# EVIDENCE FOR FOUR AND THREE WAVE INTERACTIONS IN TYPE III RADIO BURSTS: HIGHER ORDER SPECTRAL ANALYSIS

The sources of type III solar radio bursts serve as the natural laboratories of beam-plasma systems. One of the unresolved issues is the so-called Sturrock's dilemma: How does the electron beam preserve the bump-on-tail distribution over distances of 1 AU and more against the quasi-linear relaxation, which is known to disrupt the beam within 100 km or less? The second issue concerns mechanism or mechanisms, responsible for conversion of Langmuir waves into escaping radiation. Using the high time resolution observations of Langmuir waves from the improved time domain sampler (TDS) of the STEREO/WAVES experiment (improved over that of all similar high time resolution receivers flown in earlier spacecraft in precision, linearity, sample length and rate) and the newly developed higher order spectral analysis techniques, namely, bispectral and trispectral analysis techniques, for the first time, we show that (1) the four wave interaction, called the oscillating two stream instability is probably responsible for stabilization of the electron beams, (2) the second harmonic emissions are probably due to coalescence of Langmuir waves trapped in the density cavities associated with Langmuir envelope solitons, and (3) the third harmonic emissions are due to coalescence of the trapped Langmuir waves with second harmonic electromagnetic waves.

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2. Thejappa, G., R. J. MacDowall, and M. Bergamo (2012b), Phase coupling in Langmuir wave packets: Evidence of four wave interactions in solar type III radio bursts, Geophysical Research Letters, 39, L05103, doi:10.1029/2012GL051017.

3. Thejappa, G., R. J. MacDowall, and M. Bergamo (2012c), In situ Detection of Strong Langmuir Turbulence Processes in Solar Type III Radio Bursts, Journal of Geophysical Research, 117, A08111, doi:10.1029/2012JA017695, (2012c).

4. Thejappa, G., R. J. MacDowall, and M. Bergamo (2012d), Detection of Collapsing Langmuir Wave Packets in Solar Type III Radio Bursts, To appear in Proceedings of Solar Wind 13 (2012d).

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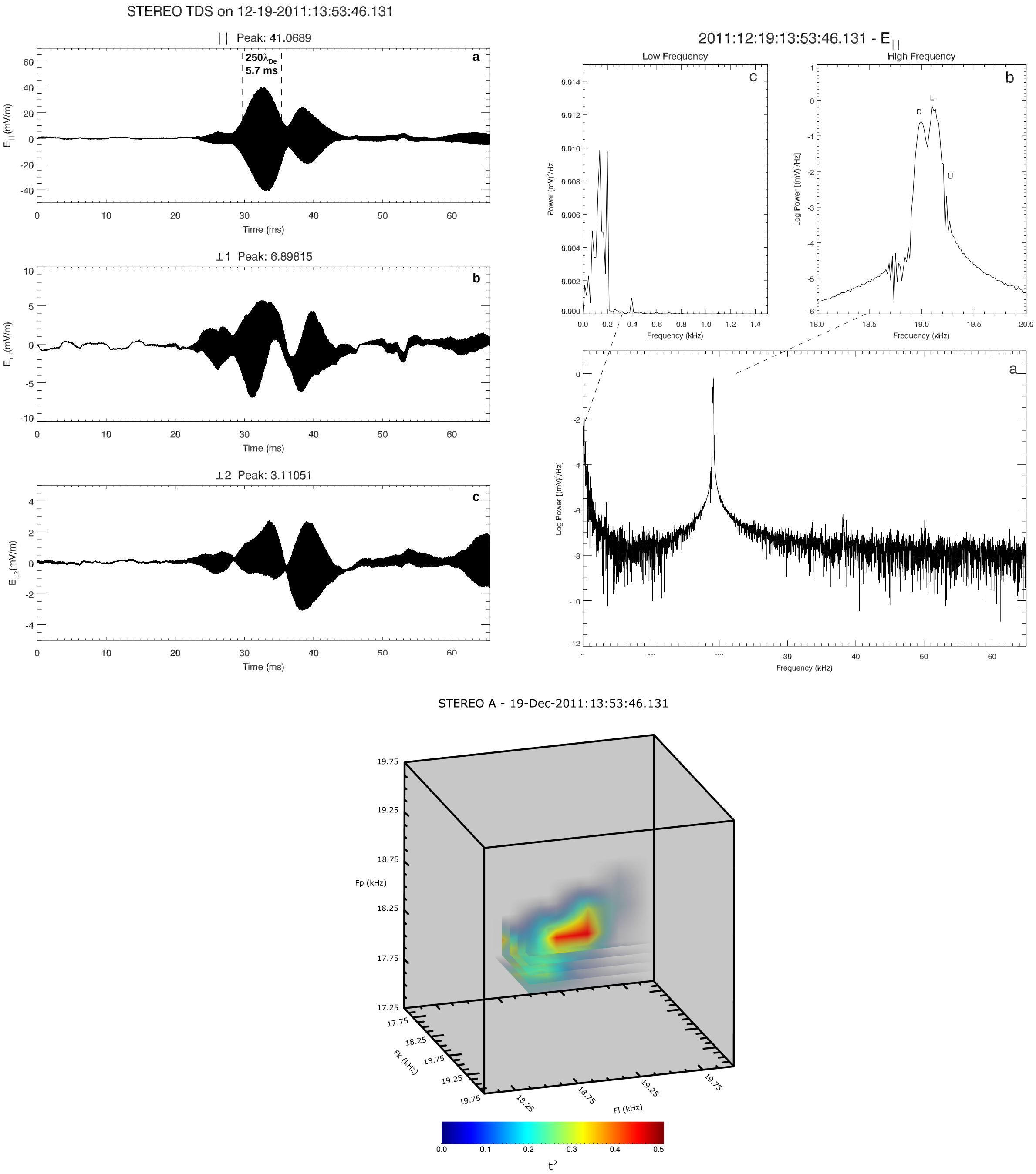


