Turbulent Transport at Finite Beta: Recent Developments in Gyrokinetics

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In the present contribution, an overview of recent developments in gyrokinetic simulation of finite beta plasmas will be given. Provided that high performance discharges will operate at medium to high beta, a solid theoretical understanding of turbulence-induced transport in that regime is called for. Various new results and insights along these lines shall be presented:

- Gyrokinetic simulations of finite-beta ITG and TEM turbulence have been carried out, pushing beta up to the ideal ballooning limit. The magnetic field is found to stochasticize already at quite moderate beta due to a nonlinear excitation of weakly damped microtearing modes, and the flutter transport can be described by a Rechester-Rosenbluth model. In certain parameter regimes, it becomes difficult for the simulations to find saturation, independent of the employed numerical technique. The current understanding of this issue will be discussed.

- Linear gyrokinetic studies performed in recent years indicated that microtearing modes are likely to play a role both in spherical (small aspect ratio) and standard (medium aspect ratio) tokamak plasmas. First nonlinear gyrokinetic investigations of microtearing modes shed light on the questions what sets the saturation levels of the magnetic field fluctuations and in which way the latter are linked to the heat transport level, establishing microtearing modes as additional candidates for explaining turbulent transport in tokamaks.

- A closely related topic of recent interest is the interaction of energetic particles with turbulent magnetic fluctuations. First, there is experimental evidence of a fast radial redistribution of beam ions under certain conditions, and second, new theoretical as well as numerical studies suggest that the magnetic fast ion diffusivity drops only very slowly with increasing particle energy. Implications of these findings for present and future experiments will be discussed, together with extensions of these investigations to runaway electrons.