ARTEMIS' PERSPECTIVE ON A DYNAMIC MOON A. R. Poppe[1], J. S. Halekas, S. Fatemi, G. T. Delory, and the ARTEMIS/THEMIS Team, [1]Space Sciences Laboratory, University of California at Berkeley, Berkeley, CA 94720, poppe@ssl.berkeley.edu

Introduction: The two ARTEMIS probes have entered their fifth year in orbit around the Moon, continuing a successful extended mission investigating heliospheric and planetary science investigations in lunar orbit. Both probes provide continuous monitoring of solar wind inputs to the Moon/Earth system, as well as regular coverage of the terrestrial magnetotail during each monthly crossing. All instruments on both spacecraft are in nominal health and all data continue to be publicly available online.

Many recent lines of investigation with the ARTEMIS data focus on dynamic processes, including correlative studies of variability in the lunar exosphere with the LADEE mission, observations and characterizations of the flux of reflected protons from the Moon, and searches for the signal of induced magnetic fields in the lunar core from upstream solar wind transient fields. These investigations address fundamental planetary science objectives regarding lunar science and many promising discoveries await us in the near future.

ARTEMIS/LADEE Synergy: One significant area of application for ARTEMIS observations has been correlated work with measurements of the lunar neutral exosphere by the LADEE mission. Many processes relevant to the lunar exosphere are driven in some way by the solar wind, including, for example, the production of the neutral helium exosphere of the Moon from the influx and neutralization of solar wind alpha particles [1] and the redistribution of the lunar sodium exosphere due in part to solar wind sputtering of the lunar surface [2]. The solar wind also represents the ultimate loss mechanism for most species in the lunar exosphere via ionization and acceleration in the interplanetary electric and magnetic fields. ARTEMIS not only observes the interplanetary magnetic and electric fields, but also, if situated properly, has extensively observed escaping pick-up ion fluxes from the lunar exosphere [i.e., 3-5].

ARTEMIS Mapping of Proton Reflection from the Lunar Surface and Crustal Anomalies: Crustal remanent magnetic anomalies on the lunar surface have been and continue to be a major research focus of ARTEMIS, especially from the context of the interaction of these fields with the ambient solar wind. Many spacecraft have observed solar wind proton reflection from both the lunar surface and crustal anomalies [i.e., 6,7] as well as the resulting formation of electromagnetic waves [5] and small-scale collisionless shocks [8]. ARTEMIS data provide an extensive dataset with which to map out the reflection of solar wind protons. We have begun processing all ARTEMIS observations of reflected protons in order to create spatially resolved maps of proton scattering functions from both the lunar regolith

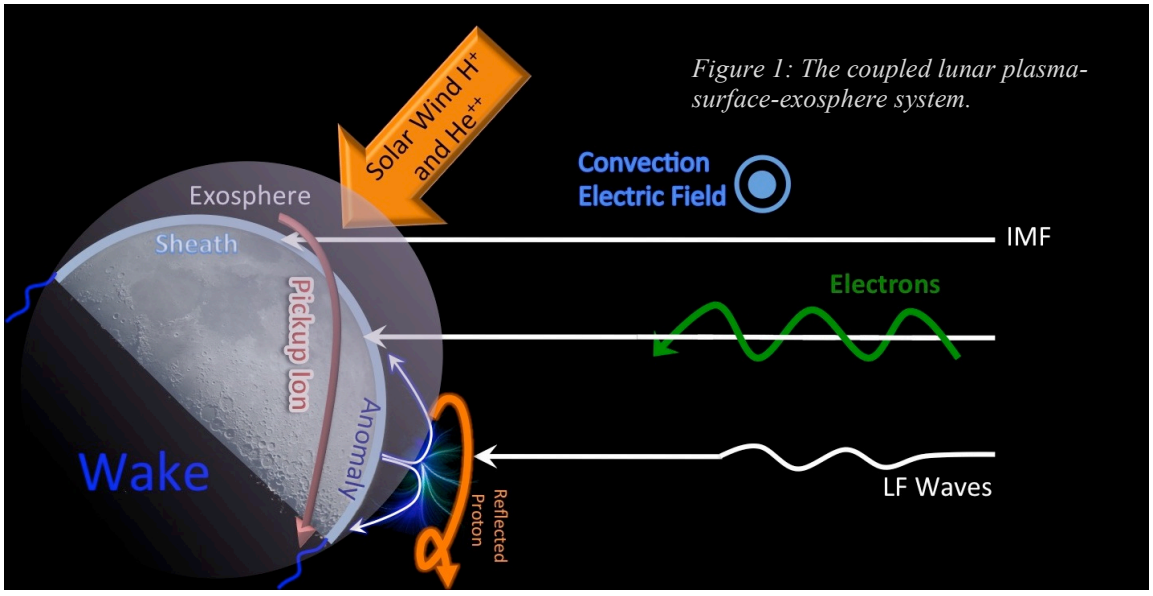

Figure 1: The coupled lunar plasma-surface-exosphere system.

