LUNAR ATMOSPHERIC CAMPAIGNS OF THE UV SPECTROGRAPH LAMP ON BOARD OF THE LUNAR RECONNAISSANCE ORBITER. C. Grava[1], D. M. Hurley[2], J. C. Cook[3], K. D. Retherford[1], G. R. Gladstone[1], T. K. Greathouse[1], S. A. Stern[3], P. D. Feldman[4], and the LRO/LAMP Team. [1]Southwest Research Institute, 6220 Culebra Road, San Antonio, TX, 78238 USA, [2]Johns Hopkins University, Applied Physics Laboratory, Laurel, MD, USA, [3]Southwest Research Institute, Boulder, CO, USA, [4]Johns Hopkins University, Baltimore, MD, USA.

Introduction: The Lunar Reconnaissance Orbiter (LRO) [1] has been studying the Moon since its orbit insertion in late 2009. Among its seven instruments, which provided an unprecedented understanding of the complex lunar environment, is the UV spectrograph LAMP (Lyman-Alpha Mapping Project) [2]. It proved to be a great remote sensing tool to study not only the properties of the lunar upper regolith such as porosity [3] and hydration [4], but also of the tenuous lunar exosphere, whose atoms and molecules resonantly scatter sunlight. Here we summarize the results of LAMP's atmospheric campaigns performed so far to study the composition and properties of the lunar atmosphere, as well as its temporal variations.

Geometry: Being pointed at the nadir most of the time to map the lunar surface, LAMP can detect resonantly scattering atoms and molecules in the lunar atmosphere when the latter is illuminated, and the instrument is pointing at the lunar nightside surface. Due to the polar orbit of LRO, such occasions occur when the spacecraft is poleward of ~75° latitude, or ~2 hours nightwards of either dusk or dawn terminators ("twilight observations"). Because of the faintness of the emission lines, LAMP needs to accumulate photons over a long period of time to obtain a decent signal-to-noise ratio (SNR). During dedicated campaigns, to increase the illuminated path along its line-of-sight and hence the SNR, LRO was also pitched along the direction of motion and rolled sideways.

Helium: The emission line of HeI at 58.4 nm is by far the brightest exospheric emission line within the LAMP bandpass (57.5 – 196.5 nm). Therefore, helium is the only element of the lunar atmosphere detectable by LAMP on a single orbit. It was detected during the first atmospheric campaign of LAMP, in 2011, looking at the sky [5]. The second atmospheric campaign was performed with LRO close to the terminator, and showed no variation of helium with latitude, but variation with time [6]. In particular, LAMP detected a decrease of a factor of 2 in the helium surface density in a 5-day period when the Moon was in the Earth's magnetotail, confirming that lunar helium has its main source in the neutralization of solar wind alpha particles upon impinging on the lunar surface [7]. However, subsequent observations with LAMP revealed sporadic enhancements of helium, uncorrelated with either solar alpha particles flux or meteor showers [8]. A plausible explanation for these "flares" is the release, by shallow moonquakes, of trapped lunar endogenic He formed from the radioactive decay of ^{232}Th and ^{238}U within the crust. Subsequent observations with LAMP [9, 10] are consistent with ~40 % of lunar helium being endogenic.

Molecular Hydrogen: LAMP detected H_2 in the vapor plume from the Lunar Crater Observation and Sensing Satellite impact [11]. Later, accumulating photons during the first 4 years, LAMP detected for the first time in the ambient exosphere the Lyman and Werner emission bands of molecular hydrogen [12]. Interestingly, the inferred surface density of H_2 was several times lower than previous upper limits inferred by the Apollo 17 Ultraviolet Spectrometer, and showed a dawn/dusk asymmetry, with surface density at dawn being 1.4x higher than at dusk.

Other species: In addition to these detections, more than 3 years of LAMP's "twilight observations" placed stringent upper limits on several other species [13], some of them (O, Mg, Al, and Ca) in agreement with models in which sputtering is the dominant source process. As the mission progresses and LAMP accumulates photons, improved upper limits are warranted in the future.

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