Energetic Particle Transport by Microturbulence*

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The confinement of energetic particles is a critical issue in ITER, since ignition relies on self-heating by the energetic alpha particles. Recent DIII-D experiments [1] show significant transport of fast ions produced by neutral beam injection (NBI) in the absence of appreciable MHD activity. We study the diffusion of energetic particles by microscopic ion temperature gradient turbulence in large-scale simulations using a global gyrokinetic toroidal code (GTC). The ion radial excursion is found to be a diffusive process and thus the diffusivity as a function of the energy and pitch angle can be calculated using the random walk model. We find that the diffusivity decreases drastically for high-energy particles due to the averaging effects of the large gyroradius and orbit width, and the fast wave-particle decorrelation [2]. The NBI ion diffusivity is found to decrease rapidly for birth energies up to ten times the plasma temperature and more gradually to a very low level for higher birth energy. Results from GTC simulations explain many features of the fast-ion transport in beam-heated DIII-D plasmas. As predicted by the simulations, the profiles and spectra of fast ions (measured by fast ion D_α diagnostic) deviate more strongly from neoclassical predictions when the plasma temperature is high and when the fast-ion energy is low. TRANSP simulations that use fast-ion diffusion coefficients derived from the GTC simulations improve the agreement with experimental measurements, indicating that the predicted transport by the microturbulence is the correct size to explain the observations.

[1] W.W. Heidbrink, et al., submitted to Phys. Rev. Lett. (2009).
[2] W. Zhang, et al., Phys. Rev. Lett. **101**, 095001 (2008).

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