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Multi-spectrometer Borehole Inspection System (MsBHIS): an instrument for subsurface exploration in permafrost environments

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Abstract

Recently, frozen subsurfaces in polar regions of Mars or surfaces of moons, such as Europa or Titan, have been shown to be high priority objectives within the plans for future missions to these bodies in our Solar System. There is no doubt that the exploration of these environments will provide new (and probably, surprising) finds and data to the scientific community.

These environments may contain valuable chemical or organic traces of biological, geological or even climatic evolution of the body under study. Therefore, these environments represent key scenarios to be studied in order to search for evidences of extinct or extant life, as well as to characterize the corresponding habitability conditions.

Within this context, it is essential to develop autonomous, robotic and robust technology not only to drill and extract the permafrost cores, but also to analyze and characterize the bored hole (it is worth to mention that, under some frequent conditions, it is not possible to extract an useful core). This *in-situ* exploration of the hole will allow us to analyze the environment under the more aseptic and non-altered conditions. These aspects are critical in a rigorous scientific exploration.

The *Centro de Astrobiologia* is designing and developing a robotic technology to characterize the subsurface in permafrost environments, from a geological and biological point of view. In that framework, this development will allow us to study the distribution and depth profile of ices, salts and organic compounds (and microorganisms) constituents of the permafrost and frozen terrains in the planetary field analogues.

This instrumentation, which is specially designed for analyzing the walls and bottom of the borehole, integrates the following subsystems as scientific payload:

- Raman spectrometer,
- IR spectrometer,
- fluorescence spectrometer,
- sampling module to take liquid samples in aseptic conditions,
- 360 degrees imager to take panoramic images of the wall as well as microscopic images (minimum detectable feature: 1 μm), and
- anchoring system to the walls.