RLS, THE RAMAN INSTRUMENT FOR THE EXOMARS 2020 MISSION OF ESA

Fernando Rull[1], Andoni Moral[2], Carlos Perez[2], Tomas Belenguer[2], Maria Colombo[2], Gonzalo Ramos[2], Guillermo Lopez[1], Pablo Rodríguez[1], Laura Seoane[1], Jose A. Rodríguez Prieto[1], Paloma Gallego[1], Maria Rosario Canchal[2], Pilar Santamaría[2]

(1) Unidad Asociada UVA-CSIC al CAB. Universidad de Valladolid 47007, Valladolid, Spain rull@fmc.uva.es
(2) Instituto Nacional de Técnica Aerospacial (INTA), Ctra. Ajalvir Km 4, 28850 Torrejón de Ardoz, Spain

Abstract

The Raman Laser Spectrometer (RLS) is one of the three Pasteur Payload instruments located inside the Rover Analytical Laboratory Drawer (ALD), for the ESA's ExoMars 2020 mission. The instrument will analyse at the mineral-grain scale Martian samples obtained from the surface and sub-surface up to 2m depth by a drill placed on the rover. In this paper a description of the instrument development is presented with particular interest on the EQM (Engineering Qualification Model). In addition the results obtained along the verification and performances evaluation processes are presented and discussed.

1. Introduction

ExoMars [1] is a double mission with two launch dates. The first part (Exomars 2016) launched in 2016 carried out an orbiter with optical instrumentation for imaging and a detector of traces of gas (TGO) plus a demonstrator for entry, descent and landing on the Mars surface called Schiaparelli. The second part (Exomars 2020) to be launched in July 2020 is a collaboration between ESA and Roscosmos, the Russian Space Agency and will deploy on the Martian surface a platform plus a rover. The rover features several unique capabilities, the most important are; the capability to drill below the surface to a depth up to two meters in order to obtain samples better preserved from the radiation effects and the severe surface alteration conditions. And the capability to observe samples processed under the form of powder at the mineral grain scale. For the last purpose the rover carry three key scientific instruments (Pasteur Payload) located inside an extremely clean container, the analytical laboratory drawer (ALD) [2]. Exomars scientific objectives are mainly related with the detection of potential traces of present and/or past traces of life and the precise study of the mineralogy and geochemistry of materials, in particular those related with the water activity.

Raman spectroscopy is a widely recognised technique based on the inelastic scattering of a monochromatic light by the matter. Raman adds to its primary analytical and structural capabilities for investigating materials several practical advantages: the possibility for in-situ analysis, in a non-destructive way, at different scales (macro to micro) and in general under quite fast experiments. Those reasons leaded to the proposal from the early stages of the Exomars mission as one of the essential techniques to accomplish the mission's scientific objectives. Recently Raman spectroscopy was also selected for Mars 2020 mission of NASA (SuperCam and Sherloc) and for future planetary mission as MMX for Phobos and Europa Lander. At the present RLS is the first Raman instrument fully qualified for space and ready to fly to Mars. The flight model is already delivered to ESA for integration inside the rover's ALD.

2. Raman Laser spectrometer (RLS) description

The Raman instrument [3] consist in three main units which are schematically presented in figure 1.

1- The excitation source is a 532nm CW laser located inside the control electronic unit which include the DC/DC power converters and the data processors. The laser is a complex unit with two excitation sources to provide redundant capabilities to the instrument

2- The spectrometer is a transmission spectrograph using a holographic grating to disperse the Raman light and projecting the bands on a 2048x512 pixel CCD.

3- The optical head. This unit focuses both the laser excitation on the sample and collected it at the same spot of 50 microns in diameter. The head also features an autofocus mechanism with a full range ±1 mm in order to optimize the optical efficiency in obtaining Raman spectra on the powdered sample surface.

Two calibration targets are also included in the instrument. They are small cylinders of polyethylene terephthalate (PET) with high crystallinity and are located inside the rover's carrousel. The first one is serving the spectrometer calibration (band position and intensity). And the second, specifically modified in the surface allowing the spatial cross-correlation between the three key instruments inside the rover ALD.

The optical head is simultaneously connected to the excitation unit and the spectrometer unit by optical fibers.

