# Electromagnetic gyrokinetic simulations of plasma turbulence

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Gyrokinetic and fluid simulations of electromagnetic turbulence in magnetically confined plasmas are reviewed. Gyrokinetic simulation of electromagnetic turbulence in finite beta plasmas is an important task for predicting performance of fusion reactors and a great challenge in computational science due to multiple spatio-temporal scales related to electromagnetic ion and electron dynamics. The simulation becomes further challenging in non-axisymmetric finite beta plasmas, where beta is the normalized plasma pressure. In finite beta plasmas electromagnetic effects are important, and they are, for instance, magnetic field line bending stabilization, anomalous transport due to magnetic perturbation (magnetic flutter), zonal magnetic field production. In the linear analysis, the growth rate of ion-temperature gradient instability (ITG), which is a drift-wave instability, is suppressed by magnetic field line bending as plasma beta increases, while kinetic ballooning mode, which is an MHD instability, is destabilized at high beta. In nonlinear simulations, whereas in low-beta torus plasmas the zonal flow shear acts to regulate ITG driven turbulence, it has been observed that instabilities continue to grow without reaching a physically relevant level of saturation at finite-beta tokamaks. On the other hand, the finite beta turbulence can be saturated by a new saturation mechanism in the presence of three-dimensional magnetic structures, even when the zonal flow is weak. Finally, non-local turbulent transport in electromagnetic turbulence is discussed by means of fluid simulations.