SUMMARY OF UNM WORK ON EDGE PLASMA MODELLING.

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RECEIVED**SEP 25 1996****OSTI**

The B2 two dimensional edge plasma code has found widespread application in modelling scrape-off layer and divertor plasma conditions for ITER and CIT (BPX). The transport physics in B2 consists of the so-called standard model that employs 2D Braginskii equations for the background plasma, anomalous cross-field transport coefficients, and classical along-field transport coefficients computed in the straight cylinder approximation. Although the code displays acceptable convergence characteristics for the class of problems of interest in ITER and CIT applications, it is remarkably resistant to improvements in the physics model. That is, extensions to including the symmetry breaking drift flows and wall or divertor plate generated impurity species in the code have not met with success - satisfactory solution convergence has not been achieved in various test problems. Given that the drift flows have been identified as being an important component of any fluid model that attempts to reconcile computational results with experimental observations and that control of impurities is vitally important in present and subsequent generations of high power machines, successful numerical models of edge plasmas must be clearly robust enough to handle a significantly expanded physical model.

The shortcomings of the B2 code stem from the numerical approach adopted, that is not suitable for the highly nonlinear and compressible flows typically encountered in tokamak edge plasmas. The segregated solution scheme used (i.e. solving each equation independently and iterating between equations) results in a shrinking radius of convergence with increasing number of equations, while the nonlinear coupling of the equations does not lend itself easily to the iterative solution employed. Further, the use of a pressure correction equation in place of the continuity equation is only appropriate for incompressible flows and thus cannot adequately handle the large changes in density and temperature driven by intense sources and radiation in the edge.

A consensus has emerged from groups working with the B2 code at LLNL and UNM that significant non-trivial changes to the numerical algorithm will be necessary if realistic models of the edge are to be successful. To this end a fully implicit and robust numerical algorithm that avoids the approximations in B2 has been developed and implemented in the NEWEDGE code at UNM. This code simultaneously solves the coupled

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plasma continuity, neutral atom diffusion, momentum and energy equations fully implicitly. Newton's method is used in conjunction with a search parameter, mesh sequencing, a banded matrix solver and reduced factorization to produce a cpu efficient algorithm. The search parameter limits the magnitude of the Newton update to prevent any variable from unphysically turning negative when the solution is far from the true solution. As a good initial guess is important for Newton's method, and one is not necessarily easily available, mesh sequencing is used to solve the early stage of the problem on a series of course grids that provides a much improved initial guess for the fine grid computation (analogous to multigrid methods). In this way the number of fine grid iterations required for convergence is reduced. Finally, cpu time reduction is further achieved by judiciously reducing (of even completely freezing) the number of Jacobian factorizations during the iteration process. As the factorization step consumes most of the cpu time per iteration a clearly significant enhancement in computational efficiency is achieved by reducing or freezing this step.

The NEWEDGE code has been tested on a number of test problems and has consistently demonstrated robustness. Specifically the standard ASDEX problem on a cartesian grid has been considered as well as on a curvilinear domain but without a private flux region. The use of an improved neutral transport model, namely the diffusion equation, has been shown to result in localized recycling near the divertor plate. Also, the advanced differencing scheme in NEWEDGE shows that the density profile is considerably more peaked compared to the lower order schemes used in other 2D codes (emphasising the role of numerical diffusion, which must be controlled). Work is ongoing to incorporate a realistic geometry into NEWEDGE based on the conformal map grids generated by B2 for ITER and BPX.

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