Geophysical Research Abstracts,
Vol. 11, EGU2009-10448, 2009
EGU General Assembly 2009

Perspective Lunar exploration instrumentation based on the methods of nuclear physics

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Methods of gamma and neutrons spectroscopy are well known as a good approach for studies of upper subsurface of planets with thin or no atmospheres (like Moon, Mars and Mercury). During 7 years until now these methods are very efficiently used by GRS, HEND and NS instruments onboard NASA's orbital mission Mars Odyssey. These measurements allowed to map the distributions of soil-constituting elements and radioisotope over the planet and also to detect the water ice in the martian subsurface. Also these methods will be used for observations of the Moon by LEND instrument (NASA's LRO mission, orbital neutron measurements with the high spatial resolution), for studies of Mars by DAN instrument (NASA's MSL rover, neutron active measurements along the trace of the rover) and for observationa of the mercury by MGNS instrument (ESA BeppiColombo mission, orbital gamma and neutron mapping). Based on the heritage of all these instruments , the concepts of new space instruments of future lunar exploration will be presented and discussed.

Operation and design concept of perspective Lunar gamma-ray telescope will be presented, which could be considered as a farther development of LEND instrument. This instrument is proposed for launched on the future Moon orbital mission. This instrument will use gamma-spectroscopy method to explore elemental composition of lunar regolith from the Moon orbit with high spatial resolution. It is suggested that telescope will consist of 9 equal detectors based on modern LaBr3 scintillation crystals, which allows to reach a spectral resolution as high as 2.9-3,2% at 660 keV. All these detectors will be surrounded by passive collimator of gamma-rays to allow to reach as high spatial resolution as 10 km from the orbit with altitude about 50 km. Resulting science product of this instrument will be a global surface maps of major soil-constituting elements and radioactive isotopes (K, Th, and U). This spatial resolution is be significantly better (more that 100 times smaller by the area of footprint) than presently available maps from the Lunar Prospector mission. Such high spatial resolution of surface composition is necessary for planning future landing missions for experiments of utilization of lunar resources.

Another future instrument for nuclear measurements will be presented for future Lunokhod (Moon rover) mission. This instrument uses neutron activation and neutron logging methods for subsurface exploration. It is farther development of the concept of DAN/MSL instrument. One of the main benefits of the suggested instrument is active neutron generator, which allow to generate pulses with high intensity of high energy neutrons (up to 10e7-10e8 neutrons per pulse) in a very short time scale (1-2 microseconds). This neutron activation technique can be used in the similar way as it is already done on Earth for various geological applications. Such instrument, as the combination of neutron generator with neutron detectors and gamma-ray spectrometer, shall be able to measure die-away time profiles of induced neutron and gamma-ray emission. Very high counting rate immediately after a neutron pulse imposes very strict requirements for the primary read-out electronics concerning fast signal processing. Results of measurements will be recorded in different spectral channels for time intervals of die-away curves for gamma-rays and neutrons. By detailed analysis of these curves one may estimate the presence and depth distribution of hydrogen-rich minerals (from the neutron data) and depth distribution of soil-constituting elements (from the gamma-ray data).