Minutes of the NIMROD Team Meeting
April 21-22, 2007
pre-Sherwood, Annapolis, MD

Saturday, 4/21

- Charlson Kim reported on hot-particle development and application. The coding for full-orbit and drift-kinetic models has been unified. Only the particle push and the moment calculation need to be distinct. With respect to performance, at present, each particle is a separate data structure, and the code will probably run faster by changing to arrays with many particles. In tearing-mode calculations with full orbit particles, Charlson has improved the initial particle load, and the numerical results no longer have any appreciable real frequency. The ratio of kinetic to magnetic energy for the modes is far larger than without the hot particles. Charlson also described a separate version of NIMROD called NIMlite.
- Dan Barnes described his algorithm for implicit delta-f particle calculations with a moving background. The formulation closes at an even moment in **v** to avoid noise, and the delta-f is with respect to a fluid velocity that is computed without pressure gradients. Dan has developed a new method to correct particle weights in velocity-space such that the discrete system has finite energy, including delta-f-squared. Thus, there is no growing weight problem!!! At this point, the computations are for the perpendicular polarization and uniform temperature, but extensions to the general case have been formulated. Dan showed results on the g-mode test case, and the standard stabilization effect is present at high and low beta, but a new larger k-parallel-to-g mode appears in the previously stable range.
- Carl Sovinec described the formulation of (anisotropic) parallel electron stress. It is computed implicitly in the magnetic advance. To work with NIMROD's C0 elements, the term requires the simultaneous solve of a scalar auxiliary field with delta-B. The linear part has been implemented and tested on damped whistler waves. Due to its anisotropic nature, it has essentially no effect on linear two-fluid tearing with guide-field.
- John James reported on his work to make the nonlocal kinetic closure computations more efficient. Without full integration along the characteristics, it is possible to use a Lomb periodogram to approximate the spectral content of the field quantity (T in this case). He starts with a linear fit to initialize a nonlinear fit. A test computation shows that this saves a considerable amount of time.
- Alexei Pankin gave a quick report on verification tests comparing results of NIMROD with ELITE. Alexei is developing a model for ELMs that estimates triggering, width, and energy loss. The present verification effort is extending Dylan's earlier work on assessing the effect of finite resistivity, its magnitude in the 'vacuum,' and the resistivity transition width.
- Val Izzo reported on her initial simulations for resonant magnetic perturbations (RMPs). The first step is to investigate plasma response without ELMs being present. The perturbation is a non-axisymmetric vacuum solution representing D3D's I-coils, C-coils, or both that is used as an initial condition. This leads to an artificial transient, but the final state is expected to be relevant. Convection cells develop and lead to particle transport, and equilibrium flow can screen-out the RMP fields.
- Ping Zhu presented nonlinear simulations of robust interchange modes. The characteristic mushroom pattern drives localized current sheets that may lead to blob formation. He is investigating the influence of different diffusion parameters.

- Adam Bayliss gave an update on helicity injection computations for Pegasus and HIT-II. When the Pegasus computations start from an axisymmetric conducting plasma channel, they can be driven through instability to flux amplification. However, toroidal resolution and possibly boundary conditions are still problematic for filament injection. There has been progress on the HIT-II simulations using surface-normal drifts to impose electrostatic potential at the absorber gap and shaping the domain to better represent the experiment.
- Michael Addae-Kagyah described theory for nonlocal stress closures with time-dependent effects. The time-dependence is very important, because it can be much larger than direct damping, and it is part of collisionless damping of sound waves. The time-dependence has been formulated using the Chapman-Enskog-like approach. Computationally, we may need to save histories of the kinetic moments in some way.
- Chris Carey described simulations of astrophysical jet-like magnetic arcades driven by differential rotation specified through boundary conditions. Recently, he has changed the initial magnetic field to represent a more localized prominence that is sheared. These configurations collimate at zero and finite beta. The current channel is unstable to an m=1 mode that leads to flux conversion nonlinearly. Lobes of converted flux are generated relatively close to the disk and are advected axially.
- Cihan Akcay discussed new simulations of HIT-SI and attempts to compare I_{tor}/I_{inj} with experiment. Though the shape of the symmetric **B** profile matches probe measurements relatively well, the current ratio is way off for realistic S-values (but Pm=5-20). Postprocessing work is assessing numerical boundary-layer effects that may lead to current loss.

Sunday, 4/22

- Carl Sovinec briefly reported on new studies by John O'Bryan and Eric Howell. John has verified classical particle transport due to electrical resistivity and has started looking at Pfirsch-Schluter transport in a torus. Eric Howell is doing new spheromak calculations based on Corsica equilibria from LLNL. He will be investigating two-fluid effects that may make stabilize MHD during the quiescent phase of the discharge.
- Scott Kruger reported on verification benchmarking for ELMs, facilitating linear calculations, and boundary condition modifications. He noted that it takes a very large vacuum resistivity to reproduce ideal free-boundary modes accurately. In addition, the accuracy of the equilibrium needs to be extremely good. He and Phil Snyder developed current profiles that fake TOQ into creating free-boundary equilibria, and they are being used for the benchmark. Growth rates from preliminary results are in the right range. Hank Strauss is running the same cases with M3D. The development for linear calculations automates time-step convergence and stops the calculation when gamma converges. The boundary condition work is intended for the Taylor problem but is also related to the resistive wall. Significant amounts of div(B) are generated with the latest approach. Finally, David Wade-Stein has taken over regression testing at Tech-X.
- Eric Held summarized his group's many activities for nonlocal closures. Jeong-Young Ji has worked-out a comprehensive moment-based solution method for the kinetic equation using the full linearized Coulomb collision operator. This decouples equations for different moments if T is uniform and may be used to generate fluid equations for higher moments. Mukta Sharma is incorporating geometry effects in the convective terms in the drift kinetic equation in order to capture neoclassical effects in steady state calculations. Eric also

described improved parallelism obtained by separating closure processor groups from a fluid processor group. He has tested strong scaling on Seaborg up to 4000 processors; it doesn't show perfect scaling, but speedup relative to 1000 processors is still very significant.

- Srinath Vadlamani has been investigating SuperLU's parallel performance for NIMROD calculations. He has checked different aspect ratios for blocks. He has also shown that most of the time in nonlinear calculations is spent in mpi_allreduce and mpi_wait. The allreduce is from our use of SLU's global interface, and Srinath will pick-up on existing development for switching to the distributed interface. Sherry Li will help check the mpi_wait on the SLU side.
- Rostom Dagazian (OFES) said that he is happy to see so many young people getting involved in NIMROD. FSP dollars have been delayed a year, but the planning committee will keep planning.
- The summer team meeting will be in Madison, but August is out. Timing is still being decided.