DPP09-2009-000136

Abstract for an Invited Paper
for the DPP09 Meeting of
the American Physical Society

Limitations of the gyrokinetic quasineutrality equation[1]

FELIX I. PARRA, Plasma Science & Fusion Center, MIT

Traditional electrostatic gyrokinetic treatments consist of a gyrokinetic Fokker-Planck equation and a gyrokinetic quasineutrality equation. The equations implemented in full f codes are typically only consistent through first order in a gyroradius over macroscopic scale length expansion. In axisymmetric configurations such as the tokamak, we will show that these gyrokinetic descriptions are unable to correctly calculate the profile of toroidal rotation and hence the long wavelength radial electric field because even turbulence dominated tokamaks are intrinsically ambipolar. We study the vorticity equation or current conservation equation in the gyrokinetic regime, with wavelengths on the order of the ion gyroradius. We use the momentum conservation equation to determine the perpendicular current density, making explicit the dependence of the current on the transport of toroidal angular momentum. Employing the vorticity equation, it is possible to show that gyrokinetics needs to be calculated to fourth order in the gyroradius expansion if the radial electric field is to be retrieved from quasineutrality. However, existing full f simulations are based on first order gyrokinetic equations that are unreliable for wavelengths longer than the geometric average between the ion gyroradius and the macroscopic scale length. Finally, we replace quasineutrality by the conservation equation for toroidal angular momentum in a form that only requires an ion distribution function correct to second order in ion gyroradius over scale length, and by exploiting an expansion in q >> 1, we propose a scheme in which the first order gyrokinetic Fokker-Planck equation already implemented in codes is enough to find the axisymmetric radial electric field.

[1]Work supported by DoE and CMPD at the University of Maryland.