IN SITU DIAGNOSTIC OF DUSTY PLASMAS AT SATURN USING AN ELECTRIC ANTENNA OF CASSINI/RPWS

Moncuquet Michel, Nicole Meyer-Vernet, Alain Lecacheux, Zhenzhen Wang, Donald A. Gurnett
LESIA, Observatoire de Paris, 5 Place J. Janssen, Meudon, France 92195

ABSTRACT

On July 1st, 2004 the Cassini spacecraft performed its Saturn orbit insertion, twice crossing the equatorial plane at 2.5 Saturn radii between the G and F rings. The Radio and Plasma Waves Science (RPWS) experiment carries a large panoply of plasma and wave sensors, among which the one wire electric antenna (called Z-monopole) is the object of our study. The spectral analysis of the antenna voltage is done by the High Frequency Receiver (HFR), within the two frequency decades from 3 kHz to 300 kHz. Depending on the spacecraft distance to the ring plane, this antenna could detect (i) dust grain impacts on the spacecraft and/or (ii) shot noise due to plasma particles impacting the antenna/spacecraft (and to photoelectrons and secondary particles) and (iii) quasi thermal noise (mainly detectable in the vicinity of the upper hybrid frequency in this monopole configuration).

The spectroscopy of the quasi thermal noise, collected by the two other electric antennas of Cassini, arranged in dipole configuration, was studied by Moncuquet et al. [2005], who deduced the electron temperature and density along Cassini's orbit in the inner magnetosphere of Saturn. But the shot noise was generally negligible on the dipole antenna (except at lowest frequencies), while it may be dominant on the Z-monopole because we measure in this case the potential between a single wire and the spacecraft, which obviously offers a larger surface to the charged particle impacts than the two wires of the dipole antenna. Furthermore, in presence of dust, another contribution to the spectral density collected by such a monopole antenna can arise from dust grains which impact the spacecraft body, then are vaporized and ionized, producing a plasma cloud which is partially recollected by the spacecraft and/or the antenna. The impact rate as a function of time can be determined from the waveform data. The spectral analysis of the voltage induced on the antenna reveals properties of the dust grains. In particular, signals from dust and shot noise can be easily differentiated by examining their power spectral indices, of –4 and –2, respectively. This comes about because the relevant frequency range is greater than the inverse of the rise time of the voltage induced by dust impacts (which can be also determined from the waveform).

The purpose of the present study is thus to derive from Cassini radio observations the signatures of dust grain impacts, when the spacecraft crossed the ring plane of Saturn, in order to provide constraints on the dust size distribution between G and F rings, in the same way as Meyer-Vernet et al. [1996, 1998] have done in the case of Voyager 1 and 2 ring plane crossings, using additional information from the waveform data.

References:

Meyer-Vernet, N., A. Lecacheux, and B. Pedersen (1996), Constraints on Saturn’s E Ring from the Voyager 1 Radio Astronomy Instrument, Icarus, 123,113.

Meyer-Vernet, N., A. Lecacheux and B. Pedersen (1998), Constraints on Saturn’s G Ring from the Voyager 2 Radio Astronomy Instrument, Icarus, 132, 311.

Moncuquet, M., A. Lecacheux, N. Meyer-Vernet, B. Cecconi and W. Kurth, (2005) Quasi thermal noise spectroscopy in the inner magnetosphere of Saturn with Cassini/RPWS: Electron temperatures and density, submitted to Geophysical Research Letter.