EARLY RESULTS FROM EXOSPHERIC OBSERVATIONS BY THE NEUTRAL MASS SPECTROMETER (NMS). M. Benna[1], P. R. Mahaffy[1], and R. R. Hodges[2], [1]NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA (mehdi.benna@nasa.gov), [2]Laboratory for Atmospheric and Space Physics, U. of Colorado, Boulder, CO 80303, USA.

Introduction: The Neutral Mass Spectrometer (NMS) of the Lunar Atmosphere and Dust Environment Explorer (LADEE) Mission is designed to measure the composition and variability of the tenuous lunar atmosphere. The NMS complements two other instruments on the LADEE spacecraft designed to secure spectroscopic measurements of lunar composition and in situ measurement of lunar dust over the course of a 100-day mission in order to sample multiple lunation periods [1]. The NMS instrument utilizes a dual ion source designed to measure both surface reactive and inert species and a quadrupole analyzer. Instrument activities are designed and scheduled to provide time resolved measurements of Helium and Argon and determine abundance or upper limits for many other species either sputtered or thermally evolved from the lunar surface.

The Neutral Mass Spectrometer (NMS): The LADEE Neutral Mass Spectrometer (NMS) is a high sensitivity quadrupole mass spectrometer with a mass range of 2 to 150 Dalton and unit mass resolution (Figure 1). The NMS instrument utilizes the engineering unit sensor from the Neutral Gas and Ion Mass Spectrometer (NGIMS) developed for the CONTOUR mission [2] and electronics with extensive heritage from the MSL-SAM instrument. This mass spectrometer is similar to the CASSINI Ion and Neutral Gas Mass Spectrometer (INMS) also designed and developed at GSFC. The LADEE-NMS instrument was modified from the heritage CONTOUR-NGIMS instrument to increase the instrument sensitivity, field of view and overall operational flexibility.

The NMS sensor consists of: two separate ion sources for sampling ambient neutrals and ions (a closed source for non-reactive neutral species, and an open source for reactive neutral species and ions); an ion deflector/trap; four hot-filament electron guns (two for the closed source and two for the open source); an electrostatic quadrupole switching lens that selects between the sources; various focusing lenses; a quadrupole mass analyzer, and two secondary electron multiplier (SEM) detectors. The sensor was sealed by a deployable cap with a residual pressure of a noble gas mix (He, Ar, Kr and Xe).

The instrument control is provided by the Command and Data Handling (C&DH) unit, according to the instructions given to a user defined script. The C&DH and all the related electronics boards are packaged together in the Main Electronics Box (MEB). A sketch of the key NMS sensor components is shown in Figure 2.

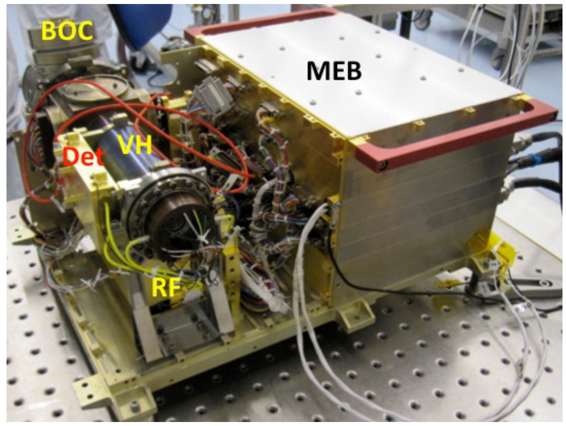

Figure 1. The NMS instrument during integration and testing. Labels identify the main electronics box (MEB), the break off cap (BOC), the vacuum housing (VH), the radio frequency (RF) electronics, and the detector (Det) electronics.

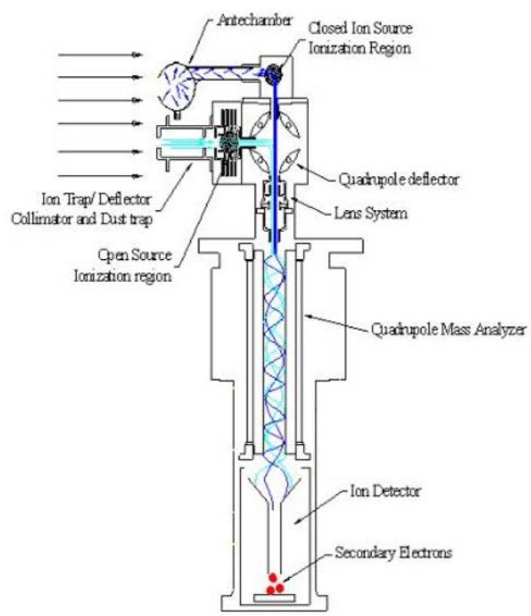

Figure 2. Schematic drawing of the NMS sensor. The neutral gas is ionized in the closed or the open sources and the resulting ions are directed to the Quadrupole analyzer for mass selection. Selected ions are detected by one of the secondary electron multipliers.

