NIMROD Team Meeting Minutes

Saturday, March 29, 2008

Development:

Carl Sovinec reported on tests of preconditioning algebraic solves for 3D computations with the Hall term. A small cylindrical computation demonstrates the sensitivity to small non-axisymmetric components in the coefficients for the Hall operator. Electron inertia adds a symmetric contribution, which does reduce the number of iterations as m_e is increased. It is not effective when used in the preconditioner alone, however. Polynomial approximation has been implemented, and GMRES iterations are minimized with a relaxation factor of 0.7 and one extra preconditioning pass, but this does not decrease CPU time.

Eric Held described his application of the mixed finite element method to improve convergence of anisotropic heat flux in regions of stochastic magnetic field. An auxiliary quantity that is proportional to $\hat{\mathbf{b}}\cdot\nabla T$ is solved simultaneously with T. This significantly improves convergence on the 2D test computation from the JCP paper. The new algebraic system is nonsymmetric and more difficult to solve in 3D computations. To obtain 3D results, Held has a test version of nimrod that generates all implicit couplings among Fourier components and sends that to SuperLU. He has also revisited the nonlinear computations in the '83 for a tokamak-relevant case that generates a stochastic layer.

Srinath Vadlamani presented work on coupling NIMROD to the PETSc package and on testing its algebraic multigrid solver for our symmetric two-dimensional matrices. The goal is scalability where the number of iterations remains fixed as the problem size and the number of processors are increased. The current MG effort uses HYPRE. The coupling to PETSc has been verified by calling SuperLU through PETSc and comparing results with direct calls to SuperLU. The comparisons also verify that there is no significant latency cost in using PETSc. For the small real systems tested so far (MHD B advance, separate div-B cleaner, and mass matrix for n-advance), SuperLU is faster. Further scaling work will be done on Franklin.

Charlson Kim reviewed topics related to hot-particle modeling. To avoid the initial loss of part of the distribution, it may be necessary to use an anisotropic P-hot equilibrium tensor that is part of a drift-kinetic equilibrium. Regarding the kink-fishbone benchmark, he has found that the results are very sensitive to the maximum velocity of the simulation-particle load. For example, increasing v_{max} by a factor 1.5 stabilizes the mode. In the RFP tearing-mode application, he finds stabilization for hot-particle orbits of ~4 cm, which is comparable to the resistive skin depth for the S-value of the computation. Future work includes synthetic diagnostics, separate parallel domain decomposition for particles, and high-order particle weights. On a separate topic, PSI-C is migrating to a merged NIMDEVEL version, and tests show that compiling with IEEE conformance slows (unnecessarily) computations.

Jeong-Young Ji presented recent results from moment-based closures that show significant corrections to Braginskii's results. In particular, high-order moments and the ion-electron collision terms have non-trivial effects on collisional friction, ion heat flux, and ion viscosities. He has investigated these changes over a range of T_e/T_i ratios.

Scott Kruger described observations where vector-potential perturbations specified in nimset as smooth functions of position at the nodes of a nimrod mesh lead to noisy magnetic field perturbations with large divergence error. The mesh is packed in these cases, but interior nodes

are distributed uniformly for a subparametric representation. Kruger finds that the error is reduced when interior nodes are also mapped. There was some discussion as to why this helps. The issue is significant, because it also affects the quality of equilibrium fields.

Eric Held presented the efforts of a development subgroup (himself, Kruger, Kim, and Izzo) for merging and modularizing closure-related information. The group is developing the appropriate 'hooks' for closure information, and most of what was in integrands has been extracted into a closures module. Another significant development is the addition of separate mass-density data structures for radiation modeling, because mass density is not tied to electron density when there are impurities. Also, advance and integrand routines have been broken into separate files according to the physical field. Dependencies are being checked. Kruger has a new way of syncing changes from nimuw, and that has been done through changes from January. A test-case library is being built. It presently includes: 1) anisotropic heat conduction, 2) sound-wave damping, 3) Holmes linear tearing, 4) RFP tearing, 5) radiation computations, and others. Plotting of extra fields for the closure computations is being discussed. With respect to dump files, switching to a self-describing format such as HDF5 is probably best.

Dan Barnes provided an update on simulation-particle closure with evolving background. The stress computation when evolving n and $\mathbf{V}$ backgrounds is stand-alone and ready for implementation. It has been tested on g-modes and Landau damping. Since APS, he has considered how to deal with nonuniform background temperature, and the present method can be extended to situations where T is a function of n. He has also considered how collisions may be incorporated.

Scott Parker described another approach that is presently intended for shorter time-scales. It solves a combined Ohm's/Faraday's law like extended MHD but uses kinetic ions. An implicit solve couples current density and separated parallel and perpendicular components of the electric field. The method has been applied to the electron-temperature-gradient driven whistler instability. A limitation is that with full-orbit ions, time-steps are on the order of a gyro-period.

Dalton Schnack briefly described the status of g-mode drift stabilization (most of the recent results are from Ping Zhu). Depending on the equilibrium, complete stabilization may not be realized at high beta. A manuscript has been submitted to PRL.

Ping Zhu presented recent work on ballooning modes in tokamak geometry. He is using the ESC code to generate circular-cross-section equilibria via the nimdevel fluxgrid. To obtain ballooning mode eigenfunctions, he starts at low-S and then lowers resistivity to the perfectly conducting limit. A clear scaling with S has not been obtained but results appear to be less than 1/3; there is other dissipation in the system. The spectrum is stable at low-n, and it turns over weakly at high-n due to the dissipation.

Fatima Ebrahimi described a new linear study of high-beta RFP stability, motivated by relatively recent experimental results with pellet injection that show record levels of plasma-beta. With Kruger's help, she has coupled MSTFIT output read by fluxgrid, accounting for the non-monotonic toroidal flux function. Schnack's computations run into an instability, and Ebrahimi also finds the instability. She has also used polynomial fits of the profiles for cylindrical computations and may be seeing the same instability, which would be very curious. There are several things to check.

Val Izzo saved her presentation for the Sunday CEMM meeting in the interest of time.

Tom Jenkins provided an update on simulations for RF/MHD coupling. The MHD island computations with the ad hoc source have been modified for better localization and to investigate the effect of moving the position of the source. A small spot size on the magnetic-axis side of the island appears to be the most effect approach, but the magnitude of the driven current may be changing in the numerical scans. A nonaxisymmetric source is also being tested. Jenkins showed how the current propagates along the field lines, eventually filling over a flux surface due to force-balance.

Ryoji Takahashi showed experimental results from JET that indicate stability beyond soft beta limits found on other machines. He is starting an effort to model hot-particle effects on tearing modes. Initial linear results show a decrease of growth rate with increasing hot-particle fraction, and the delta-f distribution becomes more asymmetric.

Dylan Brennan summarized NIMROD-related research activities at U-Tulsa. He is presently having difficulty reproducing a 2/1 mode at large beta. For the parameters tested so far, the mode only appears with a very peaked pressure profile. With respect to spheromak helicity injection, he is examining equilibria near the stability boundary for the column mode. There is good agreement between NIMROD and the SCOTS code in these equilibria.

Carl Sovinec summarized other applications efforts at U-WI. Nick Murphy's paper on 2-fluid reconnection in MRX has been accepted for publication. Eric Howell has developed an equilibrium solver using NIMROD's finite elements that allows R=0 and open-field current. John O'Bryan is modeling recent flux-compression experiments in Pegasus. Modifications for the new CDX-U series were also described.

Curt Bolton/Rostom Dagazian—view from Germantown

The next meeting will be held in San Diego during the summer—date to be decided.