EPSC2017

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13 Sep 2017 11:36:30

EPSC Abstracts
Vol. 11, EPSC2017-45, 2017
European Planetary Science Congress 2017

Innovations at a European Planetary Simulation Facility

J. P. Merrison, J.J. Iversen, S. Alois, K.R. Rasmussen
[1]Institute of Physics and Astronomy, University of Aarhus, DK-8000 Aarhus C, Denmark
(merrison@phys.au.dk/ Fax: +45-86120740)

Abstract

This unique and recently improved planetary simulation facility is capable of re-creating extreme terrestrial, Martian and other planetary environments. It is supported by EU activities including **Europlanet 2020 RI** and a volcanology network VERTIGO. It is also used as a test facility by ESA for the forthcoming ExoMars 2020 mission. Specifically it is capable of recreating the key physical parameters such as temperature, pressure (gas composition), wind flow and importantly the suspension/transport of dust or sand particulates. This facility is available both to the scientific and Industrial community. The latest research and networking activities will be presented.

1. Recent improvements and Activities

Improved functionalities of this facility include the implementation of an atmospheric (gas) cooling system (fig 1) allowing independent control of the air temperature, also a particle image velocimetry (PIV) system has been installed consisting of high speed imaging and laser illumination (fig 3). Also an LED based ultraviolet (UV) light source has been implemented capable of simulating the solar UV spectrum.

This environmental simulator facility is utilized for a broad range of research programs including; the study of other planets (such as Mars), for recreating extreme terrestrial environments, or in specific investigations involving aerosols and other forms of particulate transport.

This facility is part of a European network (VERTIGO) recently established to investigate the dynamics within volcanic ash clouds and pyroclastic flows including a detailed study of electrification.

The facility is also involved in the Europlanet 2020 Research Infrastructure through which a trans-national access program is allowing numerous research groups access to this facility.

Other activities include the development, testing and calibration of sensor and planetary lander systems, both for ESA and NASA. Currently testing for missions ExoMars 2020 and Mars 2020 are being carried out.

Figure 1 The main Planetary Simulation Facility under testing of the new liquid nitrogen atmospheric cooling system.

2. Design and Operation

The simulator consists of an environmental (thermal-vacuum) chamber within which a re-circulating wind tunnel is housed [1,2,6]. The wind is generated by a set of two fans which draw flow down the 2m×1m tunnel section and return it above and below. The test section can be fully removed for access. Wind speeds in the range 1-40 m/s have been demonstrated. Cooling is achieved by a novel liquid nitrogen flow system which has achieved temperatures below -160ºC. The inner chamber is thermally isolated from the vacuum chamber. A server based control system provides both control over wind flow, temperature, pressure, lighting, etc., but also acts as a data logger.

3. Atmospheric Aerosols

A unique capability of this wind tunnel facility is the production and controlled study of suspended particulates (dust, ash, sand, etc.). This type of experiment is a continuation of a large body of research performed over the past decade studying dust aerosols, specifically granular electrification, erosion and deposition processes [1 - 4]. This research has direct relevance to aerosol studies on

Earth which impact air quality, the environment and climate.
An advanced type of Laser aerosol and (2D) wind flow sensor is used for detailed study and control of these environmental parameters (fig 2).

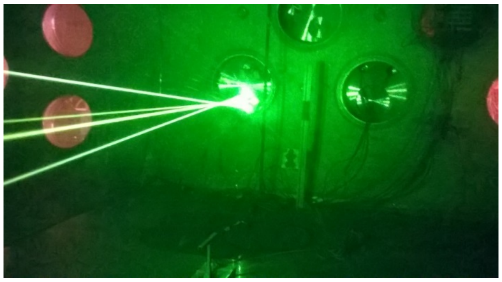

Figure 2 Laser based wind/dust sensor used for aerosol studies.

In recent studies this technology has been used to measure the size and electrification of individual (micron scale) aerosol particles as well as electrification within dispersing clouds (jets) of particles. This has direct relevance to electrification seen in volcanic eruptions and dust re-suspension where adhesion and aggregation (cohesion) are extremely important effects.

4. Planetary Surface Simulation

The combination of low pressure, low temperature, composition and aerosol injection is ideal for recreating the environment of the upper atmosphere of terrestrial planets, gas giants or even moons).
However, with control of wind flow this facility is also well suited for recreating the environment at the surfaces of terrestrial type planets such as Mars, Earth and Titan.
The interaction of wind and the planetary surface, specifically the transport of sand and dust is fundamental to understanding the evolution of the planets' surface and atmosphere. Laboratory studies of the entrainment, flow, deposition and erosion are scarce and empirical in nature. The effects of low atmospheric pressure, composition, temperature and even gravity can now be studied in detail. For example detailed measurements of sand grain trajectories are now being made under Martian pressure and composition in wind tunnel studies. This has direct relevance to the recent and still poorly understood observations of active sand transport at the Martian surface.

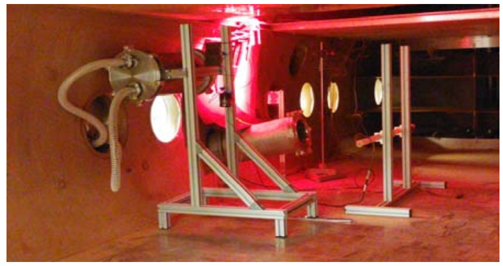

Figure 3 Inside the simulator showing a new PIV (particle image velocimetry) system using high speed imaging and laser sheets.

5. Conclusion

This planetary simulation facility has many unique and recently improved features which make it well suited for both planetary research applications and the development/testing of instrumentation. Details of this laboratory facility will be presented and some of the most recent activities will be summarized. For information on access to this facility please contact the author.

Acknowledgements

This laboratory is a member of Europlanet 2020 RI which has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208.

Stefano Alois is supported by the VERTIGO Marie Curie Initial Training Network, funded through the European Seventh Framework Programme (FP7 2007-2013) under Grant Agreement number 607905.

References

[1] J.P. Merrison, et al., Planet. Space. Sci., 60, 328-335 (2012)
[2] J.P. Merrison, Aeolian Research. 4, 1–16 (2012)
[3]C. Holstein-Rathlou, et al., American Meteorological Society, 31, 447 (2014)
[4] S. Alois et al., Journal of Aerosol Science 106, 1–10, (2017)

EPSC Abstracts
Vol. 11, EPSC2017-112, 2017
European Planetary Science Congress 2017

Constructive and Technological Aspects of the Development of Cryostats for HPGe Detectors with Electric Cooling

O.Yakovlev (1,2), V.Malgin (1), V.Gostilo (1), Y.Viba (2)
(1) Baltic Scientific Instruments, Riga, Latvia (o.jakovlev@bsi.lv / Fax: +371 67382620), (2) Riga Technical University

Abstract

The use of miniature Stirling electric coolers (EC) has made possible the application of high purity germanium (HPGe) detectors in spectrometers intended for space projects, field operations and mobile radiation monitoring systems for remote radiation monitoring, among other applications. The development of spectrometer systems requires mechanical, thermal and vacuum solutions to be applied during the design and manufacturing phases of the cryostats for HPGe detectors. These solutions determine the efficiency of the detector cooling, the time taken to cool down the detector, the level of mechanical vibrations, which impact the energy resolution of the detector, especially at low gamma-ray energies, the reliability and its operational life.

1. Introduction

Due to their excellent energy resolution and high efficiency for detecting gamma radiation, HPGe detectors stand out among all types of radiation detectors as ideal candidates for applications in precision gamma spectroscopy [1]. However, HPGe detectors must be cooled down to temperatures between 80K and 100K, which has limited their use in space projects. The development of compact electric coolers (EC) has opened up opportunities for the development of a wide range of nuclear physics devices based on HPGe detectors, including space applications [2,3]. However, the Stirling ECs create additional mechanical vibrations, which negatively impact the detector's characteristics. The present paper deals with constructive and technological aspects in the development of cryostats for HPGe detectors with Stirling ECs.

2. Mechanical Design

HPGe detectors are operated in cryostats, which must remove heat from the detector promptly and effectively, so that it can operate at its optimal temperature. Furthermore, the cryostats should permit continuous operation and multiple thermal cycles. A simplified design of a cryostat is shown in Fig. 1. The radiation reaches the HPGe detector through the input window, which can be made of aluminum (500 μm), carbon (700 μm), or beryllium (200 μm). The detector is placed in a custom-designed holder that fixes the detector by means of supporting rings made from composite materials with low thermal conductivity, while removing heat through a cold finger with elastic inserts. A modal analysis of the spatial oscillations in the detector unit was made using the SolidWorks simulation framework. The parameters of the elastic supporting rings, which remove the resonance oscillations of the detector caused by the EC operation frequency harmonics were defined in this model.

