Efficient electromagnetic emission from plasma with continuously injected counterstreaming electron beams

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Plasma with an electron beam is considered as a source of powerful electromagnetic (EM) emission in various space and laboratory environments. It is well known that in presence of two counterstreaming beams radiation efficiency significantly grows in contrast to the single beam case. This is explained by the fact that the most intense counterpropagating beam-driven Langmuir waves in such a system can directly participate in three-wave interactions with EM waves. In the case of a single beam, such emission becomes possible only due to some intermediate nonlinear processes producing backward propagating Langmuir waves.

We have shown [1] that it is possible to find the regime in which the most unstable beam-driven modes with the growth-rate $\Gamma(k_\parallel, k_\perp)$ lies inside in the region of three-wave interaction:

$$\left| \omega(k_\parallel, k_\perp) - \sqrt{k_\perp^2 + \frac{1}{4}} \right| \leq \Gamma(k_\parallel, k_\perp).$$

This has been achieved through a new algorithm, which allow to calculate the dielectric tensor in the framework of the relativistic kinetic theory that allows one to consider arbitrary axially symmetric beam and plasma distribution functions in arbitrary magnetic field.

Predictions of the linear theory has been verified by electromagnetic particle-in-cell simulations in the model of infinite plasma[1]. But in this widely used model, beams have a finite amount of energy and only a discrete spectrum of EM waves is possible. In the real problem of continuous injection of a fresh electron beam through a plasma boundary, the nonlinear stage of beam-plasma interaction differs substantially. In particular, in the regime found in [1], beam currents are not compensated by plasma electrons and beams are significantly compressed near the collision point.

In this work we investigate the possibility to find appropriate beam-plasma regimes for EM emission through three-wave process, which will holds for a realistic model[?] with open boundary conditions and continuously injected electron beams.

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References