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Direct evidence for three-wave coupling in the solar wind during a type III burst: STEREO/WAVES observations and Vlasov simulations

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The electrostatic parametric instability enables a finite amplitude Langmuir wave (L) to decay into a second Langmuir wave (L') and ion acoustic density fluctuations (S): $L \rightarrow L' + S$. This mechanism is thought to be a first step toward the generation of type III radio emission at twice the plasma frequency ($EM_{2f_{pe}}$) from the coalescence of the two Langmuir waves: $L + L' \rightarrow EM_{2f_{pe}}$.

By using the TDS (Time Domain Sampler) of the STEREO/WAVES, Henri et al. (2009) recently reported a complete set of direct evidence for electrostatic Langmuir decay during a type III burst. First, the conservation of momentum and energy is checked on the different available in-situ electric field waveforms through the resonant conditions on frequencies. Second, using information on the phase of the waves, a bicoherence analysis shows a good phase locking between the three waves on the different waveforms, characteristic of quadratic resonant interactions. Third, wavelet analysis allows to resolve for the first time the spatial scale of the coupling regions, which is estimated to be 18 ± 5 km.

This observationnal analysis was completed by numerical simulations to check validity of the parametric instability approach with solar wind conditions [Henri et al., 2010]. Two specific cases have been studied : (i) when the ratio of electron to proton temperature ratio is closed to unity (in that case the ion acoustic waves are Landau-damped, which could limit or prevent the decay instability); (ii) when the initial Langmuir wave is a wavepacket (and not a monochromatic waves as usually assumed in former studies). New instability thresholds are computed that allows to confirm the range of energy where the Langmuir decay is observed.

Bibliography:

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