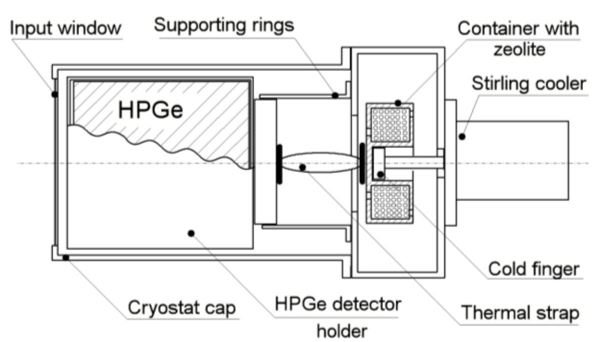

Fig.1. Simplified design of HPGe detector cryostat

3. Thermal Solutions

To increase the EC lifetime, special attention during the cryostat design process was given to the manner of achieving the most effective heat removal from the electric cooler case. Additional heat removal was provided for the surfaces in the EC case that are most prone to heating during operation. To reduce the contact resistance of heat removing connections, special thermo compounds were used, such as, for example, MUNG I (INTIVAC Corp.), which has a thermal conductance of up to 18.2 W/(m·K). Using this compound, the maximum temperature of the EC parts does not exceed 32^{o}C, even when the EC is operating at maximum power during the initial detector cool-down phase. When operating at pressures below 10^{-4} mbar, infrared radiation becomes the dominant heat transfer process, and to reduce this radiative heat transfer, heat screens were used in the cryostats. Through the application of multilayer insulation material (Coolcat2 NW), typical heat losses have been reduced to 0.2 W for chamber volumes up to 0.85 dm^3 at a detector operating temperature of 90K.

4. Vacuum Solutions

The Viton elastomer seals were replaced by Conflat CF gaskets or Wills rings to reduce the leakage rate of external gases into the cryostat. Hermetic electrical connectors were welded into the cryostat case.

Getters are placed in the cryostat (see Fig.1) to maintain a sufficiently high vacuum by absorbing remaining gases. The sorption properties of various types of getters were studied. The best results were obtained with nonvolatile SAES getters, which allow multiple regeneration cycles, and also with disposable baric getters.

To reduce the release of gas from the crystalline lattice of the metal components of the cryostat, the optimal annealing mode and technological preparation were defined for the cryostats with HPGe detectors.

5. Summary and Conclusions

In the development of gamma spectrometer cryostats, the main design effort was focused on reducing heat losses and optimizing the parameters of the detector pendant. The improved thermal design has favorably affected the lifetime of the electric cooler and decreased the typical energy consumption of the spectrometer. The success of the experiments presented here will be defined by the reliability and durability of HPGe detectors, especially in long-term space missions (Fig. 2).

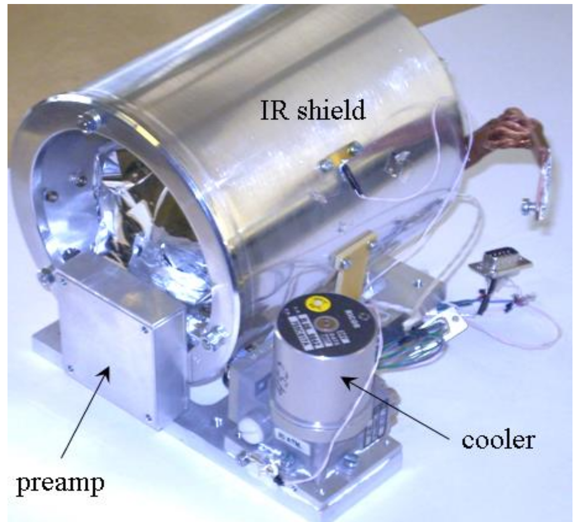

Fig.2. Miniature HPGe Gamma-Spectrometer for space applications with rotary cooler Ricor K508 [3]

Acknowledgements

This work was carried out for the European Space Agency under contract 4000114403/15/NL/NDe.

References

[1] G. Knoll. Radiation Detection and Measurements. 3rd ed., John Wiley & Sons, 2000.720 c.

[2] M. Burks, C.P. Cork, D. Eckels, E. Hull, N.W. Madden, W. Miller, J. Goldsten, E. Rhodes, and B. Williams. Thermal design and performance of the gamma-ray spectrometer for the MESSENGER spacecraft. *Proc. of the IEEE- NS, 2004*, vol. 1, pp. 390-394.

[3] A.B. Pchelintsev, A.V. Lupilov, R.M. Nurgalejev, O.I. Jakovlev, A.D. Sokolov, V.V. Gostilo, A. Owens. Miniature Compact HPGe spectrometer for space applications. (submitted to Journal of Instrumentation (JINST)).

EPSC Abstracts
Vol. 11, EPSC2017-218, 2017
European Planetary Science Congress 2017

The Distributed Planetary Simulation and Sample Analysis Facilities

J. Helbert (1), G.R. Davies (2) for the EuroPlanet Research Infrastructure DPSF and DSAF teams

(1) Institute for Planetary Research, Berlin, Germany, (2) Faculty of Earth and Life Sciences (FALW), Vrije Universiteit, Amsterdam, Netherlands (joern.helbert@dlr.de)

Abstract

The Europlanet 2020 Research Infrastructure (EPN2020-RI) provides a pan-EU infrastructure that allows the multi-disciplinary European planetary science community to address the key scientific and technological challenges of modern planetary science by providing access to state-of-the-art research facilities across the European Research Area and a structure within which such research can be coordinated.

The Distributed Planetary Simulation Facility makes laboratory facilities available capable of simulating the wide range of environments encountered on planetary bodies. The Distributed Planetary Simulation Facility provides the comprehensive capability to determine isotopic and elemental compositions of planetary samples, including analyses at high spatial resolution, high precision and high sensitivity.

1. Introduction

A central part of the Europlanet 2020 RI programme is to allow any European researcher interested in pursuing planetary science research access to a comprehensive set of laboratory facilities tailored to the needs of planetary research. Access is provided by a **Transnational Access (TA)** programme that supports travel and local accommodation costs of European researchers (and of researchers from Third Countries under certain conditions) at the facility for an approved period of time to conduct their own research programme. Applications are made in response to annual calls and are subject to peer review. It should be noted that applicants must apply to use facilities outside the country in which they are employed (i.e. it is a transnational access). Applications can be made for analytical time or access to planetary simulation laboratory ranging from single days up to several weeks and up to two researchers can be fully financed in each research visit.

2. Distributed Planetary Simulation Facility

The Distributed Planetary Simulation Facility (DPSF) joins seven of the leading laboratories for planetary science into a virtual facility. Three laboratory facilities that were already part of the EU Framework Program 7 research infrastructure have introduced new infrastructure and expanded their methodologies compared to the previous RI, allowing visitors to measure samples under analogue conditions for Mercury, Venus, Mars, the Moon and near-Earth asteroids. Among the four new additions to the DPSF, the low-temperature spectroscopy laboratory will extend this capacity to comets and the icy moons of the outer planets. The added life detection techniques will support the study of extremophiles and the range of potential habitable environments in the Solar System. The new high-temperature and pressure petrology laboratory will extend our knowledge from the planetary surface to the interior.

The DPSF consists of the following facilities:

- Planetary Spectroscopy Laboratory, Germany
- Planetary Environment Facilities at Aarhus University, Denmark
- Open University Mars Chamber, UK
- High-pressure laboratory at VUA, NL
- Cold Surfaces spectroscopy, Institut de Planétologie et Astrophysique de Grenoble (IPAG), France
- Center for microbial life detection at Medical University Graz, Austria
- Petrology-Mineralogy Characterisation Facility (PMCF), Mineral and Planetary Sciences Division, Natural History Museum, London, UK

2.1 New capabilities in the DPSF

The two world-leading spectral facilities in the DPSF (DLR and IPAG Grenoble) currently have unique capabilities that attract large demand from international users. There is, however, a growing requirement from the community for more comprehensive spectral information. An upgrade program has take these two laboratories beyond the current state-of-the-art, adding new capabilities to both facilities that will maintain their premiere status and offer users unprecedented capabilities to perform experiments that are of direct relevance for the planning and implementation phases of forthcoming missions to Mercury and the outer ice moons of the giant outer planets. In addition, the upgrade program has expanded the current world-leading capabilities of the Aarhus University Planetary Simulator Facility and allows the development of new techniques for the study of planetary dust and sand transport, with a particular focus will be on Martian conditions that the ExoMars missions expect to encounter.

