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Narrow band wave emissions and noise around the plasma frequency

in the solar wind

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The wave data obtained with a wide band instrument were recently used for interpretation of both quasi-thermal noise spectra and narrow band signals observed in the near vicinity of the local plasma frequency on CLUSTER II spacecraft in the solar wind, well upstream of the Earth's bow shock [1, 2] This approach is planned to continue with the large Cluster database and will be of use for other space missions such as Stereo and Solar Orbiter. If available, multi-component and/or multi-point measurements are expected to provide even greater insight in the generation of radio waves in the heliosphere in this frequency range.

Our approach is based on a novel study of performance of receiving antennas in resonance regions in a streaming plasma.

As far as noise spectra is concerned two distinctive features appear: a cutoff shifted down below the plasma frequency by a factor proportional to the ratio of stream velocity to the electron thermal velocity squared. The spectral maximum depends on the orientation of the antenna axis with respect to the stream velocity; it is shifted above the plasma frequency according to the antenna orientation, which is changing with the spacecraft spin. When the time resolution of the instrument is sufficient, it is possible to follow these changes. The overall form of the spectrum depends on the plasma distribution function, but even with a simplified model of two electron populations with largely different temperatures the estimates of the drift velocity and/or the temperature of the hot component can be obtained.

In the case of a quasi-harmonic wave (narrow band signal) incident on the antenna, it is the antenna's effective length that allows for conversion of the open circuit voltage induced on its terminals to the electric field of the incoming wave. We show that this effective length grows by more than an order of magnitude under resonance conditions.

This was already confirmed for waves propagating close to the lower oblique resonance cone in a magnetized plasma of the polar ionosphere in the Oedipus-C rocket experiment [3].

The fact that the effective length can exceed the antenna physical length might seem counterintuitive. Our explanation is related to the fact that in such cases the wave number surfaces (of Langmuir waves in a streaming plasma, or waves on the resonance cone in a magnetized plasma) show directions where either two waves coalesce, with the group velocity perpendicular to the phase velocity, or there exists a whole grouping of waves with a large spectrum of wave vectors but propagating in a narrow angle downstream with the solar wind at the plasma frequency.

In the spectra obtained from wide band instrument on Cluster when the spacecraft was in the solar wind, an intense narrow line appears near the plasma frequency above the background of quasi-thermal noise, sporadically but not rarely. The existence, frequency dependence, bandwidth and amplitude of the background noise are quite well explained with a model of a two temperature plasma mentioned above. The amplitude of the narrow line exceeds the noise by about an order of magnitude. According to our findings the waves going downstream from the source to the receiver are recorded with high amplitude, so that the overall appearance of the waveforms conforms well with a signature of a source of plasma waves situated upstream from the spacecraft modulated due to the interplay of radiation patterns of the source and the receiving antenna. As these wave trains are often recorded by at least two spacecraft with a small time shift, a location and even the spatial extent of the source can be estimated. The amplitude modulation of such a signal contains also information on the radiation source, which may be e.g. a particle beam radiating through the Cherenkov effect. In such a case the radiation pattern is that of an electric field distribution on a Cherenkov cone emanating from the source and crossing the receiving point on either spacecraft.

We conclude that this approach is able to help in understanding of spectral amplitudes of narrow band and noise emissions in the solar wind.

References:

[1] Yu.V. Chugunov, V. Fiala, J. Soucek, O. Santolik: Noise induced on an electric antenna and its effective length in solar wind: Application to Cluster observations, *Adv. Space Res.* **37**, 1538-1543, 2006.

[2] Yu.V. Chugunov, V. Fiala: Effective length of a receiving antenna in a streaming plasma, *IEEE Trans. Antennas and Propagation*, **54**, 2750-2756, 2006.

[3] Yu.V. Chugunov, E.A. Mareev, V. Fiala, H.G. James: Transmission of waves near the lower oblique resonance using dipoles in the ionosphere, *Radio Sci.*, **38**(2), 1022, doi:10.1029/2001RS002531, 2003.