THE ROLE OF ELECTROSTATIC DUST TRANSPORT IN THE SURFACE EVOLUTION OF AIRLESS PLANETARY BODIES.

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Introduction: Electrostatic dust charging and transport, due to the exposure to the solar wind plasma and solar radiation, has been suggested to explain a number of unusual observations on airless planetary bodies [1]. The first evidence was the so-called lunar horizon glow, which was thought to be caused by levitated dust particles scattering off the sun light. Since then, many other observations, such as the radial spokes in Saturn's rings and the "dust ponds" on asteroid Eros and comet 67P, have also been related to the electrostatic dust transport processes.

However, the exact charging and transport mechanisms remained unsolved for decades. Recent laboratory studies have greatly advanced our understanding [1,2]. Micron-sized dust particles were observed to lift off the surface to several centimeter high by exposure to ultraviolet (UV) radiation or energetic electrons (Fig. 1, left).

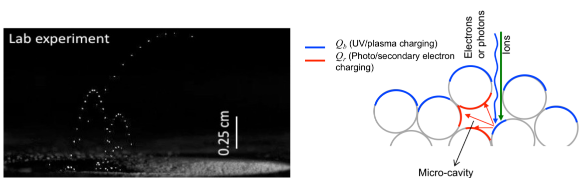

Fig. 1 Left: Trajectories of lofted dust particles under UV radiation; Right: Patched charge model.

A "patched charge model" (Fig. 1, right) was developed and validated with the laboratory experiments. It explains that emitted photo and/or secondary electrons can be re-absorbed inside microcavities formed between dust particles, causing the accumulation of surprisingly large negative charges on these particles. The resulting repulsive force ejects them off the surface. These laboratory experiments showed a strong support for electrostatic dust transport to occur on the surfaces of airless planetary bodies. The next questions are how this process changes the surface physical properties and how efficient this process can be in contribution to the surface evolution.

Effect of Dust Transport on Surface Properties: We performed new laboratory experiments to show changes of the surface properties, such as surface morphology and porosity, under exposure to photons or energetic electrons. As an example shown in Fig. 2, dust particles (38 – 48 μm in diameter, Mars simulant) exposed to UV radiation make a rough surface to become smooth (Fig. 2, left) or create the complex features on a flat surface (Fig. 2, right).

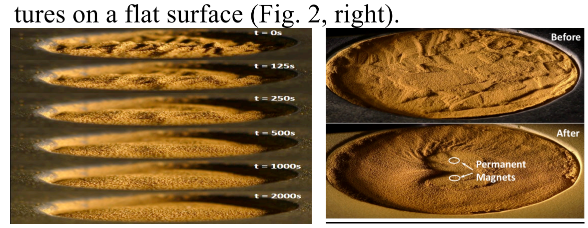

Fig. 2 Left: Time lapse of surface mobilization under UV radiation; Right: Before & after images due to UV radiation. Two buried permanent magnets form a dipole field above the surface.

Dust Lofting Rate Measurements: We recorded lofted dust particles (< 38 μm in diameter, lunar highlands simulant) over a long exposure time as a function of the incoming flux of photons or energetic electrons that mimic the space condition at 1 AU. Our preliminary results indicate that the dust lofting rate at 1 AU is around 20 particles$\cdot$cm$^{-2}\cdot$s^{-1}, which gives the depth accumulation rate about 1 cm over 2.5 months [3]. This rate seems unexpectedly fast. It was found that the dynamics of dust mobilization depend on both the surface compactness and the dust size distribution. It was also shown that this process slows down significantly as time elapses. It may be because the porosity varies with the depth of the regolith surface. These effects are currently examined in detail to accurately estimate the characteristic timescale of this process in space.

Summary and Discussion: Laboratory experiments have shown a strong support for electrostatic dust mobilization and transport to occur on the surfaces of airless bodies due to direct exposure to solar wind plasma and solar UV radiation. It was shown that this process can change surface physical properties efficiently. Dust activity level depends on both the surface compactness and the dust size distribution. The variation of porosity with the regolith depth may be critical in determining the dust dynamics.

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] J. Szalay, and M. Horányi (2016), GRL, 43.