3. Distributed Sample Analysis Facility

The new analytical capabilities offered in isotope geochemistry and cosmochemistry by "The Distributed Sample Analysis Facility" (DSAF) play a key role in understanding the complex feed-back mechanisms involved in the formation and evolution of planetary bodies and the (bio) geochemical cycles that operate within and between different parts of these bodies. The combined DSAF infrastructure provides the comprehensive capability to determine isotopic and elemental analyses at high spatial resolution, down to ~3 nanometres (nm), high precision (down to 5 part per 1,000,000 (ppm)) and high sensitivity (sub nanogram (ng) sample sizes). DSAF will allow scientists from across the ERA to access large, state-of-the-art infrastructure and to work under the guidance of scientists with expertise in sample handling and preparation. Visitors will be able to analyse terrestrial and extra-terrestrial samples (meteorites, returned samples) in order to (i) identify the nature of stellar sources that contributed material to the Solar System (ii) determine the rates and nature of the processes that controlled planetary accretion and differentiation and the subsequent evolution and interaction between the interior surface and atmosphere, (iii) constrain the nature of the Earth's building blocks, (iv) quantify biogeochemical cycles on Earth to determine proxies that can act for the detection of life elsewhere in the Solar System.

The DSAF consists of the following facilities:

- NanoSims and Stable Isotope Analytical Facilities. The OU, Milton Keynes, United Kingdom
- Radiogenic & non-traditional stable isotopes. IfP, University of Münster, Münster, Germany
- Radiogenic and non-traditional stable isotope facility, VU University, Amsterdam, NL
- Radiogenic, non-traditional stable & rare gas isotopes, CRPG, Nancy, France

3.1 New capabilities in the DSAF

Sample return missions have the potential to be truly ground-breaking as they provide scientifically unique material for detailed analysis. An upgrade focused on "Sample Handling Protocols and Ultra-Sensitive Isotopic Analysis", which includes two leading instrument manufacturers, will allow us to make measurements that will address two key goals of planetary scientists: i) to obtain 'ground truth' and calibrate remote sensing measurements; and ii) to place absolute constraints on the nature, timing and rates of processes that have operated within and on (proto-)planets. Such data will allow a critical assessment of existing models of planetary development, including the Earth, and provide indicators for the search for life elsewhere in the Solar System. Returned samples will also help to contextualise the interpretation of the diverse samples in existing meteorite collections.

4. Application and selection

European Science Foundation (ESF) coordinates the application and peer review process and no other members of the Europlanet 2020 RI consortium are involved in the evaluation procedure.

For more details go to our website:

http://www.europlanet-2020-ri.eu/

Europlanet 2020 RI is designed to support planetary science but applications in other research disciplines are also considered based on innovation and potential scientific and technological impact to the planetary sciences field.

EPSC Abstracts
Vol. 11, EPSC2017-238, 2017
European Planetary Science Congress 2017

Behaviour of phase functions of Olivine and Augite assemblages in the wavelength range 0.3-18 μm

M. A. Salgueiro da Silva (1,2), T. M. Seixas (1,2), A. Maturilli (3), and J. Helbert (3)

(1) Department of Physics and Astronomy, Faculty of Science, University of Porto, Portugal, (2) Center for Earth and Space Research of University of Coimbra (CITEUC), Portugal, (3) Institute of Planetary Research, German Aerospace Center (DLR), Berlin, Germany (massilva@fc.up.pt)

Abstract

In this work, we performed bi-directional reflectance spectroscopy measurements on single mineral assemblages of olivine and augite minerals in the wavelength range 0.3-18 μm and for several phase angles. The measured spectra show evidence for a so far unreported wavelength- and, possibly, grain size-dependent phase function for both olivine and augite samples. Two interesting spectral features were identified: change in monotonicity of the radiance versus phase angle dependence at several wavelengths; quasi-isotropic scattering in spectral regions of high absorption.

1. Introduction

Deconvolving bi-directional reflectance (BDR) spectra of intimate mineral mixtures to determine grain size and abundance of each component mineral is crucial to study the mineralogy of asteroids. Hapke's radiative transfer theory [1] provides a complete framework for modelling BDR spectra of minerals and intimate mixtures of minerals, as those forming asteroidal regoliths. According to Hapke model [1], neglecting the opposition effect for phase angles $g > 15°$, BDR spectra can be described by the equation

$$r = \frac{K\mu_i}{4(\mu_i+\mu_e)}\omega[p(g) + H(\mu_i/K)H(\mu_e/K) - 1] \quad (1)$$

where r is the radiance coefficient and ω is the single-scattering albedo; μ_i, μ_e are, respectively, the cosines of the incidence and emission angles; $H(x)$ is the Chandrasekhar function; K is a porosity factor; $p(g)$ is the single particle phase function. Using a wavelength-independent phase function of Henyey-Greenstein or Legendre polynomial type has become a common procedure in modelling BDR spectra in the typical UV-VIS-NIR range of 0.3-2.6 μm. This, however, may be inadequate in the mid-infrared (MIR) range, where dramatic changes in light absorption and scattering are likely to occur near anomalies in the refraction index. This work aims at testing the validity of such assumption by measuring BDR of olivine and augite mineral assemblages in the extended spectral range 0.3-18 μm.

2. Experimental details

The olivine (OL, Fo89) and augite (AUG) mineral samples used in this study were supplied from the minerals collection of the Planetary Spectroscopy Laboratory (PSL, Berlin). Four samples of each mineral were prepared in size fractions of 0-25, 25-63, 63-125 and 125-250 μm. BDR spectroscopy measurements were performed in the wavelength range 0.3-18 μm at phase angles of 30°, 45°, 60° and 75°, using a Bruker Vertex 80V FTIR spectrometer [2].

3. Results and discussion

In Fig. 1, we show the spectra measured for the olivine sample with size fraction 0-25 μm. For this sample, the variation of radiance with phase angle ($r(g)$) is strongly dependent on the wavelength. At a wavelength of about 5 μm, a monotonicity inversion takes place as radiance changes from a decreasing to an increasing function of phase angle. Moreover, the phase span of radiance spectra is larger in the region where radiance and, presumably, albedo are lower. Since $H(x)$ is an increasing function of albedo, these effects point to a complex wavelength dependence of phase function. For larger size fractions (see Fig. 2 for OL 63-125 μm), the change in $r(g)$ monotonicity is less evident but occurs at several wavelengths (8.2, 9.2, 14.5 and 15.5 μm). Actually, in the spectral regions around these wavelengths radiance phase span is negligible, indicating quasi-isotropic scattering. These are, at the same time, regions of high absorption.

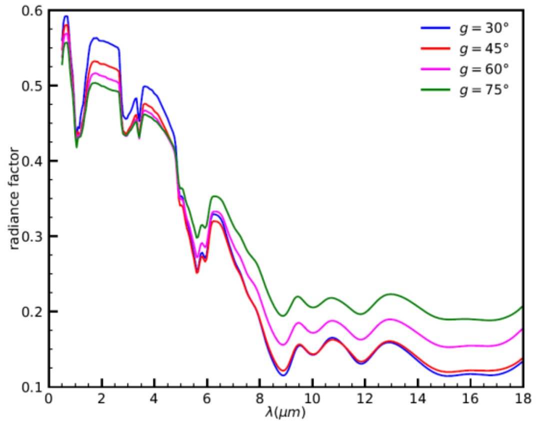

Figure 1: BDR spectra of olivine sample with size fraction 0-25 μm.

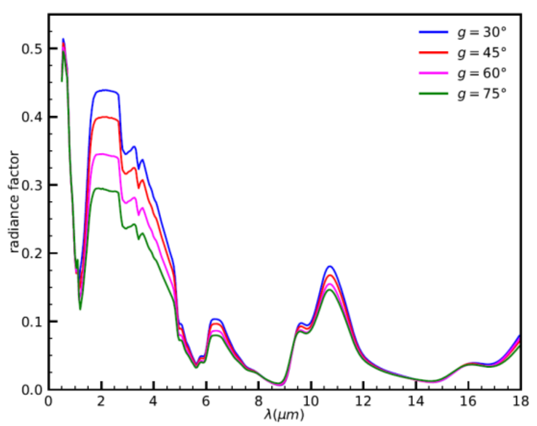

Figure 2: BDR spectra of olivine sample with size fraction 63-125 μm.

Radiance of augite samples also show evidence for a complex wavelength dependence of phase function, although no noticeable monotonicity changes in $r(g)$ are observed. As seen in Fig. 3 for the AUG 63-125 μm sample, quasi-isotropic scattering is apparent within essentially the same spectral regions as for the OL 63-125 μm sample.

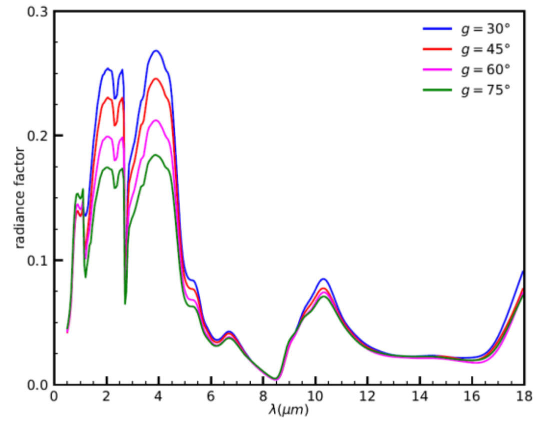

Figure 3: BDR spectra of augite sample with size fraction 63-125 μm.

