

Short Electric-Field Antennae as Diagnostic Tools for Space Plasmas and Ground Permittivity

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Certain techniques that have been used for many years in geophysical prospection, in particular to measure the ground permittivity, have been successfully transposed to space plasmas. The basic principle of these techniques is to measure the self impedance of a single electric antenna or the mutual impedance between two sets of Hertz dipoles. Since the impedance of the probe depends on the dielectric properties of the medium in which the probe is immersed, it becomes possible to determine the main characteristics of this medium.

In this way, space plasma parameters such as the density and temperature of thermal electrons may be reliably and accurately deduced. As a bonus, natural waves may also be investigated in a large frequency range including characteristic plasma frequencies such as the lower- and upper-oblique resonances, the electron gyrofrequency and its harmonics, the plasma frequency, the upper hybrid frequency, and so on.

As any electrode immersed in a plasma acquires a charge, it perturbs the plasma in its immediate neighbourhood: an ion sheath is indeed created and insulates the electrode partially from the unperturbed plasma. The way to get around this difficulty is to use four electrodes, two for transmitting and two for receiving. The transmitting electrodes are excited from a signal generator, in series with a current meter if necessary, while the receiving electrodes are connected to a voltmeter with a very high input impedance. The transmitted current I and the received voltage V being known, the mutual impedance Z is by definition $Z = V/I$. Both the imaginary and the real parts of Z may then be interpreted to deduce plasma properties.

The quadripole probe has very recently been used on CASSINI/HUYGENS to measure the ground permittivity of Titan. The quadripole probe, or something similar, has also been implemented on sounding rockets and many spacecraft (GEOS-1, GEOS-2, VIKING, ARCAD/AUREOL-3, MARS-96, ROSETTA, and in the immediate future BepiColombo/MMO).