KINETIC SIMULATION OF SHEARED FLOWS IN TOKAMAKS

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Particle simulation methods are discussed in the context of resolving sheared poloidal flows in the turbulent tokamak plasmas. Reynolds stress, turbulent viscosity, and neoclassical effects are considered and analysed for experimental small and medium sized configurations. A so called full f simulation method is presented and it is shown how both neoclassical and turbulent mechanisms in sheared flow generation and related turbulence suppression can be studied with this scheme.

A gyrokinetic particle-in-cell approach with direct implicit ion polarization is described and is implemented with kinetic electrons in global electrostatic toroidal plasma transport simulations. The method is applicable for calculation of the evolution of particle distribution function *f* up to far from its initial state including as special cases rapid transients and steep gradients in the plasma. This is made feasible by full *f* formulation and by recording the charge density change due to the ion polarization drift at the same time with the particle advancing. The code has been successfully validated against the linear predictions of the unstable mode growth rates and frequencies. Convergence and saturation in both turbulent and neoclassical limit of the ion heat conductivity is obtained with numerical noise well suppressed by a sufficiently large number of simulation particles. A first global full *f* validation of the neoclassical radial electric field in the presence of turbulence for a heated collisional tokamak plasma is obtained as shown in the figure below. At high Mach number of the poloidal flow, the radial electric field is significantly enhanced over the standard neoclassical prediction. The neoclassical radial electric field together with the related GAM oscillations is found to regulate the turbulence and heat and particle diffusion levels particularly strongly in a large aspect ratio tokamak at low plasma current.

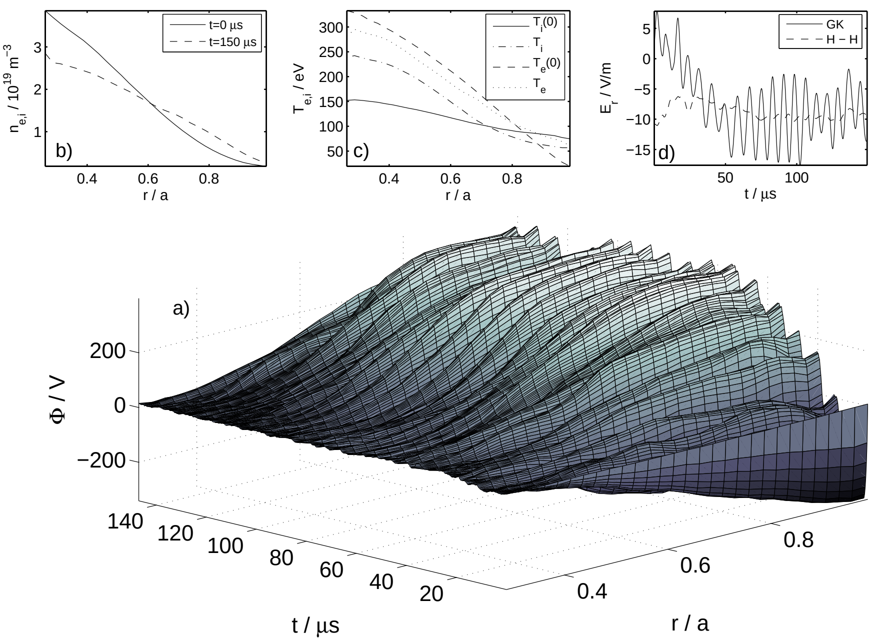

Figure: The evolution of the electrostatic potential radial profile from simulation of the FT-2 tokamak (a). The radial electric field at the mid-radius approaches the standard neoclassical result (H&H) (d) found from the evolved plasma density and temperature profiles (b),(c).