Week 11 Report

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Simulation with **B** = 0

- Bmax set to zero in header of init.c, effectively eliminates magnetic field
  - Results were indistinguishable from prior to magnetic field implementation.
  - Since our chosen stellar model as at hydrostatic equilibrium barring any magnetic field component, this agrees with the conditions we’ve set on our model.

B-field Magnitude Correction

- In our last meeting, Dr. Thompson keenly pointed out that the magnitude of our magnetic field was slightly off (disregarding the order of magnitude difference).
- Upon further inspection, I noticed that the normalization constant for the B-field was slightly off:
  - I have been correcting as $$B = \frac{B_{cgs}}{\sqrt{\rho_0 v_0^2}}$$
  - The PLUTO user manual points out that B-field normalization should follow: $$B = \frac{B_{cgs}}{\sqrt{4\pi \rho_0 v_0^2}}$$
- Normalization was corrected in init.c and B-field magnitude agrees well with Kuhn's findings.

Converting Back to cgs Units

- In converting all variables (density, pressure, etc.) back to cgs, we must multiply computed values by the reciprocal of the normalization constants.
    - Fortunately, PLUTO has the ability to handle this process by editing the .vtk data output line in pluto.ini, so at least for density and pressure we don't need to do too much:

```
[Static Grid Output]

uservar    4 T Mr Mt Mp
dbl        1.0  -1   single_file
flt       -1.0  -1   single_file
vtk        .001  -1   single_file cgs
dbl.h5    -1.0  -1
flt.h5    -1.0  -1
```

Converting User-defined Variables

- Last time, I mentioned that B-field components were not being written to these data files, and needed to be specified in userdef_output.c. Since these are user defined variables, we must code the conversion back to cgs.

```
DOM_LOOP(k,j,i){
      T[k][j][i] = (p[k][j][i]/rho[k][j][i])*(UNIT_VELOCITY*UNIT_VELOCITY); /* Compute temperature */
      Mr[k][j][i] = B1[k][j][i]*(sqrt(4*CONST_PI*UNIT_DENSITY)*UNIT_VELOCITY); /* Assign Bradial to Mr, convert to cgs */
      Mt[k][j][i] = B2[k][j][i]*(sqrt(4*CONST_PI*UNIT_DENSITY)*UNIT_VELOCITY); /* Assign Btheta to Mt, convert to cgs  */
      Mp[k][j][i] = B3[k][j][i]*(sqrt(4*CONST_PI*UNIT_DENSITY)*UNIT_VELOCITY); /* Assign Bphi to Mp, convert to cgs    */

}
```

