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Numerical simulations of PP-SESAME/Philae/ROSETTA operations during the Descent Phase and at the surface of the Churyumov-Gerasimenko nucleus

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The ROSETTA probe has never been so close to its target; the comet Churyumov-Gerasimenko that it will reach later this year. Among the instruments on board the lander, Philae, the Permittivity Probe (PP) experiment, which is part of the Surface Electric Sounding and Acoustic Monitoring Experiment (SESAME) package, will measure the low frequency complex permittivity (i.e. dielectric constant and electrical conductivity) of the first 2 meters of the subsurface of the cometary nucleus. At frequencies below 10 kHz, the electrical signature of the matter is especially sensitive to the presence of water ice and its temperature behavior. PP will thus allow to determine the water ice content in the near-surface and to monitor its diurnal and orbital variations thus providing essential insight on the activity and evolution of the cometary nucleus.

The PP instrument is based on the quadrupole array technique, which employs a set of transmitter and receiver electrodes for emitting alternating currents into a medium of interest. The complex permittivity of the cometary surface material is determined by measuring the magnitude and phase shift of both the emitted currents and the resulting potential difference at a pair of receiver electrodes. This technique has been used for many decades on Earth and recently helped to determine the electrical properties of the Huygens landing site on Titan (PWA/HASI experiment on Cassini-Huygens). In the case of PP, 5 electrodes can be used: 2 receiver electrodes are integrated into the lander feet while the transmitter electrodes are mounted on the third foot and on 2 other instruments.

In this paper we will present results from numerical simulations performed in order to model PP operations and prepare the scientific return of this experiment.

Though simple in theory, the inference of the complex permittivity from PP measurements is not straightforward in practice. In particular, the actual environment of the electrodes (lander body, feet, harpoons…) must be accounted for since the presence of nearby conducting objects will affect the data. We have thus developed a numerical model of the electrodes in their environment using COMSOL Multiphysics®. A simple version of this model was validated by comparison to laboratory measurements and analytical calculations.

This model was then used to simulate PP operations during the Descent Phase of the lander (i.e. in the void and as the ground gets closer) and once at the surface of the nucleus considering different types of surfaces. The first set of simulations will be very useful to better understand the calibration data that will be acquired after separation from the ROSETTA Orbiter while the second will illustrate the idealistic sensitivity of PP to the ground electrical properties.