Meter-scale Roughness on the Moon from Lunar Orbiter Laser Altimeter (LOLA) Pulse Spreading: Implications for Exploration.

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Introduction: The Lunar Orbiter Laser Altimeter (LOLA) [1] transmits short (~ 5 ns) pulses at 28 Hz, split into five ~0.1 milliradian-wide beams, providing up to 140 surface measurements per second. The backscattered pulses are lengthened in time due to interaction with the lunar surface. LOLA measures the width and energy of each surface return (Fig. 1). At the same time, the local slope may be estimated from a plane fit to the five adjacent altimetric spots (Fig. 2). The backscattered pulses provide a measure of the root mean square (rms) roughness of the surface at the scale of the laser footprint convolved with the instrument response and surface regional slopes, which are known or measured [2]. Such measures are employed in selection of landing sites for robotic spacecraft, e.g., [3]. Scattering of returns from heights varying by >30 cm (rms) extends the pulsewidth significantly from those over level ground. In the nominal 50-km mapping orbit of the Lunar Reconnaissance Orbiter (LRO), the effective laser footprint is a 2.5-m-diameter circular spot receiving 50% of the photons. The length scale of a single footprint is therefore of importance for exploration and corroborates findings from high-resolution imagers.

The interpretation of pulses to date has been complicated by the Lunar Reconnaissance Orbiter's ~30 km x 200 km commissioning orbit which leads to varying surface spot size and pulse amplitude. LOLA monitors the pulse width at threshold crossing of the backscattered pulse, and this parameter may also be used to infer the transmitted laser-pulse shape. The relationship between the LOLA measured pulse width and the threshold value for Laser 1 and 2 was measured prior to launch for calibration purposes. Pulse widths measured during the first month of commissioning orbit indicate returned pulses spread to as wide as 30 nanoseconds. While these observations require additional corrections, preliminary results show that pulse widths are visibly widened by the aprons of some impact structures and by South Pole-Aitken massifs, among other features. Analysis is underway to calibrate pulse widths against threshold, energy and other instrument parameters to provide a globally consistent quantitative measure of the roughness of the Moon at the scale of a few meters.

LRO attains its 50-km mapping orbit Sept. 17, 2009. Preliminary results from the commissioning period will be presented.

References:

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[2] G. A. Neumann et al. (2003) *Geophys. Res. Lett.*, 30(11), 1561, doi:10.1029/2003GL017048.
[3] Anderson, F.S. et al., *J. Geophys. Res.*, 108(E12), 8084, doi:10.1029/2003JE002125, 2003.

Figure 1: Raw pulsewidth measurements, uncorrected for altitude, etc. show surface roughness in hig

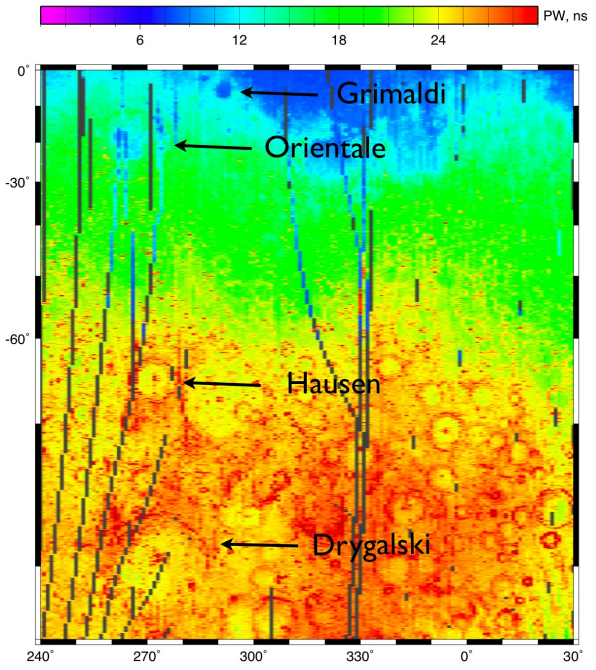

Figure 2: Position of five laser spots provides directional slope estimates at 28 Hz intervals.