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One dimensional electromagnetic simulation of multiple electron beams propagating in space plasmas

Fernando Simões Junior and Maria Virgínia Alves
National Institute of Space Research, Associated Plasma Laboratory, Sao Jose dos Campos, Brazil (fernando@plasma.inpe.br)

It is by now well known that electron beams play an important role in generating radio emissions such as type II and type III radio bursts, commonly observed by spacecraft in the interplanetary medium. Electron beams streaming back from Earth's bow shock into the solar wind have been proposed as a possible source for the electron plasma waves observed by spacecraft in the electron foreshock. Recent observations suggest that during the natural evolution of the foreshock plasma, multiple electron beams could be injected over a period of time, losing their individual identity to coalesce into a single beam. In this work we use an electromagnetic PIC code "KEMPO 1D, adapted" to simulate two electron beams which are injected into a plasma at different times. The first beam disturbs the background plasma and generates Langmuir waves by electron beam-plasma interaction. Subsequently, another beam is inserted into the system and interacts with the first one and with the driven Langmuir waves to produce electromagnetic radiation. The results of our simulation show that the first beam can produce electrostatic harmonics of the plasma frequency while the second beam intensifies the emission at the harmonics that are produced by the first one. The behavior of the second beam is strongly determined by the pre-existing Langmuir wave electric fields. The simulations also show, as a result of the interaction between both beams, a clear nonlinear frequency shift of the harmonic modes, as well as an increasing of electromagnetic and kinetic energies of the wave-particle system.