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Nonlinear Versus Linear Processes for Langmuir waves

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Langmuir waves in space plasmas are always bursty with widely varying electric fields that sometimes approach the thresholds for nonlinear physics. Radio waves near the electron plasma frequency and twice that frequency are often observed, as are ion acoustic-like waves and localized Langmuir wave packets, all possibly interpreted in terms of nonlinear processes. In contrast, the Langmuir fields typically have longnormal statistics, implying self-organization and consistent with stochastic growth theory (SGT) and primarily linear processes governing the wave growth. Similarly, the fundamental radiation can be produced by linear mode conversion of Langmuir waves in density irregularities. Recent work on four related topics is presented here. (1) Vlasov simulations show that wave damping is a critical phenomenon, with classic Landau damping occurring below a nonlinear threshold. (2) Averaging the effificeny of linear mode conversion over the distribution of Langmuir wave vectors and density irrefulatities results in an averaged efficiency near 10^{-6} for solar wind parameters, about 5 orders of magnitude smaller than the unaveraged efficoemcu. (3) Evidence exists that the nonlinear electrostatic decay $L \rightarrow L^1 + S$ proceeds in Earth's foreshock and type III sources. Here L, L^1 and S denote beam-driven and backscattered Langmuir waves and ion acoustic waves, respectively. (4) The observed Langmuir field statistics are primarily lognormal, suggesting that nonlinear processes like electrostatic decay are relevant to only a small fraction of the observed fields (i.e., the highest ones).

Keywords: Nonlinear processes; linear mode conversion; Landau damping critical phenomena; instabilities; stochastic growth theory; Langmuir waves; beam-plasma interactions.