4. Summary and Conclusions

We tested the validity of the wavelength-independent phase function assumption by measuring BDR of olivine and augite mineral assemblages in the extended spectral range 0.3-18 μm. Because quasi-isotropic scattering is present in both OL and AUG assemblages with grain-size dependent features, it is not clear that this is an intrinsic effect attributed to the wavelength dependence of the optical constants of olivine and augite minerals. Our results show that the application of Hapke model to olivine and augite BDR spectra in the MIR range requires a wavelength- and, possibly, grain size-dependent phase function.

Acknowledgements

This work was done under projects: UID/Multi/00611/2013, funded by FCT/MEC (PIDDAC) and FEDER through COMPETE-2020, with reference POCI-01-0145-FEDER-006922; EuroPlanet 2020 RI TA (ref. 16-EPN2-044), funded by the EU's Horizon 2020 research and innovation programme under grant agreement Nº 654208.

References

[1] Hapke, B.: Theory of reflectance and emittance spectroscopy, 2nd ed. Cambridge University Press, Cambridge, UK, 2012.

[2] Maturilli, A. and Helbert, J.: The Planetary Spectroscopy Laboratory (PSL): Spectral measurements of planetary analogues from UV to FIR. 47th LPSC (2016).

EPSC Abstracts
Vol. 11, EPSC2017-243, 2017
European Planetary Science Congress 2017

SHADOWS: spectrogonio radiometer for bidirectional reflectance studies of dark meteorites and terrestrial analogues

S. Potin, P. Beck, B. Schmitt, O. Brissaud
Institut de Planétologie et d'Astrophysique de Grenoble IPAG, France (sandra.potin@univ-grenoble-alpes.fr)

Abstract

A new spectrogonio radiometer SHADOWS is designed for the spectral bidirectional reflectance study of dark surfaces. Its official delivery as an European simulation facility within the Europlanet 2020 RI program is set late August 2017. This abstract presents a general description of the instrument, and some of its measurements modes. Test spectra measured with the instrument's prototype on challenging dark surfaces (Spectral Black, Metal Velvet and Vantablack) are then presented.

1. Context

Reflectance spectroscopy (sometimes combined with polarimetry) can provide information on surface chemical and physical properties. Ground-based instruments or onboard space missions have and will perform spectroscopic measurements of planetary and small bodies surfaces, such as asteroids or comets. The limits of this method depend on the instrument spectral resolution, detector sensitivity and on the surface illumination and albedo. Many solar system surfaces, particularly primitive objects (C- and D-type asteroids, cometary nuclei), are extremely dark (a few percent of reflectance in the visible). Analogue materials can be challenging to analyze in the laboratory due to the limited power reflected by the targets. The laboratory spectrogonio radiometer SHADOWS will simulate the geometrical and thermal conditions of observations of small bodies and planetary surfaces, and will be able to measure surfaces with reflectance lower than 1% with a high signal to noise ratio.

2. Instrument overview

SHADOWS (Spectrogonio radiometer with cHanging Angles for Detection Of Weak Signals) is the IPAG new spectrogonio radiometer, specially designed to record bidirectional reflectance spectra on low albedo surfaces and on small samples, that will be available as an European facility within the framework of the Europlanet 2020 RI program. SHADOWS design is based on the current IPAG spectrogonio radiometer SHINE [1,2] but with a radical change in illumination spot size dedicated to allow reflectance measurements of dark samples. In addition, small (and therefore precious) samples can be studied, since only 10 to 100 mg of material is needed. The spectral range covered, from 0.35 to 5µm allows studies of minerals, organic or ices spectral signatures. The instrument will be installed in a cold room for analysis from room temperature to -40°C. A low-temperature environmental cell can be inserted in the goniometer in order to perform reflectance measurements on samples down to 50K. The source, its stabilization device, the modulator and the monochromator produce a modulated monochromatic light. A bundle of 8 ZrF_4 multimode optical fibers leads monochromatic light from the instrumentation table. At the output of the fiber, this monochromatic light is focused on the sample surface using a spherical mirror. The goniometer part of SHADOWS consists of two arms, one sending the monochromatic light on the sample and the other holding two detectors (visible and near-infrared) that collect the reflected light. The incidence, emergence and azimuth angles can be changed to simulate a variety of observation geometries and characterize the angular dependencies of the reflected spectrum. Figure 1 represents the goniometer part of SHADOWS, showing the illumination and detection arms.

The modulated incident light and two lock-in amplifiers, one for each detector, synchronized with the modulation frequency, isolate the reflected light signal from the thermal infrared background.

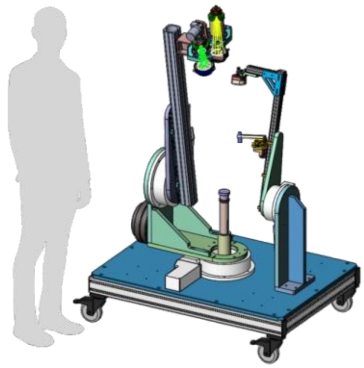

Figure 1: 3D representation of the SHADOWS goniometer. The table with the instruments for modulated monochromatic light generation and the optical fibers connecting them to the instrument are not represented. The total height is about 170 cm.

3. Spectropolarimetry

Light becomes polarized when reflected on a surface. The amount of polarization depends on the chemical and physical characteristics of the surface, as well as on the illumination/observation geometry. For spectro-polarimetry measurements, one has to minimize the polarization of the incident light on the sample as it induces measurement errors. To reduce parasite polarization from the incident light, the optical fibers are bent to induce more light reflections at the core-clad interface and thus mix the polarizations. This solution offers the best results for the whole instrument spectral range and do not affect significantly the incident flux. A rotating polarizer can be installed across the light path on the incident arm but reduces light intensity by over a factor 2. The instrument allows the operator to conduct spectra measurements with unpolarized or fully-polarized incident light, as well as to measure the polarization of the reflected light, with polarizers placed in front of the detectors. Spectra can be recorded for different angular positions of the polarizers and the polarimetric spectrum is automatically calculated. SHADOWS can be used for phase angle dependent polarimetric spectra, such as inversion angle analysis.

4. Control software and automated routines

A control-acquisition software has been specially written to control SHADOWS for automatized spectral measurements, as well as spectral-BDRF measurements. Additional routines involve, among others, the automated control of the cryostat of the environmental cell, making SHADOWS able to perform step-by-step temperature dependent spectral measurements over several hours without any interruption or manual operation.

5. Schedule and expected results

All the instrumentation table (source, stabilizator, monochromator, modulator, optical fibers) and signal analysis is already set, as well as the control program. In May 2017, the goniometer part of the instrument will be finished and installed in the cold room. The first spectra, calibrations and performance tests will be conducted during the following weeks. The official delivery is set to the 31st August 2017. The instrument prototype was used to record spectra on reference and challenging dark surfaces, such as Metal Velvet, Spectral Black or Vantablack (Figure **2**). We expect even higher S/N ratio and photometric accuracy with SHADOWS, as some optical characteristics and several components have been optimized to get the best S/N compromise.

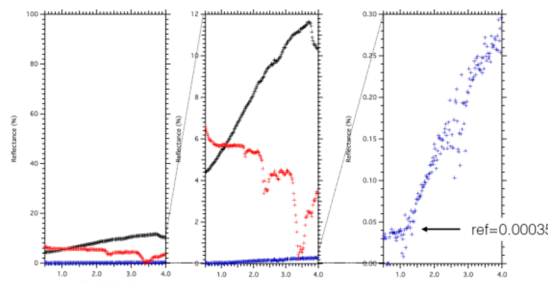

Figure 2: Reflectance spectra of Metal Velvet (black curve), Spectral black (red curve) and Vantablack (blue curve) obtained with the instrument prototype, at incidence angle 0° and measurement angle -30°.

References

[1] Bonnefoy N.: Développement d'un spectrophoto-goniomètre pour l'étude de la reflectance bidirectionnelle de surfaces géophysiques. Applications au soufre et perspectives pour le satellite Io, Ph.D. thesis, 2001.

[2] Brissaud O., Schmitt B., Bonnefoy N., Douté S., Rabou .P., Grundy W, and Fily M.: Spectrogonio radiometer for the study of the bidirectional reflectance and polarization functions of planetary surfaces. 1. Design and tests, Applied Optics, Vol.43, p. 1926-1937, 2004.

