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SELMA: a mission to study lunar environment and surface interaction

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Abstract

SELMA (Surface, Environment, and Lunar Magnetic Anomalies) is an interdisciplinary mission to study how the Moon environment and surface interact. SELMA investigates the complex interplay between the surface, lunar exosphere, plasma in the near-Moon space, dust and meteoroids, and surface magnetizations (magnetic anomalies). SELMA was proposed to ESA as a M5-class mission candidate in October 2016.

1. Introduction

SELMA (Surface, Environment, and Lunar Magnetic Anomalies) is a mission to study how the Moon environment and surface interact. SELMA addresses four overarching science questions:

- What is the origin of water on the Moon?
- How do the "volatile cycles" on the Moon work?
- How do the lunar mini-magnetospheres work?
- What is the influence of dust on the lunar environment and surface?

SELMA uses a unique combination of remote sensing via UV, IR, and energetic neutral atoms (ENA) and local measurements of plasma, exospheric gasses, and dust. It will also conduct an impact experiment to investigate volatile content in the soil of the permanently shadowed area of the Shekleton crater. SELMA carries an impact probe to sound the Reiner-Gamma mini-magnetosphere and its interaction with the lunar regolith from the SELMA orbit down to the surface.

2. Objectives and instruments

The four science questions are broken down into science objectives as given in Table 1. The objectives associated with each science question are highlighted by the same background color. The SELMA scientific instruments are shown in Table 2.

3. SELMA mission

SELMA is a flexible and short (15 months) mission including the following elements (Fig. 1) SELMA orbiter, SELMA Impact Probe for Magnetic Anomalies (SIP-MA), passive Impactor, and Relaying 6U CubeSat (RCS).

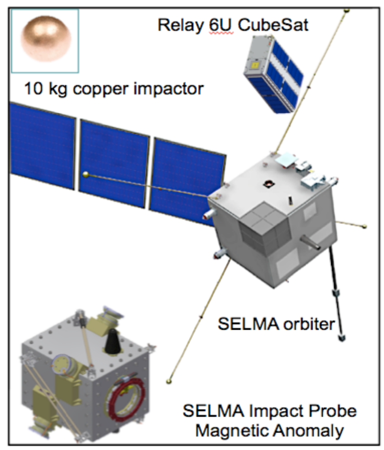

Figure 1: SELMA elements.

It launches on January 1, 2029 (flexible) by Souyz-Fregat launcher and perform direct transfer to the Moon. After 5 days it reaches it nominal quasi-frozen polar working orbit 30 km x 200 km with the pericenter over the South Pole. Approximately 9 months after the launch SELMA releases SIP-MA to sound the Reiner-Gamma magnetic anomaly with very high time resolution <0.5 s to investigate small-scale structure of the respective mini-magnetosphere. At the end of the mission the passive impactor impacts the permanently shadowed region of the Shekleton crater >10 sec before SELMA and SELMA orbiter flies through the resulted plume to perform high resolution mass spectroscopy of the released volatiles. The data are downlinked to ground and RCS. RCS stays on orbit for 2 more hours to downlink the complete data set.

SELMA uses a common 3-x stabilized nadir pointing platform of 627 kg dry-mass, carrying 106 kg payload, SIP-MA, passive impactor, and RCS with 20%m margin. The total mass at launch 1302 kg. SIP-MA is 42 kg 3-x stabilized free-flyer carrying 7.6 kg payload. SIP-MA powered by batteries operates only for about 30 min before the impact. SIP-MA communicates with SELMA via one-way 1 Mbps link. RCS is a 6U CubeSat equipped with a S-band communication package and a simple camera to monitor the SELMA impact.

Table 1: SELMA science objectives

SELMA science objectives	**SELMA measurements**
What is the origin of water on the Moon?	
Establish the role of the solar wind and exosphere in the formation of the water bearing materials	IR and UV spectroscopy, solar wind monitoring, proton flux at the surface via scattered hydrogen, exospheric gasses composition and density
Investigate the process of the solar wind surface interaction	Measurements of scattered H^0, H^+, H^-; secondary ions
Determine the water content in the regolith of the permanently shadowed region and its isotope composition	Mass spectroscopy measurements of the plume created by an impactor.
How do the “volatile cycles” on the Moon work?	
Establish variability, sources and sinks of the lunar exosphere Investigate how the lunar exosphere content is related to impact events	Exosphere gasses densities and composition with simultaneous monitoring of the solar wind, meteor impact, particle releases processes from the surface
How do the lunar mini-magnetospheres work?	
Investigate a mini-magnetosphere interaction with the solar wind Establish structure and topology of the magnetic field at the surface	Ions and electrons, waves and field with a time resoluiton <0.5 sec corresponding to the electron gyro-radius from 10s down to the surface
Investigate the long-term effects of mini-magnetospheres on the local surface	IR and UV spectroscopy, plasma and fields, proton flux at the surface via backscattered scattered hydrogen
What is the influence of dust on the lunar environment and surface?	
Investigate how the impact events affect the lunar dust environments	Dust and meteor impact monitoring
Investigate how the plasma effects result in lofting the lunar dust	Dust, plasma, field and wave measurements

Table 2**:** SELMA scientific instruments

Remote sensing instruments	**In-situ instruments**
Infrared and visible spectrometer: *Spectral range 400 – 3600 nm*	Lunar ion spectrometer : $M/\Delta M > 80$
Wide angle and transient phenomena camera: *Visible, FoV 120 °x60 °*; *Meteoroid impact (>100 g)*	Lunar scattered proton and negative ion experiment: *Energy: 10 eV – 10 keV*
Moon UV imaging spectrometer: *Spectral range 115 - 315 nm*	Lunar electron spectrometer
ENA telescope: *Energy range 10 eV – 3 keV; Ang. resolution < 10 °*	Moon magnetometer
SELMA Impact Probe for Magnetic Anomaly sounding (SIP-MA)	Lunar exospheric mass spectrometer: $M/\Delta M > 1000$
Waves and electric field instrument	Plasma wave instrument
Impact probe ions and electrons spectrometer: *Time res. < 0.5 s/3D*	Lunar dust detector: $M>10^{-15}$ kg
Impact probe magnetometer	**Passive 10 kg copper impactor**
Context camera	