TREX UV-VIS LAB MEASUREMENTS OF MINERALS AND MINERAL-ICE MIXTURES. G. M. Holsclaw[1] , M. M. Osterloo[1], T. Munsat[2], and A. R. Hendrix[3], [1]Laboratory for Atmospheric and Space Physics, University of Colorado at Boulder, 1234 Innovation Dr, Boulder, CO 80303, USA (greg.holsclaw@lasp.colorado.edu), [2]Department of Physics, University of Colorado, Boulder, Colorado 80309, USA, [3]Planetary Science Institute, Tucson, AZ.

Introduction: The Toolbox for Research and Exploration (TREX) is a NASA SSERVI (Solar System Exploration Research Virtual Institute) node. TREX (trex.psi.edu) aims to decrease risk to future missions, specifically to the Moon, the Martian moons, and near-Earth asteroids, by improving mission success and assuring the safety of astronauts, their instruments, and spacecraft. TREX studies will focus on characteristics of the fine grains that cover the surfaces of these target bodies – their spectral characteristics and the potential resources (such as H_2O) they may harbor. TREX studies are organized into four Themes: lab studies [1], Moon studies [2], small-bodies studies [3], and field work [4]). Here we describe one of several laboratory facilities to measure the spectral reflectance of fine-grained geologic materials.

Background: Some of the only existing far UV (FUV, ~120-200 nm) measurements of the spectral reflectance of geologic materials were made decades ago [5, 6], indicating features of potential value in diagnostic studies of composition. An expanding set of ultraviolet spectral reflectance measurements of solar system objects from the Hubble Space Telescope, Lunar Reconnaissance Orbiter, Cassini, Rosetta, and others has motivated a renewed interest.. For example, FUV spectra of Ceres obtained by HST suggest the presence of graphitized carbon [7], but few comparative datasets exist.

Measurement Requirements: The TREX co-I's at the University of Colorado's Laboratory for Atmospheric and Space Physics (LASP) are establishing a laboratory facility to measure the spectral reflectance of particulate geologic samples and ice-particulate mixtures with the following requirements:

- Spectral range: 120-400 nm
- Spectral resolution: ≤ 5 nm
- Photometric geometry: 30° illumination, 0° emission (observation) angle

While not required, we desire the capability to characterize photometric behavior and the degree of partial polarization of scattered light.

Facility: The measurement requirements have been exceeded with a customized Vacuum UltraViolet Analytical Spectrophotometer (VUVAS) system purchased from McPherson, Inc. (Fig. 1). A NEXT300 turbo-pumping station from Edwards provides vacuum functionality (this or N_2 purge necessary for measurements < 200 nm). A base pressure of $5x10^{-6}$ torr was demonstrated by the vendor, without inclusion of any geologic samples. The useable wavelength range is 115-600 nm.

A 30 W deuterium (D2) lamp provides illumination for the spectral range 115-250 nm. Longer wavelengths are attained with either a 100 W quartz-tungsten-halogen (QTH) lamp or a 150 W xenon arc lamp; which of these sources to baseline is currently under evaluation. A condenser using a concave mirror images a source to the spectrometer entrance slit. One source can be used at a time, and the condensing mirror can be manually located to one of two hard stops for selection. A filter wheel with five manually-selected positions is located just before the entrance slit. One position is unpopulated for the through-beam, two positions contain long-pass order-sorting filters (220 nm, 400 nm cut-on wavelengths), one position is opaque (to limit exposure of the optics to hard UV radiation), and the last position is currently unused.

The spectrometer is an f/4.5, modified Seya-Namioka scanning-grating monochromator using a concave, holographic reflection grating to disperse and image the light from the entrance slit onto the exit slit. A grating turret mechanism allows the selection of one of two gratings with different ruling densities, spectral coverage, and dispersion: 1200 gr/mm (115-350 nm) at 4 nm/mm, and 600 gr/mm (350-600 nm) at 8 nm/mm. The exit slit width is manually controlled from 0.01 to 3 mm using a micrometer; this provides a selectable radiometric bandpass and spectral resolution of 0.04 to 12 nm (115-350 nm) and 0.08 to 24 nm (350-600 nm). Grating position is computer controlled with a high-resolution sine drive mechanism.

Following the exit slit are a pair of powered mirrors that collimate the beam. An MgF_2 Rochon prism polarizer can be manually and optionally introduced into the optical path, and the angle adjusted to provide either s- or p-linear states relative to the scattering plane. The collimated beam width is ~10 mm.

