EXAMINING THE ORIGIN OF THE BLUE SLOPE IN THE FAR-ULTRAVIOLET (FUV) SPECTRA OF LUNAR SOILS: THE ROLE OF NANOPHASE IRON. U. Raut[1], P.L. Karnes[1], K.D. Retherford[1], M.W. Davis[1], Y. Liu[2], E.L. Patrick[1], P. Mokashi[1], G.R. Gladstone[1]. [1] Southwest Research Institute, Space Science and Engineering Division, San Antonio, Texas 78238, [2] Lunar and Planetary Institute/USRA, Houston, TX 77058.
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Introduction: Lunar reflectance spectra obtained by LRO-LAMP [1, 2] and previously by Apollo 17 ultraviolet spectrometer [3] were spectrally blue with higher albedo reported towards shorter wavelengths. This spectral bluing has been attributed mainly to the presence of nanophase Fe ($npFe^0$) in the exterior rims of lunar grains formed as a result of micrometeorite and solar wind space weathering [3]. Less weathered fresh crater ejecta [1] and swirls regions [2] are spectrally flatter or redder compared to surrounding mature regions. The blue slope is also corroborated by laboratory measurements of lunar soils returned by the Apollo missions [4], including our recent effort [5].

In addition to the Apollo soil 10084, we also measured the far-ultraviolet spectra of lunar simulant JSC-1A, which surprisingly exhibited a blue slope. The JSC-1A simulant resembles the lunar soil in its chemical composition but lacks space-weathering derived traits such as agglutinates and $npFe^0$ [6]. This preliminary dataset warrants additional investigation to the origin of the blue slope in the far-ultraviolet spectra of lunar soils. What other factors, besides $npFe^0$, contribute the observed spectral bluing?

Experimental Setup: The bidirectional reflectance measurements of the Apollo soil and JSC-1A lunar simulant samples were conducted in the Southwest Ultraviolet Reflectance Chamber (SwURC), a high-vacuum ultraviolet reflectance chamber [7]. Apollo soil 10084 was obtained from the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM), while the lunar simulant JSC-1A was sourced from Orbital Technology Corporation (ORBITEC). The average grain size of both samples is ~ 50 µm [8, 9].

In the SwURC system, a 30 W deuterium lamp feeds a grating monochromator which provides monochromatic light that is collimated with a pair of reflective cylindrical mirrors, prior to illuminating the samples at a fixed 45° incidence. A channeltron detector (Photonis 5901 Spiraltron, CsI-coated) is rotated in the principal plane over emission angles of -70° to + 75° with respect to the surface normal to collect diffuse light P_r over 115-180 nm reflected by the lunar soil and the simulant placed on the sample tray. Further, we also measure the incident beam intensity P_i by retracting the sample tray and directly intercepting the beam with the detector positioned at 135°. The absolute bidirectional distribution function is given by $f_{BRDF}(\theta_r) = \dfrac{P_r(\theta_r)}{[P_i \cos(-45^\circ)]\,\Omega_d}$, where Ω_d is the projected solid angle subtended by the detector. The cos(–45°) term accounts for the reduction in incident flux due to the increased illuminated surface area due to non-normal incidence. Further, the cosine of the emission is implicit in the projected solid angle Ω_d term. The units of f_{BRDF} are in sr^{-1}. The BRDF spectra are collected at 0.5 nm resolution.

Results: Figure 1 shows the absolute BRDF spectra of the Apollo soil 10084 and JSC-1A simulant collected at phase angle g = 105° (phase angle is the angle between incidence and emission). The FUV spectra are rather featureless, except for the small blue slope clearly discernable in curves obtained by smoothing the raw dataset to reduce the scatter. For instance, we find the Apollo soil Lyman-α f_{BRDF} to be 15% higher than at 165 nm. The JSC-1A spectrum shows an even larger increase, ~ 35% towards shorter wavelengths.

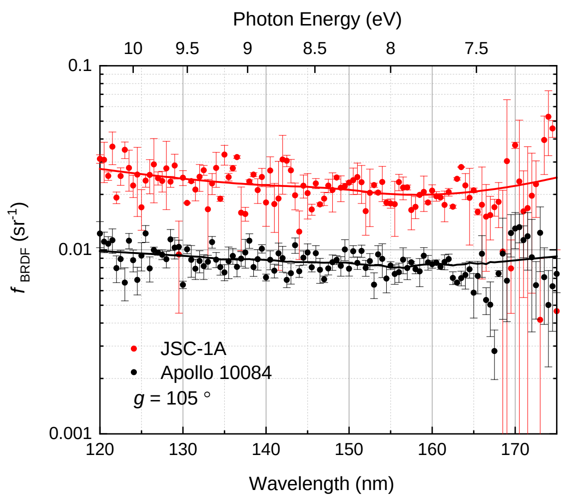

Figure 1: BRDF spectra of Apollo soil 10084 and lunar simulant JSC-1A measured at a phase angle g = 105°. Apollo soil 10084 contains nanophase Fe in the exterior rims of its grains, a product of space weathering. In contrast, JSC-1A lacks $npFe^0$. Yet, both show the small blue slope, more apparent in the smoothed BRDF spectra (solid lines).

The blue slope has been assigned to Fe nanoparticles in the exterior rims of the lunar grains from space weathering [10]. However, factors other than the nanophase Fe, possibly chemical/mineral constituents of higher opacity, geological origin, or even grain size distribution could contribute to the blue slope since it is also observed for JSC-1A.

Future plans: We plan to perform an in-depth systematic study to measure the degree of spectral bluing as a function of maturity index of lunar soils from different geological terrains (i.e., highlands and mare regions). A similar characterization of reddening in the visible-near-infrared region was conducted by the Lunar Soil Characterization Consortium (LSSC) [11]. Further, we will also investigate the dependence of blue slope on the particulate size with sieved JSC-1A samples.

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