CHARGING AND MOBILIZATION OF DUST PARTICLES ON A SOLID SURFACE IN THE SPACE PLASMA ENVIRONMENT. José H. Pagán Muñoz[1,2], Xu Wang[1,2], Mihály Horányi[1,2], Vladimir Kvon[3], Luuk Heijmans[3], Manis Chaudhuri[3], Andrei Yakunin[3], Pavel Krainov[4], and Dmitry Astakhov[4], [1]NASA SSERVI's Institute for Modeling Plasma, Atmospheres and Cosmic Dust, University of Colorado, Boulder CO, 80303, USA, [2]Laboratory for Atmospheric and Space Physics (LASP), University of Colorado, Boulder, CO 80303, USA, [3]ASML, Eindhoven, The Netherlands, [4]ISTEQ B.V, High Tech Campus 9, 5656 AE Eindhoven, The Netherlands (Email: Jose.Pagan@lasp.colorado.edu)

Introduction: Electrostatic dust charging, mobilization, and lofting on the surfaces of the Moon, asteroids and other airless bodies is a longstanding problem. Understanding of this electrostatic process is not only important for understanding its effects on the surface evolution of these bodies, but also important for human and robotic exploration to these bodies, especially the lunar surface exploration in the next decades under NASA's Artemis program. Charging and mobilization of dust particles on the lunar surface covered by the regolith has been greatly advanced with a patched charge model (PCM) [1]. The PCM shows the emission and reabsorption of secondary electrons and/or photoelectrons within microcavities between dust particles generates large charges leading to the subsequent mobilization and lofting of the dust particles due to strong Coulomb repulsion. In addition to the case of the lunar regolith which contains a thick layer of dust particles, there are many scenarios in which single layered dust particles directly rest on a solid surface, for example, on the surfaces of lunar rocks and exploration equipment like rovers, thermal radiators, solar panels, and spacesuits. The charging and lofting of these single layered particles remain poorly understood.

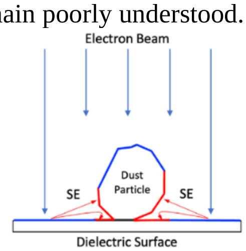

Fig 1: Diagram of the Patched Charge Model for single particles (PCM-SP) on a solid surface.

Here, we extend the PCM for Single Particles (PCM-SP) on a solid surface and present the first experimental results that validate this new charging model. The PCM-SP (Fig. 1) shows that microcavities are formed between the curved surfaces of a dust particle and the solid surface, which can absorb photoelectrons and/or secondary electrons emitted from the solid surface, resulting in the accumulation of large negative charges therein and subsequent mobilization or lofting of the particle.

Experiment and Results: The experiment is comprised of a vacuum chamber which has SiO_2 dust particles (<45 microns) dispersed on a Kapton film laid on a dielectric plate. The surface is exposed to an electron beam (50-500 eV) generated from a hot filament (or a UV source not shown). Dust Mobilization is recorded using a video camera. Plasma probes are used to characterize the electron beam and plasma potentials.

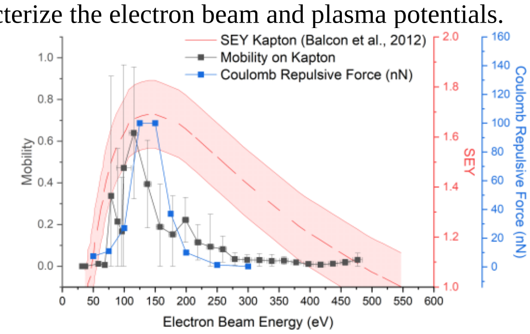

Fig 2: Dust mobility, coulomb repulsion force, and secondary electron yield curve (SEY) with error band vs electron beam energy.

Both experimental and modeling data are plotted over the Secondary Electron Yield (SEY) curve for a Kapton film [2]. The dust mobility begins when the beam energy becomes larger than 50 eV, increases rapidly with the beam energy and hits the peak at ~125 eV, then decreases at a slower rate, and finally ceases when the beam energy is larger than ~320 eV. The mobility result shows good agreement with the modeling result of the dust-surface repulsive force. Both results follow the SEY curve, verifying the role of emitted secondary electrons from the solid surface in charging and mobilization of single dust particles. The recorded dust movements under UV exposure further support the PCM-SP.

Conclusion: We presented the first experimental results showing that single dust particles mobilize on a dielectric surface and are lofted from the surface due to exposure to an electron beam or UV light. A complete charging theory for single particles (PCM-SP) on a surface is developed and verified with both the experiment and the modeling. Our results extend the understanding of electrostatic dust charging and mobilization into broader scenarios in both planetary science and exploration on the Moon, asteroids, and other airless bodies.

References: [1] Wang et al (2016), Geophys. Res. Lett., 43, 6103–6110; [2] Balcon et al (2012), IEEE Trans. Plasma Sci. 40. 282 - 290.