Fig. 1.— Left top panel: The parallel and perpendicular electric field components of the Langmuir wave packet with respect to the magnetic field. Right top panel: (a) The complete spectrum of the parallel component of the wave packet, (b) the narrow spectrum around $f \sim f_{pe} \sim 19.12$ kHz, where $L$, $D$, and $U$ correspond to the beam excited Langmuir wave, down-shifted sideband at $\sim 19$ kHz, and up-shifted sideband at $\sim 19.3$ kHz, respectively, and (c) the low frequency spectrum: the enhancement below 200 Hz corresponds to ion-sound waves. Bottom Panel: The 3-D representation of the tricoherence spectrum $t^2(F_k, F_l, F_p)$ of the parallel component of the wave packet. The tricoherence $t^2$ exhibits peak value of $\sim 0.5$ at ($\sim 19.25$, $\sim 19$, $\sim 18.75$) kHz, which quantifies the phase relation $2\phi_L = \phi_D + \phi_U$, where $\phi_L$, $\phi_D$ and $\phi_U$ are the phases of the beam-excited Langmuir wave at $\sim 19.12$ kHz, Stokes ($\sim 19$ kHz) and anti-Stokes ($\sim 19.3$ kHz) modes, respectively

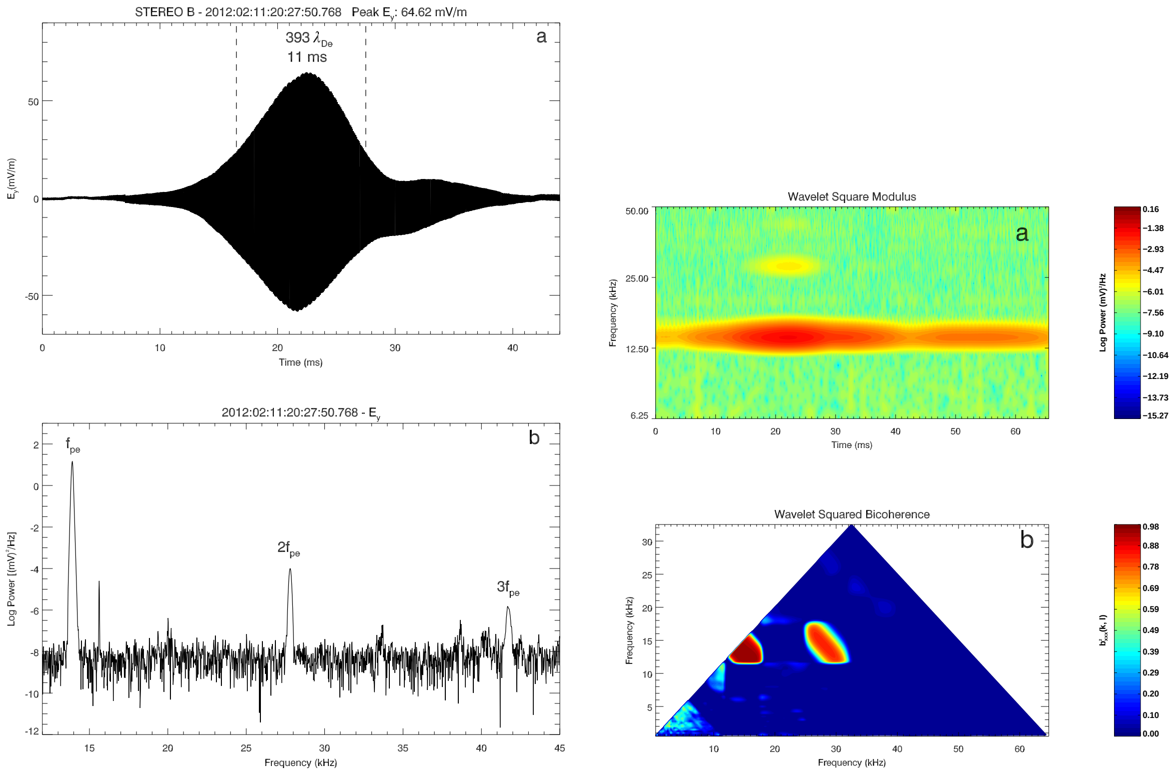


Fig. 2.— Left panel (a): The parallel electric field component of the Langmuir wave packet with respect to the magnetic field. Left panel (b): The FFT spectrum of the parallel component of the TDS event. The primary spectral peak at $\sim 14$ kHz is identified as that of Langmuir waves excited at the local electron plasma frequency, $f_{pe}$, and the secondary peaks at $\sim 28$ kHz and $\sim 42$ kHz are identified as that of electromagnetic waves at $2f_{pe}$ and $3f_{pe}$, respectively. Right panel (a): The wavelet based time-frequency spectrogram of the parallel component of the wave packet. This spectrogram clearly shows that the fundamental and higher harmonics are coincident in time, and higher the harmonic, weaker the emission. Right panel (b): The wavelet based bicoherence spectrum of the parallel component of the wave packet. The peaks seen in this bicoherence spectrum at $(f_{pe},\ f_{pe})$ =$(\sim 14, \sim 14)$ kHz and at $(2f_{pe},\ f_{pe}) = (\sim 28, \sim 14)$ kHz are the signatures of the three wave interactions: (14 kHz, 14 kHz) $\rightarrow$ 28 kHz and (28 kHz, 14 kHz) $\rightarrow$ 42 kHz, respectively.