Lunar Ice Cube: Development of a deep space cubesat mission.

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Overview: Lunar Ice Cube, a 6U cubesat mission designed for deep space, will be deployed in cis-lunar space by NASA's EM1 mission. Lunar Ice Cube was selected by the NASA HEOMD NextSTEP program to demonstrate cubesat propulsion, via the Busek BIT 3 RF Ion engine, and to demonstrate a cubesat-scale instrument capable of addressing NASA HEOMD Strategic Knowledge Gaps related to lunar volatile distribution (abundance, location, and transportation physics of water ice). We will also demonstrate for the first time in deep space an inexpensive radiation-tolerant flight computer (Space Micro Proton 400K), the JPL Iris Version 2.1 ranging transceiver, a custom pumpkin power system, and the BCT XACT attitude control system, and the AIM/IRIS microcryocooler. In addition, as required at the Preliminary Design Review, we will be delivering science data from the broadband IR spectrometer, as described below, to the Planetary Data System.

Payload: The payload consists of one instrument: BIRCHES [1], Broadband IR Compact High-resolution Exploration Spectrometer. The versatile instrument, being developed by NASA GSFC, is designed to provide the basis for amplifying our understanding [2,3,4] of the forms and sources of lunar volatiles in spectral, temporal, spatial, and geological context as function of time of day and latitude. BIRCHES is a compact version (1.6 U, 3 kg, 10-20 W) of OVIRS on OSIRIS-REx [5], a point spectrometer with a cryocooled HgCdTe focal plane array for broadband (1 to 4 micron) measurements. The instrument will achieve sufficient SNR (>200) and spectral resolution (</= 10 nm @ 3 microns) through the use of a Linear Variable Filter to characterize and distinguish spectral features associated with water. We are also developing compact instrument electronics which can be easily reconfigured to support future instruments with H1RG focal plane arrays in 'imager' mode, when the communication downlink bandwidth becomes available. An adjustable field stop allows as to change the footprint dimension in x or y direction by an order of magnitude, to adjust for variations in altitude and/or incoming signal. The compact and efficient AIM microcryocooler/IRIS controller is designed to maintain the detector temperature below 115K. In order to maintain the cold temperature (<220 K) of the optical system (all aluminum construction to minimize varying temperature induced distortion), a special radiator is dedicated to optics alone.

Investigation: Radiometric models for our instrument configuration indicate that lunar surface emission does not become significant at temperatures within the instrument according to our thermal models until beyond the three-micron band. Emission from detector surfaces remains a minor component regardless of wavelength. These models also allow us to remove thermal emission as a function of wavelength. In addition, for the three-micron band, we should have adequate signal to noise ratio (SNR) to see the absorption features even as we approach the terminator as long as we have water at the hundredths of a percent level or above.

Mission Design: Science data-taking with the BIRCHES payload will occur primarily during the science orbit (100 km x 5000 km, equatorial periapsis, nearly polar), highly elliptical, with a repeating coverage pattern that provides overlapping coverage at different lunations. Between lunar capture and the science orbit, orbits will be used occasionally for instrument calibration and capture of spectral signatures for larger portions of the lunar disk, traversing from terminator to terminator. Particular attention will be paid to systematic or solar activity dependent transient effects resulting from charged particle interactions around the terminators. Science orbit data-taking will last approximately 6 months, 6 lunar cycles, allowing for sufficient collection of systematic measurements as a function of time of day to allow derivation of volatile cycle models.

Output: We will deliver labeled EDRs, derived from packetized dating using AMPCS tools, and, to the extent that resources permit, Level 1 data products, including calibrated data, to the Geoscience Node of the PDS. We will be using SPICE/NAIF tools to capture positioning and pointing information. Such products should become available beginning in 2020. We invite SSERVI node scientists to contact us about leveraging resources to perform higher level processing.

References: [1] Clark P.E. et al. (2017) SPIE Proceedings 9978, 99780C, doi:10.1117/12.2238332; [2] Pieters C. et al. (2009) Science, 326, 568-572; [3] Sunshine J. et al. (2009) Science, 326, 565-578; [4] Colaprete A. et al. (2010) Science, 330, 463-468; [5] Reuter, D. and A. Simon-Miller, (2012) Lunar and Planetary Science, 1074.pdf.