LABORATORY MEASUREMENTS ON CHARGING OF INDIVIDUAL MICRON-SIZE APOLLO-11 DUST GRAINS BY SECONDARY ELECTRON EMISSIONS. D. Tankosic[1] and M. M. Abbas[2], [1]ORAU/NASA-MSFC, [2]NASA-MSFC.

Introduction: Observations made during Apollo missions, as well as theoretical models indicate that the lunar surface and dust grains are electrostatically charged, levitated and transported. Lunar dust grains are charged by UV photoelectric emissions on the lunar dayside and by the impact of the solar wind electrons on the nightside [e.g. 1-3]. The knowledge of charging properties of individual lunar dust grains is important for developing appropriate theoretical models and mitigating strategies.

Currently, very limited experimental data are available for charging of individual micronsize size lunar dust grains in particular by low energy electron impact [e.g. 4-5]. However, experimental results based on extensive laboratory measurements on the charging of individual 0.2–13 μm size lunar dust grains by the secondary electron emissions (SEE) have been presented in a recent publication [6]. The SEE process of charging of micron-size dust grains, however, is found to be very complex phenomena with strong particle size dependence. In this paper we present some examples of the complex nature of the SEE properties of positively charged individual lunar dust grains levitated in an electrodynamic balance (EDB), and show that they remain unaffected by the variation of the AC field employed in the above mentioned measurements.

Experimental Setup: The measurements were made on a laboratory facility based on the EDB. The experimental apparatus consists of: particle generator, EDB (with the top and bottom DC electrode and the AC ring electrode), DC and AC voltage power supplies, vacuum system, electron gun, and the monitoring equipment. The experimental setup is shown in Fig. 1.
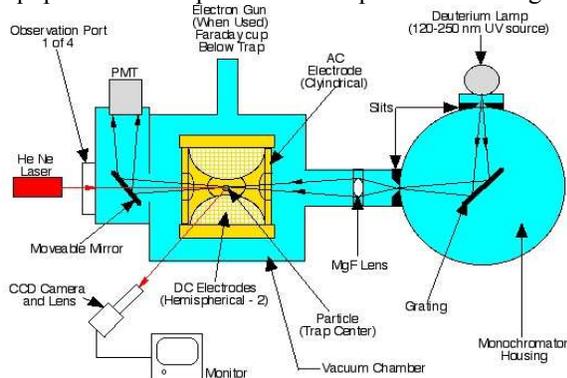

Fig.1. Experimental Setup

The particle generator employing a pressure impulse technique is used for charging the particles [e.g. 9-10]. The balance itself consists of spherically shaped DC top and bottom electrode and a ring AC electrode with apertures made to allow optical access to the trapped particle. The trap is placed in a vacuum chamber. A 5 mW-HeNe laser and a CCTV camera with a zoom microscope lens is used to observe the particle by projecting the scattered light onto a TV monitor.

Experimental technique for measurements on charging by the electron impact: The particles are injected into the balance at atmospheric pressure. Once the particle is stably trapped and the particle generator is removed, the electron gun (Kimball Physics ELG-5/EGPS-5A) is installed on the top of the chamber. The system is then evacuated to pressures of ∼ 1-5 torr at which the effective diameter is determined by measurements based on marginal stability conditions ("spring point" measurements) [e.g. 7]. The particle diameter has to be determined separately because the direct measurements on the EDB provide the charge to mass ratio only. This technique is based on slowly varying the electrical parameters of the EDB to a point near an unstable regime when the particle begins to oscillate. The system is then evacuated to pressures of ∼ 10^{-5} torr, and the suspended lunar dust grain is exposed to 25 or 100 eV electron beam. The electron beam current is measured by a Faraday cup located below the bottom electrode of the trap. As the particle charge changes, the particle is manually balanced against gravity by adjusting V_{DC}. The change in particle charge is then determined as a function of time in accordance with equation:

$$q(t) = \frac{gz_o m}{C_o} \frac{1}{V_{DC}(t)} \qquad (1).$$

With the value of V_{DC} needed to balance the gravity, the mass m is calculated using the effective particle diameter determined by the "spring point" technique and lunar dust grain density $\rho = 1.8$ gcm^{-3}, the particle charge $q(t)$ is calculated from equation (1) as a function of time. With this measurement technique one electron change in particle charge can be detected in certain regimes.

Experimental Results and Discussion: The above measurements were conducted on a number of selected Apollo 11 dust grains ranging in size from 0.49 - 0.96 μm with the amplitude of the V_{ac} voltage applied to the ring electrode of the EDB varying V_{ac} from ∼ 100 V to 600 V and the corresponding frequency f_{ac} from 120 Hz to 800 Hz. In the experimental results presented in this paper, we examine the effects of varying the AC

voltage on the SEE measurements by varying Vac from 50 V to 600V. Some pertinent results are presented in the following.
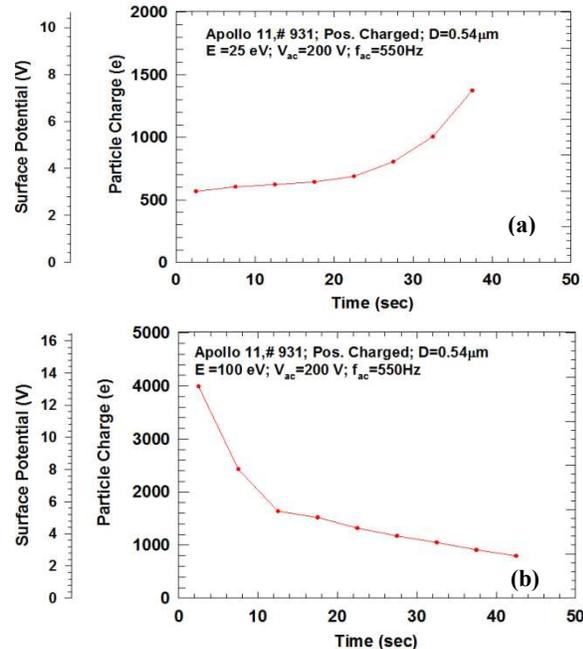

