Turbulent transport of energetic ions

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Abstract. Approaching ITER operation, the issue of anomalous transport of fast particles becomes more and more important. This is partly because the ITER heating and current drive system relies heavily on neutral beam injection. Moreover burning plasmas are heated by fast fusion α particles. In this talk, an analysis of turbulent transport for both types of fast ions is presented.

A model for beam ions injected along the equilibrium magnetic field is described. The beam ions are treated gyrokinetically in a self-consistent way with the equilibrium distribution function taken as a shifted Maxwellian. The implications of such a model for the Vlasov equation, the field equations, and the calculation of moments and fluxes are discussed. Linear and nonlinear results, obtained with the gyrokinetic flux tube code GENE [1, 2] show the existence of a new instability driven by fast beam ions. The instability has a maximum growth rate at perpendicular wave numbers of $k_y \rho_s \sim 0.15$ and depends mainly on the beam velocity and the density gradient of the beam ions. This instability leads to a replacement of bulk ion particle transport by fast ion particle transport, connected to a strongly enhanced heat flux. In the presence of this instability, the turbulent particle and heat transport is dominated by fast ions.

Compared to the beam ions, fusion α particles are characterised by larger gyroradii and more isotropic velocity distributions. The dependency of the particle diffusion of α test particles on the Kubo number $K = V_{E\times B}\tau_c/\lambda_c$ ($V_{E\times B}$ mean $E \times B$ velocity, τ_c, λ_c correlation time and length of the turbulent potential) is presented. For different turbulent regimes, different dependency of the diffusion on the gyroradius is found. For large Kubo numbers, the transport is found to remain constant for gyroradii up to the correlation length of the potential, whereas it is drastically reduced in the small Kubo number regime.

REFERENCES

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