THE FAR-UV WAVELENGTH DEPENDENCE OF THE LUNAR PHASE CURVE AS SEEN BY LRO LAMP.

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Introduction: The Lunar Reconnaissance Orbiter (LRO) Lyman Alpha Mapping Project (LAMP) provides global coverage of both nightside and dayside of the Moon in the far ultraviolet (FUV) wavelengths between 57 and 196 nm [1]. The nightside observations use roughly uniform diffuse illumination sources from interplanetary medium Lyman-α sky glow and UV-bright stars so that traditional photometric corrections do not apply. In contrast, the dayside observations use sunlight as the illumination source where bidirectional reflectance is measured. The bidirectional reflectance is dependent on the incident, emission, and phase angles as well as the soil properties. Thus the comparisons of dayside mapping and nightside mapping techniques offer a method for cross-comparing the photometric correction factors because the observations are made under different lighting and viewing conditions.

In this study, we discuss the FUV wavelength dependence of the lunar phase curves as seen by the LAMP instrument in dayside data. Sample mare and sample highlands have been selected for our investigation. Our preliminary results indicate that the reflectance in the FUV wavelengths decreases with the increasing phase angles. This is similar to the phase curve in the UV-visible wavelengths as studied by Hapke et al. [2] and Sato et al. [3] using the LRO Wide Angle Camera (WAC) data, among other visible-wavelength lunar studies. Also, phase reddening at FUV wavelengths was observed; at UV-visible wavelengths, such phase reddening has been attributed to interparticle multiple scattering as the albedo increases [2, 3]. Finally, we report current derived Hapke parameters at FUV wavelengths for our study areas.

Data and Method: The LRO LAMP instrument is a push-broom style FUV imaging spectrograph with a spectral resolution of ~2 nm and standard spatial resolution of ~250 m/pixel. Nominally pointed nadir, LAMP provides repeated observations of the Moon, enabling accumulation of FUV signal and higher data quality over the regions of interest. LAMP data were radiometrically calibrated to give the radiance factor $I/F(i,e,g)$ (i.e. the radiance relative to a perfectly diffusing Lambert surface illuminated and viewed normally). Then the I/F values were divided by the Lommel-Seeliger (LS) function to get the reduced reflectance, where *LS* is a common factor in the radiative transfer equation for the theoretical photometric functions of particulate media. To further improve signal/noise, we use 10 nm bandpasses combining five bins in the normal 2 nm products and lower spatial resolution (i.e., 10 km/pixel as compared to the standard 250 m/pixel) such that more photon events can be captured at each pixel for a given wavelength. Finally, we used the Hapke equation to fit the phase curves for each wavelength to derive the single scattering albedo *w* and asymmetric factor *b*.

Results: For both sample mare and highlands, the reflectance decreases with increasing phase angles. Phase reddening at FUV wavelengths was observed. The wavelength dependent single scattering albedo and asymmetric factor in the single-particle phase function for the sample mare and highlands were derived, which are listed in Table 1. These parameters will be used to perform better photometric corrections for LAMP FUV dayside reflectance data. Future work includes deriving Hapke parameters for more refined mare and highlands areas and testing shadow hiding and coherent backscattering effects in FUV wavelengths when small phase angles are available in the areas investigated.

References: [1] Gladstone, G. R., et al., LAMP: The Lyman Alpha Mapping Project on NASA's Lunar Reconnaissance Orbiter Mission, Space Sci. Rev., 150, 161-181, 2010. [2] Hapke, B., B. Denevi, H. Sato, S. Braden, and M. Robinson (2012), The wavelength dependence of the lunar phase curve as seen by the Lunar Reconnaissance Orbiter wide-angle camera, J. Geophys. Res., 117, E00H15, doi:10.1029/2011JE003916. [3] Sato, H., M. S. Robinson, B. Hapke, B. W. Denevi, and A. K. Boyd (2014), Resolved Hapke parameter maps of the Moon, J. Geophys. Res. Planets, 119, 1775–1805, doi:10.1002/2013JE004580.

Table 1. Retrieved wavelength dependent Hapke parameters for sample mare and sample highlands (*w* is the single scattering albedo, and *b* is the asymmetric factor for single-particle phase function)

λ (nm)		134	144	154	164	174	184
Mare	*w*	0.092± 0.002	0.085± 0.001	0.078± 0.001	0.065± 0.001	0.059± 0.001	0.055± 0.001
	b	0.483± 0.023	0.467± 0.023	0.484± 0.023	0.476± 0.023	0.483± 0.023	0.501± 0.023
High lands	*w*	0.086± 0.002	0.082± 0.002	0.074± 0.002	0.059± 0.002	0.056± 0.002	0.058± 0.002
	b	0.478± 0.023	0.471± 0.023	0.478± 0.023	0.468± 0.023	0.452± 0.023	0.446± 0.023