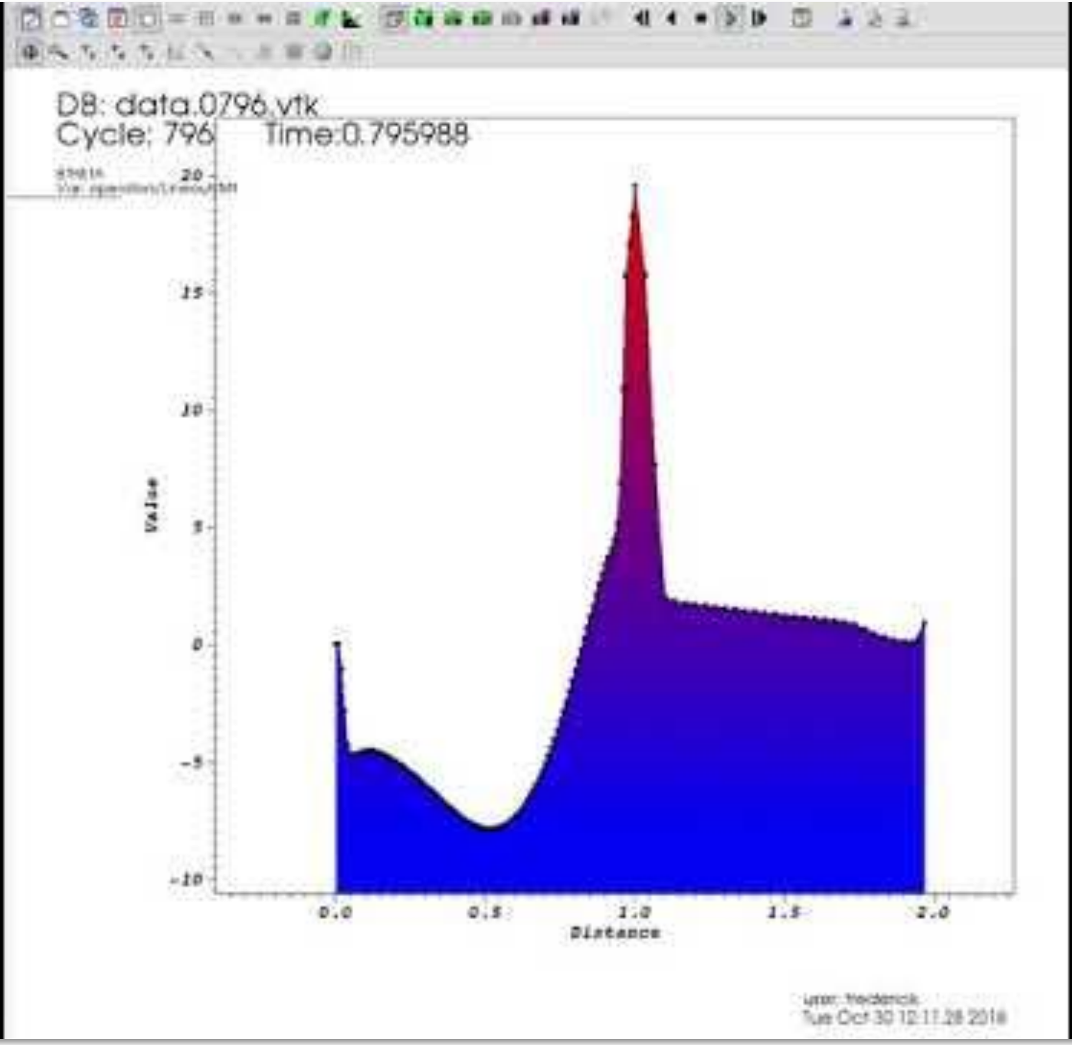
Automatic Suspend Disabled

- Realized that in addition to setting power saving mode to never activate, I needed to also disable automatic suspend.
- Automatic suspend essentially halts all processes after 30 minutes of dormancy and logs the user out. A consequence of this is that any programs the user has running will be closed.
  - This meant I couldn’t set the computer to run longer/more demanding simulations without being at the computer.
- After setting automatic suspend to “disabled”, the computer will not go to sleep and longer or more detailed simulations are possible to compute while being away from the computer.

Correction to B_θ at $r = 1.0$

- B_θ was developing a sharp spike at $r = 1.0$
- I ran a test with time step-size Δt = 1e-6 to determined whether simulation time step was a factor; this did not change outcome.
- Dr. Kuchera recommended matching boundary conditions at $r = 1.0$ so that B_θ immediately interior and exterior to the star are set equal.

