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Observations of Lunar Exospheric Helium with LAMP UV Spectrograph onboard the Lunar Reconnaissance Orbiter

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Helium was one of the first elements discovered in the lunar exosphere, being detected by the mass spectrometer LACE (Lunar Atmosphere Composition Experiment) deployed at the lunar surface during the Apollo 17 mission. Most of it comes from neutralization of solar wind alpha particles impinging on the lunar surface, but there is increasing evidence that a non-negligible fraction of it diffuses from the interior of the Moon, as a result of radioactive decay of thorium and uranium. Therefore, pinpointing the amount of endogenic helium can constrain the abundance of these two elements in the crust, with implication for the formation of the Moon. The Lyman-Alpha Mapping Project (LAMP) far-UV spectrograph onboard the Lunar Reconnaissance Orbiter (LRO) carried out an atmospheric campaign to study the lunar exospheric helium. The spacecraft was pitched along the direction of motion to look through a longer illuminated column of gas, compared to the usual nadir-looking mode, and therefore enhancing the brightness of the emission line at 58.4 nm of helium atoms resonantly scattering solar photons. The lines of sight of the observations spanned a variety of local times, latitudes, longitudes, and altitudes, allowing us to reconstruct the temporal and spatial distribution of helium and its radial density profile with the help of an exospheric model. Moreover, correlating the helium density inferred by LAMP with the flux of solar wind alpha particles (the main source of lunar helium) measured from the twin ARTEMIS spacecraft, it is possible to constrain the amount of helium which comes from the interior of the Moon via outgassing. While most of the observations can be explained by the exospheric model, we have found discrepancies between the model and LAMP observations, with the former underestimating the latter, especially at northern selenographic latitudes, when LRO altitude is maximum. Such discrepancies suggest that the vertical distribution of helium differs from a Chamberlain exospheric model, an interesting result considered that helium does not interact with the lunar surface, and may be indicative of a different thermal population of helium atoms. We present results from over 150 observations performed routinely from 2013 to 2016 to look for trends in the spatial and temporal distribution of helium and to constrain the fraction of endogenous helium compared to the solar wind contribution.