NANOSWARM: A PROPOSED DISCOVERY MISSION TO STUDY SPACE WEATHERING, LUNAR WATER, LUNAR MAGNETISM, AND SMALL-SCALE MAGNETOSPHERES. I. Garrick-Bethell[1,2], D.A. Paige[3], M.E. Burton[4], and the NanoSWARM team. [1]University of California, Santa Cruz, igarrick@ucsc.edu, [2]Kyung Hee University, Republic of Korea, [3]University of California, Los Angeles, [4]Jet Propulsion Laboratory.

Introduction: The NanoSWARM mission concept addresses a number of open problems in planetary science: 1) The optical effects of space weathering, 2) The origins, distributions, and migration processes of surface water on airless bodies, 3) The origins of planetary magnetism, and 4) The physics of small-scale magnetospheres. To accomplish these goals NanoSWARM targets scientifically rich features on the Moon known as swirls (Fig. 1). Swirls are high-albedo features correlated with strong magnetic fields and low surficial water. NanoSWARM makes the first near-surface measurements of solar wind flux and magnetic fields at swirls. NanoSWARM also performs measurements to provide key constraints on the distribution of polar hydrogen concentrations, which are important volatile sinks in the lunar water cycle. NanoSWARM's results have direct applications to the geophysics, volatile distribution, and plasma physics of numerous other bodies in the inner solar system. Below we describe the four science objectives of NanoSWARM.

Space weathering: Space weathering alters surfaces exposed to the space environment. On the Moon space weathering results in darkening, reddening, and reduction of absorption band strength. Understanding how these changes occur is critical for interpreting the spectra of all airless silicate bodies, from Mercury to Vesta [1-3]. Despite advances from returned lunar and asteroid samples and spacecraft spectral studies, numerous problems remain in understanding how space weathering operates. In particular, the relative importance of micrometeoroids vs. the solar wind is actively debated [3, 4], and is important due to the latter's order of magnitude variation in different parts of the solar system. In addition, the effect of variable FeO content of the surface is not completely known. NanoSWARM addresses these outstanding problems by making the first *in situ* measurements of variable solar wind flux, at surfaces with variable spectral properties and FeO content.

Lunar water: Understanding the distribution of water in the solar system is a key goal in planetary science. In the last 20 years, there have been important discoveries about the distributions of water and other volatiles on the Moon and other airless bodies. Lunar Prospector discovered a broad signature of hydrogen at both lunar poles, and M^3 discovered a latitude dependent signal of surface-bound OH/H_2O. However, critical questions remain about the origins and distributions of lunar surface water, such as how much OH/H_2O is generated by solar wind interactions, and is the polar hydrogen distribution definitively correlated with geological structures, such as permanently shadowed craters [5]? By correlating variable solar wind proton fluxes near the surface, with variable surface OH/H_2O abundances at swirls inferred from M^3 measurements, NanoSWARM addresses the first question. NanoSWARM answers the second question with data collected at the lunar poles.

Lunar magnetism: The first spacecraft to leave the Earth and pass the Moon, Luna-1 in 1959, carried with it a magnetometer. Luna-1 measured no global magnetic field, but in the subsequent decades, we have found that portions of the lunar crust and samples returned by the Apollo program are magnetized [6]. We have also come to conclude that a lunar dynamo is required to magnetize most, if not all of these materials [7]. However, many questions remain about the type of dynamo, its power source, its duration, and what it implies about the thermal history of the Moon. NanoSWARM will make the first high frequency measurements of lunar magnetic anomalies at low altitudes to help answer some of these questions.

Small-scale magnetospheres: The study of small-scale magnetospheres has the potential to inform a number of basic phenomena in space physics. For example, the interaction of magnetized asteroids with the solar wind is not entirely understood, yet it is important for understanding the magnetization of these small bodies [8]. It may be important for understanding the nature of the fields observed at the asteroid Psyche. By measuring the 3D plasma flux at swirls, NanoSWARM will provide an in-depth study of small-scale magnetospheric processes.

Synergies: A common theme in NanoSWARM is how measurements of particles and fields can inform a diverse number of processes in planetary science. For example, understanding solar wind space weathering is essential for interpreting planetary spectra, and this process also influences the generation of species which eventually may be trapped at the lunar poles. As another example, detailed models of field-particle interactions at small-scale magnetospheres can predict the variable amounts of H and He ions that penetrate the magnetic field at swirls. The optical space weathering efficiencies of each of these particles are likely different.

Conclusions: NanoSWARM addresses a number of important problems in planetary science by visiting some of the most complex and least explored geologic features on the Moon.

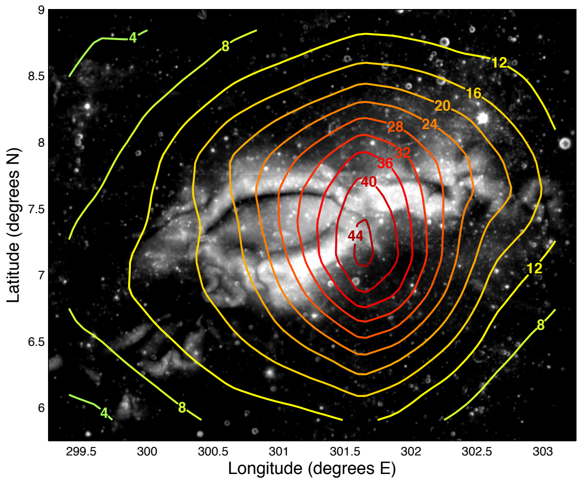

Figure 1: NanoSWARM targets some of the most scientifically rich regions in the inner solar system: lunar swirls. The image shows Reiner Gamma swirl with superimposed magnetic field contours in nT (100 km scale horizontally). No measurements exist at the scale of the sinuous albedo markings that are typical of lunar swirls.

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