Week 5 Report
Spring 2019

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Mixed Magnetic Field Model

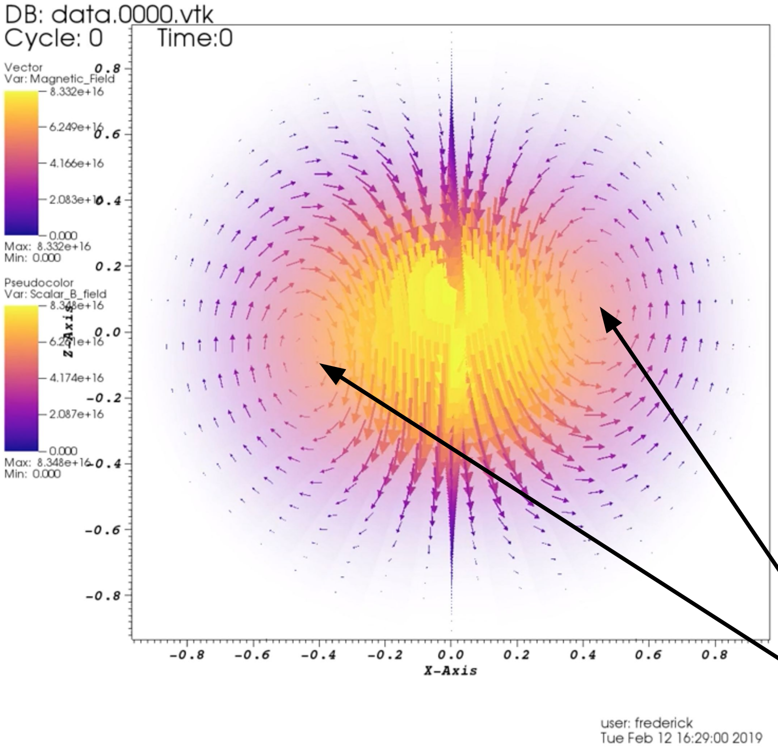
Put function declarations in pluto.h

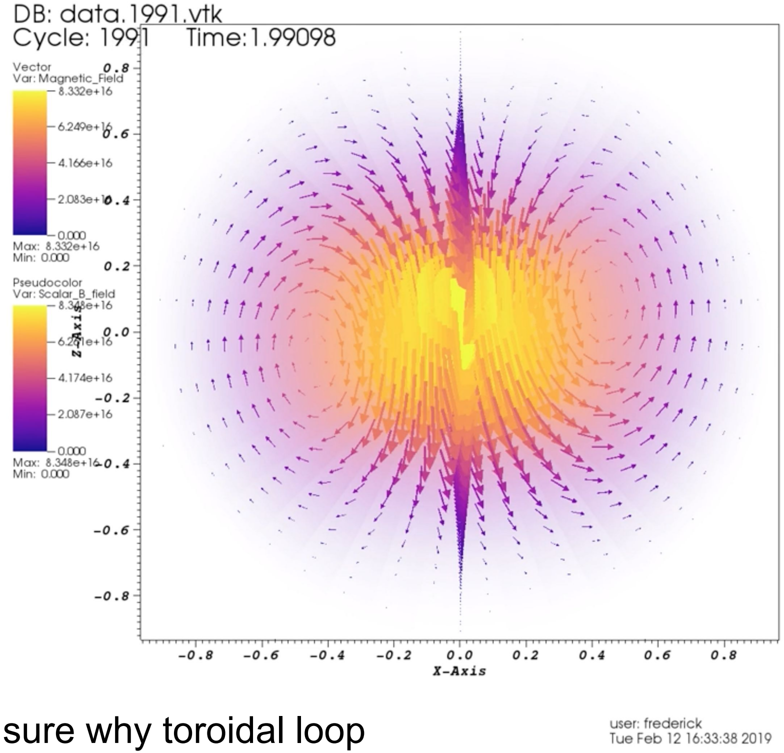
- To recap, we need to replace our “pure poloidal and pure toroidal” magnetic field model with a *mixed* field model.
    - Obtain both models from same source: Haskell et al. (2008)
    - Two things to note:
        - Combining the pure poloidal/toroidal model into one configuration is inaccurate because the two fields are not strictly independent of each other.
        - Our **ultimate goal** is to determine the strength of GWs that may result from deformations due to the B-field. Practically, this involves calculating the ellipticity of the star.
            - Haskell et al. makes specific note of the distinct difference between computing the ellipticity by combining pure poloidal/toroidal results and calculation via mixed field results. The difference is at least an order of magnitude!
- In short, calculations for the ellipticity which use the mixed field would offer a marked improvement in comparison to prior work by Kuhn.

