LRO-LAMP OBSERVATIONS OF THE LUNAR EXOSPHERIC HELIUM COORDINATED WITH LADEE.

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Introduction: Helium was one of the first species identified by the Apollo 17 surface-based mass spectrometer LACE [1], with maximum densities recorded at the night side, typical of a non-condensable gas whose density follows the $T^{-5/2}$ dependence on surface temperature [2]. Helium resonant scattering emission (584 Å) was then detected for the first time remotely in 2011 with the Lyman Alpha Mapping Project (LAMP) UV spectrograph [3] on board the Lunar Reconnaissance Orbiter (LRO) [4], during off-nadir observations [5]. Helium in the lunar exosphere was long considered to originate from neutralization of solar wind alpha particles (He^{++}), and LRO/LAMP observations during January 2012 confirmed a decrease in helium density by a factor of 2 when the Moon was in the Earth's magnetotail [6]. But episodic bursts of helium density were first suggested [5] and finally confirmed by LRO/LAMP [7]. These bursts are uncorrelated with solar activity or meteor showers, implying that an endogenic source (radioactive decay of ^{232}Th and ^{238}U in the crust followed by release triggered by moonquakes) is likely involved.

The Observations: The polar orbiting LRO/LAMP experiment carried out a campaign dedicated to the study of the lunar exosphere at the same time that the Lunar Atmospheric and Dust Environment Explorer (LADEE) mission was sampling the lunar exosphere in a retrograde equatorial orbit. Two types of off-nadir maneuvers (forward/backward pitches and lateral roll slews) were performed routinely to increase line-of-sight column brightness while minimizing background radiation levels by looking at the night side surface. The campaign spanned a wide range of "beta angles", i.e. the angle between the Moon – Sun direction and the normal to the orbital plane of LRO, allowing the study of the lunar exosphere as a function of local time. During backward pitch slews, the LRO spacecraft was pitched to look opposite its direction of motion to a point just inside the limb in the nightside region around the polar terminator. Forward pitch slews were also obtained, and the angles of 63 deg or 77 deg from nadir were used at the north pole and south pole, respectively. For the lateral roll slews, LRO rotated by 60 deg towards the nightside limb, maximizing the amount of illuminated atmosphere in the foreground probed by the LAMP field of view.

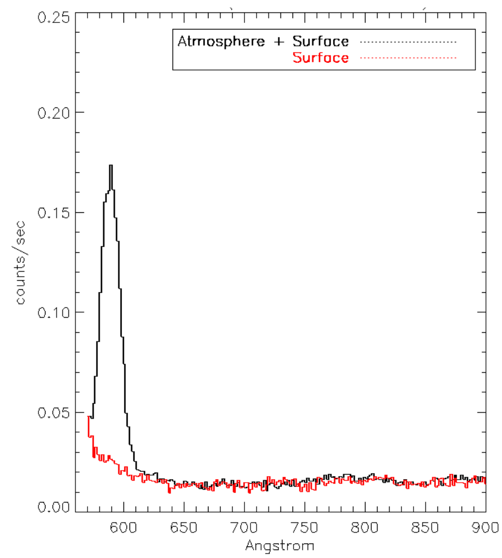

Figure 1 Total spectrum of lunar exospheric helium, integrated over 190 minutes.

We extract day-to-day density variations on helium, the only element in the lunar exosphere distinguishable on a day-to-day timescale with LAMP (Figure 1), spanning a period from October 2013 to April 2014, which is the science phase of LADEE. Different lateral roll angles allow sampling different local times on the Moon. Dependence on latitude is also studied, and we continue our search for episodic releases of endogenic helium ("helium flares") previously detected by LRO/LAMP [7]. Constraints on helium density are complemented by measurements of solar wind alpha particles from the ARTEMIS (Acceleration, Reconnection, Turbulence, & Electrodynamics of Moon's Interaction with the Sun) spacecraft [8]. This comparison provides a comprehensive picture of abundance and of spatial and temporal dependence of the lunar exospheric helium.

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