CHARACTERIZATION OF A UV-GENERATED PHOTOELECTRON SHEATH. A. Dove, S. Dickson, S. Robertson, Z. Sternovsky, X. Wang, and M. Horányi, Colorado Center for Lunar Dust and Atmospheric Studies, Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO, 80309 (adrienne.dove@colorado.edu)

Introduction: Surfaces in space are exposed to a variety of charging environments that can generate variable plasma conditions. When the Moon is outside of the Earth's magnetosphere, charging on the lunar dayside (sunlit) surface is dominated by photoelectrons emitted due to solar UV radiation that create a positive surface potential (Figure 1), while a negative night side surface potential is built up by the collection of electrons [1]. The interaction of charged dust grains with the photoelectron sheath is often invoked to explain the many observations that indicate dust levitation and transport above the lunar surface.

Two sets of instruments have returned *in situ* measurements that provide estimates of the lunar surface potential, and the Lunar Prospector orbiter provides additional measurements of the electron distribution around the Moon. The Apollo Suprathermal Ion Detector Experiment (SIDE) measured the energy of ions at the lunar surface, which can be used to estimate the accelerating electric field [2]. However, it is difficult to derive the lunar surface potential from this estimate because the Debye length (λ_D) on the lunar surface varies from ~1 m in the denser dayside plasma environment to >> 100 m on the night side. SIDE was situated approximately 50 cm above the surface, comparable to λ_D on the dayside, but measuring only a fraction of the surface electric field on the night side.

The Charged Particle Lunar Environment Experiment (CPLEE) measured both ion and electron energy 26 cm above the surface, detecting 200 eV electrons while the Moon was in the Earth's magnetotail. These

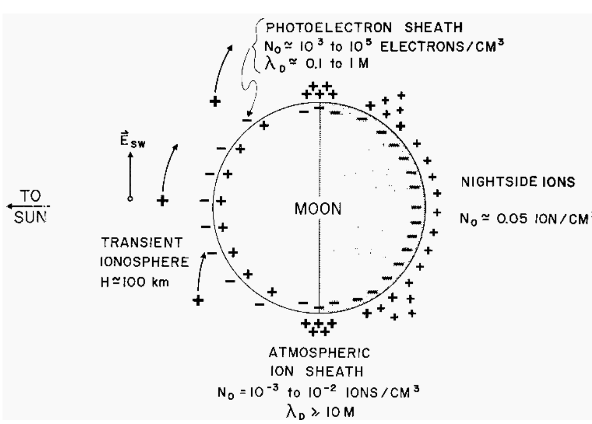

Figure 1. Electric charge density distribution predicted by Freeman and Ibrahim (1975) [12].

high-energy electrons were likely photoelectrons emitted from the lunar surface with energies of a few eV due to incident solar UV radiation. Subsequently, the photoelectrons gained energy due to a strong electric field generated by surface potentials up to +200 V that can be present when the Moon is in the Earth's magnetotail, shielded from the solar wind [3].

Because the solar wind electron thermal speed is much faster than both the bulk flow and the thermal speed of solar wind protons, there is a void in the solar wind protons on the night side of the Moon. A polarization electric field builds up due to the separation of electrons and ions, accelerating the ions into the void and creating energetic ion beams toward the surface and enhancing electron temperatures [4]. Lunar Prospector obtained measurements of electrons in the lunar night side that support this model and indicate that the night side lunar surface potential is at least -35 V and likely closer to -100 V [5]. Additionally, the potential may exceed -500 V when the Moon is in the Earth's magnetotail because of the high-energy electron fluxes to the surface [4].

The Moon's plasma sheath is characterized by a typical photoelectron density of approximately 60 cm^{-3} and a Debye length on the order of 1 m [6]; however, both the density and size of the sheath fluctuates according to the variation in UV flux with the solar cycle. Measurements of photoelectron yield from lunar soil samples find emission currents of about 5 μA/m^2 [7], although during a solar maximum this could increase to around 16 μA/m^2, and solar flares could result in emission currents on the order of 40 μA/m^2 [8].

