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LRO-LAMP Determination of FUV Reflectances in the Moon's Permanently Shadowed Regions

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Abstract

The Moon's permanently shadowed regions (PSRs) near each pole present difficult targets for remote sensing. The Lyman Alpha Mapping Project (LAMP) instrument on the Lunar Reconnaissance Orbiter (LRO) mission is able to map PSRs at far-ultraviolet (FUV) wavelengths using faint sources of illumination from the night sky; the all-sky Lyα glow produced as interplanetary H atoms scatter the Sun's bright Lyα emission line, and the much fainter source from UV-bright stars.

1. Introduction

LAMP [1] is an FUV imaging spectrograph on NASA's LRO mission [2]. Since September 15, 2009 The LAMP instrument has been observing FUV brightnesses on the nightside of the Moon to search for indications of water frost and other surface volatiles in PSRs. LAMP accomplishes this by measuring the signal reflected from the nightside lunar surface and in PSRs using interplanetary medium (IPM) Lyα and FUV starlight as light sources. Both these light sources provide fairly uniform, faint illumination and are estimated using model fits of SOHO/SWAN data for the IPM Lyα illumination and IUE data for stellar fluxes (plus LOLA topography for sky visibility) in order to convert LAMP-observed brightnesses into albedos.

2. Observations

LRO's ~50-km polar orbit provides for repeated observations of PSRs, enabling accumulation of the faint reflected FUV signal with the photon-counting LAMP instrument. LAMP has an FUV passband of 57-196 nm, and its 6°×0.3° slit is mostly nadir pointed (long axis normal to LRO's ground track). With LAMP's sensitivity the nightside count rate due to reflected IPM Lyα light is ~200-300 counts/s over the entire slit, which from an altitude of ~50-km amounts to >150 counts/km^2 from each ~5-km wide orbit swath. The background count rate is very low (~20 counts/s), so the signal-to-noise ratio (SNR) for a Lyα albedo map is approximately the square root of the number of counts per bin.

3. Results

The Lyα albedos of PSRs are quite variable, as shown in Figure 1. Most PSRs (e.g., Haworth, Shoemaker, Faustini) are considerably less reflective (A~0.03) at Lyα wavelengths than are their surroundings (A~0.04). However, some PSRs (e.g., Shackleton, and a similar-sized crater on the southern rim of Nobile crater) are comparably or more reflective than their surroundings. The lower albedo regions are roughly correlated with the coldest regions reported in Diviner temperature maps [3].

In this presentation we investigate some possible causes of this albedo darkening at Lyα wavelengths, e.g. the presence of UV-absorbing volatiles at the surface and/or changes in surface properties (e.g., roughness) at these interesting locations. Because of the near-uniform illumination by the IPM Lyα (and somewhat less uniform stellar illumination), the LAMP-determined surface albedos are closely related to the single-scattering albedo (ϖ_o) of the surfaces particles [4], with ϖ_o~4A. Fig. 2 shows how FUV albedos of the PSR and non-PSR surfaces inside Haworth crater vary with wavelength, compared with previous observations and simple

expectations. Note the relative redness of the PSR versus non-PSR locations, possibly indicating the presence of volatiles.

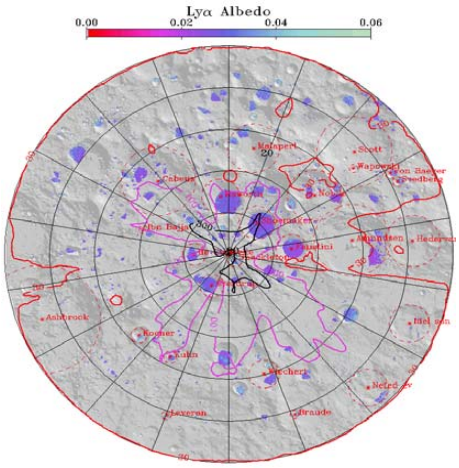

Figure 1: LAMP nightside Lyα albedos of LOLA-determined PSRs [5] near the south pole, overplotted on a shaded relief map of a LOLA 240m DEM. The 30 (red), 100 (purple), and 300 (black) contours show accumulated LAMP counts in counts/240-m pixel, which is approximately SNR^2. Some important craters with PSRs are indicated.

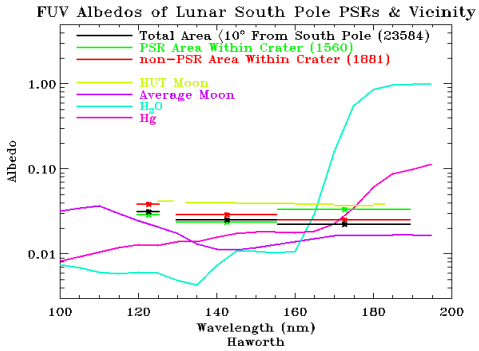

Figure 2: LAMP nightside FUV albedos near the south pole (black), compared with the PSR (green) and non-PSR (red) parts of Haworth crater. The continuous curves show the sub-solar geometric albedo (yellow-green) measured by HUT [6], and calculated plane albedos [7,8] for the average Moon [9], water [10], and elemental mercury [11].

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