Overview of NMS activities: Following the initial in-flight checkout and calibration, the instrument break-off cap was deployed on 10/04/2013 exposing the sensor to vacuum. The instrument has been effectively observing the lunar exosphere since 10/17/2013, initially from a near circular 250 km altitude orbit and since 11/11/2013 from an elliptical orbit that reaches to 30-60 km altitude near the sunrise terminator.

Instrument activities are scheduled to alternate between mapping campaigns of Helium, Neon, and Argon at low altitudes, detection of energetic sputtered neutrals on the lunar day side, observations of exospheric ions, and general survey and inventory of species in the exosphere. These activities are prioritized and scheduled to not conflict with resources (power and spacecraft pointing) need by UVS observations or spacecraft operations.

Early Results From NMS Observations: Owing to its very low chemical background at M/Z = 4, the NMS instrument was successful at detecting and mapping exospheric Helium during the high altitude (250 km) commissioning phase. This early mapping campaign provided the unique opportunity to observe the variation of Helium at a constant altitude and for nearly a full lunation. Figure 3 shows results of Helium spatial and temporal variability as the Moon moves in and out of the Earth's magnetotail.

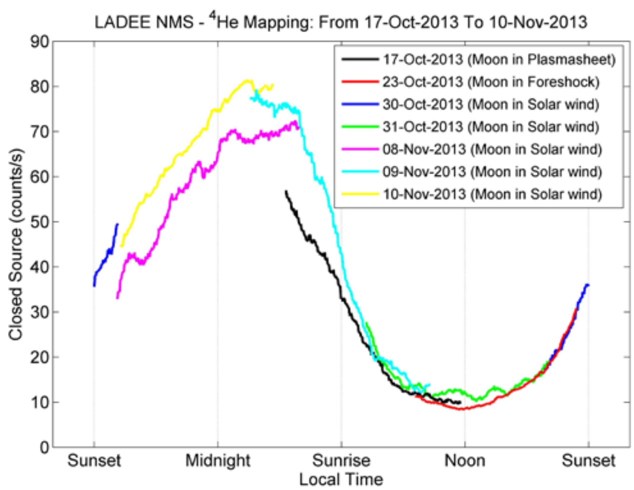

Figure 3. Evolution of the Helium abundance (in instrument counting units) as a function of solar local time observed during the LADEE commissioning phase.

At the end of the commissioning phase and after the orbit's periselene was lowered to ~ 50 km, the NMS instrument was able to detect Argon (M/Z = 40) and Neon (M/Z = 20). Mapping of the temporal and spatial variation of these two species along LADEE's orbit is being conducted systematically.

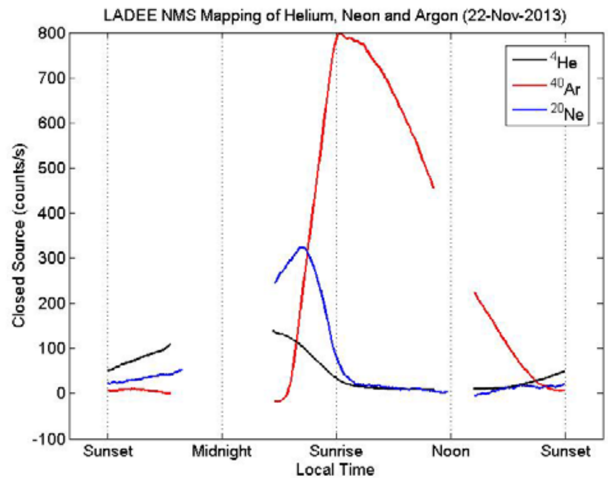

Figure 4. Variations of the abundance (in instrument counting unit) of Helium, Neon and Argon along one LADEE orbit. Because LADEE's orbit is elliptical, these profiles are the result of the convolution of the longitudinal variation of the exosphere by the altitude variation of the spacecraft along its orbit.

The diurnal variation of Ar follows was already observed by the Apollo 17 mass spectrometer [3] and can be easily associated with adsorption as the surface cools post-sunset and with rapid desorption at sunrise as predicted by Hodges and Johnson [4] for a condensable gas, like water vapor.

Neon exhibits an intermediary behavior between the thermally accommodated condensable Argon and the non-condensable Helium.

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References: [1] Elphic et al., Proc. Lunar. Sci. Conf. 44th, 1719 (2013). [2] Mahaffy et al., Bull. Am. Astron. Soc. 33, 1148 (2001). [3] Hodges and Hoffman, Geophys. Res. Lett. 1, 69 (1974). [4] Hodges and Johnson, J. Geophys. Res. 73, 7307 (1968).