EPSC Abstracts
Vol. 11, EPSC2017-468, 2017
European Planetary Science Congress 2017

Reflectance spectroscopy under planetary conditions: the Cold Surface Spectroscopy Facility at IPAG

Pierre Beck, Bernard Schmitt, Sandra Potin, Olivier Brissaud, Institut de Planétologie et d'Astrophysique de Grenoble (IPAG), Université Grenoble Alpes – CNRS, France (pierre.beck@univ-grenoble-alpes.fr)

1. Context

Planetary surfaces can be subjected to extreme thermal and pressure conditions. These environmental conditions can impact the optical properties of surface material, and should be taken into account for valid compositional interpretation of remote sensing observations. Here, we present the capabilities of the cold surface spectroscopy laboratory, a trans-national access (TNA) facility accessible though the Europlanet 2020-RI framework, as well as some scientific results obtained so far.

2. Facility overview

The facility is constructed around two instruments that are dedicated to the high precision spectro-gonio radiometry of rocks, organics and ices over most of the solar spectrum range (0.35 – 5 µm). These two instruments are roughly similar, but dedicated to two different types of samples: i) SHINE, for large (> 10 g) and translucent samples (> 5 cm) [1] ii) SHADOWS, for precious (< 1g) and dark samples [2]. Both instruments are located in a cold room in order to minimize the atmospheric water vapor and to decrease the thermal background.

Each instrument is constituted of two arms (illumination arm and detection arm) that can rotate in order to sample a range of incidence and emergence angles (up to 80°). Also, measurements outside of the principal plane are possible since the azimuth can vary of 180° in order to sample the full bi-directional distribution reflectance function. The incident light is modulated before being sent on the sample, and two lock-in amplifiers, synchronized with the modulation frequency, isolate the reflected light signal from the thermal infrared background. The measured reflected light is analyzed by two detectors (Si, 0.35-1.1 µm and InSb, 1.1-5 µm). The polarization of the reflected light can also be measured.

Each instrument is equipped with a home-made control software enabling automated sampling of the spectral bi-directional reflectance distribution function (BRDF). A sample preparation laboratory is connected to the facility, where grinding (manual or automated) and sieving (manual or automated) can be performed.

3. Environmental chambers

Two different environmental chambers can be coupled to SHINE and SHADOWS. The first one, SERAC (Pommerol et al., 2009 [3]) enables to expose a particular sample to a controlled relative humidity, and to quantify the amount of water that is adsorbed on the sample [3] or absorbed by the sample [4]. A second cell, named CARBONIR, enables to maintain a sample under cryogenic temperature (down to 50 K) while maintaining a given total gas pressure of controlled composition. This cell can also be used to directly condense volatiles on a given surfaces. Also using a specific sample holder, this cell can be used to measure reflectance spectra of minerals (or meteorites) under low temperature. Because of the cells geometry, spectra can only be measured under restricted observation geometries when using them. Because both instruments are located in a cold room (down to -20°C), it is possible to study the spectro-photometry of water-ice and its mixture with dust without using an environmental chamber [5].

4. Some examples of applications

Low-temperature spectra of minerals: Some absorption features can be strongly dependent on temperature. This is the case of transition from excited states (see for instance the case of brucite 3.06 µm feature, [6]) or absorption features related to OH/H_2O in hydrated minerals (Fig. 1; see [7]).

Mars seasonal condensates: The seasonal evolution of Martian atmospheric CO_2 is intimately related to deposition and sublimation processes of CO_2 ices. With the CARBONIR environmental chamber we were able to simulate deposition, metamorphism and sublimation of Mars seasonal CO_2 deposits, pure (Fig.2, [8]) or mixed with water ice or martian dust simulant [9].

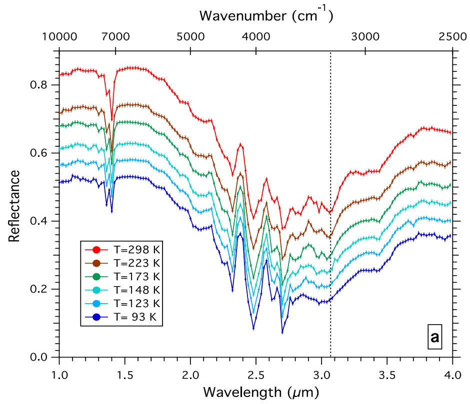

Figure 1: Temperature evolution of the reflectance spectrum of brucite. From [5].

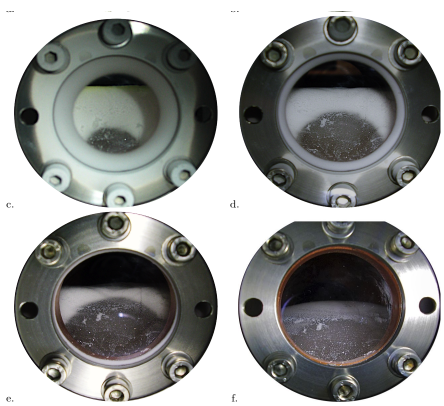

Fig. 2: Progressive metamorphism of CO_2 snow into CO_2 ice [7].

Reflectance of cometary analogues: The high signal to noise ratio of the SHADOWS instrument, even for low reflectance values (< 3 %) is particularly well suited for studies of cometary analogues. These have been undertaken in the framework of VIRTIS observation of comet 67P surface material.

References

[1] Brissaud, O., Schmitt, B., Bonnefoy, N., Douté, S., Rabou, P., Grundy, W., Fily, M., 2004. Spectrogonio Radiometer for the Study of the Bidirectional Reflectance and Polarization Functions of Planetary Surfaces. 1. Design and Tests. Applied Optics 43, 1926–1937.

[2] Potin S., Beck P., Schmitt B., Brissaud O.,SHADOWS: spectro-gonio radiometer for bidirectional reflectance studies of dark meteorites and terrestrial analogues, EPSC 2017.

[3] Pommerol, A., Schmitt, B., Beck, P., Brissaud, O., 2009. Water sorption on martian regolith analogs: Thermodynamics and near-infrared reflectance spectroscopy. Icarus 204, 114–136. doi:10.1016/j.icarus.2009.06.013

[4] Massé, M., Beck, P., Schmitt, B., Pommerol, A., McEwen, A., Chevrier, V., Brissaud, O., Sejourne, A., 2014. Spectroscopy and detectability of liquid brines on mars. Planetary and Space Science 92, 136–149. doi:10.1016/j.pss.2014.01.018

[5] Dumont, M., O. Brissaud, G. Picard, B. Schmitt, J.C.Gallet, and Y. Arnaud, 2010. High-accuracy measurements of snow Bidirectional Reflectance Distribution Function at visible and NIR wavelengths; comparison with modelling results. *Atm. Chem. Phys* **10,** 2507-2520.

[6] Beck, P., Schmitt, B., Cloutis, E.A., Vernazza, P., 2015. Low-temperature reflectance spectra of brucite and the primitive surface of 1-Ceres? Icarus 257, 471–476.[7] De Angelis, S., Carli, C., Tosi, F., Beck, P., Schmitt, B., Piccioni, G., De Sanctis, M.C., Capaccioni, F., Di Iorio, T., Philippe, S., 2017. Temperature-dependent VNIR spectroscopy of hydrated Mg-sulfates. Icarus 281, 444–458. doi:10.1016/j.icarus.2016.07.022

[8] F. Grisolle, PhD. 2013**.** Les condensats saisonniers de Mars : étude expérimentale de la formation et du métamorphisme de glaces de CO2. Université Joseph Fourier, Grenoble, France.

[9] S. Philippe, PhD, 2016. Microphysique des processus saisonniers des glaces de Mars et Pluton : suivi par télédétection hyperspectrale et étude expérimentale. Université Grenoble Alpes, Grenoble, France.

Aknowledgment : “Europlanet 2020 RI has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208”

EPSC Abstracts
Vol. 11, EPSC2017-505, 2017
European Planetary Science Congress 2017

Looking for water related environments on Mars: analysis of reflectance spectra for present and future exploration

B. De Toffoli (1,2), C. Carli (3), A. Maturilli (4), F. Sauro (5), M. Massironi (1,2) and J. Helbert (4)
(1) Department of Geosciences, University of Padova, Padova, Italy (barbara.detoffoli@gmail.com), (2) OAPD, Istituto Nazionale di Astrofisica, Padova, Italy, (3) IAPS, Istituto Nazionale di Astrofisica, Rome, Italy, (4) Institute for Planetary Research, DLR, Berlin, Germany, (5) Department of Biological, Geological and Environmental Sciences, Italian Institute of Speleology, University of Bologna, Italy

Abstract

Spectroscopic analyses of basalt epithermal alterations, clay minerals and samples representative of wet sedimentary environments in a broad wavelength range from the ultraviolet to the far-infrared provide new loads of information for present and future exploration of environments that could have been linked to water and gas emission. Specifically, methane emission centers on the Martian surface are high interest targets for Exo-Mars mission since they involve environments where life could have potentially arisen, grown and given a contribution to the degassing phenomenon.

