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The Dynamics of Near-Surface Dust on Airless Bodies

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The behavior of dust particles under the influence of electrostatic forces has been investigated near the surface of asteroids and the Moon. Dust particle motion on airless bodies has important implications for our understanding of the evolution of these bodies as well as the design of future exploration vehicles. Electrostatically-dominated dust motion has been hypothesized to cause the observed Lunar Horizon Glow and dust ponds on the asteroid Eros.

The first major contribution of this thesis is the identification of the electric field strength required in order to electrostatically loft dust particles off the surface of the Moon and asteroids Eros and Itokawa, taking into account the gravity of the body (assumed to be spherical) and the cohesion between dust grains (assumed to have the material properties of lunar regolith). In order to solve for the electric field strength required as a function of dust particle size (assumed to be spherical), we assumed that the charge on the dust particle was given by Gauss law. It can be seen that it is easiest to launch intermediate-sized particles, rather than the submicron-micron sized particles that have been previously considered due to the dominance of cohesion for small particle sizes. Additionally, the electric field strength required to loft particles is orders of magnitude larger than is likely to be present *in situ*, unless grain charging is amplified beyond the levels predicted by Gauss' law.

The significance of cohesion in electrostatic dust lofting has also been demonstrated experimentally. Piles of uniformly sized dust grains are placed on a biased conducting plate in a plasma. We see that the pile of 15 micron dust spreads more than piles of 5, 10, 20, and 25 micron dust grains. This observation confirms our theory-based prediction of the importance of cohesion for small grain sizes. The experimental proof presented also has implications for interpretations of horizon glow observations and studies of electrostatic dust lofting feasibility.

The dynamics of dust particles moving in the plasma sheath, independent of the launching mechanism, is of interest since dust particle levitation could significantly change our understanding of the evolution of asteroids as well as pose a hazard to future exploration vehicles. By studying the levitation behavior in a 1D system for a range of particle sizes, a range of central body masses and three different plasma sheath models, we have gained a more detailed understanding of the drivers of the dynamics of the particles. The equilibria about which dust particles are expected to levitate are identified. The equilibria can be generalized to non-spherical grains (as actual lunar and asteroidal grains are highly angular) by presenting the results as a function of the particles charge-to-weight ratio. Notably, we see that the behavior of levitating dust is driven by the particle size rather than the mass of the central body. Additionally, we can begin to constrain the range of initial launching conditions that result in levitation.

Finally, we expand our 1D analysis of dust levitation to a 3D system. Due to the rotation of the central body (particularly with fast rotating asteroids), the plasma environment will be changing radically through a particle's trajectory. Additionally, asteroids have highly non-spherical shapes, thus variations in the bodys gravity may significantly influence the trajectory of a given particle. For the case of a spherical asteroid, it can be seen that the time variation of the plasma environment will not cause the particle to reimpact prematurely. We also find that the transverse electric fields present in a 3D model noticeably influence particle trajectories.

This thesis presents detailed investigations of electrostatic dust lofting and the dynamics of electrostatic levitation. The results have implications for understanding the evolution of airless bodies, the interpretation of spacecraft observations, and the design of future spacecraft. It is possible to expand the experimental work presented here by testing the influence of grain shape and polydispersity on electrostatic dust lofting. Our theoretical studies of dust levitation in a 3D model could be improved by using an accurate asteroid shape model coupled with a high fidelity plasma simulation.