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Laboratory dielectric constant determination for planetary surface characterization

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Abstract

A program of dielectric constant determination on various analogues, over a large range of frequencies and porosities, is under development in relation with the interpretation of Rosetta spacecraft observations. The analogues are meteoritic samples (compact and powdered), likely to be representative of the asteroids that have already been flown-by and of the cometary nucleus that is to be encountered. First results have already been obtained for asteroid Steins.

1. Introduction and motivation

On board the ESA Rosetta spacecraft, which is to rendezvous comet 67P/Churyumov-Gerasimenko in mid-2014, the MIRO (Microwave Instrument for The Rosetta Orbiter) and CONSERT (Comet Nucleus Sounding Experiment by Radiowave Transmission) experiments will allow the characterization, respectively of the cometary nucleus sub-surface and of its internal structure. MIRO is a dual-frequency radiometer, with one continuum channel at 190 GHz (1.6 mm) and another one at 562 GHz (0.5 mm) [1]. CONSERT is a new type of experiment, aimed at investigating the deep interior of the nucleus through radiowaves at 90 MHz, transmitted from the orbiter and returned from the lander [2]. MIRO has already observed the two asteroids that were flown by Rosetta, (2867) Steins in 2008 and (21) Lutetia in 2010. MIRO results have shown that (2867) Steins surface has a relatively high thermal inertia of 110 $JK^{-1}m^{-2}s^{-0.5}$, whereas (21) Lutetia surface has a low thermal inertia less than 30 $JK^{-1}m^{-2}s^{-0.5}$, suggesting a lunar-type regolith [3, 4].
We propose to provide complementary results by comparing MIRO (and later also CONSERT) observations with measurements in the laboratory of the dielectric constants of samples of meteoritic analogues for both asteroids and for the cometary nucleus. Laboratory measurements of the dielectric constant on meteoritic analogues will allow for better constraining the properties of the asteroids and of the nucleus. Associated with a shape model of these small bodies, dielectric constant determination (real part and imaginary part) on meteoritic analogues should lead to the prediction of emissivity of these objects, as a function of the solar phase angle.

2. Laboratory experiments

Such measurements on meteoritic analogues are to be obtained on a large range of frequencies (for the sub-millimeter up to possibly the meter domains) and porosities, taking into account the formation of layers of regolith on the surface, with different ranges of size distribution and compaction degree (possibly related to the gravity of the asteroids and of the nucleus). Table 1 lists the spectral domain of the instruments that are available for such measurements, at LERMA in Paris, as well as at IMS (Laboratoire de l'Intégration du Matériau au Système) in Bordeaux.

Table 1: Spectral domain of available laboratory experiments for permittivity measurements.

Experiment (laboratory)	Spectral domain
Impedance analyzer (IMS)	100 MHz
Coaxial sensor (IMS)	0.5-6 GHz
Resonant cavities (IMS)	1.2-13.4 GHz
Millimeter benches (IMS and LERMA)	30-550 GHz

It should be added that, as far as atmosphere-less bodies are considered, the properties of the regolithic surfaces are also approached by remote polarimetric observations (see e.g., [5]). Light scattering laboratory measurements (in the visible and near-infrared domains) on meteoritic analogues with the PROGRA2 experiment (operating in the laboratory or during parabolic flights to reduce the gravity) can indeed be used to establish whether the analogue is appropriate or not and to estimate the size distribution of the dust particles.

3. Samples and preliminary results

Dielectric constant measurements for different frequencies have already been obtained on an aubrite, an enstatite achondrite meteorite, which is considered as a good analogue for Steins (and other E-type asteroids) surface [6]. Dielectric constant values are systematically smaller than those derived by MIRO measurements: 6 for the real part and 0.1 for the imaginary part for the aubrite, instead of 7.2 and 0.3 respectively for Steins [3], suggesting that the complexity of Steins surface needs to be studied through complementary measurements. Meanwhile, polarimetric measurements have shown that aubrite powders and Allende meteorite powders could represent good analogues for the surface light scattering properties of respectively Steins and Lutetia [7, 8].

Acknowledgements

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