1. Introduction

Mud and water resurgences features on Mars are primary objectives for the astrobiology and climate change studies and investigating the nature of the unconsolidated materials that have been mobilized will lead to step forward in the understanding of the processes that lie behind. Such environments have been recognized in numerous locations on the Martian surface [1], [2], [3] and accordingly various scenarios need to be tackled. Indeed, during the Martian ancient past, sediments could have been deposited and trapped thanks to surficial sedimentary processes, hence hydrous alterations and possibly putative organic matter could be found. Differently, basalts could have experienced alteration linked to fluid circulation in the subsurface, so serpentinisation related to hydrothermal systems should be taken also into account. A suitable analogue for both environments could be the group of the epithermal ore systems [4] due to: (i) characteristic interaction between hydrothermal fluids and groundwater within the first kilometers of crust, (ii) low temperatures ranges of mineral deposition, (iii) surface expression through mud volcanoes, hot springs and pools and (iiii) the connection with loss of methane and other gasses.

2. Materials and methods

21 samples belonging to water related environments were investigated, among which clays, epithermal minerals and siliceous stromatolites. Spectroscopic analyses were coupled to XRD chemical characterization to provide a complete dataset of information. The sample grain size, obtained by grinding and sieving, never excided 100 µm; powders went then through an exsiccation process by means of oven and drier. Acquisitions were thus performed on powdered and dried samples under vacuum at room temperature conditions by means of reflectometric interference spectroscopy at one constant geometry. The chosen setup was fixed at 43° phase angle in a non-symmetric arrangement with illumination and emission disposition set respectively at 30°and 13°. Even conditions were used across all spectral ranges and samples preparation to facilitate reproducibility and comparison. During the analyses the acquisition spot was 4 mm in diameter, resolution was fixed at 4 cm-1 (8 cm-1 in the UV field) and 500 scans were performed for each sample (250 in the far-IR field). Spectralon 99% (LabSphere ®) of reflectance and a gold-plated standard were used as reference for calibrating ultraviolet, visible (VIS) and IR reflectance.

3. Preliminary results

A broad range of wavelengths was investigated in order to widen and enhance spectral libraries. We assigned, in the VIS and near-IR (see Fig.1), the absorptions features to specific crystal field or vibrational processes, identifying diagnostic spectral parameters or indicator to be applied on CRISM (onboard MRO) and OMEGA (onboard MEX) hyperspectral images [5 and references therein]. Moreover, we have investigated less common windows of analysis (e.g. UV, far-IR) to evaluate if markers and signatures could be there recognized and therefore considered for future planetary probing.

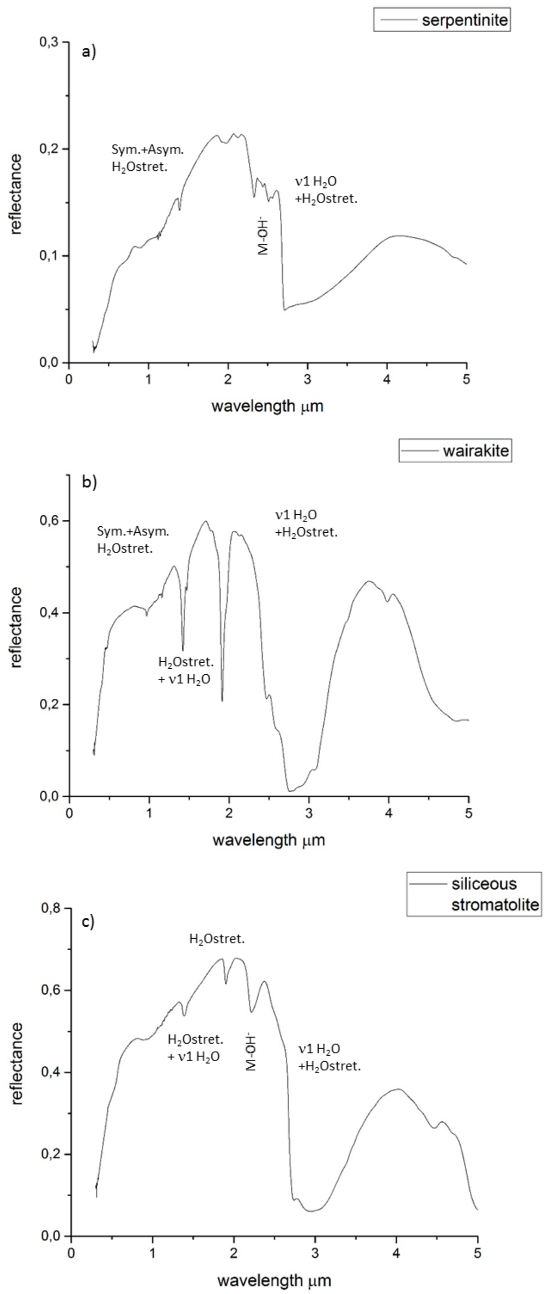

Figure 1: Example of VIS and near-IR spectra of three investigated samples belonging to different alteration processes and biologically mediated concretions. In the plots assignments of the overtone absorptions are reported.

4. Future works

Evidence of absorption and spectral variability, as retrieved in this work for well characterized mineralogies, will be applied to drive the analysis on remotely sensed hyperspectral images of Martian regions where surface expressions of water and sediments resurgences are recognisable such as the mound fields detected in Utopia and Hellas basins and Vastitas Borealis [6].

Acknowledgements

We acknowledge the Europlanet 2020 Research Infrastructures Program (grant agreement No 654208) that supported our project (15-EPN-022) and made this international cooperation possible.

References

[1] Oehler D. and Allen C.: Evidence for pervasive mud volcanism in Acidalia Planitia, Icarus, Vol. 208, pp. 636-657, 2010.

[2] Pondrelli M., Rossi A., Ori G., van Gasselt S., Praeg D. and Ceramicola S.: Mud volcanoes in the geologic record of Mars: the case of Firsoff crater, Earth and Planetary Science letters, Vol. 304, p. 511-519, 2011.

[3] Okubo, C.: Morphologic evidence of subsurface sediment mobilization and mud volcanism in Candor and Coprates Chasmata, Valles Marineris, Mars, Icarus, Vol. 269, pp. 23-37, 2016.

[4] Hedenquist J. and Lowenstern J.: The role of magmas in the formation of hydrothermal ore deposits, Nature, Vol. 370, pp. 519-527, 1994.

[5] Clark R.N.: Spectroscopy of Rocks and Minerals, and Principles of Spectroscopy, John Wiley and Sons, Inc A. Rencz, Editor New York, 1999.

[6] De Toffoli B., Pozzobon R., Mazzarini F., Massironi M. and Cremonese G.,: Evidence of mud volcanism rooted in gas hydrate-rich cryosphere linking surface and subsurface for the search for life on Mars, Geophysical Research Abstract, Vol. 19, EGU2017-251, 2017.

EPSC Abstracts
Vol. 11, EPSC2017-513, 2017
European Planetary Science Congress 2017

CRPG facilities available through Europlanet 2020 RI

C. Cloquet, A. Galy
CRPG-CNRS, Univ. Lorraine, UMR 7358, Vandoeuvre les Nancy, France, agaly@crpg.cnrs-nancy.fr / Fax: +33 383511798

Abstract

Europlanet H2020 program include Transnational Access (TA) supporting travel and local accommodation costs of European researchers to conduct their own research. At CRPG, TA3-Distributed Sample Analysis Facility is available, giving access to the state of the art of 4 analytical facilities.

1. EuroPlanet

Europlanet 2020 RI is a Research Infrastructure that is addressing key scientific and technological challenges facing modern planetary science by providing open access to state-of-the-art research data, models and facilities across the European Research Area. It is a 9.95 million euros project to integrate and support planetary science activities across Europe. The project is funded under the European Commission's Horizon 2020 programme; it was launched on 1st September 2015 and will run until 31 August 2019.

A series of networking and outreach initiatives will be complimented by joint research activities and the formation of three Trans National Access distributed service laboratories (TA's) to provide a unique and comprehensive set of analogue field sites, laboratory simulation facilities, and extraterrestrial sample analysis tools.

A central part of the Europlanet 2020 RI programme is to allow any European researcher interested in pursuing planetary science research access to a comprehensive set of laboratory facilities and field sites tailored to the needs of planetary research.
Access is provided by a **Transnational Access (TA)** programme that supports travel and local accommodation costs of European researchers (and of researchers from Third Countries under certain conditions) at the facility for an approved period of time to conduct their own research programme. Applications are made in response to annual calls and are subject to peer review. It should be noted that applicants must apply to use facilities outside the country in which they are employed (i.e. it is a transnational access). **Applications can be made for analytical time or access to planetary analogue sites ranging from single days up to several weeks and up to two researchers can be fully financed in each research visit**

Europlanet 2020 RI is designed to support planetary science but applications in other research disciplines are also considered based on innovation and potential scientific and technological impact to the planetary sciences field.

