CHARACTERIZING THE NEAR LUNAR PLASMA ENVIRONMENT. T. J. Stubbs, University of Maryland, Baltimore County, Goddard Earth Science and Technology Center, and NASA Goddard Space Flight Center, Mail Code 674, Greenbelt, MD 20771, (Timothy.J.Stubbs.1@gsfc.nasa.gov).

Summary of Science Topic: The ambient plasma and solar UV incident on the lunar surface cause it to become electrically charged [1,2]. On the dayside, solar UV photocharging typically dominates, so the surface charges positive [3,4]; while on the nightside the plasma electrons usually dominate and thus the surface charges negative [5]. The resulting surface electric potential is confined to a near-surface sheath region. The height of this sheath region, which is controlled largely by plasma density and temperature, determines the electric field strength [6]. This interaction is complicated by variations in: solar UV intensity, the ambient plasma, formation of dusty plasmas, surface composition and topology, magnetic anomalies and the lunar wake.

Value of Science Topic: Surface charging is believed to drive the transport of micron-scale dust, a recognized potential hazard [7]. The differential charging of objects on the surface could lead to unanticipated electrical discharges. Understanding this environment will be of benefit to on manned and robotic surface exploration activities and various other scientific observations (e.g., lunar-based astronomy). Surface charging is a fundamental universal process affecting all airless regolith-covered bodies. Cross-disciplinary impacts: Astronomy and Astrophysics, Environmental Characterization and Operational Environmental Monitoring.

Description of Science Topic: The surface of the Moon, like any object in a plasma, charges to an electric potential that minimizes the total incident current [8]. The charging currents come from four main sources: photoemission of electrons, plasma electrons, plasma ions and secondary electrons (arising from surface ionization by plasma electrons). The lunar dayside typically charges a few volts positive with a "photoelectron sheath" extending to ~1 m [3,9]. On the nightside, the lunar surface usually charges ~50-100 volts negative in the solar wind with a "Debye sheath" extending up to ~1 km [1,9,10]. This basic picture comes from Apollo-era and Lunar Prospector observations together with analytical theory.

Lunar surface charging in the solar wind is complicated by variations in the solar spectrum, ambient plasma environment, surface composition [4] and topology, magnetic anomalies [11], and the formation of

