Terminator Double Layer Explorer (TerDLE): A Plasma Lunarcube Concept

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Abstract. As the solar wind flows by the Moon, an anti-sunward directed low density wake forms as the plasma expands back into the trailing void. For the most part, it is thought that the wake fills in via a self-similar expansion like that trailing the space shuttle with low mass thermal electrons moving into void immediately behind the obstruction point, thereby creating an ambipolar E-field that then deflects ions into the void. However, analytical modeling and modern plasma simulations suggests that quasi-neutrality is actually broken, leading to the formation of a standing (time-stationary) double layer (or species separation in the plasma). TerDLE is a cubesat with an ion spectrometer and plasma wave system to search the flanks of the lunar wake for the existence of this predicted double layer. TerDLE's objectives are to:

- Examining the lunar wake formation region at low altitudes near the terminator location.
- Observing the ambipolar/double layer region and assess the solar wind's affect on its presence and structure
- Determine if plasma neutrality is maintained or lost during passages through the double layer region

The 6U TerDLE is proposed to be a secondary payload on the HEOMD EM-1 mission. A combination of unique low energy orbit insertion and micro-thruster system ensures that TerDLE can obtain its final elliptical orbit, with periselene over the lunar terminator. The ion spectrometer will obtain the ion density while the plasma wave system will sense the environmental emissions at the local plasma frequency to obtain the electron density. Comparison of these two quantities will reveal the presence of the double layer. We discuss the TerDLE science objectives ,the 6U cubesat, its sub-systems, the proposed flight design and the instrumentation necessary for completion of the science objectives.

Cubesat. The spacecraft system is designed and built at Morehead State University, who provides a bus, a rad tolerant C&DH system, a 72 W solar panel power system, communications including ground station via a 21-m dish system, navigation and guidance support, and will be the host site for the critical element of system integration. A C&DH will handle payload operations while a modified Blue Canyon Technology ACS system will ensure cubesat stability.

Instruments. Modern day Langmuir probes do not have the sensitivity to detect the nightside low density wake plasma (<0.01/cm^3). As such, we build a density sensing system from complementary components: An **ion spectrometer (IS)** and **plasma wave system (PWS)** for measuring f_{pe} are provided by GSFC and have considerable previous spaceflight heritage.

Flight Dynamics and Propulsion. The TerDLE team recognizes that the two elements are very strongly coupled, with GSFC flight dynamics team presenting a low ΔV manifold (i.e., orbit energy pathway) to achieve lunar orbit insertion and placement into an elliptical orbit with periselene over the terminator regions. The George Washington University micro-thuster system is built to match. **TerDLE is the epitome of 'slow and steady wins the race':** Using an indirect orbit insertion technique involving the Lagrange points (a technique previously applied to ARTEMIS) requires only small micro-thrusting - at fractions of a milli-Newton for insertion.

Illustration of TerDLE transit through the lunar wake flank at low altitudes – in search of non-nuetral plasma regions.