RADIATIONS AT TWICE THE SOLAR-WIND PLASMA FREQUENCY UPSTREAM OF THE EARTH'S BOW SHOCK

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ABSTRACT

Radiations at twice the plasma frequency, Fpe, have been commonly observed in the foreshock regions upstream of the Earth's bow shock and far beyond. These electromagnetic radiations are thought to be produced in the electron foreshock and most probably close to the interplanetary magnetic field line tangent to the shock surface. They are often seen simultaneously with suprathermal electrons that are energized at the shock and are backstreaming from it. The objective of the current presentation is to show and discuss 2Fpe radiation events recorded onboard the four CLUSTER spacecraft by the WHISPER relaxation sounder.

INTRODUCTION

Radiations at twice the plasma frequency, Fpe, have been commonly observed in the foreshock regions upstream of the Earth's bow shock and far beyond. They have indeed been detected onboard several spacecraft, such as OGO 1 and 3, IMP 6 and 8, ISEE 1, 2, and 3 [1], and GEOTAIL [2]. These electromagnetic radiations are thought to be produced in the electron foreshock and most probably close to the interplanetary magnetic field line tangent to the shock surface. They are often seen simultaneously with suprathermal electrons that are energized at the shock and are backstreaming from it. Electrons accelerated at the shock over a wide range of energies propagate along field lines that are connected to the shock surface. From a time-of-flight effect, these electrons have a velocity distribution function that is unstable to the production of Langmuir waves. How the 2Fpe radiations are forwards generated is not fully understood, nevertheless a mechanism similar to the one proposed for type III solar radio bursts has been put forward. Primary Langmuir waves would be generated by an electron beam, they would produce backscattered Langmuir waves by a decay or a coalescence involving ion sound waves. The 2Fpe radiations would then result from a coupling between primary and backscattered waves.

2Fpe RADIATIONS AS SEEN BY THE CLUSTER/WHISPER

The objective of the current presentation is to show and analyse 2Fpe radiation events recorded on the CLUSTER spacecraft by the WHISPER experiment [3]. In passive mode, in addition to the 2Fpe radiation an intense broadband noise is usually observed above and/or below the plasma frequency, Fpe, when the spacecraft is in the electron foreshock (on a magnetic field line connected to the bow shock and not too far from the tangent field line), while a weak narrow band noise may be seen a little bit above Fpe in the free solar wind (Fig. 1). This means than sometimes the Fpe determination is somewhat uncertain. Fortunately, the strong resonance triggered by the WHISPER relaxation sounder, when in an active mode, allows us to reliably and accurately give this frequency value [4] [5].

To determine whether the spacecraft is in the electron foreshock region or not, connection parameters are computed: in particular the depth of penetration, which is the distance from the spacecraft to the shock tangent field line measured parallel to the solar wind velocity vector, and the time-of-flight distance, which is actually the distance from the bow shock to the spacecraft covered by the electrons that are reflected at the tangent point (see Fig.2). The reference plane is the so-called B-v plane, which contains the spacecraft, the solar wind velocity, and the magnetic field line that passes through the spacecraft position [6]. The bow shock model used to compute the connection parameters is a conic section with a cylindrical symmetry about the mean solar wind direction, assuming a 4° aberration angle [7]. For each of the spacecraft orbits, the conic semi-latus rectum is determined by the position of the inbound and outbound shock crossings.