Fig.2. A positively charged 0.54 μm Apollo 11 dust grain at V_{ac}=200V, f_{ac}=550Hz a) **Charges** with 25eV electron beam and b) **Discharges** with 100 eve elec-
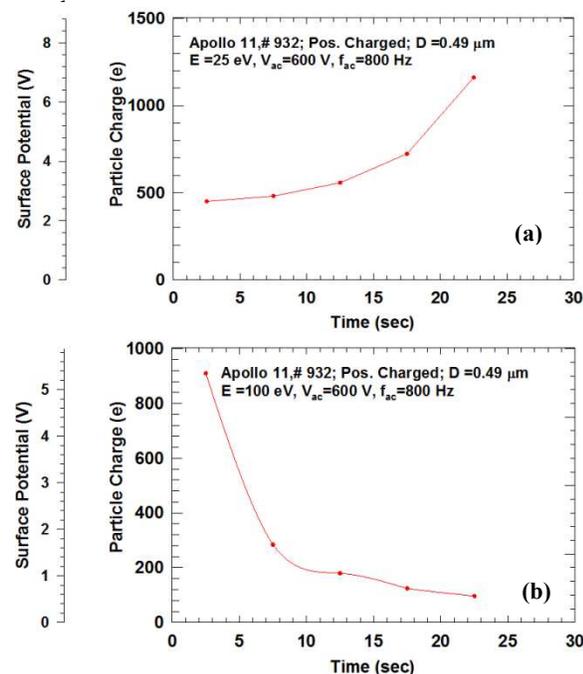

Fig.3. A positively charged 0.49 μm Apollo 11 dust grain at V_{ac}=600V, f_{ac}=800Hz a) **Charges** with 25eV electron beam and b) **Discharges** with 100 eV
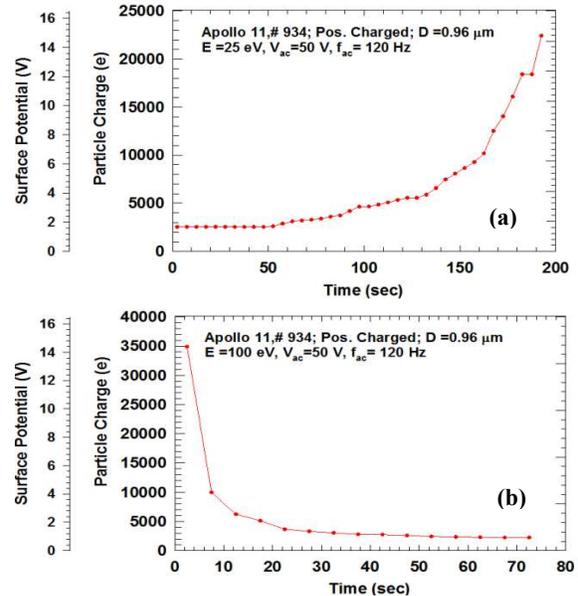

Fig.4. A positively charged 0.96 μm Apollo 11 dust grain at V_{ac}=50V, f_{ac}=120Hz a) **Charges** with 25eV electron beam b) **Discharges** with 100 eV electron

Fig. 2.(a) shows a charging of a positively charged 0.54 μm Apollo 11 dust grain when the exposed to a 25eV electron beam with V_{ac}=200V and f_{ac}=550Hz applied to the ring electrode of the trap (with SEE yield >1). Fig. 2(b) represents the discharging of the same particle with a 100 eV electron beam at V_{ac}= 200V (with SEE yield <1). Figs. 3 and 4 show the results from the same measurements for a 0.49 μm (at V_{ac} =600 V, f_{ac}=800 Hz) and 0.96 μm Apollo 11 dust grain (at V_{ac}=50 V, f_{ac}=120 Hz) respectively.

Conclusion: The experimental data presented here represent some typical examples of the complex nature of SEE properties of positively charged individual lunar dust grains. They also indicate that the measurements of SEE properties in the EDB are unaffected with the variation of the AC field employed in the experimental set-up with Vac varying by a factor of 12, from 50 to 600 V. All three particles of size 0.49 μm, 0.54μm, and 0.96 μm, discussed here charge to higher values for electron energy E = 25 eV, and discharge to lower values for electron energy E = 100 eV. More detailed investigations on these phenomena remain to be carried out.

References: [1] Halekas, J. S. (2009) *J. Geophys. Res., 114*, 5110. [2] Stubbs, T. J. et al. (2006) *Adv. Space Res., 37(1)*, 59-66. [3] Colwell, J. E., et al. (2007) *Rev. Geophys.*, 45, RG2006. [4] Ziemann, P. J. et al. (1996) *J. Aerosol. Sci., 27*, 587. [5] Ziemann, P. J. et al. (1995), *J. Phys. Chem., 99*, 5126. [6] Abbas M. M. et al. (2010) *ApJ, 718*, 795–809. [7] Davis, E.J. (1985) *Langmuir, 1*, 379-387.