So it's important, but does it work?

- As of Monday, still had issues with negative densities.
- A key notion of Haskell et al. (2008) is that it defines ***internal*** magnetic fields, so we don't assign a B-field for $r > R$!
- In *init.c*, I assign the field only for $r < R$.
    - Valuable constraint which allows us to lower the "Vacuum Density". Recall initially referencing Kuhn, this was set to 1×10^{10} g cm^{-3}, we can lower it down to 1×10^{6} g cm^{-3}
- Things run smoothly, it works!

Stability of Field in Time Evolution

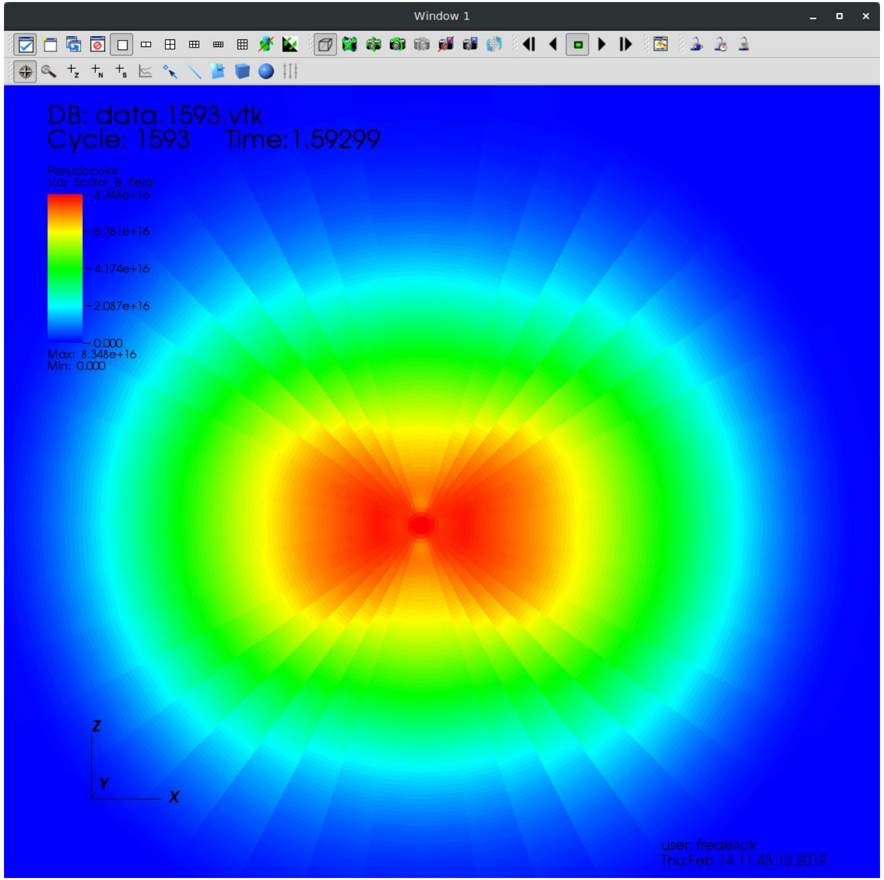




Not sure why toroidal loop
is off-axis slightly.

