Electromagnetic gyro-kinetic simulation with a fluid-kinetic hybrid electron model

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In gyrokinetic simulations, overcoming steep numerical constraints imposed by the kinetic electrons has been a crucial issue. The split-weight scheme[1] separates the adiabatic and the non-adiabatic electron responses which reduced the statistical noise of the particle simulation. Lin and Chen furthered a hybrid electron model[2] which can relax the numerical constraints. Based on a small parameter expansion by the square-root of the electron-ion mass ratio, the hybrid model solves the adiabatic response in the lowest order and solves the kinetic response in the higher orders. The model preserves the linear and the nonlinear wave-particle interactions. One of the advantages of the hybrid model appears in the simplified field equation. A new finite element field solver is implemented in the GTC code[3] for the electrons with an assistance of algebraic multi grid method.

We initially focus on the effects of the non-tearing-parity modes on the transport using the hybrid model. Electromagnetic fluctuations can enhance drift wave induced turbulent transport even when the magnetic topology is preserved. In the presence of magnetic flutter effects, one expects the guiding center drifts associated with the magnetic perturbation to be comparable to the electrostatic $E \times B$ drifts. Furthermore, trapped electrons having their own adiabatic invariant can cause the temperature to vary along the magnetic field lines, and thus contribute to net radial transport (rapidly bouncing trapped particles are insensitive to the low frequency magnetic perturbations). At a critical β value, we expect excitations of new branches of electromagnetic modes, that are the Alfvenic ion temperature gradient mode (AITG)[4] and the kinetic ballooning mode (KBM). The linear growth rate and the onset (the threshold β value) of the modes are investigated. This work is supported by Department of Energy (DOE) Cooperative Agreement No. DE-FC02-03ER54695 (UCI), DOE Contract No. DE-AC02-76CH03073 (PPPL).

References

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