Nonlinear features of the energy beam-driven instability

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A concern with ignited fusion plasmas is that, as a result of the instabilities they trigger, the high-energy particles eject themselves before they could give their energy to the core to sustain the reaction. Similarities between this class of instabilities and the so-called Berk-Breizman problem [1] motivate us to study a single-mode instability driven by an energetic particle beam.

For this purpose, a one dimensional Vlasov simulation [2] is extended to include a Krook collision operator and external damping processes. The code is benchmarked with previous work [3]. The fully nonlinear behavior is recovered in the whole parameter space characterized by an effective relaxation rate ν_a and an external damping rate γ_d. Steady state, periodic and chaotic behaviors are observed in nonlinear solutions.

In the regime above marginal stability where both ν_a and γ_d are smaller than the linear drive γ_L, we observe a good agreement of steady saturation levels between the simulation and theory [4]. Near marginal stability, the role of the normalized relaxation rate $\nu_a/(\gamma_L-\gamma_d)$, which is a key parameter to predict the behavior of the solution [5], is investigated for an initial distribution with relatively small γ_L, which correspond to the situation considered in the theory. In the low relaxation rate regime, frequency sweeping events are observed, and the time-evolution of such event is investigated.

Reference

[1] B.N. Breizman, H.L. Berk, and H. Ye, Phys Fluids B 5 (9), 3217-3226 (1993)

[2] M. Lesur, Y. Idomura, and S. Tokuda, JAEA-Research 2006-089 (2006)

[3] R.G. Vann, et al., Phys Plasmas 10(3), 623-630 (2003)

[4] H.L. Berk, and B.N. Breizman, Phys Fluids B 2 (9), 2226-2234 (1990)

[5] H.L. Berk, B.N. Breizman, and M. Pekker, Phys Rev Lett 76 (8), 1256-1259 (1996)