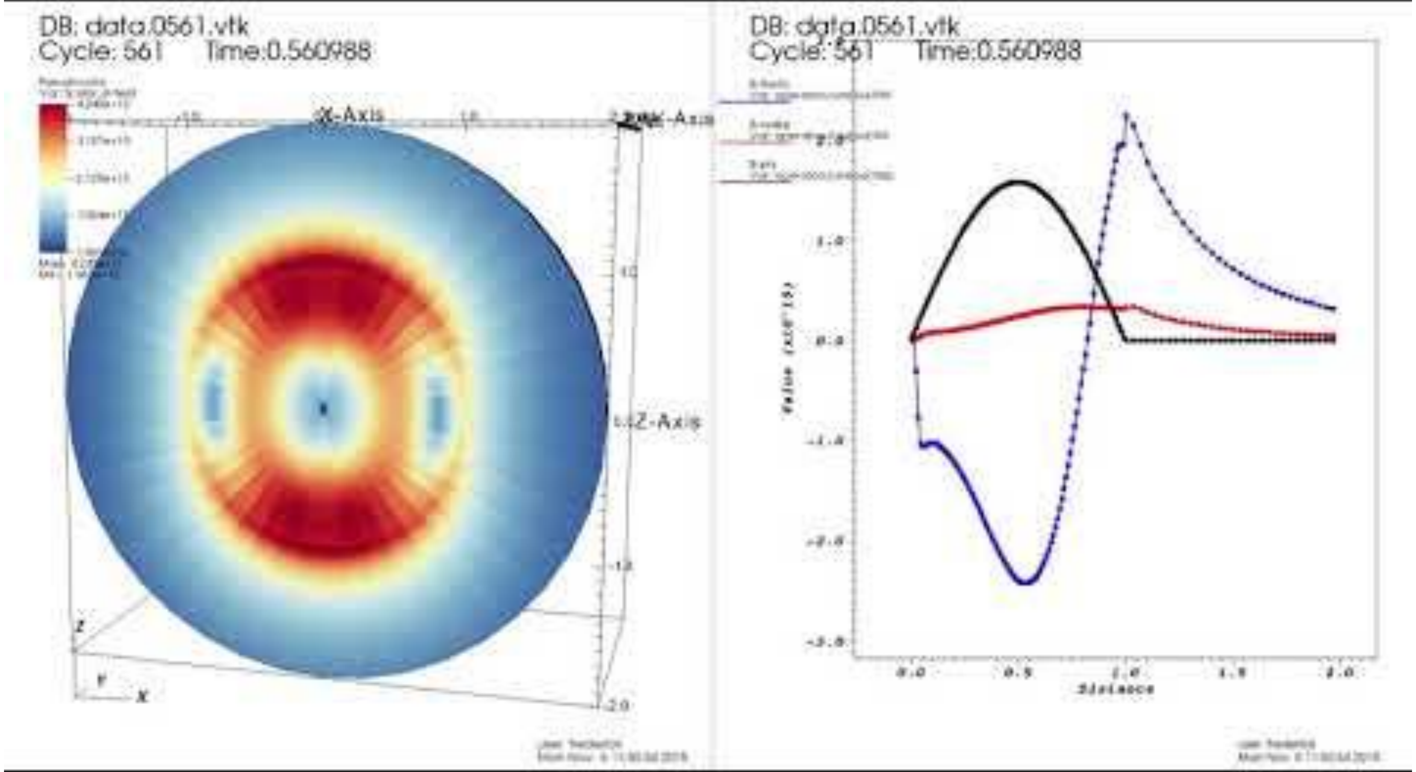
- **Video on next slide shows spike prior to correction**


DB: data.0796.vtk
Cycle: 796 Time:0.795988
20
15
10
5
0
-5
-10
Value
0.0
0.5
1.0
1.5
2.0
Distance
Tue Oct 30 12:11:28 2018

More B-field Boundary Corrections

- A general constraint that our model requires is that the toroidal component of the B-field be non-zero inside the star and zero everywhere else.
- I added a internal-boundary condition (which is capable of setting values inside the computational domain rather than the ghost zones we specify with X1_BEG,X1_END,...) to init.c for $B_\varphi = 0$ for $r > 1.0$. This condition is also restrictive in time so $B_\varphi = 0$ for $r > 1.0$ is always true.
- Adding this condition dramatically improved the behavior of B-field evolution.
- I set a similar condition for B_r as I set with B_θ such that the magnetic field component matches value immediately interior and exterior to $r = 1.0$.

The next slide shows results of B-field evolution after making these corrections. Behavior is improved, although I'm curious about the way B_θ changes interior to the star.



DB: data.0561.vtk
Cycle: 561 Time:0.560988
X-Axis
Y-Axis
Z-Axis
DB: data.0561.vtk
Cycle: 561 Time:0.560988
Value (x10^15)
Distance

Goals for Next Week

- Continue investigating B_θ behavior
- As B-field evolution appears increasingly stable, I will test velocity perturbations Kuhn used to test the dynamical behavior of her simulated B-field.
- Investigate effect of resolution in spherical θ coordinate axis on simulation?
- Work to practically implement SLyEOS, an alternative structural EOS for density and pressure that takes neutron star crust into account.