A COMPACT PLANETARY SIMULATION CHAMBER FOR THE CHARACTERIZATION OF THE BI-DIRECTIONAL REFLECTANCE OF ASTEROID, COMETARY AND SOLAR SYSTEM SMALL BODIES (SSSB) ANALOGUES AT LOW-TEMPERATURE ENVIRONMENTS. Y.M. Rosas Ortiz[1, 2], J. Helbert[1], A. Maturilli[1], M. Lehmann[2], [1]Institute of Planetary Research, German Aerospace Center DLR, Berlin, Germany, [2]Technische Universität Berlin, Department of Aeronautics and Astronautics, Berlin, Germany. Y.RosasOrtiz@campus.tu-berlin.de, Joern.Helbert@dlr.de

Introduction: Over the course of more than 3 decades, the Institute for Planetary Research of the German Aerospace Center (DLR) has gained considerable expertise in spectroscopy of minerals, rocks, meteorites and organic matter. At DRL's Planetary Spectroscopy Laboratory (PSL), a wide range of planetary analogue materials are routinely analyzed.

PSL facilities are equipped to provide unique capabilities in measuring emissivity of fine-grained powder materials over a very wide spectral range, bulk materials and coatings at temperatures up to 1000K across the whole infrared wavelength range.

A set up for the characterization of asteroid analogues by means emission and reflectance spectroscopy is available [1] and reflectance spectra at room temperature have been measured [2]. As a response to the current and future research ambitions at the PSL, the extension of the capabilities towards low-T reflectance measurements has been started. Currently, PSL is operating a test setup cooled by liquid nitrogen and using the internal sample chamber of a Bruker VERTEX 80V. The goal is the development of a compact low-temperature vacuum chamber for bi-directional reflectance measurements.

This will allow the characterization of analog materials for icy moons, asteroids, comets and solar system small bodies (SSSB) at low-temperature environments.

Low temperature spectroscopy: Objects in space are subjected to its almost perfect vacuum, cold and solar radiation. For instance the maximum day-light temperature at the surface of the dwarf planet Ceres was estimated to be 235K [3], the surface temperatures distributions of Vesta is from 40K to 248K [4] and the surface temperatures of Asteroid 21 Lutetia reaches a maximum value of 245K [5].

Pronounced spectral effects at the lowest temperature of 80K are shown by Moroz et al. [6] in a reflectance spectra measurement of olivine and orthopyroxene, which are very common rock-forming minerals in the solar system. The temperature dependence of the reflectance spectra at the primitive surface of Ceres has been addressed by Beck et al. [7] to investigate the reflectance spectrum under decreasing temperatures (down to 93K).

Setting up a system for reflectance spectroscopy experiments at cryogenic temperatures represents a unique opportunity for the PSL.

Experimental setup: At PSL, there are currently two instruments equipped with external chambers to measure emissivity. One of them is a vacuum chamber built to measure at very high temperatures and the second chamber (that can be cooled down to 270K) is for measurements at low to moderate temperatures. In the latter samples can be heated from room temperature to 420K in a purging environment. The sample compartment on the spectrometer has been used to simulate the low-T chamber and a cooling sample container has been designed and adapted to the reflectance unit. The icy-samples have been cooled down to 190K using a full controlled freezer and they have been kept cool using liquid nitrogen.

Technical Approach: During the concept phase, various cooling systems have been examined. The possibility of using a closed based cycle cooling by helium gas or liquid nitrogen with temperatures typically ranging between 70 – 90K in order to provide distributed cooling power for a cooling surface, is under evaluation. The nominal cooling capacity of the miniature cryocooler system currently at use at DLR is 65K [8]. The system we are developing it is expected to reach a cryogenic temperature within the range of 70K – 100K. As a reference, the daytime surface temperature at the main-belt asteroids and dwarf planet Ceres is between 200 and 300K (-73.15°C to 26.85°C) [9].

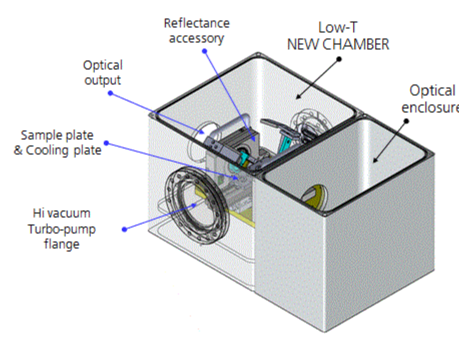

Figure 1. Chamber Interior

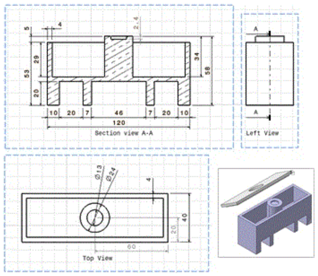

Figure 2. Cooling Sample container for preliminary experiments

Summary and Conclusions: In summary, laboratory spectroscopy investigations of minerals are key to support the interpretation of remote sensing data returned by the interplanetary missions.

A compact low-temperature reflectance chamber for FT-spectroscopy experiments at the PSL is currently under development. The expected cryogenic temperature to reach is approximately within the range of 70K – 100K. The potential experiments are promising. The current and future missions (e.g., NASA/DAWN and ESA/ExoMars 2020, NASA/EUROPA Multiple Flyby Mission, ESA/JUICE respectively) indicate the high potential usage of this development, which may result in many scientific or even commercial applications.

References: [1] Maturilli, A. et al. (2016) *Characterization of asteroid analogues by means of emission and reflectance spectroscopy in the 1 to 100μm spectral range*, Earth, Planets and Space, 68:113. [2] Maturilli A. et al. (2014) *Komatiites as Mercury surface analogues: spectral measurements at PEL.* EPSL 398:58–65. [3] Tosi, F. et al. (2015) *Dwarf Planet Ceres: Preliminary Surface Temperatures from Dawn*, Geophysical Research Abstracts, Vol.17, EGU2015-11960. [4] Leyrat, C. et al. (2012) *Thermal properties of (4) Vesta derived from Herschel measurements,* Astronomy and Astrophysics, 539. [5] Coradini, A. et al. (2011) *The surface composition and temperature of Asteroid 21 Lutetia as observed by ROSETTA/VIRTIS,* Science 334 (6055), 492–494. [6] Moroz, L., et al. (2000) *Reflectance Spectra of Olivine–Orthopyroxene-Bearing Assemblages at Decreased Temperatures: Implications for Remote Sensing of Asteroids,* Icarus 147, 79-93, 2000. [7] Beck, P., at al. (2015) *Low-temperature reflectance spectra of brucite and the primitive surface of 1-Ceres?*, Icarus 257, 471–476. [8] Richter, H., et al. (2010) *A compact, continuous-wave terahertz source based on a quantum-cascade laser and a miniature cryocooler*, Optics Express, Vol. 18, No. 10. [9] Tosi, F. et al. (2014) *Thermal measurements of dark and bright surface features on Vesta as derived from Dawn/VIR,* Icarus 240, 36-57.