PHOTOELECTRIC EMISSION MEASUREMENTS ON APOLLO 17 LUNAR DUST GRAINS:

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Introduction: The deleterious effects of the ubiquitous presence of small micron/sub-micron size dust grains in the lunar surface environment are recognized to be one of the major issues that must be addressed in planning the forthcoming missions for robotic and human exploration of the Moon. On theoretical considerations as well as observational evidence, it has been well accepted since the Apollo missions that small-size dust grains on the lunar surface are electrostatically charged, levitated, and transported to higher altitudes and over large distances [1,2,3,4,5]. The lunar dust grains are believed to be charged by photoelectric emissions induced by the solar UV radiation and by interaction with the solar-wind plasma. Theoretical studies are being performed along with the development of analytical models and a variety of experimental investigations, to better understand the lunar dust phenomena. [e.g., 6,7,8,9,10,11].

Charging by photoelectric emissions is the dominant process during the lunar day, and an evaluation of the grain charge and equilibrium potential requires knowledge of the fundamental quantity of the photoelectric yields of grains in the size distribution of lunar dust. Rigorous theoretical expressions for calculations of the yields of various materials are not yet available, and the information must be obtained by experiment. However, the only published data on photoelectric yield available to date are those conducted on bulk materials [12], although on theoretical considerations, it is well recognized that the photoelectric yields for small-size grains would be different from the corresponding bulk values [e.g., 13,14,15,16]. An important consideration for determination of the yield is its variation with the size of the dust grains. In this paper, we present the first measurements of the photoelectric yields of micron-size dust grains, with effective radii in the 0.18 to 11.8 μm range, selected from sample returns of the Apollo 17 Mission. The measured yields of micron-size individual dust grains are determined to be more than an order of magnitude larger than the bulk values reported in the literature, with a size dependence that indicates higher values for larger grains.

Experimental Technique: The measurements presented here were made on an experimental facility based on an electrodynamic balance (EDB) described in previous publications [17,18,19,20].

Basic Equation for Measurement of Yield: The photoelectric yield, Y, is a function of the particle's surface potential ϕ_s, and is defined here as the number of electrons emitted (n_d^e) per photons absorbed ($n_d^{ph} * Q_{abs}$) by the dust particle; where (n_d^{ph}) is the number of photons incident on the dust particle, and Q_{abs} is the absorption efficiency, calculated by using Mie scattering theory. The yield may be expressed as:

$$Y = n_d^e(\phi_s) / n_d^{ph}.Q_{abs}$$

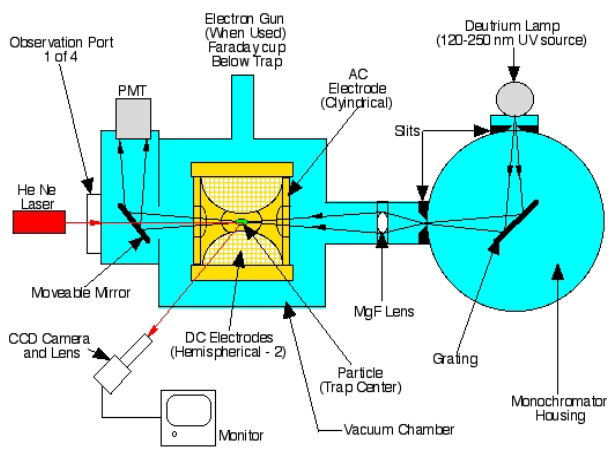

Figure 1. A schematic of the experimental setup for UV photoelectric emission measurements.

A negatively charged particle is injected into the trap, the effective diameter is determined, the particle is illuminated with UV radiation, and the number of photons incident on the particle is determined by measurement of the photons in the beam. As the particle discharges, the charge is determined as a function of time, with the rate of change of charge providing the number of electrons emitted as a function of time.

Photoelectric Yields of Apollo 17 Dust Grains:

The Apollo 17 dust grains employed in the photoelectric emission measurements are from the finest portion (<20 micron) of soil sample 71501, which is the sieved portion (<1 mm = 601 g) from parent soil 71500 (1066 g). The measurements were

made on 11 negatively charged Apollo 17 dust grains, by illuminating them to UV radiation at wavelengths of 120 nm, 140 nm, and 160 nm (10.3 eV, 8.9 eV, 7.8 eV resp.). The effective radii of the 11 particles covered the range from 0.18 to 11.8 μm. A composite plot of the photoelectric yields versus the size parameter, calculated for all the Apollo 17 dust grains, is shown in Fig. 2. The yields shown in the plots have been reduced to represent the values when the particle's surface potential approaches zero. The measurements on bulk lunar materials at the three corresponding wavelengths are also shown for comparison, as determined by Feuerbacher et al. [12]

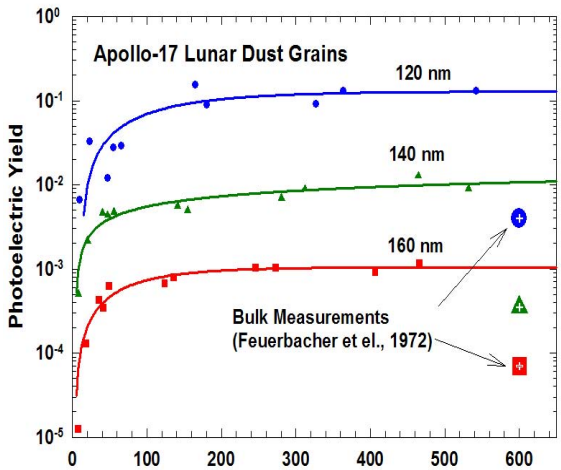

Figure 2. Photoelectric yields of 11 dust grains selected from Apollo 17 sample 70051, with effective radii in the range of 0.18 to 11.8 μm.

Conclusion: Plots of the photoelectric yields of individual dust grains, in Fig. 2, indicate a strong size dependence of the yields for size parameters less than ~ 100, corresponding to particles of ~ 2 to 3 μm radii, at wavelengths of 120-160 nm (photon energies of 7.8 eV to 10.3 eV). The yields increase with size by an order of magnitude from lower values for small particles to higher values for larger particles; these approach constant asymptotic values for particles larger than a few micron radii. The asymptotic values are found to be significantly higher than the bulk values given in the literature [12], by factors of ~14 to 38 for the corresponding photon energies.

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