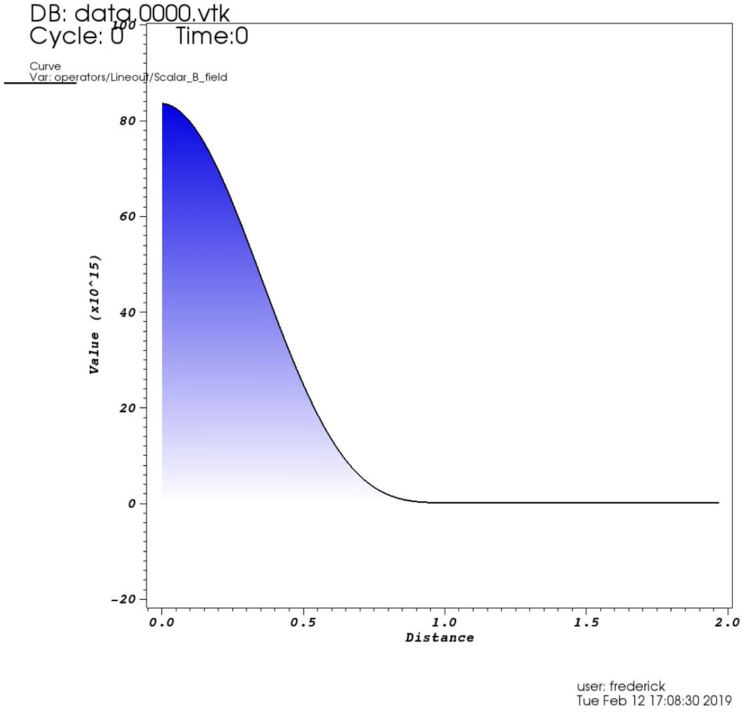
Some Interesting Notes

- After updating field the peak magnitude of the field increases.
- Peak magnitude of right image reaches 8 x 10^{16} gauss.
    - Clearly this requires adjusting the ‘Bmax’ parameter in my code so field magnitudes fall within physical range.
- As seen in the image, field magnitude appears diminished near z-axis.

