**ESTIMATION OF THE HYDROGEN CONCENTRATION IN LUNAR SOUTH POLAR REGIONS OF PERMAFROST IN VICINITY OF CABEUS AND SHOEMAKER CRATERS.** A. B. Sanin[1], I .G. Mitrofanov[1], M. L. Litvak[1], W. V. Boynton[2], G. Chin[3], L. G. Evans[5], J. Garvin[3], D. V. Golovin[1], K. Harshman[2], T. P. McClanahan[1], A. Malakhov[1], M. I. Mokrousov[1], G. Milikh[4], R. Z. Sagdeev[4], R. D. Starr[6], [1]Institute for Space Research, RAS, Moscow 117997, Russia, sanin@mx.iki.rssi.ru, [2]Lunar and Planetary Laboratory, University of Arizona, Tucson AZ, USA, [3]NASA Goddard Space Flight Center, Greenbelt MD, 20771, USA, [4]Space Physics Department, University Maryland, College Park, MD, USA, [5]Computer Sciences Corporation, Lanham MD 20706, USA, [6]Catholic University of America, Washington DC, USA.

**Introduction:** In 1693 G. D. Cassini published the three empirical laws on the motion of the Moon. According to the second of these laws the inclination of the Moon's equator to the ecliptic plain is a constant approximately equal to 1.5°. Due to such excellent alignment, there are a number of permanently shadowed regions (PSRs) at deep craters near to the both North and South lunar poles. More than 50 years ago, it was suggested that all or some of these PSRs are sufficiently cold to trap and preserve for a long time (~Gy) hydrogen bearing volatiles – primordial or produced by solar wind interaction with regolith or brought to the Moon as water ice by comets and meteoroids [1,2,3,4].

Several attempts have been made in the past to test PSRs for water ice presence. Observations made by bistatic radar onboard the Clementine spacecraft identified some anomalous regions on the Moon associated with PSRs as possible evidences of the water ice presence [5]. These observations have been criticized as ambiguous [6]. Another attempt to test lunar PSRs for water was performed using neutron (LPNS) and gamma-ray (LPGRS) spectrometers onboard the Lunar Prospector mission launched in 1998 [7]. These instruments were able to create global elemental and neutron albedo maps and discover significant reductions of epithermal neutron fluxes in lunar polar regions poleward of 70°S and 70°N latitudes. This result was interpreted as an enhancement of hydrogen abundance in these areas [8]. The best spatial resolution of LPNS (full width at half maximum ~46 km at 30 km orbit altitude [9]) didn't allow resolving individual local areas with highest hydrogen abundance. Water on the Moon has also been recently detected by IR imaging spectrometers [10]. The IR data have shown that the content of water (or hydroxyl) is gradually increasing toward both poles.

Neutron spectrometer LEND (Lunar Exploration Neutron Detector) [11] launched into lunar orbit onboard the Lunar Reconnaissance Orbiter (LRO) mission [12] became the next mission to test the presence of a hydrogen bearing regolith in the lunar polar regions. LEND have the significant advantage in respect to LPNS – due to presence of a neutron collimation module LEND can provide resolution ~10 km from 50 km orbit during mapping phase of LRO mission.

**Data analysis:** The galactic cosmic rays produce in regolith high energy neutrons (with energy about 1 – 20 MeV). These neutrons are moderates to epithermal energies by multiple collisions with nuclei of regolith before they are able to escape from the surface and may be detected by a neutron detector on orbit. The leakage flux of epithermal neutrons depends on the concentration of hydrogen in the regolith, because more collisions with hydrogen nuclei lead to faster moderation and thermalization of neutrons before they can escape. In addition to the well known reductions of epithermal neutron fluxes in both lunar polar regions poleward of 70°S and 70°N latitudes (observed by both LPNS and LEND) several local spots of epithermal neutron flux suppression in comparison with surrounding areas were found from analysis of LEND data [13]. These suppressions marks enhanced content of hydrogen or water in the regolith. Figure 1 presents a map of epithermal neutron flux at the South pole. It was found that epithermal neutron flux from most of PSRs is not significantly different in comparison with neutron emissions from surrounding areas. Only PSRs in Cabeus and Shoemaker craters near the South pole show a significant suppression [14]. On the other hand several spots of epithermal flux suppression were found completely or particularly outside of any large PSRs [13].

We would like to present the results of estimations of hydrogen concentration in regolith in South polar regions at vicinity of Cabeus and Shoemaker craters. The estimations are based on analysis of LEND collimated detectors data accumulated from September 15, 2009 till December 20, 2012 and on numerical simulations of the neutron fluxes from regolith with different hydrogen concentration.

**References:** [1] Watson K. et al. (1961) *JGR, 66(9),* 3033–3045. [2] Arnold J. R. (1979) *JGR, 84,* 5659–5668. [3] Starukhina L. V. and Y. G. Shkuratov (2000) *Icarus, 147,* 585–587. [4] Vondrak R. R. and Crider D. H. (2003) *Am. Sci., 91,* 322–329. [5] Nozette S. et al. (2001) *JGR, 106(E10),* 23253–23266. [6] Fa W. et al. (2011) *JGR, 116,* E03005. [7] Feldman W. C. et al. (2004) *JGR, 109,* E07S06. [8] Feldman W. C. et al. (2001) *JGR, 106(E10),* 23231–23251. [9] Maurice S. et al. (2004) *JGR, 109,* E07S04.

[10] Pieters C. M. et al. (2009) *Science*, *326(5952)*, 568–572. [11] Mitrofanov I. G. et al. (2010) *Space Sci. Rev.*, *150(1–4)*, 183–207. [12] Chin G. et al. (2007) *Space Sci. Rev.*, *129*, 391–419. [13] Mitrofanov I. G. et al. (2012) *JGR*, *117*, E00H27. [14] Sanin A. B. et al. (2012) *JGR*, *117*, E00H26.

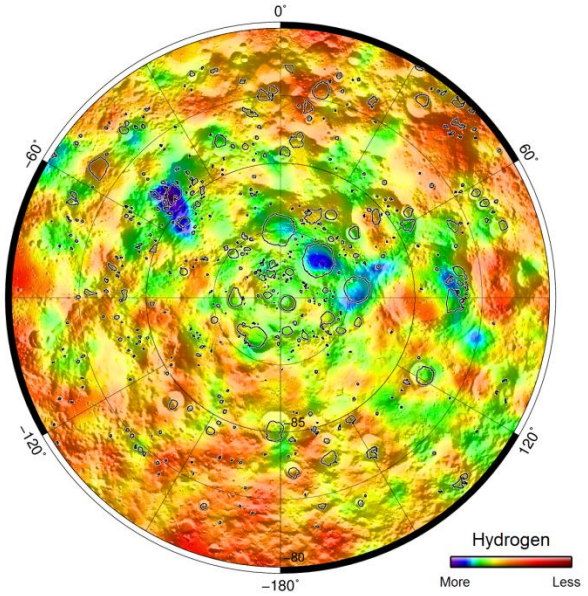


**Figure 1.** LEND map of epithermal neutron fluxes at the South lunar pole. The red color is corresponds to high neutron flux and less concentration of hydrogen in regolith. The green, blue and violet colors are represent low neutron flux and more hydrogen concentration.