#### M3D-C1 ZOOM Meeting 12/14/2020

#### **CS** Issues

- 1. GPU solve status
- 2. Eddy status
- 3. Local and other systems
- 4. NERSC Time
- 5. Changes to github master since last meeting
- 6. Question regarding fusion-IO (Brendan)
- 1. Physics Studies
  - 1. JRT Quarterly Report
  - 2. Other meeting (and Chang Liu summary of JOREK zoom)
  - 3. Helical band to remove runaway electrons (B. Lyons)
  - 4. Wei Zhang paper status
  - 5. DIII-D shot 178555/3055 (Andreas Wingen)
  - 6. DIII-D shot 177053 with Argon Chen Zhao
  - 7. Status of other simulations
  - 8. Other?

#### **GPU solve status**

From Jin Chen 12/14: These are the timings for superlu\_dist on traverse gpu and cpu for a small case: (3 nodes)

log.superlu\_on\_gpu: Tot 1.3949E+01 compute 7.2235E+00 solve 6.7254E+00 log.superlu\_on\_cpu: Tot 1.6665E+01 compute 9.7442E+00 solve 6.9210E+00 log.mumps\_on\_cpu: Tot 2.5310E+01 compute 1.7777E+01 solve 7.5327E+00

We were sent the paper: "Toward Performance-Portable PETSc for GPU-based Exascale Systems"

In conclusion: "....will allow us to achieve Exascale performance, and we have noted that no crucial outstanding technical problems remain"

#### **Eddy Status**

- slurm operating system was upgraded to 20.11
- This caused 3 of the 6 regression tests to fail, OOM or timeout
- After a lot of back and forth with the consultants, we found that everything works if you replace mpiexec/mpirun with srun
- I got a Dec 12 email from Bill Wichser: "Aren't upgrades just wonderful?"

#### Local Systems

- PPPL centos7(12/13)
  - All 6 regression tests PASSED on centos7:
- PPPL greene (12/7)
  - 5 regression tests PASSED
  - No batch file found for pellet
- EDDY (12/7)
  - All 6 regression tests PASSED
- TRAVERSE(11/16)
  - Code compiles
  - Regression test failed: split\_smb not found in PATH
  - Have not yet tried shipping .smb files from another machine

## **Other Systems**

- Cori-KNL (11/16)
  - 6 regression tests passed on KNL
- Cori-Haswell (11/16)
  - 5 regression tests passed
  - KPRAD\_RESTART did not pass, but differences are very small in velocity variables. All magnetic and thermal good. Similar difference as Cori-KNL
- PERSEUS
  - All 6 regression tests PASSED on perseus (J. Chen, 9/04/20)
- MARCONI
  - All regression tests PASSED on MARCONI (J. Chen, 9/04/20)
- CORI GPU (10/26)
  - ??

#### **NERSC** Time



Closed for general use

- New NERSC allocations start Jan 15 2021: mp288 received only 10M Hrs
- Cori Down Dec 15 10 AM ET, back up Dec 21 3:00 AM ET

## **Changes to github master since last meeting**

- S. Jardin
  - 12/10/20: removed toroidal derivatives from eta by integration by parts. (This allows toroidal variation In the vessel resistivity)
- A. Kleiner
  - 12/7/20: Python routines bug fix related to reading C1.h5 in unit conversion
  - 12/9/20: Python routines: Plot plasma shape for multiple simulations

#### **Question regarding Fusion IO**

Brendan Lyons to Nate Ferraro

#### **JRT Quarterly Report**

- We are part of a high-level Fy21 Joint Research Target: Shattered pellet injection for disruption mitigation on ITER
- 1<sup>st</sup> Quarter Milestone Report is due end of December:
- Identify existing JRT-relevant datasets from DIII-D and Alcator C-Mod, as well as from international SPI collaborations on JET and KSTAR. Identify existing dataset of SPI simulations with extended MHD codes, and develop a plan for additional simulations utilizing latest code developments. Develop a plan for upcoming DIII-D experiments to be conducted in this fiscal year. Execute new DIII-D experiments consistent with the facility operational schedule.
- Draft report done. Need to sharpen material regarding to coupling M3D-C1 and LP code (Brendan, Roman)

#### Other Meetings

- This Friday, 10 AM ET, Brendan will report on M3D-C1 disruption mitigation simulations on ITER DMS task force. Other material needed?
- This Wednesday 12:00 NOON ET, the FASTMATH institute will give a 1 hour presentation on their activities. Zoom info was sent. Posted: https://scidac5-fastmath.lbl.gov/science-partnerships/fastmath-webinars
- Last Wednesday the RAPIDS institute gave a webinar. Slides and video are posted: <u>https://rapids.lbl.gov/engagement</u>
- Today 9:15 AM ET Chang Liu organized a zoom call with the JOREK group concerning benchmarks involving Runaway Electrons. A short summary follows on the next 2 vgs.

#### Benchmark with JOREK on RE simulation

- Thermal electron to RE current conversion.
  - We need to develop an avalanche source term for RE, which will dominate the RE generation in later phase.
- RE-MHD coupling in tearing mode simulation
  - Set up a benchmark case without RE generation, compare the linear growth rate and nonlinear saturation.
- Do a complicated ITER simulation including RE generation and MHD instabilities (VDE, RE termination, ...)

