STEREO/WAVES Science Nugget
November 20, 2012

Electrostatic decay of Langmuir/z-mode waves in type III solar radio bursts

Intense Langmuir waves observed in the source regions of type III solar radio bursts are generated by electrons streaming along magnetic field lines away from the Sun. These electron beams can propagate several AU, requiring a process to shift Langmuir waves out of resonance with the beam. The process or processes which shift Langmuir waves out of resonance with the electron beam and produce the observed radio waves are not well understood.

One of the proposed mechanisms for shifting Langmuir waves out of resonance with an electron beam and producing radio waves is electrostatic decay, in which Langmuir waves decay into counter-propagating Langmuir waves and forward-going ion-acoustic waves. It is not widely known that magnetization effects are important for Langmuir waves even in the weakly magnetized solar wind. These effects cause the unmagnetized Langmuir mode to combine with the magnetoionic z-mode to form the Langmuir/z mode: at the typical wave numbers driven by type III electron beams the combined mode is closely Langmuir-like, with electric fields parallel to the magnetic field, but at lower wave numbers the z-mode character can dominate and the wave electric field is almost perpendicular to the magnetic field.

STEREO/WAVES records electric field waveforms in three orthogonal directions and the high cadance and long recording time ($\sim 65\,\mathrm{ms}$) mean the Doppler-shifted frequency differences between Langmuir/z-modes at distinct wave numbers can be resolved and the relative strengths of fields parallel and perpendicular to the local magnetic field can be calculated.

A survey of approximately 600 waveforms observed in type III source regions reveals that approximately 40% have two or more distinct spectral peaks near the electron plasma frequency that are suggestive of electrostatic decay. The frequency differences observed between the two stongest spectral peaks agree very well with the prediction for electrostatic decay and with the observed frequency of the ion-acoustic waves (Figure 1). For slower beam speeds ($v_b/c \lesssim 0.1$) the perpendicular electric field is generally weak and the Doppler-shifted frequency differences are generally consistent with decay to counter-propagating Langmuir-like waves [Figure 1(a) and (b)]. For faster beam speeds ($v_b/c \gtrsim 0.1$) strong perpendicular fields are often observed and Doppler-shifted frequency differences are generally consistent with decay of Langmuir-like waves to z-mode waves at low wave numbers [Figure 1(c) and (d)].

These analyses provide evidence for electrostatic decay of Langmuir/z-mode waves being a common process in type III source regions, plausibly playing major roles in decoupling Langmuir waves from the electron beam and producing radio waves.

Graham, D. B.; and Cairns, Iver H.: 2012, Journal of Geophysical Research, Submitted. *Electrostatic decay of Langmuir/z-mode waves in type III solar radio bursts*

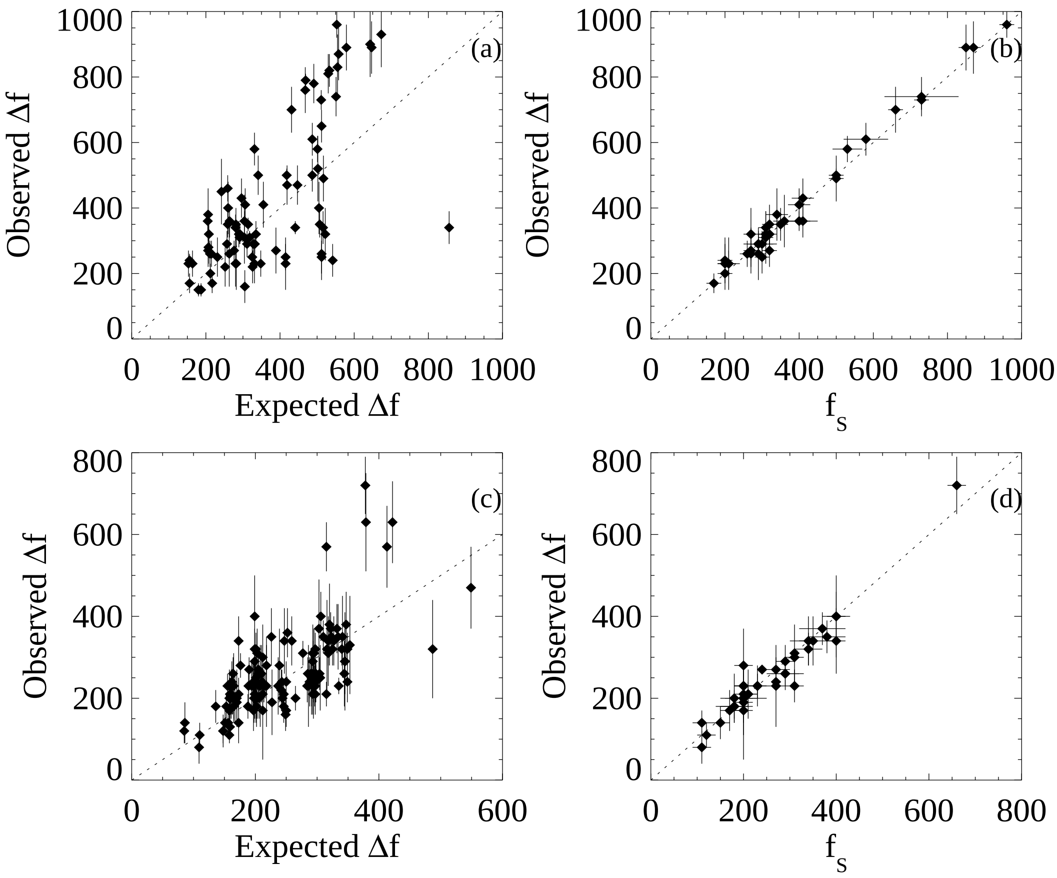

Figure 1: (a) Observed Doppler-shifted frequency differences $\Delta f^d_{LL'}$ versus predicted $\Delta f^d_{LL'}$ and (b) Observed $\Delta f^d_{LL'}$ versus Doppler-shifted ion-acoustic frequency f^d_S for events with weak fields perpendicular to $\mathbf{B}$. (c) Observed Doppler-shifted frequency differences Δf^d_{LC} versus predicted Δf^d_{LC} and (d) Observed Δf^d_{LC} versus Doppler-shifted ion-acoustic frequency f^d_S for events with strong fields perpendicular to $\mathbf{B}$. Dotted lines correspond to equal observed and predicted values in (a) and (c) and frequency differences equal to the observed ion-acoustic frequency in (b) and (d).