A REVIEW OF PASSIVE R.F. ELECTRIC ANTENNAS AS *IN SITU* DETECTORS OF DUSTY PLASMAS IN SPACE

N. Meyer-Vernet, M. Moncuquet, I. Zouganelis, K. Issautier, M. Maksimovic, A. Lecacheux, P. Zarka, S. Hoang, and J.-L. Bougeret

nicole.meyer@obspm.fr, LESIA, Observatoire de Paris, 92195 Meudon Cedex, France

We review the basic principles and recent applications of (passive, radio frequency) electric antennas for *in situ* measurements of dusty plasmas in space, as summarised below.

Electric antennas as passive wave detectors are reliable and versatile tools for measuring plasma and dust in space, with the technique of Quasi Thermal Noise spectroscopy and its generalisation to dusty plasmas. Applications include the interplanetary medium, cometary plasma and dust tails, plasma environments of the Earth, Venus, Jupiter, and Saturn, and the E and G rings of Saturn, with antennas of various shapes aboard a number of spacecraft, including, most recently, Cassini. The technique is planned for plasma measurements on Bepi-Colombo at Mercury, on Stereo in interplanetary magnetic clouds, and in the Solar Orbiter and Solar Probe projects.

The diagnostics is based on the spectral analysis of the wave electric potential induced by the plasma particles and dust grains as they pass by the antennas, and/or impact them or the spacecraft. The technique has a great advantage over usual particle or dust detectors: its cross-section for detection is much larger than the surface of the detector itself, ensuring a great sensitivity and a quasi-immunity to spacecraft perturbations.

The spectral density induced by the passage of plasma particles - with their dressing popularly known as Debye shielding, Langmuir waves, Berstein waves and other members of the plasma menagerie - is easily calculated under stable conditions from the theory of the plasma quasi-thermal fluctuations. At low frequencies, the spectrum is dominated by the shot noise produced by particle impacts on (and/or emission from) the antenna (in dipole mode) or the spacecraft (in monopole mode), which produce a f^{-2} spectral density, proportional to the impact rate.

The generalisation to dust measurement is based on two main processes. The first one, which is generally dominant, is that dust grains impacting the spacecraft and antennas are vaporised and ionised, producing a plasma cloud that is partially recollected by the target. Since the charge delivered by vaporisation of a dust grain is roughly proportional to its mass, the signal is determined by the grain mass. The wave form and the spectral shape depend on the time scales of dust vaporisation and recollection. At frequencies greater than the inverse of the time scale for vaporisation and recollection, the spectrum varies as f^{-4}. The second technique is based on the electric potential induced by passing-by charged dust grains. Since the charge carried by a dust grain is essentially proportional to its size, the amplitude is determined in this case by the size of the grains rather than their mass.