Recent progress in simulations of kinetic-MHD instabilities

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Recent progress in simulations of kinetic-MHD instabilities, toroidicity-induced Alfvén eigenmode (TAE) bursts, fast frequency sweeping (fast FS) mode in the JT-60U experiments, and precessional fishbone instability, is reported.

Recurrent bursts of TAE were studied using a self-consistent simulation model [1]. Bursts of beam ion losses observed in the neutral beam injection experiment at the Tokamak Fusion Test Reactor are reproduced using experimental parameters. Surface of section plots demonstrate that both the resonance overlap of different eigenmodes and the dissapearance of KAM surfaces in phase space due to overlap of higher-order islands created by a single eigenmode lead to particle loss. Only co-injected beam ions build up to a significant stored energy even though their distribution is flattened in the plasma center. They are not directly lost as their orbits extend beyond the outer plasma edge when the core plasma leans on a high field side limiter.

Particle-magnetohydrodynamic hybrid simulations of the fast FS mode in the JT-60U experiments were carried out [2]. For a JT-60U experiment a new kind of energetic particle mode (EPM) was found near the plasma center at frequency close to the central frequency of the fast FS mode. The new EPM is a nonlocal mode destabilized by passing energetic ions in monotonic magnetic shear plasma. Two types of nonlinear evolution take place depending on the initial energetic ion pressure. When a classical distribution is taken for the initial condition, frequency shifts only downward after saturation and large redistribution of the energetic ions occurs. On the other hand, when reduced distributions are considered for the initial condition, frequency shifts both upward and downward at a rate of frequency sweeping close to that of the fast FS mode.

For the precessional fishbone instability, linear and nonlinear evolution is investigated for the initial conditions with parameters similar to those of the PDX experiments [3]. It is demonstrated that the spatial profile of the fishbone mode is different from the kink mode, and frequency shifts downward at saturation of the fishbone instability.

[1] Y. Todo, H. L. Berk, and B. N. Breizman, Phys. Plasmas **10**, 2888 (2003).
[2] Y. Todo *et al*., J. Plasma Fusion Res. **79**, 1107 (2003).
[3] Y. Shiozaki and Y. Todo, to appear in Proceedings of the 13th International Toki Conference, JPFR SERIES **6**.