Experimental Studies on Electrostatic Charging of Individual Lunar Dust Grains by Photoelectric Emissions and Electron Impact;

Investigators: P.I.-Dr M.M. Abbas C.I. D. Tankosic Collaborators: Dr. J. Spann, Dr. P.Craven Dr. E.West, R. Hoover

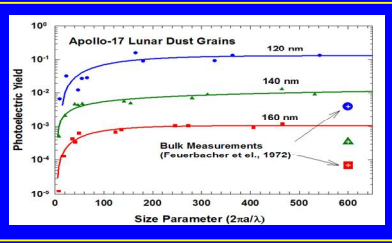
ABSTRACT

Observations made during Apollo missions as well as theoretical models indicate that the Moon's surface and lunar dust grains are electrostatically charged, positively during the lunar day by UV photoelectric emissions, and negatively by the solar wind electrons during the lunar night. Since the high adhesive characteristics and toxic nature of lunar dust may have severe impact on human habitat as well as operations and lifetime of a variety of equipment, it is of great importance to investigate the physical and optical properties of lunar dust to develop appropriate mitigating strategies. In this paper, we present some results on charging of Apollo 11 & 17 lunar dust grains by low energy electrons (5-100eV) to study the charging of lunar dust by the solar wind electrons.

Significance of measurements of charging properties of individual micron size dust grains

- **It has been well recognized for long that the charging properties of individual small size particles are expected to be substantially different from measurements on bulk materials**
- **However, currently available experimental data for calculation of dust grains charges and equilibrium potentials are all based on measurements or theoretical models that are valid for bulk materials only.**
- **Indeed the measurements carried out on individual micron/submicron size dust particles levitated in an electrodynamic balance indicate substantial differences.**

Charging by Photoelectric Emissions

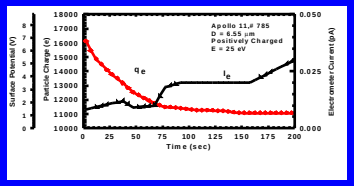


A composite plot of the photoelectric yields of Apollo 17 dust grains

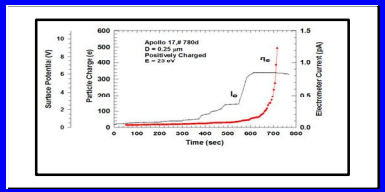
Important Conclusions
Charging by photoelectric emissions:

- **Photoelectric emission yields of particles larger than a micron or two in size are more than an order of magnitude higher than for the bulk materials.**
- **The photoelectric yields of submicron size particles are lower than for large size particles. This is in contrast with the existing models indicating higher values for smaller particles.**

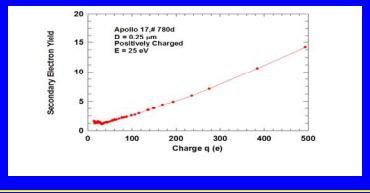
Charging of Apollo 11 & 17 Lunar Dust Grains by Electron Impact



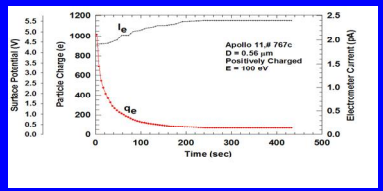
Discharging of a positively charged 6.55μm diameter Apollo 11 grain with a 25eV electron beam.



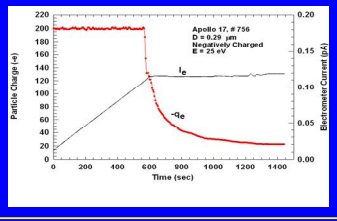
The charge q and electrostatic potential for charging of a positively charged 0.25 μm particle exposed to a 25eV electron beam with a current Ie (pA).



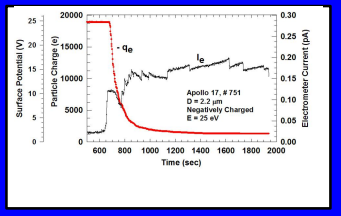
The calculated SEE yield for the particle shown in the above fig. increasing from an initial yield value of ~ 1 to a final value of ~ 14



Discharging of a positively charged 0.56μm diameter Apollo 11 grain with a 25eV electron beam.



Discharging of an Apollo 17 negatively charged 0.29 μm particle exposed to a 25 eV beam



Discharging of an Apollo 17 negatively charged 2.2 μm particle exposed to a 25 eV beam

Important Conclusions:
Charging by electron impact

- **Large size positively charged particles discharge to some equilibrium potential when exposed to 25 -100 eV electrons.**
- **Submicron size positively charged particles at low surface potentials generally charge more positively when exposed to low energy electrons (< 25 eV), and discharge at higher energies (>100eV); the SEE yields are higher for small particles compared with the large.**
- **Negatively charged particles exposed to 5-100 eV electron beams generally discharge to equilibrium potentials.**
- **Equilibrium charges of dust grains are a function of the size, electron energy, and density.**
- **The complex nature of the SEE process implies that both negative and positive dust grains may exist in the same lunar environment.**
- **The experimental data for charging properties of individual micron size lunar particles is in conflict with the available experimental data for bulk materials as well as with the current semi-empirical theoretical models.**
- **Comprehensive measurements for charging properties of individual dust grains to address the hazardous issues of dust on lunar robotic and human missions.**

Charging measurements on individual micron/submicron size dust grains indicate substantial differences with respect to measurements on bulk materials.

Selected References: Spann, J.F. et al. (2001) *Physica Scripta*, T89, 147; Abbas, M.M. et al. (2006) *ApJ.*, 645, 324; Abbas, M.M. et al. (2007) Planet. Space. Sci., 55, 953; Abbas, M.M. et al. (2008), STAIF-2008, 942.. Abbas, M.M. et al. (2008) *39th LPSC, 1153.pdf*. [15] Tankosic, D. et al. (2008) *39th LPSC, 1202.pd*