Nonlinear traveling waves in energetic particle phase space[1]

BORIS BREIZMAN, Institute for Fusion Studies, The University of Texas at Austin

— The near-threshold regimes of wave excitation by energetic particles reveal a rich family of nonlinear scenarios, including formation of nonlinear structures with time-dependent frequencies. Previous descriptions of such structures were limited to the case of small deviations of their frequencies from bulk plasma eigenfrequencies. However, in many frequency-sweeping events, the range of sweeping is comparable to the frequency itself. The need to interpret such dramatic phenomena requires a non-perturbative formalism, which this work presents. The underlying idea is that the time-dependent frequencies represent nonlinear traveling waves in fast-particle phase space. Such waves form due to initial instability and resonant particle trapping, and they then evolve slowly due to dissipation. The coherent bunches of trapped particles slow down considerably during this process, which results in significant frequency sweeping. An analytic solution of this type has been constructed for a simple one-dimensional model. This solution suggests an efficient numerical approach to modeling frequency-sweeping events in tokamaks.

Boris Breizman
Institute for Fusion Studies, The University of Texas at Austin

Date submitted: 16 Jul 2009   Electronic form version 1.4