GLOBAL MAPPING OF NEUTRON EMISSION FROM THE MOON ACCORDING TO LEND DATA.

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Introduction: The Lunar Exploration Neutron Detector (LEND) is designed to perform orbital mapping of Moon neutron flux in wide energy range starting from thermal neutron up to high energy neutrons about 10 MeV [1]. It consists of 8 gas-filled proportional counters of neutrons and one organic scintillator. Four of eight gas-filled proportional counters are surrounded by collimator module which makes narrow field of view for these counters. The primary goal of the LEND experiment is a search of enhanced content of hydrogen in the circumpolar regions of Moon. LEND is installed onboard Lunar Reconnaissance Orbiter (LRO) which has been successfully launched in June 2009 and now operates more than 1.5 years at a polar orbit around the Moon [2].

Here we are presenting the results of global mapping of neutron emission from the Moon according to LEND data accumulated during the LRO mission.

Scientific background: There are three large planets in the Solar system which emit gamma-rays and neutrons from surfaces: the Moon, Mars and Mercury. This nuclear emission is produced by bombardment of galactic cosmic rays and, episodically, by solar energetic particles. High energy protons and nuclei of cosmic rays collide with nuclei in the soil within a depth of first meters and produce secondary neutrons with high energies. Neutrons diffuse in the subsurface colliding with soil nuclei until they leak from the surface, or are absorbed due to capture reaction, or decay due to finite life time. The neutron leakage emission (albedo) is detectable by an instrument observations from a low altitude orbit.

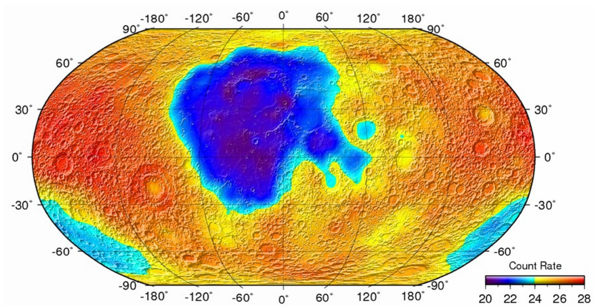
Neutrons lose energy with collisions; the moderation of escaped neutrons is greater for those particles which have a greater number of interactions. The energy spectrum of emitted neutrons has a thermal component (corresponding to particles which have been thermalized before escaping), and a power-law tail from epithermal energies up to original energy (representing particles which escaped before thermalization) [3]. The energy spectrum of leaking neutrons depends on the soil composition and, mostly, on the content of hydrogen, because H nuclei are the best neutron moderators. Even a fraction of hydrogen as small as 100 ppm is known to produce a measurable change of epithermal neutron albedo from the surface of a planet with thin or no atmosphere.

Lunar orbital observations by Neutron Spectrometer on Lunar Prospector [4] have shown that the lunar maps of neutron emission provide evidence of high content of hydrogen (or water ice deposits) at polar regions of Moon.

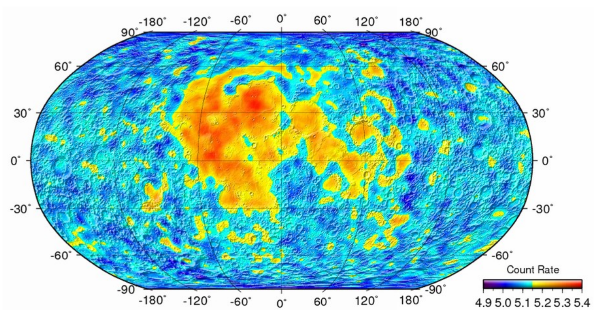
Here we present maps of thermal, ephithermal and fast neutrons have been measured by the LEND instrument, which is the large orbital neutron telescope for orbital mapping of the Moon's neutron albedo. The LEND is a collimated neutron detector system with a up to 10 km (FWHM) diameter field of view foot print at circumpolar regions for the nominal 50 km orbital altitude. Global maps of neutron albedo have spatial resolution of 70 – 100 km due to broad field of view of the instrument's thermal neutrons sensor and low exposure time at equatorial belt of the Moon. At moderate latitudes and at the equator the integrated exposure time for corresponding surface elements is rather small in comparison with the poles. However, counting statistics for particular spatial elements could be increased by increasing the surface area. LEND is the Russian contributed instrument for NASA's Lunar Reconnaissance Orbiter [2], and its investigation team includes scientists from leading research centers for nuclear and planetary science both from Russia and from the United States.