and crustal anomalies. Such maps will take advantage of the long-term nature of the ARTEMIS dataset, with ~1000 lunar fly-bys with reflected proton observations. This investigation, while ongoing, will help to constrain the nature of proton interaction with the Moon.

ARTEMIS/Hybrid Model Investigations of the Lunar Core/Mantle Response: Another promising line of investigation with the ARTEMIS probes is the search of signatures of induced electromagnetic fields generated within the lunar core and mantle. These fields are driven by impulsive changes in the upstream solar wind magnetic and electric field and were first observed by the Apollo surface magnetometer instrument [9]. Detection and characterization of these fields represents an indirect method of characterizing the thickness and conductivity of various lunar interior layers, including the mantle and core. One particular challenge of interpreting possible signatures of induced fields is the complex interaction between the solar wind, the lunar wake, and the induced magnetic fields from the lunar interior. Early Apollo-era work made simplifying assumptions in order to further the analysis [9]; however, the quality and applicability of these assumptions has not been further investigated.

Recent work by Fatemi et al. [10] has begun to model the self-consistent interaction between these various fields in order to test these Apollo-era assumptions and to provide further guidance on the search for and characterization of possible induced magnetic field observations by ARTEMIS. Figure 2 shows the results of a simulation of the interaction between the solar wind, the lunar wake, and hypothetical induced fields from the lunar interior, represented by a single dipole place at the center of the Moon and, in this case, oriented 45° with respect to the solar wind flow and antiparallel to the IMF. Colors denote the relative strength of the perturbation induced by the induced dipole, showing that the induced fields are compressed on the dayside yet extend into and along the lunar wake. Favorable positions for the detection of such fields are thus typically found within the lunar wake.

Conclusions: The ARTEMIS mission continues to return a wealth of data on lunar plasma interactions and represents a critical dataset for understanding many dynamic planetary processes occurring at the Moon. Alongside increasingly sophisticated simulations, the

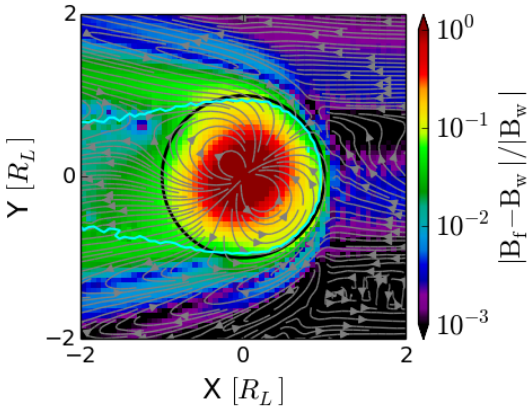

Figure 2: Hybrid simulation results of the interaction between induced magnetic fields in the lunar interior and the lunar wake [10]. Colors denote the relative pertubation of the magnetic field strength, while lines denote the induced field.

ARTEMIS data will continue to yield fundamental discoveries about the nature of the Moon in the years to come.

References: [1] Benna, M., et al., *Geophys. Res. Lett.* (2015) [2] Sarantos, M., et al., *NASA ESF Forum* (2015) [3] Halekas, J. S., et al., *J. Geophys. Res.* (2012) [4] Poppe, A. R. et al., *Geophys. Res. Lett.* (2012) [5] Harada, Y., et al., *J. Geophys. Res.* (2015) [6] Saito, Y., et al., *Geophys. Res. Lett.* (2008) [7] Lue, C. et al., *Geophys. Res. Lett.* (2011) [8] Halekas, J.S., et al. *Geophys. Res. Lett.* (2014) [9] Dyal, P. and C. Parkin, *J. Geophys. Res.* (1971) [10] Fatemi, S., et al., *Geophys. Res. Lett.* (2015)