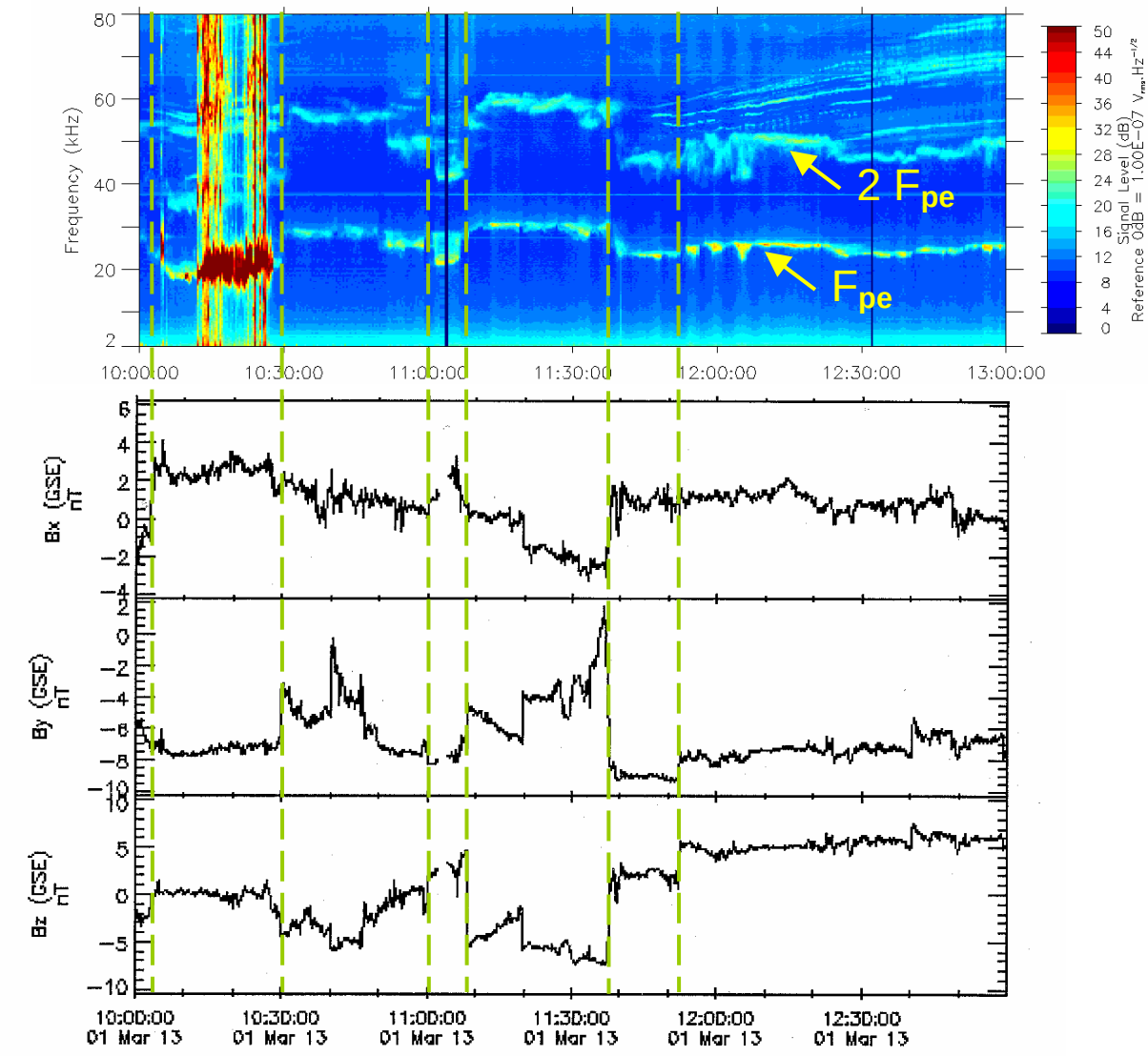

Fig.1. A 2Fpe radiation event recorded by the WHISPER relaxation sounder onboard CLUSTER 1 on 13 March 2001 (top) and magnetic field components expressed in GSE coordinates (courtesy of the magnetometer team).

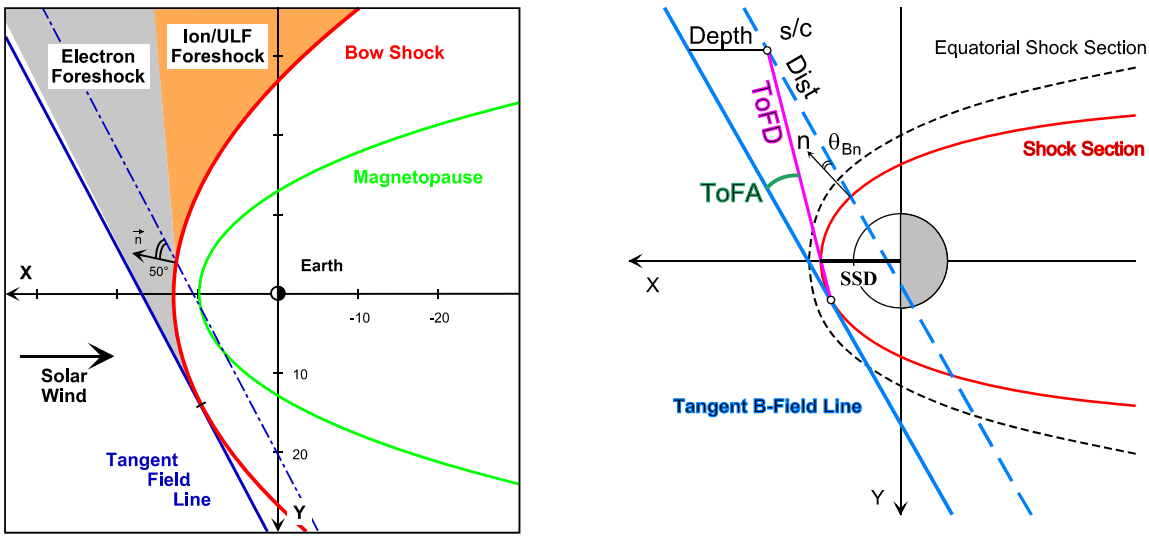

Fig. 2. Foreshock geometry (left) and parameters in the so-called B-v plane (right).

In addition, the observed strong modulations of the 2 Fpe signal intensity have been used to determine the apparent location of the 2Fpe radiation source. Surprisingly the source extension seems to be often limited. This could be due to current solar wind behaviours. Indeed, the interplanetary magnetic field direction and the solar wind density were sometimes varying abruptly (Fig.1).

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