

# Overview & Future Plans PSI-Center 2018

Compiled by Brian A. Nelson

# Tom Jarboe

- Sustainment of a stable equilibrium
- Do we need more than MHD to model electron shear?
  - Suggestion: Test on toy problem
- Reorganization
  - Add John O'Bryan as Leader of "Plasma Self-Organization and Sustainment"
  - Groups have physics-based names
  - Perhaps Focus Areas vs Groups, as there is overlap
- **Future Plans:**
  - Explore role of electron physics in self-organization

# Carl Sovinec & Jacob Maddox

- Least-squares FE
  - Symmetric equations; **B** and **J** mixed success; **B** and **A** being studied
- New meshing and stitch
  - Fixed “tangling” of internal points with block orientation; allows higher-order
- Abstract block development
  - Had loosely-integrated linear-element triangles
  - F2008/13 block objects allow structured/unstructured quads/tris; Help with  $H(\text{curl})$
- **Pegasus Future Plans:**
  - Energy conversion during reconnection
    - Simulations have  $T$  lower than in experiment
  - 2D slabs
    - See thermal heating
    - Artificial diffusion doesn't conserve energy
    - Fast reconnection in rMHD
    - Hyper-resistivity
  - Filament studies

# Jeong-Young Ji

- Closures in inhomogeneous magnetic field & arbitrary collisionality
- Closures in partially-ionized plasmas
- $Z_{\text{eff}} > 10$
- Non-linear terms in NIMROD
- **Future Plans:**
  - Closures for 10 or 13 fluid moments
  - Parallel closures in  $k$  space
  - Closures for e-i-n plasmas

# Kyle Morgan

- Need  $D$ , but does not conserve energy
- Formation:
  - Lower freq:  $n=1$  rotating
  - Higher freq:  $n=2$  non-rotating
  - Breakpoint in freq is around inverse Alfvén transit time
    - Should be different between HIT-SI and HIT-SI3; need to run more HIT-SI3 high freq
- Sustainment:
  - Start with equilibrium
  - Higher gain, beta, and magnetic energy with freq; Viscous heating > Ohmic at high freq
  - More hollow density profiles with freq => flat P
  - Look at  $n=3$  content => phase scan
  - “Big HIT” showing closed flux, decay, kink, *etc.*;  $T_e > T_i$  at times
- **Future Plans:**
  - Add neutrals
  - Two-temperature important
  - Vary geometry; James is looking at Carl’s updated meshing

# Derek Sutherland

- MC neutral codes are expensive
- Fluid-based neutrals
- Add loss of charge-exchange neutral (via  $\lambda$  parameter)
- Simulation of decaying plasma in HIT-SI3
- Higher-res sims to reduce  $D$
- Add sheath boundary
- Transport of ions in Matter (TRIM) MC code
- **Future Work:**
  - Resolution scan
  - Scan  $n_n$  at edge
  - Driven simulations
  - Ability to “lose” charge-exchange particles
  - Sheath (and magnetic fields)
  - Velocity BCs
  - Free-flow of plasma to wall; Poloidal field may affect ion flow to wall

# Sina & Uri

- Neutrals implemented in NIMROD (own branch)
- BCs: Dirichlet for  $\mathbf{B}$ ; Neumann for  $\mathbf{v}$
- Parallel plate test problem
  - Ramp current to flattop
  - Issues when Ohmic heating included  $\Rightarrow T_n \rightarrow 0$
- Cylindrical geometry rMHD
  - Probably should have Neumann for both (to do insulator)
- **Future Plans:**
  - Parallel plate w/neutrals
  - Coaxial w/neutrals
  - Compare to FuZE data (surface  $\mathbf{B}$  probes and accelerator interferometry)

# Jan (via Carl)

- TREX
  - Reverse current on (fast) internal coils (*a la* FRC)
  - Collisionless and plasmoid reconnection
- Extending 2D VPIC to NIMROD 2D & 3D rMHD
  - $V_A \sim 100$  km/s; “evacuation” resistivity (in addition to Spitzer)
  - Loop voltage on coil “holes”
  - Linearly increase voltage applied until code crashes
  - $pd=2$  similar to  $pd=3$
- 3-coil experiments do not see plasmoids
- **Future Plans:**
  - Low  $n$  near coils
  - Replace applied voltage with current
  - Two fluid
  - 3D sims



# Chris Hansen (1 of 3)

- LTX-beta
  - Upgrading fields & pulse length; adding liquid Li & neutral beams
  - Equilibrium reconstruction w/3D eddy currents
  - **Future Plans:**
    - Chris's grant:
      - Add plasma rotation to PSI-Tri; improve eddy current model
      - Explore 3D equilibria
    - PSI-Center:
      - Test Jeong-Young's non-local transport model w/3D error fields
        - => Needs support for NIMROD implementation (John?)
        - Or write transport into PSI-Tri ...
      - MHD sims of mode activity (from HBT-EP studies)
      - Plasma-neutral sims of LTX-beta
        - Use NIMROD for initial 2D studies

# Chris Hansen (2 of 3)

- HBT-EP
  - Well diagnosed; GPU feedback control
  - PSI-Center
    - Linear sims of external kink
      - NIMROD & PSI-Tet
    - Non-linear sims of mode saturation
    - Equilibrium reconstructions
  - **Future Plans:**
    - SOL self-organization (NIMROD & PSI-Tet)
    - Tearing modes w/Cole & Brennan (NIMROD & PSI-Tet)
    - Wall modes (NIMROD & PSI-Tet)
      - Can wall resistivity mimic 3D geometry?

# Chris Hansen (3 of 3)

- PSI-Tet
  - FE; H1 H(curl); thick & thin walls; neutral fluid; ...
  - **Future Plans:**
    - Finish resistive wall
    - Add simple electron temperature equation
    - Continue HIT, HBT, SSX, & LTX
      - Non-linear Hall-MHD in HIT-SI(3)
      - Linear/non-linear & Hall of HBT-EP
      - Taylor state for field-line tracing in SSX
    - Least-squares implementation

# Tom Benedett

- PSI-Tet full hMHD of HIT-SI & HIT-SI3 frequency scans
  - 4 freqs, cold start-up
  - BD comps of shape of A w/experiment; w/freqs; & chronos
  - Comparison with IMP & IDS data
- **Future Plans:**
  - Full hMHD
  - HIT-TD
    - Various injector configurations
  - More data analysis of freq scan and NIMROD
  - Investigate current direction
  - Finish 68.5 kHz HIT-SI3 run
  - General Exam

# John O'Bryan

- Self-organization in a narrow region Sun's surface
  - Self-organization largely ignored
  - S-O may produce super granules and magnetic field
- Solar physics and measurements primer
- NIMROD using low-frequency MHD
  - Logarithmic cont and temp equations; better  $n$  &  $T$  resolution at lower  $pd$
- **Future Plans:**
  - Modify  $\gamma_p$  profile
  - Change from dispersive to diffusive semi-implicit iMHD force operator
    - Discuss w/Carl
  - Study granulation and super granulation

# Alan Kaptanoglu

- BD and DMD for validation
- Issues w/BD & DMD
  - BD is orthonormal; DMD is not
  - BD is complete; DMD is not
    - DMD works well with data using a sliding window
  - Applying BD metrics to DMD
- **Future Plans:**
  - More evaluation of DMD and metrics
  - Look at DMD control scheme