

DETERMINING ELECTROSTATIC FORCES ON LUNAR DUST REGOLITH. A. Mendoza¹, T. Herrera, L. S. Matthews, and T. W. Hyde, Center for Astrophysics, Space Physics and Engineering Research, One Bear Place #97283, Baylor University, Waco, TX, 76798-7283, USA. ¹Alexandria_Mendoza1@baylor.edu

Introduction: The phenomenon known as the lunar horizon glow was observed by Surveyor missions and Apollo astronauts during lunar sunrise and sunset. It is believed to be caused by the electrostatic lofting of dust particles into the atmosphere above the lunar surface [1]. This lofting is also argued to be the mechanism responsible for the high albedo formations on the moon known as lunar swirls [2]. Samples of lunar dust taken by the Apollo astronauts reveal that lunar dust particles are very sharp and jagged. It was also noted by the Apollo astronauts that the lunar dust obscured visors and instrument readouts, degraded seals, and abraded materials. The dust was also found to be difficult to remove from spacesuits, which lead to eye, nose, and throat irritation [3]. Thus an understanding of the physics underlying lunar dust transport is important for future lunar missions.

An important aspect of lunar dust lofting is the charge acquired by the irregularly-shaped dust. Here we apply a numerical simulation, developed at CASPER to model the charging and dynamics of irregular dust aggregates, to model the charging of a dusty surface. The electrostatic forces, gravitational force, and contact forces acting on each dust particle are used in order to predict lofting events.

Dust Transport: Prior experiments ([4], [5]) have shown that forces due to the lunar sheath potential on the dayside are too small to overcome cohesive forces. However a proposed model, known as the “patched charge” model [6], takes into consideration the charge fluctuation due to photoemission and recollection of electrons in the microcavities between dust grains. In this model, the local electric fields vary inside the microcavities, depending on the surface irregularities. This model was shown to lead to electrostatic forces that are large enough to overcome gravitational and cohesive forces, as well explaining results seen experimentally.

Model: The surface regolith is charged by collected electrons and ions from the solar wind. In addition, exposure to high-energy photons (UV light) may excite electrons within the dust grain which are then emitted from the surface. The numerical model OML_LOS (Orbital-Motion-Limited theory with a Line-of-Sight approximation) is used to resolve the charge distribution on the irregular surface [7]. In this model, the dust pile is assumed to consist of microspheres with differing radii. Points are uniformly assigned across the surfaces of each monomer. The charging currents to each point on

each grain are calculated assuming collection of electrons and ions in the solar wind as well as photoemission. Currents to each grains are calculated only for points which have open lines of sight (LOS). The LOS are also used to determine which patches are illuminated and may emit photoelectrons. Photoelectrons are emitted in random directions and may be captured by another surface blocking the LOS. Electrons emitted along an open LOS are subsequently recaptured by a randomly selected point on the exposed surface. In this manner the time-varying charge across the aggregate surface is determined. A representative charged pile is shown in Figure 1. Note that the underside of particles within the pile are tend to be charged negatively from collected photoelectrons, while the upper surfaces of monomers are charged positively by photoemission.

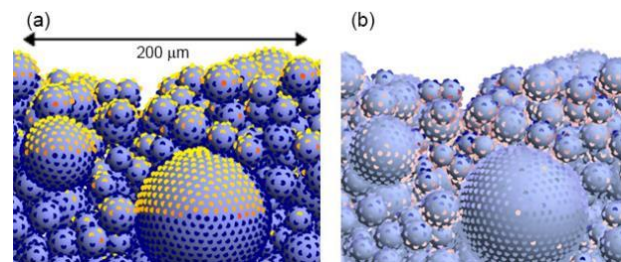


Figure 1: Simulated dusty surface consisting of spherical grains. (a) The surface is illuminated from overhead. (b) The charge at each point is calculated due to primary electron and ion currents as well as photoemission. Blue shades indicate positive charges, while red shades indicate negative charges.