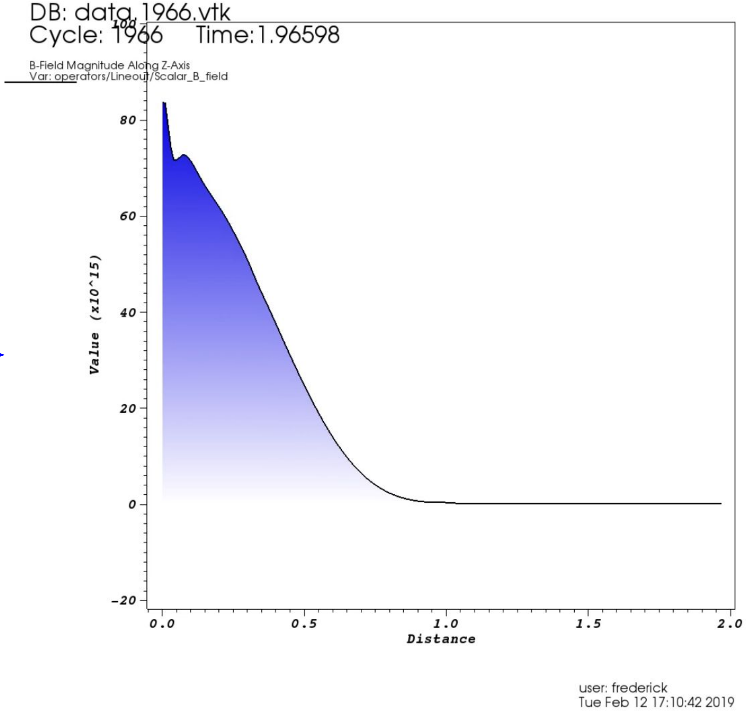


Core structure of B-field

Lineout for B-field magnitude along Z-axis

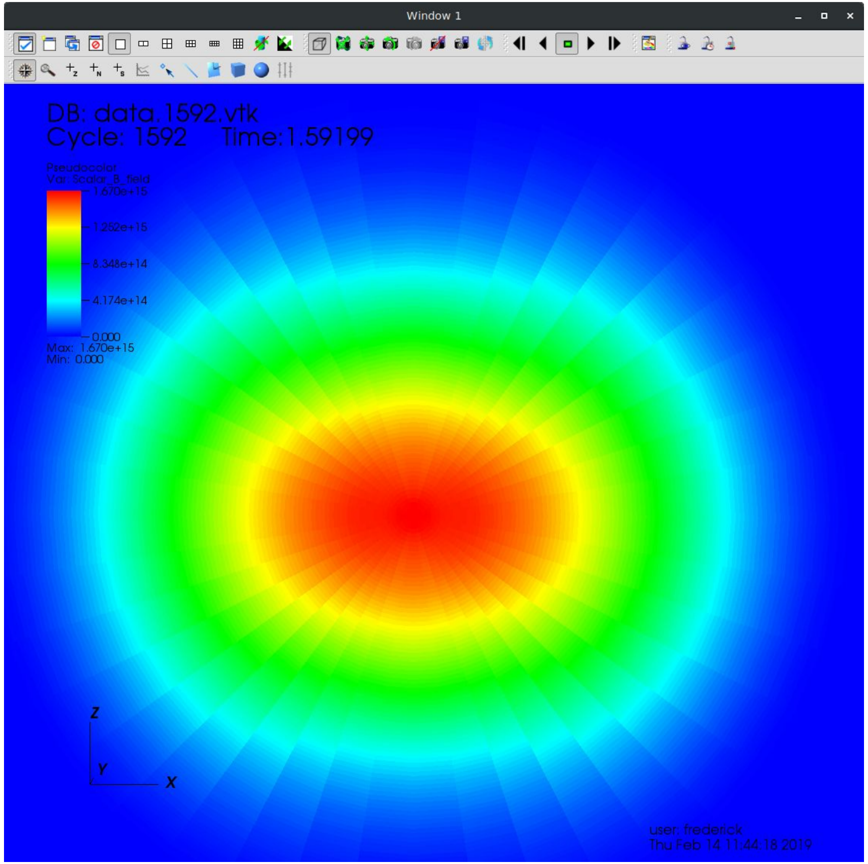


(Time)



Updated Bmax Value

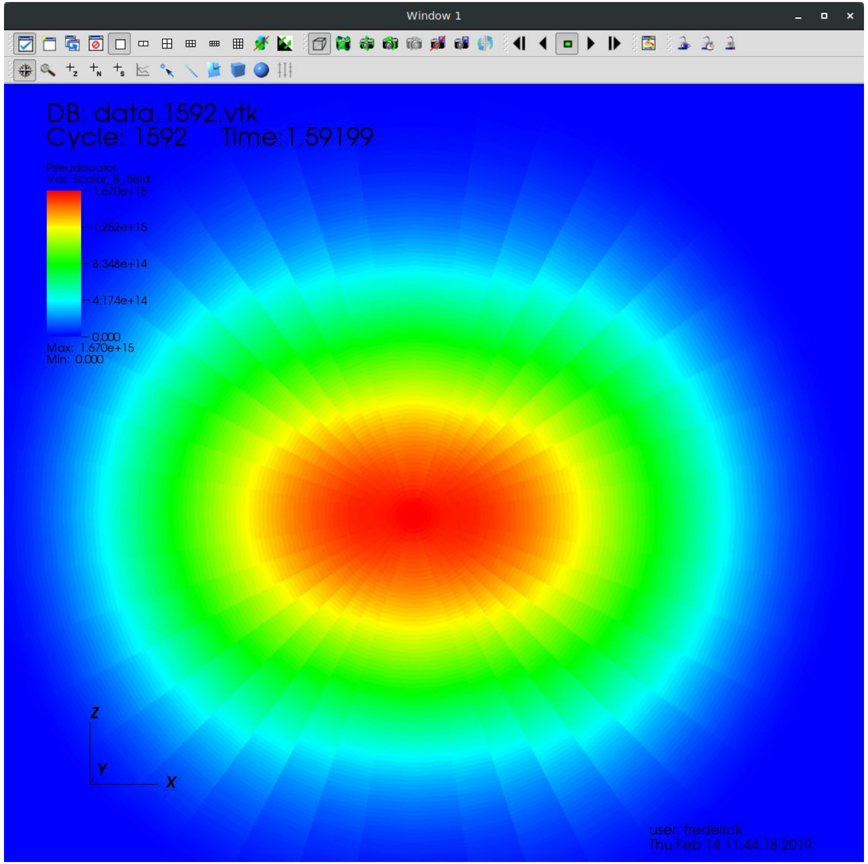
- Bmax was set to 1 x 10^{14} so that the *overall* field peaks at roughly ~1 x 10^{15} gauss
- The simulated field to the right has a peak magnitude of 1.7 x 10^{15} gauss
- The overall structure of the field is maintained significantly more under evolution.



