Proposed goals for GPSC

- Code development: general geometry, electron dynamics, finite-beta effects

- Turbulence transport simulations of ITG, TEM, KBM and TAE modes related to NSTX and D3D

- Development of the simulation capabilities for ITER-size burning plasmas
  -- Physics requirement
  -- Size requirement

- Code performance enhancement on vector-parallel and cache-based MPP platforms.

- Interactions with Integrated Software Infrastructure Centers (ISICs)
  -- Terascale Optimal PDE Simulations (TOPS): solver technology
  -- Scientific Data Management (SDM): data storage, data streaming, data sharing, real time visualization for GTC data on the order of Terabytes.

- Team coding based on an object-oriented GTC.

New Priorities for GPSC

- Convergence studies on ITG simulations using GTC

- Convergence studies on ETG simulations using GTC and GEM

- Both are manpower and resource intensive

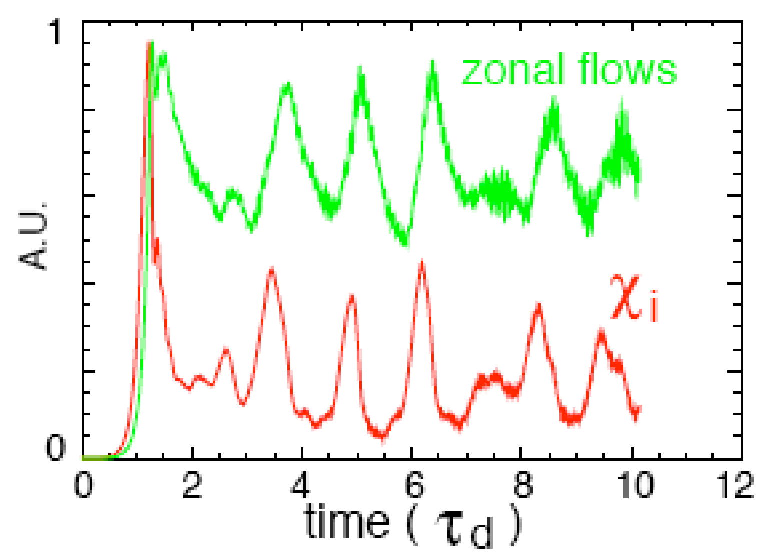
W. W. Lee

GPSC's response to the PSACI PAC Recommendations

• As recommended by the PSACI PAC, the effects of velocity space nonlinearity in turbulence transport have been further studied using both adiabatic electrons and non-adiabatic electrons for ITG simulations in circular as well as shaped plasmas. All these studies have given similar results: enhanced zonal flows and a long steady state flux with near constant amplitude. Theoretical understanding is ongoing.

• The noise issue, which has also been mentioned in PSACI PAC letter, has consumed most of our manpower and computing resources for the past year. It is now generally agreed that ITG simulations are free of particle noise. We expect that the noise issue for ETG simulations will be resolved soon.

• Collision operators have been implemented in GTC. However, they have only been exercised in relation to the neoclassical transport studies for NSTX plasmas. The studies of collisional effects on ITG and TEM modes have just begun. This delay is partly due to our work on noise and also due individuals' priorities. The work in this area was initiated in '99.



[Lin, et al., 1999]

W. W. Lee

Terascale activities for GPSC

• GTC running on the Earth Simulator in Japan for a case using 13.2 billion particle (6000 particles/cell) on a 250x250x64 grid (a/rho = 125) on 4096 processors has achieved the performance of 7.2 TeraFlop/sec (peak performance 40 TF/s with 5120 PE's).

• GTC running on Jaguar (XT3@ORNL) has achieved 0.73 GigaFlop/sec per processor for about 15% of the peak performance (5 GigaFlop/sec). With the present 5000 processors, we can achieve 3.65 TeraFlop/sec (25 TeraFlop/sec peak).

• We are currently working on the second domain decomposition based on the radial zones so that we simulate larger plasma volumes. (The first domain decomposition is along the field line direction.) This is the first step toward simulating ITER-type plasmas.

• We need to improve the single processor efficiency for the particle pushing. Kevin Bowers developed a particle code at LANL which achieved close 75 % of the peak performance for a single processor using the methodology from the video gaming industry.

• Our experiences indicate that steady state turbulence can be achieved with the order of 10^4 time steps.

• The time step is limited by the zeroth order orbit of the electrons not by the Courant condition of shear Alfven waves. Field line following coordinates are important. There is no need for implicit schemes.

W. W. Lee

Path to Petascale computing for GPSC

- One needs 200,000 processors on Jaguar (XT3@ORNL) to achieve 1 PetaFlop/sec peak performance.

- Presently, IBM BlueGene/L has 131,000 processors with 367 TeraFlop/sec peak performance.

- We can use 1 trillion particles on 1PF XT3 by assuming 1GB of the 2GB memory can be used for storing particle information. The rest can be used for storing grid information for pushers and solvers.

- For a 10,000x10,000x100 grid, we can use 100 particles/cell, or we can 5 different species with 20 particles/cell. This is ITER-type plasmas with a grid of the order of the electron skin depth.

- The solver will have 10^8 elements and we need help from TOPS.

W. W. Lee