Here we report on the infrastructure that comprises the facilities offered at CRPG under TA3: Distributed Sample Analysis Facility (DSAF). The modular infrastructure represents a major commitment of analytical instrumentation and forms a state-of-the-art analytical facility. The centre perform research in the fields of geochemistry and cosmochemistry, studying fluids and rocks in order to better understand the keys of the universe.is the introduction section of your paper. All section headings are in a large bold font. Sections can be with or without numbering. In order to guarantee the correct formatting of section titles with or without numbers, please use the auto-formatting styles "Section_heading_numbered" or "Section_heading", respectively, provided in this document.

2. Ion Probe facilities

This facility comprises a CAMECA IMS 1280 HR2 and a CAMECA IMS 1270 Ion microprobe, upgraded in 2014 to match the capabilities of the recently installed IMS 1280. Ion microprobe is a CNRS-INSU national facility. About a third of the useful analytical time of the ion probe (about 3 months each year) is allocated to the national community. French scientists have to submit their projects to a national committee for selection. The selected projects are allocated time in the following 6 months twice a year. About 15 to 20 projects are run each year. There are only few such instruments in Europe, with cosmochemistry only performed at CRPG. Different analyses can be performed on a routine basis; which include U-Pb dating on zircon, monazite or pitchblende, C, O, Si isotope ratios and light and trace elements contents of different matrixes. A notable speciality is the measurement, at high precision, of the isotopic ratios of light elements (H, Li, N, Mg, S) including mass independent fractionation of sulfur isotopes.

3. Helium and Nitrogen Facility

Helium isotope measurements can be performed to determine the origin of gases and to date surface exposure with cosmogenic 3He using the latest He isotope mass spectrometer, the GV Helix SFT, the first instrument of its kind installed in Europe. Analysis of nitrogen at the nanomole level in rocks can also be done on static gas-source mass-spectometer VG5400.

4. Stable Isotope Facility

ThermoFinnigan Neptune Plus MC-ICPMS & MAT253 and GV Isoprime provide the capability for C, O, S, H isotope analyses of rocks, minerals, organic matter and fluids (water, natural gases) by continuous flow mass spectrometry coupled with elemental analyser or off line extraction and "novel" stable isotopes by sector field ICP-MS (Neptune+). This includes O isotopes on silicates by fluorination and H, C & O on fluids from single inclusions. The determination of high precision Mg, Ca, Fe and Ge isotopes is offered.

5. Radiogenic Isotope Facility

Analysis by TIMS (FinniganMat 262 and ThermoFinnigan Triton). This includes the Re-Os isotopic system and the extinct system 146Sm-142Nd as well as the Sr Nd and Pb isotopic systems that are the “traditional” isotopic systems in meteorite, lunar and terrestrial rock studies.

6. Summary and Conclusions

Currently planetary research is limited to meteorites and lunar samples but future return missions will provide enough material from comets and asteroids. A major focus of research in the next 5-10 years will be comparative planetology to understand the types of geochemical processes that can be expected on the (former) water rich regions of Mars to be sure that the detection of past life is unambiguous. The aim of this infrastructure is to provide a structured access to state of the art analytical facilities for European users.

There will be 2 calls (or more) between September 2017 and September 2018 for access to these facilities.

http://www.europlanet-2020-ri.eu/research-infrastructure/field-lab-visits

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Vol. 11, EPSC2017-568, 2017
European Planetary Science Congress 2017

The Planetary Spectroscopy Laboratory (PSL)

A. Maturilli, J. Helbert, I. Varatharajan and M. D'Amore
Institute for Planetary Research, German Aerospace Center DLR, Rutherfordstr. 2, 12489 Berlin, Germany – alessandro.maturilli@dlr.de

Abstract

In the last decade the Planetary Emissivity Laboratory (PEL) of DLR in Berlin has provided spectral measurements of planetary analogues from the visible to the far-infrared range for comparison with remote sensing spacecraft/telescopic measurements of planetary surfaces [1-5]. Bi-directional reflection, transmission and emission spectroscopy are the techniques we used to acquire spectral data of target materials. In fall 2015 we started upgrading our laboratory set-up, adding a new spectrometer, three external sources, and new detectors and beamsplitters to further extend the spectral range of measurements that can be performed in the laboratory. The new facility received the name of Planetary Spectroscopy Laboratory (PSL). The purpose of this paper is to illustrate all of the possible measurements that can be done at the Planetary Spectroscopy Laboratory (PSL).

1. Introduction

Two FTIR instruments are operating at PSL, in an air-conditioned room. The spectrometers are two Bruker Vertex 80V that can be evacuated to ~.1 mbar. One spectrometer is equipped with aluminum mirrors optimized for the UV, visible and near-IR, the second features gold-coated mirrors for the near to far IR spectral range. Because the two instruments are identical apart of the mirrors, they can share the collection of detectors and beamsplitters we have in our equipment to cover a very wide spectral range. The instruments and the accessory units used are fully automatized and the data calibration and reduction are made with homemade DLR developed software. Table 1 list the spectral coverage of detectors we have available at PSL, Table 2 describes the associated beamsplitters we use at PSL.

Detector	Spectral Range (µm)	Operating T
GaP Diode	0.2 – 0.55	Room T
Silicon Diode	0.4 – 1.1	Room T
InGaAs Diode	0.7 – 2.5	Room T
InSb	0.78 – 5.4	Liquid N_2
2x MCT	0.8 – 16	Liquid N_2
MCT/InSb SW	1 – 16	Liquid N_2
2x DTGS/KBr	0.8 – 40	Room T
DTGS/CsI	0.8 – 55	Room T
DTGS/PE	14 – 1000	Room T

Table 1. Detectors equipment at the PSL.

Beamsplitter	Spectral Range (µm)
UV/VIS/NIR CaF_2	0.18 – 2.5
Si on CaF_2	0.66 – 8.3
Ge on KBr (Wide)	1 – 25
Ge on KBr substrate	1.2 – 25
Multilayer	14.7 – 333
50 µm Mylar	181 – 666

Table 2. Beamsplitters in use at the PSL.

To allow high precision transmission and reflectance measurements, three external sources have been added to the PSL set-up. A deuterium lamp is used to cover the UV (0.2 to 0.5 µm) spectral range. A 24V, water cooled, Tungsten lamp has been added for measurements in the VIS (0.4 to 1.1 µm) spectral range. Another high power Globar lamp (24 V, water cooled) is used in the VNIR+TIR (1 to 16 µm) spectral range.

2. Facility Support Equipment

A number of sample preparation and analysis tools and experiment sub-systems are available to the facility: a collection of hundreds of rocks and minerals, synthetic minerals, an Apollo 16 lunar sample, several meteorites, set of sample holders for reflectance (plastic, aluminum or stainless steel), various sets of sieves, grinders, mortars, saw, balances, microscope, an oven (20° to 300°C), ultra-pure water, wet chemistry materials, a second ovens (30° to 3000°C) for sample treatments, a press to produce pellets (10mm or 20mm diameter), a large dry cabinet (moisture < 1%) for sample storage, 3 small exsiccators (moisture < 20%) for sample storage, a rotating device for producing intimate mixtures, purge gas generator for water and CO2 free air, liquid-nitrogen tank, an ultrasonic cleaning unit, 2 microscopes, air compressor pistol for cleaning. When enough sample material is available, the typical grain size separates that we produce for spectral measurements are <25 µm, 25-63 µm, 63-125 µm, 125-250 µm. Larger separates as well as slabs are often measured too.

3. Emissivity Measurements

An external chamber is attached to one of the FTIR spectrometers to measure the emissivity of solid samples. A shutter allows separating the spectrometer from the external chamber, that can be evacuated to the same pressure as of the spec-trometer. If needed, an optical window (vacuum tight) can be mounted at the entrance of the emissivity chamber to operate while keeping the external chamber at ambient pressure under purged air or under inert gases. Sample targets are brought to measuring temperature using an induction heating system. Also, our sample cups and heating surfaces are made of stainless steel and heat the samples from below. Our high efficiency induction system heats the samples to temperatures from 320K up to 900K. A sample caroussel driven by a very precise stepper motor (computer controlled) allows measuring several consecutive samples without breaking the vacuum. A large number of temperature sensors in the emissivity chamber serve to monitoring sample as well as equipment and chamber temperature. A webcam is mounted in the emissivity chamber to monitor the heated sample and its vicinity.

4. Reflectance Measurements

With the Bruker A513 accessory on Vertex 80V, we can obtain bi-directional reflectance of minerals, with variable incidence and emission angles between 13° and 85°. The viewing cone of the A513 has an aperture of 17°, small enough to define our measurements as bi-directional. We measure at room temperature, under purge or vacuum conditions, covering the 0.2 to above 200 µm spectral range.

5. Transmittance Measurements

The Bruker A480 parallel beam accessory mounted on the Vertex 80V allows us to measure transmission of thin slabs, optical filters, optical windows, slabs, etc, in the complete spectral range from UV to FIR avoiding refraction, typical in this kind of measurements.

