Summary: The magnetotail and solar wind plasmas that impact the moon affect the lunar environment where astronauts and robots will operate. As an example, large negative surface potentials of up to many kilovolts have been observed when the Moon is in the plasma sheet and during solar energetic particle events. These potentials depend on the ambient plasma environment. In addition, the moon also perturbs the surrounding environment. Studies of the plasma-Moon interaction both further our understanding of fundamental plasma physics and provide environmental characterization of benefit to the lunar program.

Description and Value: The interaction of solar wind and magnetotail plasmas with the Moon is important for environmental characterization and for fundamental (space) plasma physics studies. The plasma, energetic particles, and solar illumination interact with the lunar surface to produce, on occasion, large surface electric fields, analogous to spacecraft charging. Total potentials measured by Lunar Prospector go up to many kilovolts [Halekas et al., 2002, 2005a, 2006a]. These fields may be hazardous, and they are likely to be related to transport of dust, another possible hazard [Stubbs et al., 2006].

The solar wind colliding with the Moon produces a cavity behind the Moon, but electrons traveling along the magnetic field (generally not parallel to the solar wind) can enter the cavity, so very large charge separation electric fields are generated [Ogilvie et al., 1996; Halekas et al., 2005b]. The evolution of this plasma interaction produces a variety of waves and beams.

The moon has numerous patches of surface magnetic fields. These fields range in size from kilometer scale, well below the solar wind thermal ion gyro-diameter, to hundreds of kilometers, large enough to produce shocks for some solar wind conditions [Colburn et al., 1971; Russell and Lichtenstein, 1975; Lin et al., 1998; Halekas et al., 2006 b]. Thus studies of the interaction of the solar wind with these magnetic patches allows us to explore the fundamental physics of the transition from kinetic to fluid (MHD) scales, and the related phenomena of shock formation. The Moon appears to be the only place where we can do these studies. In the solar wind interaction with crustal fields, the ions should decouple from the magnetic field first (an ion diffusion region) because of their much larger gyrodiameter, and then (depending on crustal field scale size) the electrons may also decouple. This plasma process may be similar to what happens in the fundamental collisionless plasma process of magnetic reconnection, and furthermore, we know where these regions are and don't have to be lucky to catch them. Thus, a wide range of fundamental plasma physics can be uniquely studied by lunar orbiters and surface instruments - mostly, if not all, robotic.

Methodology: Studies would involve plasma, fields, and energetic particle measurements on orbiters and/or on the lunar surface.

Implementation: A complete set of plasma and field instrumentation for an orbiter would include the following (also useful for dust-plasma, magnetotail dynamics, and crustal magnetism objectives):

Instrument	Mass	Power
Ion and electron Electrostatic Analyzers	4 kg	3.0 W
Ion Composition	8 kg	8.0 W
Energetic Ions	1.5 kg	1.7 W
Magnetometer boom and sensor	5 kg	1 W
E-field booms and sensors	15 kg	8 W

Modified versions of the particle and field sensors with similar resources could also be used on ground packages.

Benefits of human/astronaut involvement:
The orbiters do not require or benefit from astronaut involvement. For ground-based packages, astronaut involvement could simplify deployment and troubleshooting, but is not required.

Rationale of timing with respect to lunar exploration: The lunar orbiters do not require human presence, and so can be implemented in the early stages. Ground packages could also be done robotically, but could benefit from human presence.

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