Electrostatic dust transport in shaping the regolith surfaces of airless planetary bodies

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Electrostatically transported dust particles on the regolith surfaces of airless bodies due to exposure to solar UV radiation and solar wind plasma have been suggested to explain a number of space observations, e.g. the lunar horizon glow, the dust ponds on asteroid Eros and the spokes in Saturn's rings. The electrostatically transported dust may play a critical role in the regolith surface processes, such as the surface morphology, porosity, thermal inertia and the space weathering effect. However, a fundamental question of how regolith dust particles attain large enough charges and electrostatic forces to become mobilized or lofted remained unsolved for decades until our recent laboratory experimental discoveries. We have recorded micron-sized insulating dust jumping to several centimeters high with an initial speed ~ 0.5 m/s exposure to UV illumination or plasmas (Fig. 1). A newly developed "patched charge model" shows that the emission and re-absorption of photo- and/or secondary electrons at the walls of micro-cavities formed between neighboring dust particles within the surface is responsible for generating unexpectedly large charges and particle-particle repulsive forces to mobilize dust particles. Our charge measurement shows that electrostatically transported regolith dust carries large negative charges even under the UV radiation, contrary to the predictions from the classical charging models. This paper will present the laboratory results of the dynamics of lofted dust, the effect of dust mobilization on regolith surface features (e.g., morphology, porosity) and consequently on remote sensing spectra measurements.

Keywords: Small bodies, Regolith dust, Dust charging, Plasma , Photoelectrons, Electrostatic dust transport