Gyrokinetic Simulation of Particle and Heat Transport in the Presence of Wide Orbits and Strong Profile Variations

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The electromagnetic gyrokinetic (GK) 3D plasma simulation for toroidal magnetic fusion devices has become a standard tool for transport analysis. However, based on delta *f* technique and analytic GK field equations [1], transport phenomena involving wide orbit effects, steep gradients, and rapid dynamic changes in profiles become difficult if not impossible to model with the present GK methods. In the present work, we describe an implicit solution method for the full f plasma quasineutrality, where the ion density change by polarization drift is evaluated directly from the ion orbit motion in terms of the unknown electrostatic potential at each time step. Being also full *f* and treating electrons kinetically within the drift-kinetic approximation, the present nonlinear method can provide a rigorous treatment of such global and dynamic transport phenomena as transport barrier generation and wide orbit effects. Within this method, one can also model the neoclassical and turbulent transport at saturation at the same time.

A full f nonlinear 3D gyrokinetic code ELMFIRE implementing an analytical GK method has been upgraded to incorporate the described direct solution method [2]. The validation of the code is described in Ref. [3]. The developed code is applied for global transport analysis in an FT-2 tokamak plasma involving lower hybrid heating [4]. In the latter, both an internal transport barrier and edge H mode have been observed in strongly heated discharges. The transport coefficients and electrostatic field together with the density and temperature profiles including impurity oxygen ions are solved for the heated plasma and compared with the published experimental results. The role of turbulence and neoclassical equilibrium in determining the flux surface averaged radial electric field component are investigated, as well as the role of the latter in affecting the saturation level of the turbulence. The ion temperature gradient and trapped electron mode instability is investigated in the context of the simulated turbulent mode spectra.

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