Results: LEND is performing global mapping of the entire Moon with spatial resolution 70 – 100 km (see Fig. 1 – 3). The global maps of thermal, epithermal and fast neutrons are well correlating with lunar maria regions. It is well known the concentration of heavy nucleus like Fe, Th, U is high at the regolith at these regions. Some large craters and highland areas are also well visible on global maps. South Pole – Aitken basin is visible on the map of thermal neutron abledo.

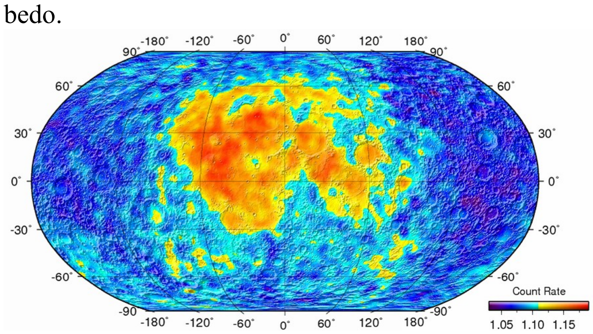
Unique capability of LEND to measure epithermal neutron albedo with high spatial resolution allow to create maps with resolution up to 10 km of this type of neutrons albedo for circumpolar areas (see Fig. 4 – 5). Analysis of these maps for both poles shows existence of areas with relatively strong suppression of epithermal neutron flux (named as Neutron Suppressed Regions = NSRs), which are interpreted as areas with high concentration of Hydrogen in regolith. The most unique property of NSRs is that their boundaries may located outside of or may not correlate at all with a positions of Permanently Shadowed Regions (PSRs). This subject is discussed in more details in [5].



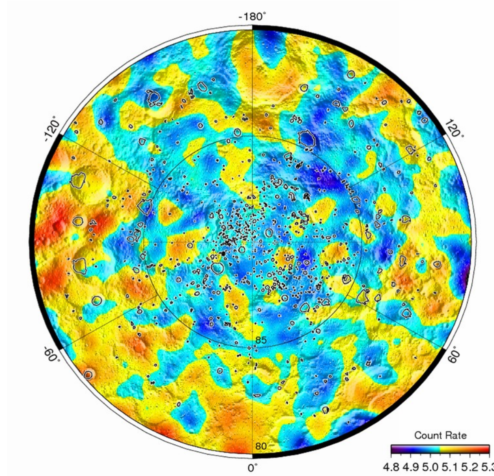
Figire 1. Global map of the thermal neutron albedo.



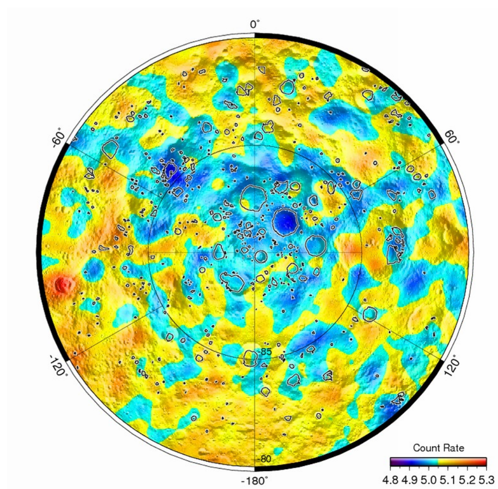
Figire 2. Global map of the epithermal neutron albedo.



Figire 3. Global map of the fast neutron albedo.



Figire 4. North polar map of the epithermal neutron albedo.



Figire 5. South polar map of the epithermal neutron albedo.

References: [1] Mitrofanov I.G. et al. (2008) *Astrobiology*, 8, 4, 793–804. [2] Chin G. (2007) *Space Science Reviews*, 129, 4, 391–419. [3] Drake D.M. et al. (1988) *JGR,* 93, 6353–6368. [4] Feldman W.C. et al. (1998) *Science*, 281, 1496-1500. [5] Mitrofanov I. et al. (2011), abstract of *LPSC 42nd*.