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Dielectric properties of porous granular matter, in relation with Rosetta cometary mission.

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Abstract

Dielectric property measurements over a large range of frequencies on two different samples of granular matter (JSC-MARS1 martian soil simulant and Etna pyroclastic deposits, each them divided at least in three size distribution) are presented. They are under development to prepare the interpretation of Rosetta spacecraft observations of the subsurface and interior of the comet nucleus.

1. Introduction and motivation

Rosetta will rendezvous with comet 67P/Churyumov-Gerasimenko in 2014. Two radiometric experiments are on-board: one passive, MIRO [1] and one active CONSERT [2]. MIRO, a dual-frequency radiometer, with one continuum channel at 190 GHz and another one at 563 GHz will determine the brightness temperature of the target surface and sub-surface. It has already provided data during the flybys of (2867) Steins and (21) Lutetia. CONSERT will investigate the deep interior of the nucleus by radio-waves transmitted from the orbiter and returned from the lander, with a carrier frequency at 90 MHz.

To support the Rosetta mission, dielectric properties of the target cometary nucleus have to be considered. A very low density is expected for the nucleus, with the surface and sub-surface possibly build up of porous fluffy granular material [e.g., 3]. With the density, size distribution and porosity of the dust particles still unknown (and most likely not uniform within the nucleus), the dependence of the dielectric properties on such parameters needs to be investigated on different frequencies. We are performing dielectric measurements (real and imaginary parts of the relative permittivity, respectively ε' and ε'') encompassing the above-mentioned frequencies on two types of porous granular materials.

2. Laboratory experiments

Dielectric properties of two porous granular materials, with different size distributions have been measured: Etna volcano pyroclastic deposits and JSC-MARS1 martian soil simulant. For each, we have prepared sub-samples, with relatively comparable sizes distributions. It was possible to obtain 4 sub-samples ($\phi < 50$ µm, $50 < \phi < 160$ µm, $160 < \phi < 355$ µm, $355 < \phi < 500$ µm) for Mars simulant and 3 sub-samples ($\phi < 80$ µm, $80 < \phi < 200$ µm, $200 < \phi < 315$ µm) for Etna deposits. Obtaining measurements on different size ranges of the same sample should point out the dependence of dielectric properties upon grain size distribution (and surface over volume ratio), if any.

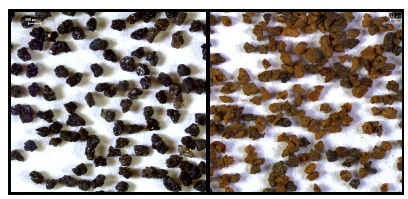

Figure 1: Etna pyroclastic deposits (left: $355 < \phi < 500$ µm) and JSC-MARS1 (right: $200 < \phi < 315$ µm).

Table 1 lists the spectral domain of the instruments that we used for dielectric property measurements on all sub-samples, at LERMA in Paris, as well as at IMS in Bordeaux (France).

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

Experiment (laboratory)	Spectral domain
Impedance analyzer (IMS)	50, 100, 500 MHz
Millimeter bench (LERMA)	190 GHz

3. Results and discussion

For a given sub-sample of JSC-MARS1 at 0.05, 0.1, 0.5 and 190 GHz, a slight decrease of the dielectric properties with increasing frequency is noticed. As an example, for sizes between 80 and 200 µm, ε' equals 3.7 ± 0.05, 3.6 ± 0.05, 3.5 ± 0.05, and 2.41 ± 0.04, respectively; ε'' equals 0.28 ± 0.05, 0.24 ± 0.05, 0.21 ± 0.05 and 0.15 ± 0.01, respectively. Besides, ε' and ε'' decrease when the grain size increases for 50, 100 and 500 MHz ; at 190 GHz, no significant change with the grain size distribution is noticed.

For Etna pyroclastic deposits, a slight decrease of ε' with increasing frequency is noticed at 0.05, 0.1 and 0.5 GHz for a given sub-sample. As an example, for sizes between 50 and 160 µm, ε' equals 3.54 ± 0.05, 3.51 ± 0.05, and 3.50 ± 0.05, respectively. Meanwhile, no significant change is noticed for ε''. At 190 GHz, dielectric properties tend to slowly increase with the grain size.

Previous measurements on JSC-MARS1 have been performed between 10 MHz and 1 GHz without splitting samples in sub-samples with narrower sizes distributions [4]. Our results at 50, 100 and 500 MHz are consistent with those measurements. Our measurements of ε' at 190 GHz for JSC-MARS1 are also consistent with other measurements at lower frequencies where ε' equals 3.09 ± 0.09 at 1.24 GHz [5], taking into account the suspected increase for lower frequencies.

Differences between the dielectric properties of the two samples could be due to intrinsic differences in composition and/or porosity. These topics will be addressed, together with possible further measurements, of interest to estimate the dielectric properties of cometary nuclei.

Acknowledgements

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