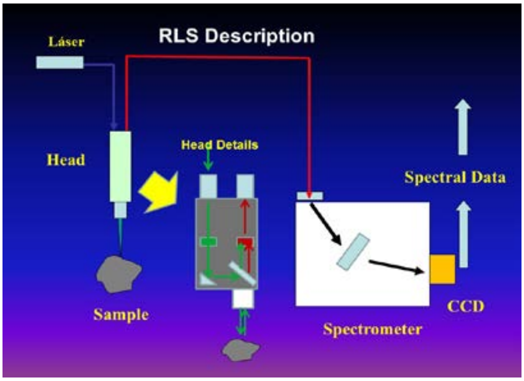

Figure 1. Schematic description of the RLS configuration.

In figure 2 a detailed description of the FM units including the international partner's contribution is depicted.

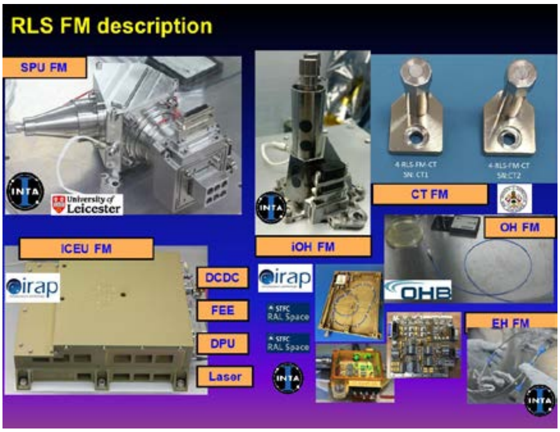

Figure 2. RLS unit's description indicating the associated international contributions.

And in figure 3 the current integration of the RLS-EQM inside the rover ALD is presented.

The instrument also contains a complex on-board software featuring two main tasks, the instrument control and the spectral acquisition in automatic mode. Which complement with the on-ground software. The last one also contains two parts, the Instrument Data Analysis Tool (IDAT) and SpecPro. This software is used for the reception, decodification, calibration and verification of the telemetries generated by the RLS instrument, including both science and housekeeping (HK) data as well as spectral treatment and interpretation during the operation on Mars.

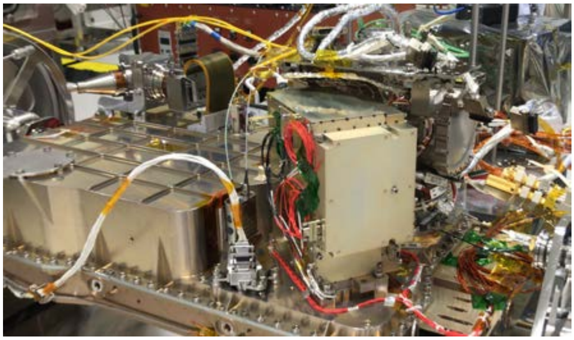

Figure 3. The RLS-EQM instrument integrated inside the ALD-QM at TAS-I facilities in Torino (Italy). The spectrometer can be seen at the upper-left part of the picture.

3- Instrument verification and scientific performances

Calibration of the instrument was performed in several steps. Using emission lamps (withe-lamp at selected wavelengths and Ne and Ar-Hg lamps) precise calibration was obtained at room temperature. This calibration was verified using the Raman spectra on the calibration target and in several standard materials. Then this procedure was extended to the mission relevant temperature range. Allowing to obtain calibration functions at several temperatures.

Finally the instrument spectral response analysis was performed from Raman spectra of solid and liquid samples in order to verify the scientific requirements and to compare the data with those obtained with a RLS simulator at the University of Valladolid. Results at room temperature and Martian conditions allow to guaranty the expected scientific performances and the capability of the instrument to afford the assigned Exomars scientific objectives.

4 References

[1] http://exploration.esa.int/mars/46048-programme-overview/

[2] http://exploration.esa.int/mars/45103-rover-instruments/

[3] Rull et al., Astrobiology, 2017, 17, 627-654.

Acknowledgements

Authors would like to acknowledge MINECO and the Agencia Estatal de Investigación (AEI) for the financial support through ESP2014-56138-C3-2-R and ESP2017-87690-C3-1-R projects. Also to our institutions UVA-CAB and INTA and to all our national and international partners.