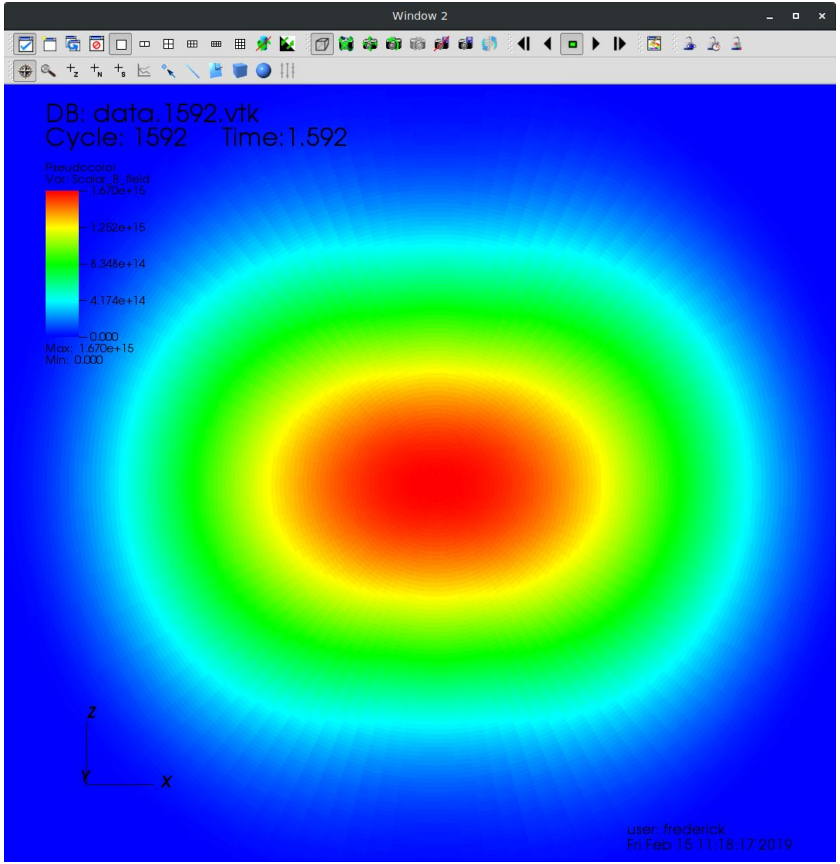
Core structure of B-field

The Effect of Angular Resolution

- To add to the positive impact lower ‘Bmax’ has on field structure evolution, I test the impact of resolution in ϴ on field evolution.
- Angular resolution increased from 20 grid cells to 50 grid cells from $(0,\pi)$.
- Further improvements are found in comparing the lineout graphs for data with adjusted ‘Bmax’ value prior to increasing resolution and data following the increase in resolution.
- These changes are not dramatic, but still worth mention to address understanding of how resolution can change results of our simulation.