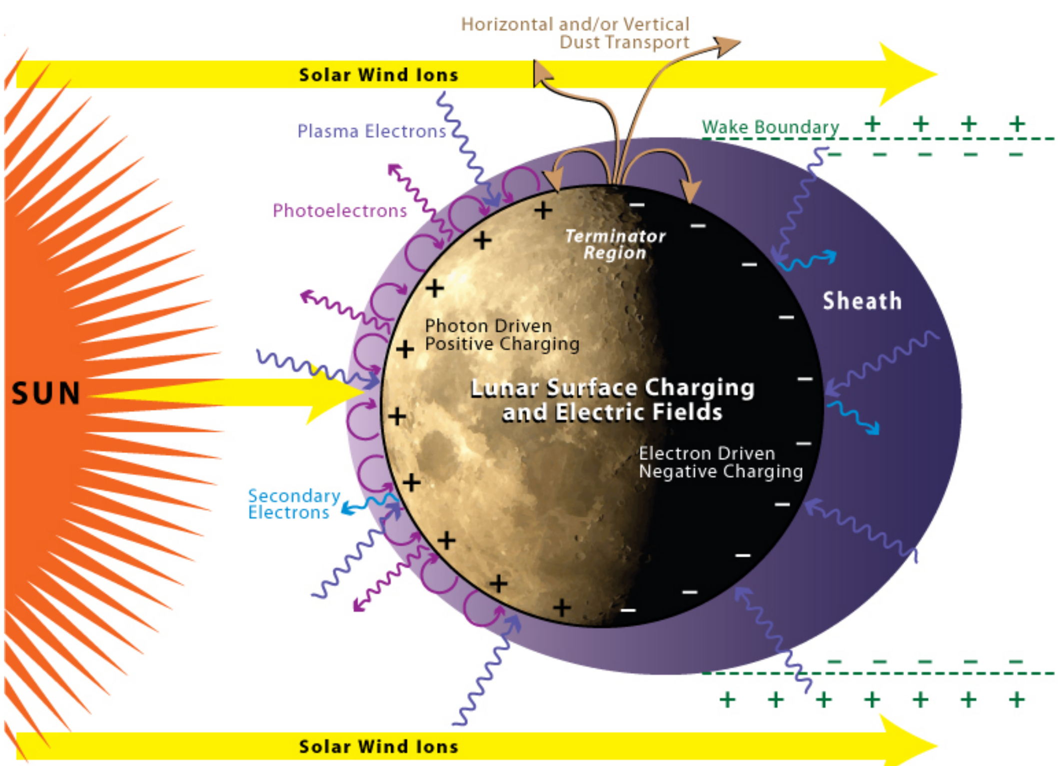

Figure 1. Schematic of the lunar electrostatic environment in the solar wind (not to scale).

a lunar wake [12–14] and dusty plasmas. In addition to these effects, when the Moon passes nightside of the Earth it traverses the tail lobes and plasma sheet of the Earth's magnetoshere. In particular, the plasma sheet is much more tenuous and significantly hotter than the solar wind [2]. Observations from Lunar Prospector indicate that nightside potentials can reach a few kilovolts negative during both space weather events and plasma sheet passages [15]. There remain significant uncertainties in lunar surface charging processes, and relatively little is known about either spatial or temporal variations.

Surface charging processes also likely drive the transport of charged dust (<10 μm), as observed during the Apollo era [16–19]. The most probable mechanism for dust transport involves the like-charged surface and dust grains acting to repel each other. Hazards could arise both due the differential charging of surface equipment, resulting in unanticipated electrical discharges, and the transport of charged dust with its adhesive and abrasive properties. Since the lunar surface is an insulator, it makes finding a common ground for electrical systems much more difficult than on Earth.

Description of Methodology and Implementation: The necessary in situ measurements for characterizing the near lunar plasma environment are summarized in Table 1. They can be achieved from orbit to give a global-scale view, or from the surface for a local view. To optimize the characterization of this environment, it is recommended that measurements from orbit and the surface are coordinated, such that we may understand the connection between processes at these scales. Several landers would be advantageous, since not every point on the lunar surface experiences the same conditions, e.g., locations near the poles will be quite different from those nearer the equator.

Measurement	**Instrument**
Plasma characteristics (e.g., moments)	Electron and Ion spectrometers
Electric fields	E-field Probes
Magnetic fields	Magnetometer
Solar Ultraviolet	UV Spectrometer

Table 1: Required measurements and instrumentation.

The instruments described above have a high TRL, with many of them being standard on many heliophysics missions. Requirements for mass and power are a few kg and a few Watts, and the size can be kept relatively small. Telemetry rates are relatively low, but this depends on time resolution of measurements.

Benefit of Astronaut Involvement: Astronauts could be used to distribute a network of sensors on the lunar surface. In addition to measuring the natural environment, the instrumentation described above will also detect the charge on the astronauts. This will reveal how astronauts and equipment are coupled to the local plasma environment.

Rationale of Timing with Respect to Lunar Exploration: From the experiences of the Apollo astronauts it is known that dust (which is coupled to the near-surface plasma environment) will be a significant impediment to surface operations; therefore, it is crucial that we have a much better understanding of this environment as early as possible.

Early Robotic Phase (<2018). Acquire vital early measurements of natural environment from orbit and strategic locations on the surface.

Early Human Phase (2018 – 2025). Continue monitoring of natural background, as well as study impact of surface operations on this environment.

Beyond (>2025). Deploy large-scale surface network to monitor this environment in order to make predictions (analogous to weather forecasting on Earth).

Future Wider Benefits: The characterization of this environment, and the resulting development of dust mitigation technology, will permit a sustainable exploration program requiring surface operations, (particularly astronaut EVAs). This will pave the way for future missions, In Situ Resource Utilization (ISRU) activities and the commercialization of the Moon.

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