STABILIZATION OF ELECTRON BEAM PLASMA INTERACTION IN A LANGMUIR TURBULENCE REGIME

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An electron-beam plasma system constitutes one of the most simple and interesting configuration to study plasma wave particle interactions, significant for basic plasma physics research. The electron beam provides a free energy source for a rich variety of nonlinear processes to evolve in a plasma. The collective relaxation of the electron beam depends on the resonant interaction between the beam and the wave that it has excited. For small amplitude, $\bar{W}_0 \ll (k_0\lambda_D)^2$, the theories can be classified into two categories: the cold beam case with $\Delta v/v_b \ll \eta^{1/3}$ and the warm beam case with $\Delta v/v_b \gg \eta^{1/3}$, where $\eta = n_b/n_0$. For the cold beam case, axial beam broadening occurs through the process of beam trapping. For the warm beam case, the beam relaxation occurs through "plateau" formation by flattening the beam distribution function within a characteristic propagation distance $L_r \propto \eta$. If the wave intensity is strong enough to reach the nonlinear threshold, $\bar{W}_0 \gg (k_0\lambda_D)^2$, the beam relaxation process is completely changed. In that case the wave can naturally excite self-modulation of the wave packet inside density cavities which is called modulational instability (MI). As a result, the electron beam can propagate through the plasma relatively unperturbed while retaining most of its energy. In this paper we present experimental results on the beam plasma interaction in a wide region of parameters that gives the possibility to study the transition from quasilinear to nonlinear regime of beam relaxation. The plasma and the beam parameters used are: $10^8 \leq n_0 \leq 10^{10}\, cm^{-3}$; $10^{-4} \leq n_b/n_0 \leq 5 \times 10^{-2}$; $T_e \simeq 2\, eV$; $50 \leq E_b \leq 250 eV$; $\Delta v_b/v_b \simeq 10\%$. The variation of the relaxation length against n_b/n_0 presents three different regions of behavior: the first part corresponds to the quasilinear theory; the second part shows that the relaxation length enters a plateau, as a result of the long wavelength oscillation dissipation by density fluctuation scattering due to development of MI; the third part, at large beam plasma ratio densities, the relaxation length decreases as n_b/n_0 increases as a result of a "free" development of MI. The range of n_b/n_0 for the three regions depends on the beam energy E_b.