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Dynamics of Fundamental Electromagnetic Emission via Beam-driven Langmuir Waves

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The nonlinear process of electromagnetic Langmuir decay, which leads to radio emission near the plasma frequency, is studied for situations in which Langmuir waves are directly driven by an electron beam and indirectly generated via electrostatic Langmuir decays. The electromagnetic Langmuir decay is stimulated by the presence of ion-acoustic waves from the electrostatic decays. An approximate method is devised for studying this emission process with axial symmetry (along the direction of beam propagation) in three spatial dimensions, based upon the Langmuir and ion-acoustic wave dynamics in one spatial dimension. Numerical studies of the fundamental emission process starting from electron dynamics are then carried out via quasilinear theory, and the results are explored for illustrative parameters of type III solar radio emissions at 1 AU. The evolution of the fundamental transverse waves shows the combined effects of local emission and propagation away from the source. At a given location, the emission rate shows a series of peaks associated with successive electromagnetic decays of the Langmuir waves, which are either driven by the beam or produced by successive electrostatic decays. In addition, the relevant dominance of the fundamental emission and the second harmonic emission studied in our previous work is examined.