Solution of the Quiet Implicit Particle-in-Cell Moment Equations in Toroidal Geometry

Publication No. ____________________

William David Nystrom, Ph.D.
The University of Texas at Austin, 1996

Supervisor: Toshiki Tajima

A computer program, `QIP3D`, has been developed to solve the Quiet Implicit Particle- in-cell (QIP) moment equations in three-dimensional toroidal geometry. This model provides an efficient algorithm for computing the time evolution of the full two-fluid (ion/electron) plasma. The coordinate system is based on a conformal mapping of the poloidal plane from a circular outer boundary and origin coincident with the magnetic axis to form a logically polar computational mesh. A Fourier, pseudospectral representation is employed for the poloidal and toroidal angles and finite differencing for the radial coordinate. The QIP equations are differenced implicitly in time and solved using a predictor-corrector algorithm. The implicit electric field equation (and other elliptic equations) are solved using advanced iterative methods. Efficient algorithms implement the required matrix-vector product and preconditioner.

Two series of calculations in toroidal geometry with $q_0 = 0.9$ establish

the two-fluid physics of the $m = 1$ internal kink mode where q_0 is the safety factor at the magnetic axis and m is the poloidal mode number. In each series, the mode is excited and exhibits the proper eigenmode structure. With the aspect ratio, $A = R_0/a$, constant at 10 and β_0 varying from 0.0 to 0.01, the growth rate of the kink is found to increase with β_0 and to be in quantitative agreement with previous calculations. Here, R_0 is the distance of the magnetic axis from the axis of rotational symmetry for the torus, a is the minor radius of the torus and β_0 is the ratio of kinetic pressure to magnetic field pressure at the magnetic axis. With $\beta_0 = 0.0$ and A varied from 5 to 10, the growth rate is found to be independent of A in agreement with theory.