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Nonlinear decay of Langmuir waves observed by CLUSTER in the terrestrial foreshock

J. Soucek (1,2), V. Krasnoselskikh (2), T. Dudok de Wit (2), J. Pickett (3), O. Santolik (4)

(1) Department of Space Physics, Institute of Atmospheric Physics, Prague, Czech Republic, (2) LPCE/CNRS, Orléans, France, (3) Department of Physics and Astronomy, University of Iowa, Iowa, USA, (4) Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic

In this work we investigate the nonlinear decay of Langmuir waves in the terrestrial foreshock. Beams of energetic electrons accelerated by the bow shock are known to generate electrostatic waves in the vicinity of the plasma frequency via the beam-plasma instability. In cases where the waves grow to very high amplitudes, the wave-particle processes are not sufficient to saturate the growth and a non-linear decay process sets in. In maxwellian plasmas this decay transfers the energy of the primary wave to two other waves at lower frequencies: another Langmuir wave and an ion-acoustic wave. However, the presence of a suprathermal electron population in the solar wind plasma opens a second channel for this decay process where the primary wave decays into an electron-acoustic wave and an ion-acoustic wave.

The existence and importance of the decay instability in the terrestrial foreshock has not been sufficiently assessed by previous works. We address this problem by analysis of high frequency electric field waveforms from the WBD instrument of CLUSTER. The spectra observed in the foreshock often contain triplets of peaks corresponding to two waves close to the plasma frequency and one low frequency wave in the range from 1 kHz to 5 kHz. Consistently with previous studies, we interpret these spectra as a signature of a parametric decay of Langmuir waves. By statistical analysis, we show that the frequencies of these wave triplets in often satisfy the resonance conditions required for the decay process and they are more likely to be satisfied for the larger amplitude waves. Another indication in favor of the decay scenario is a strong correlation of ion-acoustic wave activity observed by STAFF instrument with bursts

of most intense Langmuir waves observed by WBD. All the observed spectral peaks are significantly Doppler shifted in frequency by the solar wind flow. For some waveforms the observed Doppler shift of the secondary wave is larger than a theoretical maximum allowed by a dispersion relation of Langmuir waves. From this discrepancy we conclude, that at least in some cases the secondary wave produced by the decay is an electron-acoustic wave.