GENERATION OF UPSTREAM ELECTROMAGNETIC PLASMA OSCILLATIONS IN DENSITY GRADIENTS

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ABSTRACT

Electrostatic and electromagnetic wave emissions at the electron plasma frequency and its harmonics are commonly observed in the upstream region of the bow shock. Here, the generation of plasma waves by an electron beam moving through a density gradient in the upstream foreshock region is examined. Numerical simulations have been carried out for the case of a beam moving through various types of density gradients to study the generation of electromagnetic waves through linear mode conversion and other processes.

RESULTS

A one-dimensional (1D) electromagnetic (EM) particle in cell simulation has been run that includes a background plasma that has a bowl shaped density cavity. The density at the lowest point is 0.5 the background density (n_o). A spatially finite beam with density $n_{beam} = 0.05n_o$ and drift speed $U = 0.5v_{te}$ is included. Fig. 1 shows the initial density profile on the left (cavity at the system center), and the phase space at the beginning and end of the simulation run.

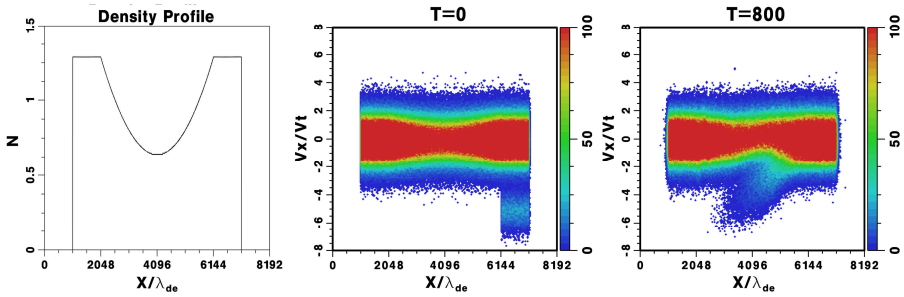

Fig. 1. Initial density profile and phase space (velocity vs. position) at two different times during the 1D EM run.

The electrostatic (ES) and electromagnetic (EM) wave spectrum from the simulation run is shown in Fig. 2.

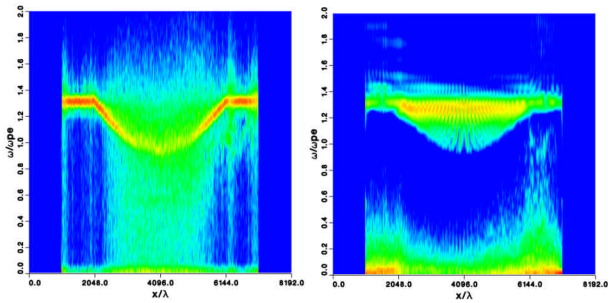

Fig. 2. Power spectrum shows frequency vs. position color-coded (red most intense) for ES (left) and EM (right) waves.

The beam generates electrostatic waves at the local electron plasma frequency (ω_{pe}), which decreases inside the density cavity (left panel of Fig. 2). The presence of the electrostatic plasma waves in the density gradient leads to the generation of electromagnetic waves due to linear mode conversion and the EM waves propagate within the density cavity, forming a strong EM emission at the local ω_{pe} (right panel of Fig. 2). This process only occurs at an oblique angle with respect to the ambient magnetic field and it was found by doing a number of simulation runs at different angles that the peak EM emission occurred at about 40° (results shown above). This result is in approximate agreement with linear mode conversion analytic theory.