**Incorporating Electrostatic Effects in DEM Modeling of Lunar Dust Dynamics.** A. Dove¹, H. Wang², J. Phillips¹, T. Eloghary².¹Department of Physics, University of Central Florida, ²Department of Mechanical and Aerospace Engineering, University of Central Florida (adove@ucf.edu).

**Introduction:** Lunar dust hazards will affect systems across the architecture of lunar missions, including landing plume interactions, rovers traversing the surface, operations in habitable volumes, and even orbital spacecraft interactions. Any spacecraft- or human-regolith interactions may disturb the charged dust particles, causing interactions between grains that will influence their subsequent dynamical evolution.

Discrete Element Method (DEM) models are designed to capture the dynamical interactions of granular matter. This typically includes mechanical (and thermal) interactions but leaves out significant effects due to electrostatic interactions, which may occur both in contact forces (i.e., tribocharging) and long-range forces. This is especially important in the natural lunar plasma and electric field environment, and, for example, in the charged interactions that may occur in rocket exhaust plumes. These forces are often explored in models more focused on the electrostatic interactions, leaving off mechanical forces. For this reason, we have begun working on incorporating electrostatic forces into the LIGGGHTS DEM [1].

**Improving the DEM:** While many electrostatic interactions exist in LAAMPS, the basis for LIGGGHTS, they were not ported into the latter granular matter distribution package. Thus, we are working to include key components for grain-grain and grain-surface interactions. For now, all models assume spherical particles. A tribocharging model based on instantaneous collisions between particles is adopted and validated by comparing the simulation results to published simulation and experimental data. The tribocharging interactions rely on knowledge of the work function, size, and charge of the particles. Additionally, we implement electric fields and long-range Coulomb electrostatic interactions between particles.

One challenge with any of these models is to accurately describe the behavior of surface charges, which in reality will be unevenly distributed, but in the model, we must make simplifying assumptions for spherical particles with charge evenly distributed. Future work will incorporate multi-sphere or aspherical particles to account for non-uniform charging.

After implementing short- and long-range interactions, we perform sensitivity analyses to quantify the effects of initial charge, tribocharging, and the presence of an external electric field on the particle transport. We also validate the tribocharging model by comparison with previous numerical and experimental results [2].

**Initial Lunar DEM Simulation:** A DEM simulation is conducted in the presence of lunar gravity and lunar-relevant potentials, in order to evaluate the different dynamical behavior between charged particles and uncharged particles. The results indicate that the charged dust particles have higher dispersion of position and velocity due to electrostatic effects, as shown in an example figure below. These results provide a potential explanation for the phenomena of the extended dust lofting following Apollo Lunar Module landings. It is also shown that in the presence of greater initial charge, tribocharging can have a more significant effect on the dynamics.

![Comparison of the dispersion of final position (top) and velocity (bottom) of a distribution of particles with (blue) and without (orange) initial charge.](image_url)

**Ongoing experiments and future simulations:** To further validate the numerical model, we are developing some simple experiments to explore tribocharging and charged dust grain behavior in the presence of an electric field. We will use video to track the particle dynamics and will measure final particle charges.

While have focused primarily on the behavior of clouds of dust particles, relevant to cases such as plume interactions or natural lofting, these model improvements are key to accurate predictions of mechanical interactions on the lunar surface.