6. Facility Access

PSL is a Trans-national access (TA) facility supported by the European Union within the EuroPlanet Research Infrastructure framework for the next four years. In this period once per year a call for proposals will be issued for investigations using PSL. Details can be found at:

http://www.europlanet-2020-ri.eu/.

7. Conclusion

The PEL already provides the planetary community with reflectance, transmission and emissivity measurements highly complementary to existing spectral databases, already in covering a very large spectral range (1-100 µm).

With the recent and still ongoing update of the facility PSL can now provide measurements under vacuum, that cover the whole spectral range from UV (0.2 µm) to the FIR (200 µm and above).

In addition the high temperature spectroscopy capabilities of PSL are currently extended to start at 700nm instead of 1000nm.

References

[1] Maturilli, A. and Helbert, J.: Emissivity measurements of analogue materials for the interpretation of data from PFS on Mars Express and MERTIS on Bepi-Colombo, PSS, Vol. 54, pp. 1057-1064, 2006.

[2] Maturilli, A., Helbert, J., and Moroz L.: The Berlin Emissivity Database (BED), PSS, Vol. 56, pp. 420-425, 2008, spectral library now available at http://figshare.com/articles/BED_Emissivity_Spectral_Library/1536469.

[3] Helbert, J. and Maturilli, A.: The emissivity of a fine-grained labradorite sample at typical Mercury dayside temperatures, EPSL, Vol. 285, pp. 347-354, 2009.

[4] Maturilli A, Helbert J: Characterization, testing, calibration, and validation of the Berlin emissivity database. Journal of Applied Remote Sensing, 2014.

[5] Maturilli A, Helbert J, St. John JM, Head III JW, Vaughan WM, D'Amore M, Gottschalk M, Ferrari S: Komatiites as Mercury surface analogues: Spectral measurements at PEL. EPSL, Vol. 398, pp. 58-65, 2014.

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Vol. 11, EPSC2017-841, 2017
European Planetary Science Congress 2017

Modelling of thermal-IR spectra of forsterite: application on remote sensing for Mercury

C. Stangarone (1), J. Helbert (1), A. Maturilli (1), M. Tribaudino (2), M. Prencipe (3)

(1) Institute for Planetary Research, Deutschen Zentrums für Luft- und Raumfahrt, Berlin, Germany, (2) Department of Physics and Earth Science, University of Parma, Italy, (3) Department of Earth Sciences, University of Torino, Italy (claudia.stangarone@gmail.com)

Abstract

In this work, we study experimental thermal emissivity spectra with an innovative approach: we calculate IR spectra, with ab initio methods, of the main mineral families that presumably compose the surface of Mercury and we compare them with high temperature laboratory measurements. The measurements are carried out at the Institute of Planetary Research, Deutschen Zentrums für Luft und Raumfahrt (DLR) Planetary Spectroscopy Laboratory (PSL). The laboratory has the unique capability to obtain emissivity measurement of samples at temperature up to 1000K, by means of a planetary emissivity chamber. This allows measuring samples at realistic temperature conditions for the surface of Mercury. The goal is to interpret the high temperature infrared (HT-IR) emissivity spectra that will be collected by the Mercury Radiometer and Thermal infrared Imaging Spectrometer (MERTIS), the spectrometer developed by DLR that will be on board of the ESA BepiColombo Mercury Planetary Orbiter (MPO) [1].

1. Introduction

Spectral signatures of minerals are intimately related to the crystal structure; therefore, they may represent a remote sensing model to determine surface composition of planetary bodies, analysing their spectral reflectance and emission. For Planetary surfaces, which are influenced by extreme environmental conditions as Mercury, which is the closest planet to the sun, data interpretation must take into account changes in spectral characteristics induced by the high temperatures conditions [2].

2. Methodology

The approach was firstly used on olivine [3], one of the possible major phases in the surface of Mercury. A natural sample of olivine (Fo#89) has been studied at Planetary Spectroscopy Laboratory [4]. The emissivity of the sample has been measured at different steps of temperature by means of a planetary simulation chamber that has the unique capability to heat samples to temperatures up to 1000K. IR reflectance spectra of forsterite has been then simulated using the Hybrid HF/DFT Hamiltonian WC1LYP [5, 6], by means of the CRYSTAL code [7]. IR vibrational frequencies at high temperature are calculated evaluating the vibrational frequencies at the Γ point of first BZ of the unit cell at different volumes corresponding to increasingly higher temperatures. Thus, in order to simulate extreme environmental conditions, IR frequencies and intensity has been calculated for volumes estimated at 0, 300 and 1000K (taking into account zero point effects). The comparison with the experiment reveals that such computational approach can reliably be used to predict band shifts due to temperature: a significant good agreement between measurements and simulated data is shown, especially within the spectral range 1200-600 cm^{-1}.

3. Figure

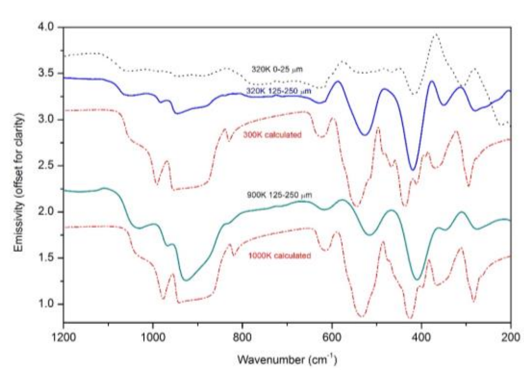

figure 1: Comparison between calculated 1-R mid IR spectra and experimental emissivity measurements. Solid line: experimental thermal emissivity spectra of an Mg-rich olivine (Fo89) measured at 320K and 900K

(extreme situations). Dotted lines: calculated IR reflectance (inverted 1-R) bands of an Mg_2SiO_4 endmember. Spectra are offset for clarity.

4. Summary and Conclusions

This study aims to enhance the knowledge of spectroscopic techniques applied to remote sensing and it might occur on two levels.

The first one concerns the IR frequencies that are influenced by temperature and occur during the insolation of the surface and which not and which structural feature are involved. These temperatures changes must be taken into account since they induce variation not only on the bond distances and on angles of minerals, but also on the density of rocks that compose the surfaces of a planetary body. The temperature factor also affects the interpretation of thermal emissivity spectra, which appear extremely challenging to unravel, due to the broadening of the bands, which is observed especially at high temperature.

At a higher level, results will be useful to create a theoretical background to interpret high temperature infrared (HT-IR) emissivity spectra that will be collected by the Mercury Radiometer and Thermal infrared Imaging Spectrometer (MERTIS), the spectrometer developed by DLR that will be on board of the ESA BepiColombo Mercury Planetary Orbiter (MPO).

Acknowledgements

We would like to acknowledge Europlanet 2020 RI-TA to have founded for further measurements at PSL

References

[1] Helbert, J., Hiesinger, H., Walter, I., Säuberlich, T., Maturilli, A., D'Amore, M., Knollenberg J., Lorenz E., Peter G., Arnold, G. E.: MERTIS: understanding Mercury's surface composition from mid-infrared spectroscopy, SPIE Optical Engineering Applications, International Society for Optics and Photonics, 1-5 August 2010, San Diego, California, USA

[2] Helbert, J., Nestola, F., Ferrari, S., Maturilli, A., Massironi, M., Redhammer, G. J., Capria M. T., Carli C., Bruno, M.: Olivine thermal emissivity under extreme temperature ranges: Implication for Mercury surface, Earth and Planetary Science Letters, Vol. 371, pp. 252-257, 2013.

[3] Sprague, A. L., Hanna, K. D., Kozlowski, R. W. H., Helbert, J., Maturilli, A., Warell, J. B., & Hora, J. L.: Spectral emissivity measurements of Mercury's surface indicate Mg-and Ca-rich mineralogy, K-spar, Na-rich plagioclase, rutile, with possible perovskite, and garnet, Planetary and Space Science, Vol. 57(3), 364-383, 2009.

[4] Maturilli, A., & Helbert, J.: The Planetary Spectroscopy Laboratory (PSL): Spectral Measurements of Planetary Analogues from UV to FIR, Lunar and Planetary Science Conference, 21-25 March 2016, The woodlands, Texas, USA, 2016

[5] Wu, Z., & Cohen, R. E.: More accurate generalized gradient approximation for solids, Physical Review B, Vol. 73(23), 235116, 2006.

[6] Lee, C., Yang, W., & Parr, R. G.: Development of the Colle-Salvetti correlation-energy formula into a functional of the electron density. Physical review B, Vol. 37(2), 785, 1988

[7] Dovesi, R., Saunders, V. R., Roetti, C., Orlando, R., Zicovich-Wilson, C. M., Pascale, F., Civalleri B, Doll K, Harrison N. M., Bush I. J., D'Arco Ph., Llunell M., Causà M., Noël Y.: CRYSTAL14 user's manual. University of Torino, Torino 2014.