Abstract

Statistics of Langmuir waves associated with type III solar radio bursts

Abstract: Interplanetary electron beams, produced by solar flares, are unstable in the solar wind and generate Langmuir waves at the local plasma frequency, f_p. These waves are then converted into the so-called Type III radio bursts which are freely propagating electromagnetic emissions at f_p or its harmonic. The Type IIIs are therefore observed as drifting emissions from high to low frequencies, in the kilometric wavelengths range. Since the first theoretical explanation by Ginzburg and Zhelezniakov (1958a), several refined models have attempted to describe in details the physical processes at the origin of Type III bursts. The mechanisms of "Bump-on-tail" instabilities, Langmuir waves generations, conversion of these Langmuir waves into radio emissions throughout nonlinear wave-wave interactions etc, have been studied in detail. Of particular interest from the observational point of view are the so called in-situ Type III bursts for which the electron beam, at the origin of the emission and traveling along open interplanetary magnetic field lines, is observed directly in-situ by a spacecraft, together with the local Langmuir waves and the resulting radio emissions. Until now only a few of these in-situ Type IIIs have been reported in the literature.

The first research study performed in this thesis was to examine the first 16 years of radio, waves and particles data recorded by the WIND spacecraft in the Solar Wind and to look for in-situ Type IIIs. Applying rigorous and careful criteria, this examination has yielded to a data set of 36 high-quality events. With such a numerous data set, which is statistically representative of the studied phenomenon, it is now possible to constrain observationally and with a better confidence the Type III generation models. After having built our statistical dataset, we have studied, for each of the events, the precise shapes of the Langmuir wave power distributions, observed in the spectral domain. We have fitted these observed distributions by a Pearson's system of probability distributions and have shown that the probability distributions of the logarithm of the Langmuir waves power spectral density belong to three "main" types of Pearson's probability distributions: type I, type IV and type VI. In addition we have modeled the effects of the instrumental integration time of the WIND radio receivers on the observed Langmuir wave power distributions. By combining our observations with our models we have shown that it was not possible to conclude definitively, that the distribution of the Langmuir waves energy in the real temporal domain is lognormal, as it is predicted in some theories as the Stochastic Growth Theory by Robinson (1992).

In the last part of the thesis, we have shown how our high-quality data set of 36 in-situ Type III events can be used for further studies that could allow to constrain the theoretical models even better. For instance we have investigated the correlation between the Langmuir waves power and the energy of impulsive electron or with the power of the radio emissions themselves.

Keywords: Solar wind; Langmuir waves; Electron beam; Type III radio bursts.