Profile evolution and momentum transport in the core and pedestal

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Abstract

Simulating radial profile evolution across the core of a tokamak plasma is one of the major challenges for gyrokinetic turbulence codes. The main complication is the evolution of the electrostatic potential profile [1], which along with the plasma density and temperature profiles enters the ion flow velocity. To evolve the potential the radial transport of angular momentum must be evaluated in the presence of turbulence in a weakly collisional plasma [2]. The off diagonal elements of the stress tensor determine the potential. In ITER and reactor relevant regimes the ion flow will be diamagnetic rather than sonic. In this diamagnetic regime, symmetries of the gyrokinetic equation [3] require that the ion distribution function be determined from a higher order gyrokinetic equation than is employed in local gyrokinetic simulations. In the near term, the only practical way to completely evaluate the required off diagonal stress tensor (including the residual stress needed to determine intrinsic rotation), is to solve a more accurate gyrokinetic equation to provide closure for the conservation of toroidal angular momentum equation [4], as well as for the number and energy conservation equations [5] (which do not normally require the added gyrokinetic accuracy). An additional challenge to gyrokinetic simulations is using a hybrid closure scheme in the pedestal [6], where the radial scale lengths of the density, ion temperature, and potential can become comparable to a poloidal ion gyroradius and strong poloidal variation can occur [7] and thereby remove the symmetries acting in the core. The tutorial will stress the need to deal with these important issues so that meaningful comparisons can be made between theory and experiment [8].

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