Tearing instabilities in turbulence

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Effects of micro-turbulence on tearing instabilities are investigated by numerically solving a reduced set of two-fluid equations. Micro-turbulence excites both large-scale and small-scale Fourier modes through energy transfer due to nonlinear mode coupling. The energy transfer to large scale mode does not directly excite tearing instability but it gives an initiation of tearing instability. When tearing instability starts to grow, the excited small scale mode plays an important role. The mixing of magnetic flux by micro-turbulence is the dominant factor of non-ideal MHD effect at the resonant surface and it gives rise to magnetic reconnection which causes tearing instability.

Tearing instabilities were investigated against static equilibrium or flowing equilibrium so far. On the other hand, the recent progress of computer power allows us to investigate interactions between turbulence and coherent modes such as tearing instabilities in magnetically confined plasmas by means of direct numerical simulations. In order to investigate effects of turbulence on tearing instabilities we consider a situation that tearing mode is destabilized in a quasi-equilibrium including micro-turbulence. We choose an initial equilibrium that is unstable against kinetic ballooning modes and tearing instabilities. Tearing instabilities are current driven modes and thus they are unstable for large scale Fourier modes. On the other hand kinetic ballooning modes are unstable for poloidal Fourier modes that are characterized by ion Larmor radius. The energy of kinetic ballooning modes spreads over wave number space through nonlinear Fourier mode coupling. We present that micro-turbulence affects tearing instabilities in two different ways by three-dimensional numerical simulation of a reduced set of two-fluid equations. One is caused by energy transfer to large scale modes, the other is caused by energy transfer to small scale modes. The former is the excitation of initial perturbation of tearing mode. The latter is small scale turbulent mixing of magnetic flux and it produces magnetic reconnection due to large non-ideal MHD effects at the resonant surface of tearing instability. The turbulent mixing consists of ExB flow mixing and electron diamagnetic flow mixing. The non-ideal MHD effect by ExB flow mixing is larger than that by electron diamagnetic flow mixing.