Theory, Verification and Validation of Finite-Beta Gyrokinetics*

J. Candy, General Atomics

In this tutorial presentation, both historical challenges and present open issues related to finite-beta gyrokinetic simulation will be discussed, with emphasis on the GYRO code but including material from relevant codes worldwide. There will be focus on numerical issues and solutions (such as the Ampere cancellation problem and its resolution), complicating physical effects (such as magnetic surface destruction and stochastic electron transport) and unresolved issues (for example, the finite-beta runaway observed in multiple codes). Successes related to code benchmarking exercises, and the role of finite-beta effects in experimental validation (for example, when finite-beta effects must be retained and when they may be neglected) will also be discussed. Categorization of finite-beta effects as they relate to different modes (ion temperature gradient, trapped electron, kinetic ballooning, microtearing and toroidal Alfven) will be clarified, and recent success in both numerically resolving and explaining electron transport in spherical tokamaks via flutter nonlinearity and associated magnetic stochasticity will be summarized. The material will be organized in roughly chronological order. Also covered will be practical aspects of the topic, including simulation strategies and best practices. This is relevant because the overall difficulty and potential pitfalls of electromagnetic turbulence simulation are far greater than for electrostatic turbulence simulations.

*Supported by the US DOE under DE-FG02-95ER54309.