A three-position sample stage can be manually located without breaking vacuum. Nominal positions are: 1) unpopulated for measurement of the source, 2) the sample under test, and 3) a reference target. The sample cup is 1.9 cm in diameter, and 0.6 cm deep, allow-

ing measurement of particulates 1.6 cm^3 in volume, or ~2.4 grams in mass (assuming a density of 1.5 g/cm^3).

The detector consists of a tilted scintillator (sodium salicylate) plate coupled to a reflective light pipe, feeding a photomultiplier tube (PMT) that physically exists outside the chamber. The scintillator plate is surrounded by a thin metal hood with an aperture slightly larger than the beam. This and the light pipe are attached to a manually-actuated and externally-accessible rotation stage that allows direct measurement of the illuminating beam and an accessible emission angle range of at least 0° to 60° (phase angle range of 30° to 90°). The illumination angle is fixed at 30°. The rotation axis of the detector is perpendicular to the scattering plane, and thus the system is restricted to variation of in-plane angles for photometric studies. The gimbaled detector will allow us to compare two different methods of deriving reflectance: 1) absolute, with direct observation of the beam illuminating the sample and 2) via reference, by observation of a surface with well-understood reflectance and scattering characteristics.

The PMT functions in analog mode with picoammeter readout. Acquisition of a sample spectrum across a limited spectral range with a fixed configuration (source, filter wheel position, grating, polarizer angle, detector angle, PMT high voltage) is automated. A complete spectrum (115-600 nm) requires at least four modifications (permutations of source selection, filter wheel position, grating, exit slit width, and PMT high voltage). To obtain absolute measurements, the detector is rotated so that it observes the collimated source, and the sequence repeated. A spectrum of both the sample and illuminating beam (to monitor for lamp drift) must be acquired for any change in detector position (emission/phase angle), polarizer angle, or reference target.

A cryogenic system is required to prepare and maintain ice and ice-mineral mixtures for spectral reflectance measurements. In the near future, we will implement a system similar to that developed at the University of Colorado's Institute for Modeling Plasmas, Atmospheres, and Cosmic Dust (IMPACT) SSERVI project [8]. In this configuration, the standard sample stage will be replaced with a temperature-controlled cold plate and sample. Our focus will be on water ice, though other ices (e.g. CO_2, SO_2) may be measured as well. We will study several ice mixtures relevant to solar system regoliths, created with samples of various fine-grained minerals in ratios of 1, 5, 10, and 30% (sample to water wt. %).

Status: The complete VUVAS system was delivered to LASP in December 2018, and we are currently bringing up the system to operation. We will present an overview of the system and initial test spectra.

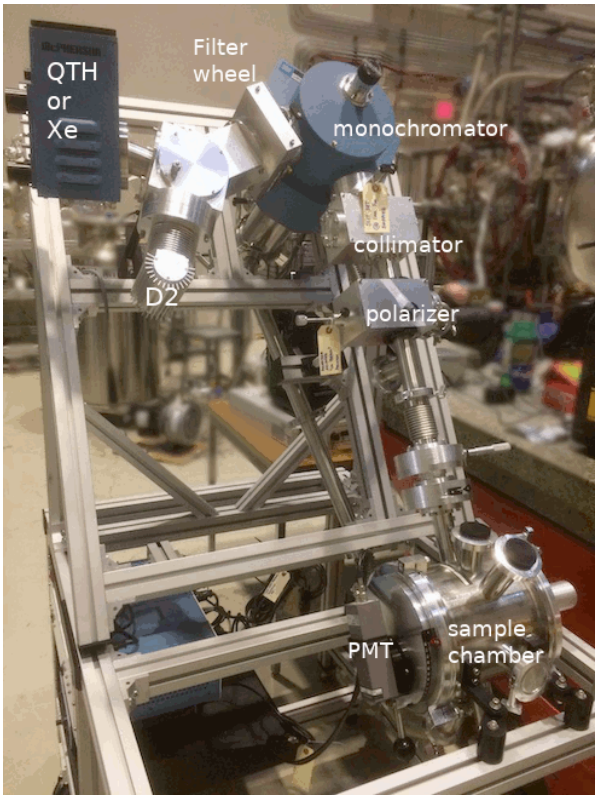

Figure 1: Complete UV-VIS (115-600 nm) spectral reflectance vacuum system at CU/LASP.

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