#### RE source term benchmark

- 2D MHD simulation with RE generated from Dreicer (early phase) and avalanche (later phase).
- JOREK and GO have reached good agreement.
- In order to suppress numerical instabilities, thresholds need to be set up for both Dreicer and avalanche terms.



Chang Liu

#### Helical Band to remove runaway electrons

- Brendan Lyons performed a calculation last year with a conducting helical band that did not show large helical currents
- Can we try it again with the new coding that treats toroidal derivatives of resistivity correctly?
- GA is interested in getting a postdoc to work on this. (Still need supporting letter?)

## Wei Zhang received reviewer comments from benchmark paper

Requested that we redo the M3D-C1 tearing mode and resistive kink benchmark with full MHD (NUMVAR=3) instead of reduced MHD (NUMVAR=1). Now DONE for tearing mode, resistive kink in progress.





#### DIII-D 178555/3055 (Andreas Wingen)

rrange=[1.8,2.2], zrange=[0.7,0.8]



cutz = 0.74





#### **Tried increasing EFIT resolution**



#### Other ideas

- 2. I tried larger Te and ne boundary conditions in the past. The runs diverge even earlier, although I did not use eta\_te\_offset with that. I used eta\_te\_offset with the current boundary of Te =1eV, but it did not help the convergence. It rather made it worse.
- 3. I already use amu = 1e-5 but the other transport terms as default (1e-6).
  I started a new run with amu = 1e-5, denm = 1e-5, kappat = 1e-5 and eta as given by spitzer (iresfunc = 4). The run diverges already after 5 Alfven times with significant negative Te in the SOL. The previous runs made it to 20-30 Alfven times. So increasing one (or all) of the terms made it worse, not better.

4. Yes, I considered that, but the 3D linear runs do not have the pellet ablation physics included, yet are very costly. For the nonlinear 2D runs, how can they capture any growing modes? Can I use ntor = [1,2,3,...] with such runs, as in the 2D linear runs? The only alternative I can think of is using an axisymmetric pellet (ipellet = 13) in a nonlinear 3D run. I might try that, but I would rather get the above runs working.

#### My Suggestions

- Don't try and model actual case with actual parameters and actual geometry
- Keep resistivity,  $\eta > 10^{-6}$  (at most)
- May need a much larger viscosity. Charlson Kim used a magnetic Prantel number  $v/\eta = 10^5$ . He later did a scan and saw that the global parameters were not very sensitive to v
- Spread out bootstrap current over larger region
- First get the calculation to run nonlinearly in 2D before trying 3D



Chen Zhao

#### Same calculation in a Cylinder

# M3D-C1 runaway generation with cylinder geometry



Parameters: β<sub>0</sub> = 0.15

 $\begin{array}{l} a = 0.65m \\ R = 1.7m \\ B_0 = 1.9T \\ \eta = 1.0 \times 10^{-4} \\ n_0 = 1.0 \times 10^{20} m^{-3} \\ c = 150 v_A \\ N_{elements} = 12261 \\ \Delta t = 1.0 \tau_A \end{array}$ 

- The plasma current was equal with plasma current by the runaway current at about 12ms.
- The radial profile of runaway current profile are exactly same when the plasma current equal to runaway current.

#### **Progress on other shots?**

• M3D-C1/NIMROD 3D Benchmark

NSTX shot 1224020 – Fast ion transport with coupled kink and tearing modes Chang Liu

DIII-D Neon pellet mitigation simulation for KORC

• Brendan Lyons trying to extend 8 plane case to 32 planes

SPARK ? Do we need to do anything?

# That's All I have

Anything Else ?









#### NSTX shot 1224020 – Fast ion transport with coupled kink and tearing modes Chang Liu



- In the original geqdsk file, the equilibrium was poorly converged. New one is much better. Has q(0) = 1.3
- Chang has analyzed new equilibrium (left)
- No ideal (1,1) mode, several tearing modes
- If goal is to get unstable (1,1) mode, likely need to lower q(0)
- Adding sheared toroidal rotation should help stabilize resistive modes.

#### Grad-B drift in M3D-C1—HF side

Request to calculate grad-B drift in M3D-C1 and to compare with that being put into

the LP Code

- (a) Density source in1F toroidalequilibrium
- (b) Change in density after  $10^3 \tau_A$
- (c) Poloidal velocity stream function

(d) Toroidal velocity contours





#### **Grad-B drift in M3D-C1– LF source**

Request to calculate grad-B drift in M3D-C1 and to compare with that being put intothe LP Codeσ

- (a) Density source in 1F toroidal equilibrium
- (b) Change in density after 10<sup>3</sup>  $\tau_{\text{A}}$
- (c) Poloidal velocity stream function
- (d) Toroidal velocity contours





## Grad-B drift in M3D-C1—2F effects

- (a) 2F density change after  $10^3 \tau_A$  for LF side source
- (b) Difference in 1F and 2F density (LF)
- (c) 2Fdensity change after  $10^3 \tau_A$  for HF side source
- (d) Differencein 1F and 2F density (HF)





#### Sawtoothing discharge with runaway electrons



Profiles of nre, jy, and E\_par after 30 timesteps

Original: /p/tsc/m3dnl/Isabel/Chen2D Mod: /p/tsc/m3dnl/Isabel/Chen2D-mod1

Changed: mesh size "regular" "integration points" ipres=1 cre pedge viscosity denm equilibrium density

#### **Longer times develops oscillations**



- Short wavelength oscillations occur first in nre and then in other quantities (jy, e\_par)
- Could we add some smoothing?