Experimental Work: In order to simulate the lunar surface environment in the laboratory, a photoelectron sheath with a characteristic Debye length much smaller than the size of the vacuum chamber is required. Previous experiments have used a 1 kW Hg-Xe arc lamp to generate photoemission from surfaces with current densities on the order of 0.1μA/cm^2. While these experiments were able to demonstrate that dust particles charge negatively in the electron cloud above a photoemissive surface, the number density of photoelectrons above the surface is insufficient to generate a realistic sheath with space charge. [9]. We use commercially available xenon excimer (Osram Xeradex) lamps that emit ~10 W of ultraviolet radiation in a narrow band centered at 172 nm (7.21 eV). In initial experiments with these lamps in vacuum, we have observed photocurrent densities of ~1 μA/cm^2 from a Zr surface positioned 10 cm from the lamp (Figure 2) [10]. Assuming a photoelectron energy of 2 eV, this corresponds to a sheath Debye length on the order of 0.1 m.

Experiments are conducted in a 0.6 m^3, 60-cm diameter vacuum chamber, with one or multiple Xe excimer lamps positioned inside the top of the chamber (Figure 3). A 50-cm diameter photoemitting surface is placed horizontally in the chamber. We use either Zr, which is a strong photoemitter, or Pl, which is a well-characterized material. Our setup allows an emitting surface to reach a floating potential of several volts relative to the surroundings. Because the Debye length is on the order of 0.1 m above the surface, we are able to characterize the sheath up to several scale heights. We measure the electron density and temperature in the plasma with a cylindrical Langmuir probe. An emissive probe is used to measure local potentials within the plasma to determine the electric field above the surface. We will compare measured values with a model of the photoelectron distribution and potential profiles in a photoelectron sheath [11].

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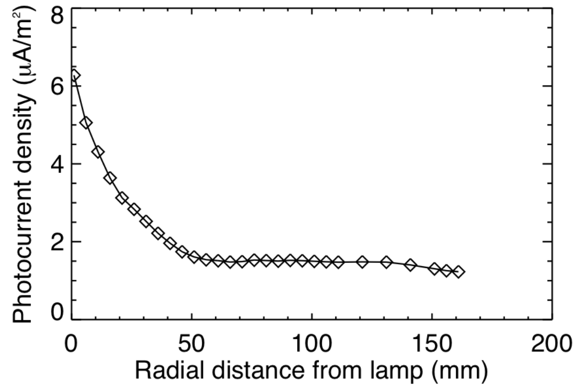

Figure 2. Variation of photocurrent density with radial distance from the Xe lamp, measured by a Zr surface, in vacuum.

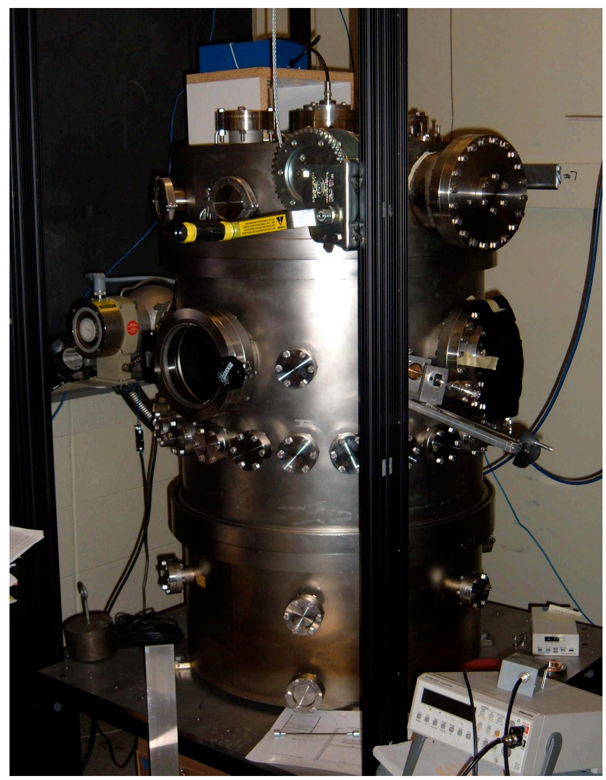

Figure 3. Vacuum chamber. One Xe excimer lamp is placed vertically in the top in the arrangement seen here.