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Lunar Surface FUV Illumination Modeling for LRO-LAMP Albedo Maps

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Abstract

A core objective of Lunar Reconnaissance Orbiter's (LRO) onboard ultraviolet spectrograph Lyman Alpha Mapping Project (LAMP) is to produce global maps of surface albedo from observed brightness in the FUV wavelength range 57-196 nm. To do so requires accounting for the interplanetary medium Lyman-α background, UV-bright stellar sources, sunlight, and topographic occlusions that limit the fraction of the sky visible to a point on the surface. Modeling has been performed based on the latest LOLA elevation results [1] and measured spectra of all sources considered, and has been included in delivered LAMP albedo maps.

1. Introduction

Surface composition can be inferred via ultraviolet spectrometry by albedo measurement as a function of wavelength. For accurate comparison between localized regions, source anisotropy and temporal variability in the FUV illumination requires detailed modeling. Of equal importance is the effect of topography on limiting the incident light reaching the surface. This is especially true when searching for water ice in permanently shadowed regions (PSR) and differentiating crater properties from surrounding material as is an objective of LAMP.

2. Modeling

The illumination model is time and location specific and is synchronized to LAMP observations with resolution of 120 meters near the poles and 64 pixels per degree within ±60° of the equator [2]. LAMP observes reflectance spectra from both the lunar night side, where IPM Lyman-α emissions and starlight diffusely fill the sky, and the lunar dayside where shadowing of sunlight is crucial to illumination variations. A pinhole in the aperture door is used on the dayside to account for the dynamic range between night and day. Our model robustly describes the flux to the surface from these sources.

2.1 Sources

For surfaces directly exposed to the Sun, solar illumination accounts for virtually all incident light and is applied with a daily averaged spectrum from TIMED-SEE whose passband covers that of LAMP's. Otherwise the predominant source is the smoothly varying IPM background at Lyman-α which has been modeled and matched to all-sky maps from SOHO-SWAN [3]. For all other wavelengths, the night side is only illuminated by stars and other discrete sources [4]. We have compiled results from all observations made by the International Ultraviolet Explorer (IUE) mission made with their short wavelength primary camera [5]. The data were reduced to a catalog of the brightest 1000 sources and included in our database.

2.2 Topography

The topographic aspect of illumination has proved crucial to accurate modeling. On areas illuminated by the Sun, the surface orientation to the solar point source introduces a cosine term [6]. Further, solar occlusion by nearby mountains or crater walls cast shadows that reduce the total UV illumination by six orders of magnitude. Lastly, nearby topography can reduce the visible fraction of the sky to tens of percent smaller than 2π sr (or a few percent above). For regions diffusely illuminated (i.e. by IPM and, effectively, stars) this fraction must be applied as a constant factor to accurately represent the albedo, particularly in the deep craters of interest.

3. Results

Illumination results have been included in LAMP albedo map products where time and location are matched to observation. Additionally, average illumination conditions for a single location can be determined, as Figure 1 shows for the LCROSS impact site [7]. Shadowing is calculated throughout the year and found to never be exposed to the Sun. Although space weathering of surface constituents is expected to be considerably slowed in PSRs such as Cabeus, photon stimulated processes are still active and can be better understood with the aggregate spectra of these sources. Special attention is given to the residence time of water [8] in PSRs and variations in exposure to UV flux as restricted by the sky visibility presented in Figure 2.

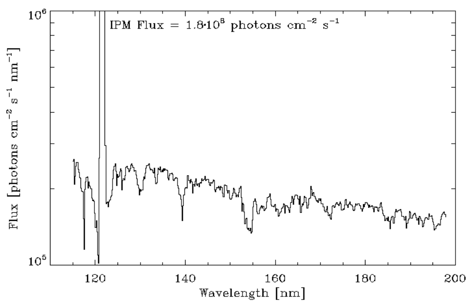

Figure 1: Calculated illumination spectrum at Cabeus crater (lat: -84.675° / lon: -48.719°), averaged over calendar year 2010. Sky visibility is 0.89·(2π) sr.

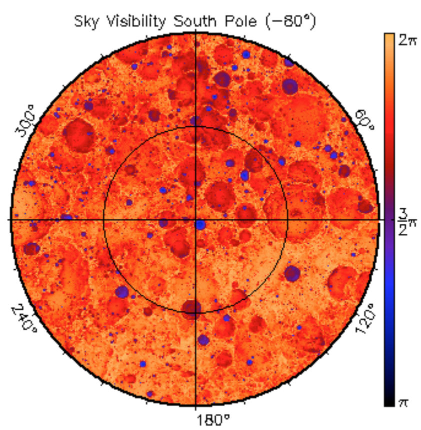

Figure 2: Sky visibility map at lunar south pole.

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References

[1] Mazarico, E., et al.: Illumination conditions of the lunar polar regions using LOLA topography, Icarus, Vol. 211, pp. 1066-1081, 2011.

[2] Gladstone, G. R., and 15 coauthors: LAMP: The Lyman Alpha Mapping Project on NASA's Lunar Reconnaissance Orbiter Mission, *Space Sci. Rev., 150*, pp. 161-181, 2010.

[3] Pryor, W.R.: Radiation transport of heliospheric Lyman-α from combined Cassini and Voyager data sets, A&A, Vol. 491, pp. 21-28, 2008.

[4] Henry, R. C.: The Local Interstellar Ultraviolet Radiation Field, ApJ, Vol. 570, pp. 697-707, 2002.

[5] Massa, D. and E.L. Fitzpatrick: A Recalibration of IUE NEWSIPS Low-dispersion Data, ApJS, Vol. 126, pp. 517-535, 2000.

[6] Horn, Berthold K. P.: Hill Shading and the Reflectance Map. Proceedings of the IEEE, Vol 69, No. 1, 1981.

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

[8] Morgan, T. H. and D. E. Shemansky: Limits to the Lunar Atmosphere, J. Geophys. Res., Vol. 96, pp. 1351-1367, 1991.