Abstract for an Invited Paper
for the DPP10 Meeting of
The American Physical Society

Nonlinear Energetic Particle Modes with Time-dependent Frequencies[1]

BORIS BREIZMAN, University of Texas at Austin

The near-threshold regimes of wave excitation by energetic particles reveal a rich family of nonlinear scenarios ranging from benign mode saturation to explosive behavior. The choice between these scenarios depends on relaxation processes that restore the unstable distribution function. The processes of interest are velocity-space diffusion and electron drag. Recent analysis shows that the instability is always explosive when drag dominates at the wave-particle resonance [1]. This gives rise to a "hard" non-linear scenario in which the saturation level is insensitive to the small initial growth rate. Alfvénic instabilities driven by beam injection in MAST tend to follow this scenario. In contrast, the instabilities excited in JET via ion cyclotron resonance heating (ICRH) are typically in a soft nonlinear regime, because the ICRH-produced fast ions are less affected by drag than by velocity-space diffusion. The explosive development of the hard nonlinear regime serves as a seed for spontaneous generation of phase space holes and clumps. In previous work, description of such structures was limited to the case of small frequency deviations from the bulk plasma eigenfrequency. However, there are numerous observations of frequency sweeping events in which the change in frequency is comparable to the frequency itself. The need to interpret such dramatic phenomena requires a non-perturbative theoretical formalism, which this new work provides. The underlying idea is that coherent structures represent traveling waves in fast-particle phase space. A rigorous solution of this type is obtained for a simple one-dimensional model [2]. This model captures the essential features of resonant particles in more general multidimensional problems. The presented solution suggests an efficient approach to quantitative modeling of actual experiments.

[1] M. K. Lilley, B. N. Breizman, S. E. Sharapov, Phys. Rev. Lett. **102**, 195003 (2009).
[2] B. N. Breizman, Nucl. Fusion, to be published (2010).

[1] Work supported by the U.S. DoE Contract No. DE-FG03-96ER-54326, by the UK EPSRC, and by the Swedish Research Council, EURATOM.