Another view on electron beam-plasma interaction and related phenomena

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Common studies of electron beam-plasma interaction of the last decades were mainly focused on the beam instability and associated saturation processes due to wave-particle interaction. In spite of constant efforts, there are still unsolved problems of great importance. One is the interpretation of Langmuir amplitude modulations which are observed in the solar wind or in the planetary foreshock regions. Another challenge is still the question how the (electromagnetic) second harmonics of the Langmuir wave, in space physics known as type III radiation, is generated over large distances.

Here, we go another way by looking for the wave spectrum which belongs to the plasma state after the beam has saturated. Especially, the appearance of Langmuir oscillations is studied in beam-plasmas in which the saturation process ends with the formation of a plateau distribution. This saturated state represents a current which is shown to drive homogeneous electric field oscillations at the plasma frequency. This simple mechanism has been ignored in most numerical studies based on Vlasov or particle-in-cell (PIC) simulations because of the use of the Poisson equation which is not suitable to describe the mechanism of current drive; instead Ampere's law must be used. A simple fluid description of stable plateau plasmas, coupled with Ampere's law, is applied to illustrate the basic elements of current-driven Langmuir oscillations. If beam-generated Langmuir/electron-acoustic waves with frequencies above or below the plasma frequency are simultaneously present, the beating of both wave modes leads to Langmuir amplitude modulations. Thus, no parametric decay process is required to explain this often-observed phenomenon.

In addition, linear plasma response theory and PIC simulations have proven to be useful tools for investigating different aspects of Langmuir oscillations and related phenomena. A particularly interesting aspect concerns the evidence of electromagnetic second harmonic generation (type III radiation) by nonlinear interaction of Langmuir oscillations. Since the stabilized plasma plateau may propagate over large distances, the originally existing discrepancy between fast beam stabilization and long lasting type III radiation seems to be resolved.