [3] N. Hood, A. Carroll, R. Mike, X. Wang, H.-W. Hsu and M. Horányi (2018), GRL, 45.