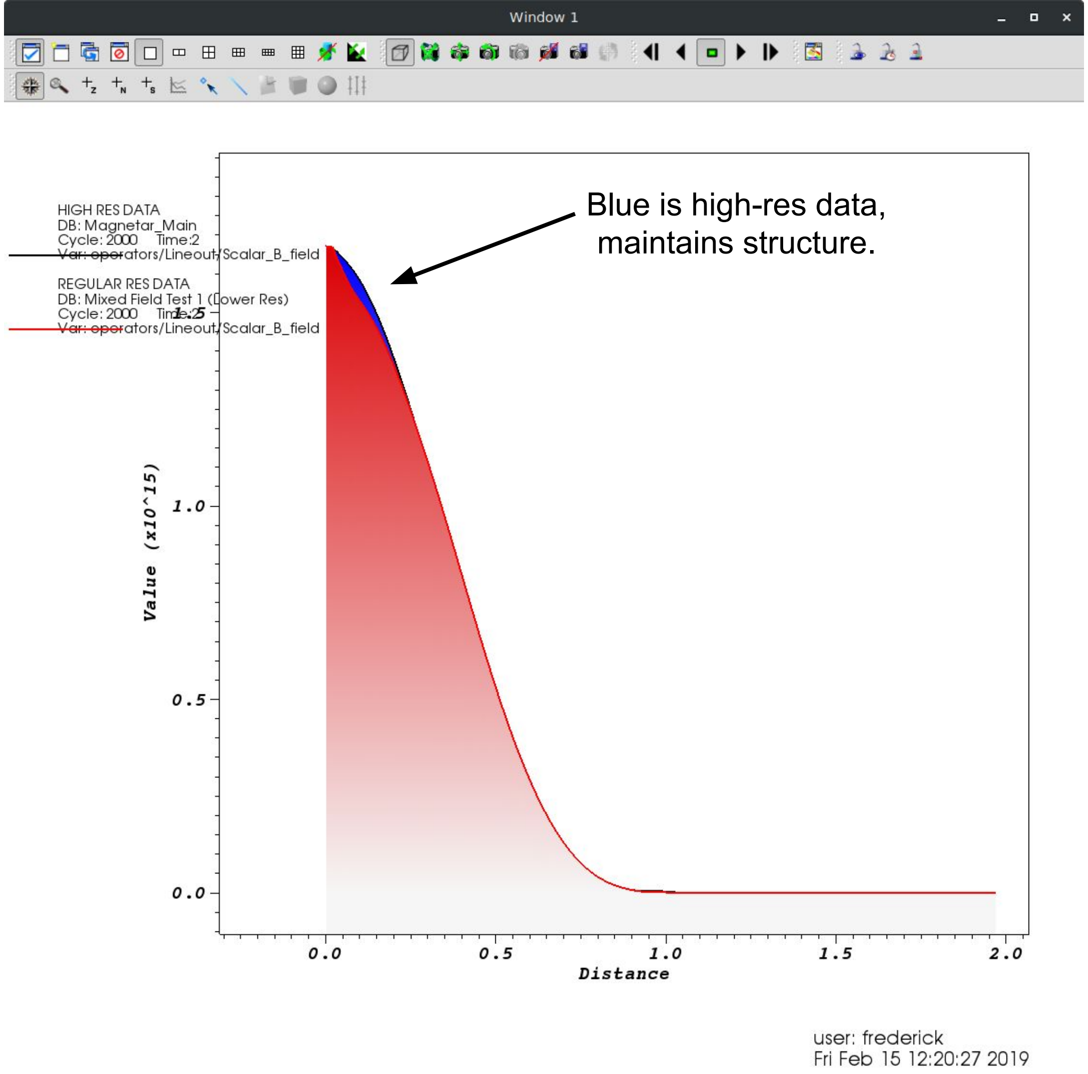


Regular-res Data at 1.59 s

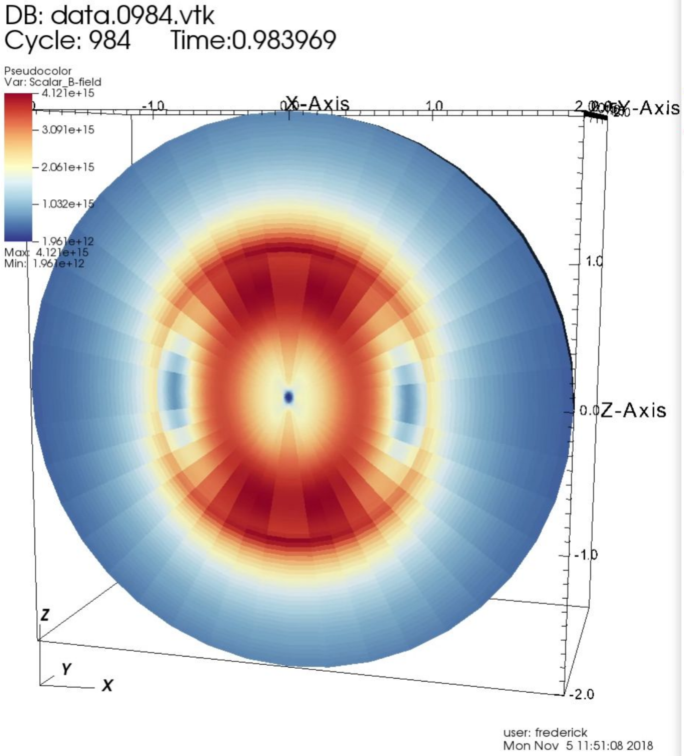


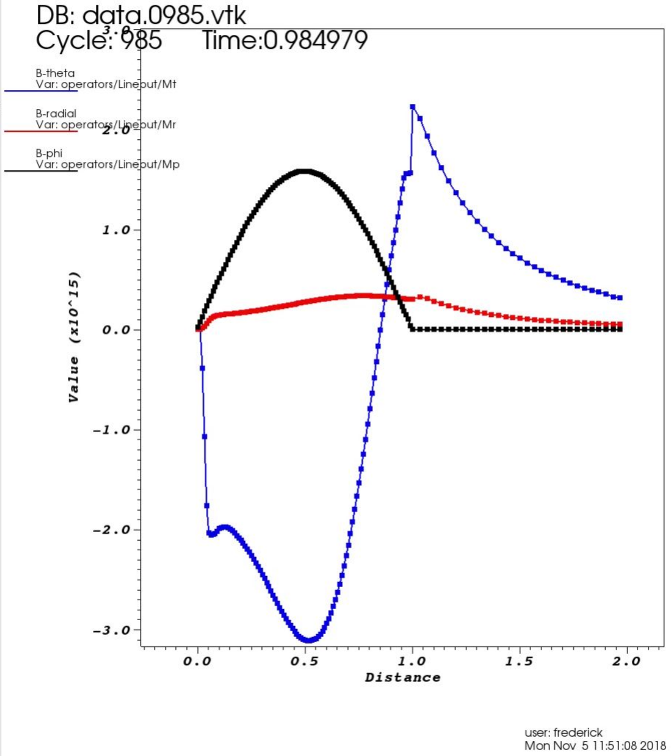
High-res Data at 1.59 S

Lineout along Z-axis comparing high and regular res. data



Data from November 5th, prior B-field model





Interesting to note stability of mixed field especially in comparison to the unusual behavior we were seeing in prior model evolution.
Worth mentioning in thesis?

Future Work

- With this B-field model in place, I can begin focusing on computing ellipticity
  - Continue looking through literature to determine the best way to go about this, Kuhn gives some details and Haskell et al. also provides a pretty detailed analytic procedure. I'd like to find other sources which discuss this procedure.
  - Determine ellipticity for a number of scenarios; recall the mixed field equations introduce a parameter λ relating toroidal and poloidal field strength. Haskell et al. show that high values for λ (corresponding to strong toroidal fields) produces higher levels of ellipticity.
- Once I have ellipticity computations in place, I can reference the McGill Magnetar Catalog to insert physical parameters into simulation and compute estimates for wave strain.