Forces: A simple force diagram illustrates the four main forces acting on each dust particle. The upward-directed electrostatic forces act to levitate the grains. In opposition to the electrostatic forces are the gravitational and cohesive forces.

The contact force between two grains generally scales with the reduced radius, $r_d^{-1} = r_1^{-1} + r_2^{-2}$. This general form is most applicable to spherical grains, as it has been shown that contact forces depend on the geometry of the microcavity [8]. Another model has been developed in order to account for the “surface cleanliness” of the dust particles with the cohesive force written as $F_{CO} = -CS^2r_d$ where $C = 5.14 \times 10^{-2} \text{ kg/s}^2$ [9]. The surface cleanliness factor, S , accounts for gases adsorbed on the surface. In the high vacuum on the lunar surface the surface cleanliness is estimated to be in the range of $S = 0.75 - 0.88$.

Electrostatic Forces: In order to calculate the electric field the electric field is calculated at each point by summing the Coulomb force due to all the other charged points in the dust pile, as illustrated in Figure 2. The total electric field acting on a single spherical monomer is then calculated by summing the forces acting on all of the points on the monomer surface.

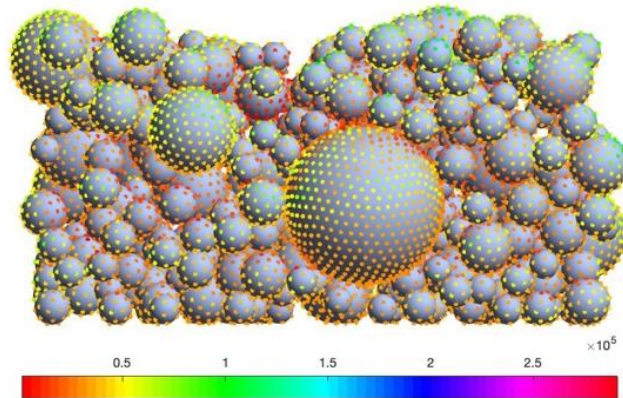


Figure 2: Magnitude of the vertical electric field at each point on the aggregate.

Figure 3 shows a comparison of the total vertical electric force acting on each monomer compared to the gravitational force. It is readily apparent that the electrostatic force exceeds the gravitational force, which allows lofting of the grains. The contact forces between grains as well as the weight of overbearing dust grains then determine the number and size of lofted dust clumps.

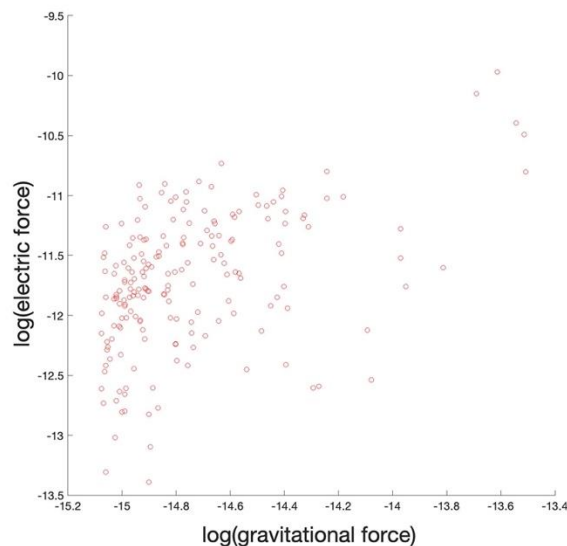


Figure 3: Scatterplot of the vertical electrostatic force vs the gravitational force acting on each dust particle.

Conclusion: This work investigated the electric field and electric force felt by spherical particles in a dust aggregate in order to further understand lunar dust lofting. It was found that a significant fraction of the individual dust particles have the possibility of lofting. Currently, the force calculations only take into consideration a single particle without considering the weight of neighboring particles. The predicted lofting events and size distribution of particles lofted will be verified with experimental measurements conducted.

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