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AOTF near-IR spectrometers for study of Lunar and Martian surface composition

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Abstract

The series of the AOTF near-IR spectrometers is developed in Moscow Space Research Institute for study of Lunar and Martian surface composition in the vicinity of a lander or a rover.

Lunar Infrared Spectrometer (LIS) is an experiment onboard Luna-Glob (launch in 2015) and Luna-Resurs (launch in 2017) Russian surface missions. The LIS is mounted on the mechanic arm of landing module in the field of view (45°) of stereo TV camera.

Infrared Spectrometer for ExoMars (ISEM) is an experiment onboard ExoMars (launch in 2018) ESA-Roscosmos rover. The ISEM instrument is mounted on the rover's mast together with High Resolution camera (HRC).

Spectrometers will provide measurements of selected surface area 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.

The study of hydrated minerals is important for understanding of past evolution of Mars. Two kind of hydrated minerals, phyllosilicates and sulfates, indicate 2 different periods and evolution of Mars climate [3]. The phyllosilicates have been discovered in old terrains and have likely been formed in the early period of the Mars' evolution when the water could remain liquid on Mars during a long time on the surface. The sulfates have been formed later in the history, when the intense volcanism took place on Mars.

The spectral range of the spectrometers allows the detailed study of hydrated minerals and surface composition on Mars and Moon.

2. AOTF based instruments

LIS and ISEM are the AOTF-based spectrometers working in the spectral range of 1.1-3.3 µm with spectral resolution better than 25 cm^{-1}. The instruments have low mass of 1.3 kg. The field of view of the instruments is 1°. The characteristics of the spectrometers and the instruments' mounting are presented in Table 1 and Fig. 2-4.

LIS is designed based on technical solutions of AOTF spectrometers developed by IKI team or with participation of IKI. In SPICAM IR spectrometer [4] 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 [5] and SOIR [6] 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 [7].

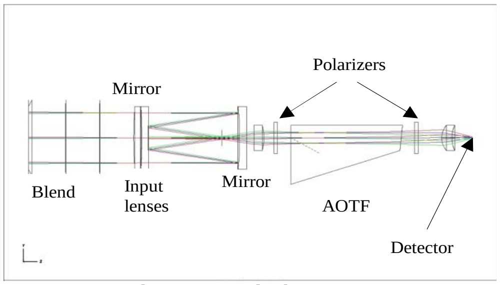

Figure 1: LIS and ISEM optical scheme.

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	not more than 12 W
Operating temperatures	From minus 40 to plus 20° C.
Storage temperatures	From minus 60 to plus 60° C. To be expanded after thermal tests
Output interface	RS-485 or RS-422
Overall dimension	not more than 170x65x76 mm (Optical Box) 84x84x55 mm (Electronics Box)
Mass	0.9 kg (optical box including cable). 0.4 kg (electronic box)

3. Science objectives

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.

The main science objectives of ISEM include geological investigation and study a composition of Martian soils in the uppermost few millimeters of the surface; characterization the composition of surface materials, discriminating between various classes of silicates, oxides, hydrated minerals and carbonates; identification and mapping of the distribution of aqueous alteration products on Mars; real-time assessment of surface composition in selected areas, in support of identifying and selection of the most promising drilling sites; studies of variations of the atmospheric dust properties and of the atmospheric gaseous composition (hampered by limited number of observation cycles)

4. Status of development

At present the laboratory prototype of LIS is passing mechanical, thermal and electrical tests. The optical scheme and the AOTF parameters are to be verified, and modified if necessary. ISEM is in process of preparing for preliminary design review.

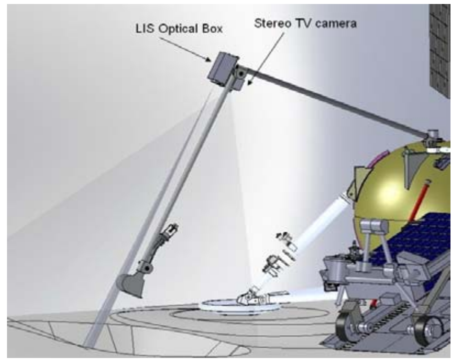

Figure 2: LIS Optical Box and stereo TV camera mounted on mechanical arm (credit: Lavochkin Association).

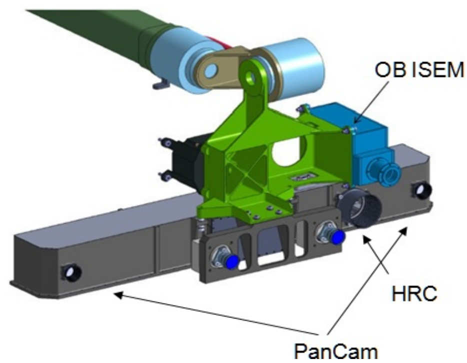

Figure 3: ISEM Optical Box, high-resolution camera and PanCam mounted on the science desk on the mast of rover (credit: TAS-I).

Figure 4: ISEM Optical Box mounted on the science desk on the mast of the rover (credit: TAS-I).

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