APR12-2012-000455

Abstract for an Invited Paper
for the APR12 Meeting of
the American Physical Society

Energetic Particle Transport by Instabilities in Fusion Plasmas[1]

WILLIAM HEIDBRINK, UC Irvine

Recent experimental confirmation of various mechanisms of fast-ion transport by instabilities in magnetically-confined plasma is presented. Energy transfer depends on $\oint \vec{v} \cdot \vec{E}$, where $\vec{v}$ is the fast-ion velocity, $\vec{E}$ is the perturbed electric field produced by the instability, and the integral is over the orbit. For instabilities that do *not* coincide with frequencies of orbital motion (non-resonant instabilities), the large orbits of fast ions reduce transport via phase-averaging of the electric field. Drift waves with small spatial structure cause less transport than drift waves with large structure, and coherent waves cause less transport than turbulent waves. For a sawtooth instability with a large, transient electric field, trapped particles with large drift orbits that decouple the ions from flux surfaces suffer less transport than passing particles. Resonant instabilities are qualitatively different. The standard resonance condition for modes with frequencies $\omega \ll \omega_{ci}$ is $\omega = n\omega_\zeta + p\omega_\theta$. Here ω_{ci} is the cyclotron frequency, n is the toroidal mode number of the instability, p is an integer, and ω_ζ and ω_θ are the toroidal and poloidal frequencies of the orbital motion. Coherent resonant losses occur when Alfvén waves push fast ions onto loss orbits. A large fraction of the fast-ion population is expelled via coherent losses when large global modes maintains the resonance condition across much of the plasma. Multiple resonances often produce diffusive transport. Many small-amplitude Alfvén eigenmodes cause diffusive flattening of the fast-ion profile. For large mode amplitudes, other resonant transport mechanisms become operative. Above a certain threshold, an avalanche of different Alfvén waves can be excited, causing substantial transport. Large amplitude waves can nonlinearly excite new resonances at harmonics and subharmonics of the orbital frequencies, as recently observed for energetic-particle driven geodesic acoustic modes.

[1]Supported by DOE