EPSC Abstracts
Vol. 6, EPSC-DPS2011-1509, 2011
EPSC-DPS Joint Meeting 2011

Lunar Ultraviolet Reflectance Experiment (LURE): Exploring Signatures of Water Ice on Planetary Surfaces

K. D. Retherford (1), M. W. Davis (1), G. S. Winters (1), E. L. Patrick (1), S. M. Escobedo (1), G. R. Gladstone (1), P. F. Miles (1), J. Wm. Parker (2), S. A. Stern (2), A. R. Hendrix (3)
(1) Southwest Research Institute, 6220 Culebra Rd., San Antonio, TX 78238 (kretherford@swri.edu), (2) Southwest Research Institute, 1050 Walnut St., Boulder, CO 80302, (3) Jet Propulsion Laboratory, Pasadena, CA.

Abstract

Laboratory measurements of the far ultraviolet (FUV) spectral signatures of many common minerals and ices are few to nonexistant. To better interpret Lunar Reconnaissance Orbiter (LRO) Lyman Alpha Mapping Project (LAMP) observations of the moon and its permanently shaded regions we've developed an experiment to measure the bidirectional reflectance of samples at FUV wavelengths (1150 – 2200 Å) over various reflectance angles to investigate the reflective properties of water ice and lunar soils. Named the Lunar Ultraviolet Reflectance Experiment (LURE), our study characterizes the FUV bidirectional reflectance distribution function (BRDF) of water ice and lunar regolith simulants. Our first results will be reported.

1. Introduction

Despite the prevalence of UV surface reflectance measurements of planetary objects obtained with modern interplanetary and Earth-orbiting instruments, laboratory ground-truth measurements of FUV spectral properties of materials greatly lags behind similar measurements routinely performed at visible and infrared (IR) wavelengths. A dearth of UV measurements for water ice is particularly surprising, based on its prevalence in the solar system. Working with the vacuum UV lab equipment required to perform reflectance measurements is comparatively difficult, which has precluded these important data.

LRO/LAMP is designed to search for reflected light from the surface of the lunar nightside and permanently shaded regions (PSRs) such as the one within Cabeus crater, which is known through LCROSS impact measurements to contain water and other volatile compounds [1]. If surface water ice exists in sufficient abundances and is exposed to viewing from space, then diagnostic water ice features may be detected with LAMP. While spectral analysis of the LAMP dataset is currently underway and no detections of water frost are yet available, we've identified the need for improved laboratory measurements of previously identified spectral signatures of water ice and lunar soils at FUV wavelengths to improve this LAMP analysis and improve its search for surface water features.

2. Previous Studies

UV reflectance spectroscopy is a historically untapped resource for studying airless planetary surfaces (Moon, Mercury, etc.). Visible and IR spectra are common by contrast, since the Sun is brighter at these wavelengths and there are many diagnostic mineral spectral features. Studies of planetary surfaces using FUV reflected light have been limited, focusing on the Moon, asteroids, and the moons and rings of Saturn (e.g., [2, 3, 4]). Nevertheless, the study of surface reflected light at near-UV, mid-UV, and FUV wavelengths has provided much valuable knowledge that is otherwise unattainable at other wavelengths [5].

The only existing FUV measurements of lunar soil samples were performed decades ago [4]. These measurements were rather primitive in nature – e.g., involving only one angle of incidence and reflection, with relatively poor wavelength sampling, and were reported at the time to have an uncertain calibration near Lyman-α (1216 Å). Water frost and a few other volatiles were similarly measured with these Apollo returned samples. A comparison between lab measurements and theoretical predictions of the UV BRDF of water ice has never been performed, which is surprising since such empirical data often vary from predictions.

3. Experimental Setup – the SwRI UV Reflectance Chamber (SwURC)

Southwest Research Institute (SwRI) developed the SwURC facility to conduct the LURE experiment (Figure 1). The chamber consists of a six-way cross. The six ports include connections to a scanning monochromator, a vacuum pump station, a linear actuator that moves a sample tray in or out of the beam path together with an LN_2 feedthrough to cool the sample tray, rotary and electrical feedthroughs for a photomultiplier tube (PMT) detector, a load-lock door for easy sample exchanges, and lastly a blank plate future additional instruments. The chamber recently completed its calibration phase (Figure 2).

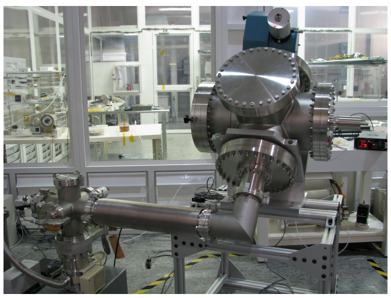

Figure 1: The SwURC facility.

Our technique alternates measurements of the horizontal sample using a monochromatic beam of light from a deuterium lamp at 45° incidence, and the PMT detector rotated at multiple angles of emission relative to the sample (-15° to ~85°). In addition, the direct beam orientation is measured for reference by moving the sample tray away from the beam. In this way, we bypass the need for calibration reference standards of diffuse reflectance (which are poorly defined for the FUV). The spectral resolution is 5 Å.

4. LURE Measurements

The LURE set of measurements include the JSC-1A lunar simulants at course (1 mm – 5 mm) and fine (< 20 µm) grain sizes. Crystalline water ice is formed in situ using our custom made liquid N_2 cryocooling feedthrough, and if time permits amorphous frost will be created via injection onto the cold sample plate.

5. Future Work

The lunar simulants measured in this study are a precursor (a demonstrator) for obtaining and measuring Apollo samples. We plan to repeat the Apollo returned sample measurements performed by Wagner, Hapke, and Wells [4]. This new facility is also well suited (e.g., highly adaptable and customizable) to measurements of numerous planetary ices and minerals, meteorites and returned samples, and other optical materials.

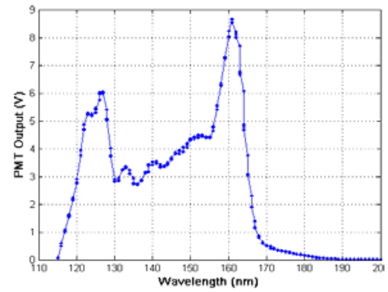

Figure 2: Example FUV spectrum of the deuterium lamp input beam (instrument "first-light").

6. Summary and Conclusions

As of the writing of this abstract our experimental setup is complete, and measurements of lunar simulants and water ice have just begun. We plan to report the reflectance spectra of our water ice and lunar simulant measurements together with angular distribution functions for each.

Acknowledgements

LURE is funded by NASA ESMD as part of LRO/LAMP, which we gratefully acknowledge. The SwURC facility was developed by SwRI capital equipment and IR&D funds.

References

[1] Gladstone, G. R. et al., LRO-LAMP Observations of the LCROSS Impact Plume, *Science,* 330, pp. 472-476, 2010.

[2] Hendrix, A.R. et al., The Effects of Space Weathering at UV Wavelengths: S-Class Asteroids, *Astron. J.,* 132, *3*, 1396-1404, 2006.

[3] Hendrix, A.R. et al., The Ultraviolet Reflectance of Enceladus: Implications for Surface Composition, *Icarus*, 206, 608-617, 2010.

[4] Wagner, J.K., et al., Atlas of Reflectance Spectra of Terrestrial, Lunar, and Meteoritic Powders and Frosts from 92 to 1800 nm, *Icarus*, 69, 14-28, 1987.

[5] Cloutis, E. A., et al., Ultraviolet spectral reflectance properties of common planetary minerals, *Icarus*, 197, 321-347, 2008.