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Lunar Infrared Spectrometer (LIS) for Luna-Resurs and Luna-Glob missions

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Abstract

Lunar Infrared Spectrometer (LIS) is an experiment onboard Luna-Glob (launch in 2015) and Luna-Resurs (launch in 2017) Russian surface missions. The experiment is dedicated to the studies of mineralogy of the lunar regolith in the vicinity of the lander. The instrument is mounted on the mechanic arm of landing module in the field of view (45°) of stereo TV camera.
LIS will provide measurements of selected surface region in the spectral range of 1.15-3.3 μm. The electrically commanded acousto-optic filter scans sequentially at a desired sampling, with random access, over the entire spectral range.

1. Introduction

One of the most impressive results of recent Moon studies is the discovery of water in the surface layer. The M^3 spectrometer (Moon Mineragoly Mapper, spectral range of 0.46-3.00 μm) onboard Chandrayaan-1 discovered that significant part of Moon surface contains bound water (H_2O and/or OH) [1]. The M3 results are in line with earlier Moon observations made in 1999 with the VIMS optical spectrometer from the Cassini spacecraft and are confirmed by new SIM/Deep Impact mapping spectrometer observations [2]. M^3 was the first spectrometer, which carried out systematic mapping of the Moon in the IR and showed that hydrated mineral band at 3 μm is widely spread. The IR measurements detect H_2O and/or OH in the thin (few microns) surface layer of the Moon regolith.

Depletion of neutrons allows to estimate the hydrogen contents in the upper 1-2 meters of the lunar soil. First, the evidence for water ice was detected by Lunar Prospector [3], and the detailed neutron map of lunar hydration was obtained by LEND on Lunar Reconnaissance Orbiter [4]. The estimated contents vary from 0.5 to 4.0 % of water ice by weight, depending on geographic location and the thickness of overlying dry regolith layer [4].

An attempt of measuring water abundance in the bulk of Moon regolith was made in experiment LCROSS (Lunar Crater Observation and Sensing Satellite) in 2009. The measured water vapor abundances are an equivalent of 2.7-8.5 % of water ice [5].

2. LIS and AOTF based instruments

LIS is an AOTF-based spectrometer working in the spectral range of 1.1-3.3 μm with spectral resolution better than 100 cm^{-1}. The instrument has low mass of 1.3 kg. The field of view of the instrument is 1° (figure 1-3). The main characteristics of the spectrometer presented in Table 1. The instrument is mounted on the mechanic arm of landing module in the field of view (45°) of stereo TV camera (fig 4).

LIS is designed based on technical solutions of AOTF spectrometers developed by IKI team or with participation of IKI.

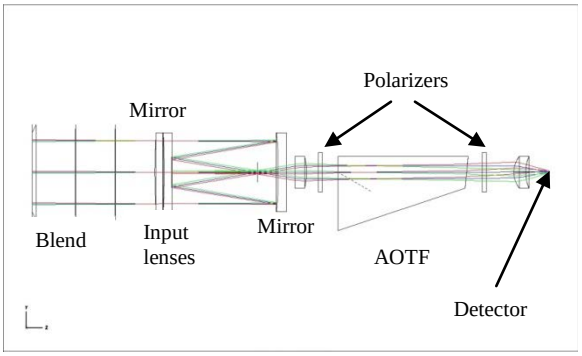

Figure 1: LIS optical scheme.

In SPICAM IR spectrometer [6] on board of Mars Express mission the technology of an acousto-optic tunable filter (AOTF) has been first applied in planetary research allowing unprecedented mass reduction. SPICAV IR [7] and SOIR [8] have been successfully working onboard of Venus Express since 2006. On the International Space Station cosmonauts worked with the RUSALKA AOTF echelle-spectrometer from 2009 to 2012 [9].

Table 1. Technical parameters of the instrument

Spectral range	1.15-3.3 µm
Field of view	1º
Optical point detector	InAs (Hamamatsu P10090-21), Two stage thermoelectrically cooled. Ø1 mm
ADC	16 bit
Power consumption	10 W
Operating temperatures	From minus 40 to plus 20° C.
Storage temperatures	From minus 60 to plus 60° C.
Output interface	RS-485
Overall dimension	170x65x76 mm (optical box) 84x84x55 mm (electronic box)
Mass	0.9 kg (optical box including cable). 0.4 kg (electronic box)

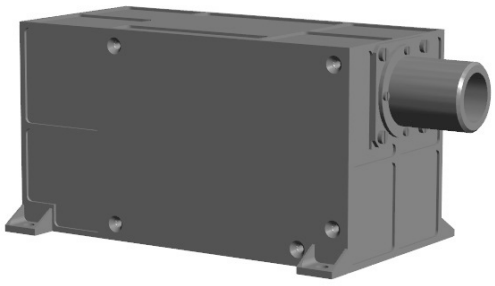

Figure 2: LIS Optical box.

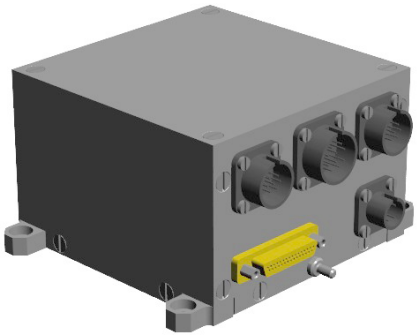

Figure 3: LIS Electronic box.

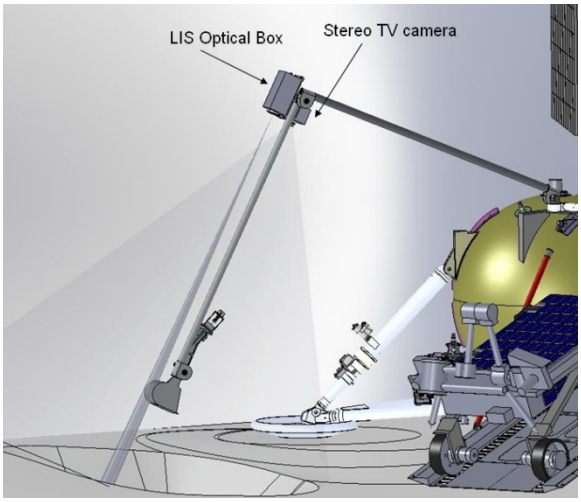

Figure 4: LIS Optical box and stereo TV camera mounted on mechanical arm (credit: Lavochkin Association).

LIS is primarily dedicated for the measurements of regolith hydration at 3µm, identifying hydration form, changes of surface hydration during the day, study of mineralogical composition. Also, LIS will be used for selection of soil samples to be analyzed by other instruments.

3. Status of development

At present the laboratory prototype of the instrument is passing mechanical, thermal and electrical tests. The optical scheme and the AOTF parameters are to be verified, and modified if necessary.

Synthetic reflectance spectra of regolith, an estimation of bandwidth absorption of hydration minerals with different abundance of H_2O/OH are to be calculated.

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