Week 10 Report

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Specifying Boundary Conditions

- Created Haskell_BCs.xlsx
  - Organizes boundary conditions into clear categories.
  - B_r and B_θ boundaries will be assigned user-defined boundary conditions.
    - Boundary conditions for B_φ are left as outflow (gradient set to zero).

	r = 0	r = rmax	theta = 0	theta = Pi	Phi = 0	Phi = 2Pi	theta = pi/2 (necessary specified BC?)	R = 1
Br	0	Functional form	Functional form	Functional Form			0	N/a
Btheta	0	Functional form	0	0	Equivalent		N/a	N/a
Bphi	0	0	0	0			N/a	0 (and r > 1)

User-defined Boundary Conditions in init.c

- User-defined boundary conditions for B_r and B_Θ
  - $B_r(r = 0)$ -> X1_BEG, $B_r(r = 2.0)$ -> X1_END, $B_\Theta(\Theta = 0)$ -> X2_BEG, $B_\Theta(\Theta = \pi)$ -> X2_END

Conditions interior to star

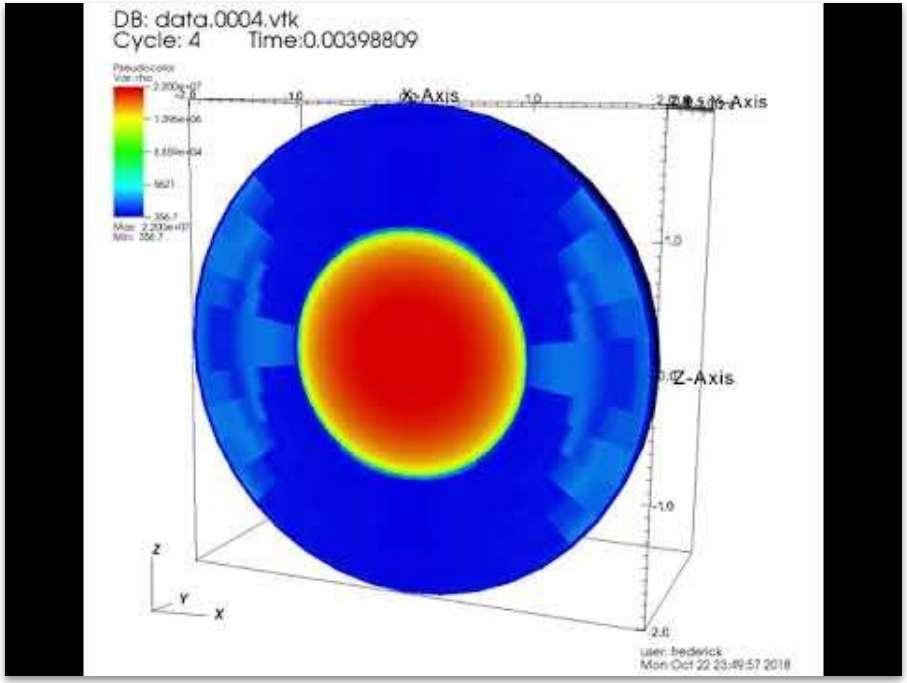
Conditions exterior to star

```
if (side == X2_BEG){  /* -- X2_BEG boundary -- */
  if (box->vpos == CENTER) {
    BOX_LOOP(box,k,j,i){
      if (x1[i] < 1.0){
        d->Vc[BX1][k][j][i] = CONST_PI*CONST_PI*CONST_PI*x1[i]*x1[i]*x1[i] +
          3*(CONST_PI*CONST_PI*x1[i]*x1[i] -2)*sin(CONST_PI*x1[i])+6.0*CONST_PI*x1[i]*cos(CONST_PI*x1[i]);
        d->Vc[BX1][k][j][i] = (d->Vc[BX1][k][j][i]*(BMAX*1))/(CONST_PI*(CONST_PI*CONST_PI-6));
        d->Vc[BX1][k][j][i] = d->Vc[BX1][k][j][i] / (sqrt(UNIT_DENSITY)*UNIT_VELOCITY);

        d->Vc[BX2][k][j][i] = 0.0; /* No theta bfield component at central (theta) axis*/
        d->Vc[BX3][k][j][i] = 0.0;
      }
    else{
      d->Vc[BX1][k][j][i] = (BMAX*1)/(x1[i]*x1[i]*x1[i]);
      d->Vc[BX1][k][j][i] = (d->Vc[BX1][k][j][i])/(sqrt(UNIT_DENSITY)*UNIT_VELOCITY);

      d->Vc[BX2][k][j][i] = 0.0; /* No theta bfield component at central (theta) axis*/
      d->Vc[BX3][k][j][i] = 0.0;
    }

    }
```

$B_\Theta(\Theta = 0)$ boundary conditions

Preliminary Results (Using “Outflow” BCs)

I tested whether or not the B-field was having an impact on the simulation by letting $B_{max} = 10^{17}$ Gauss. We see that imposing this non-physical field creates a strong magnetic field pressure, abruptly accelerating mass away from the surface of the star.

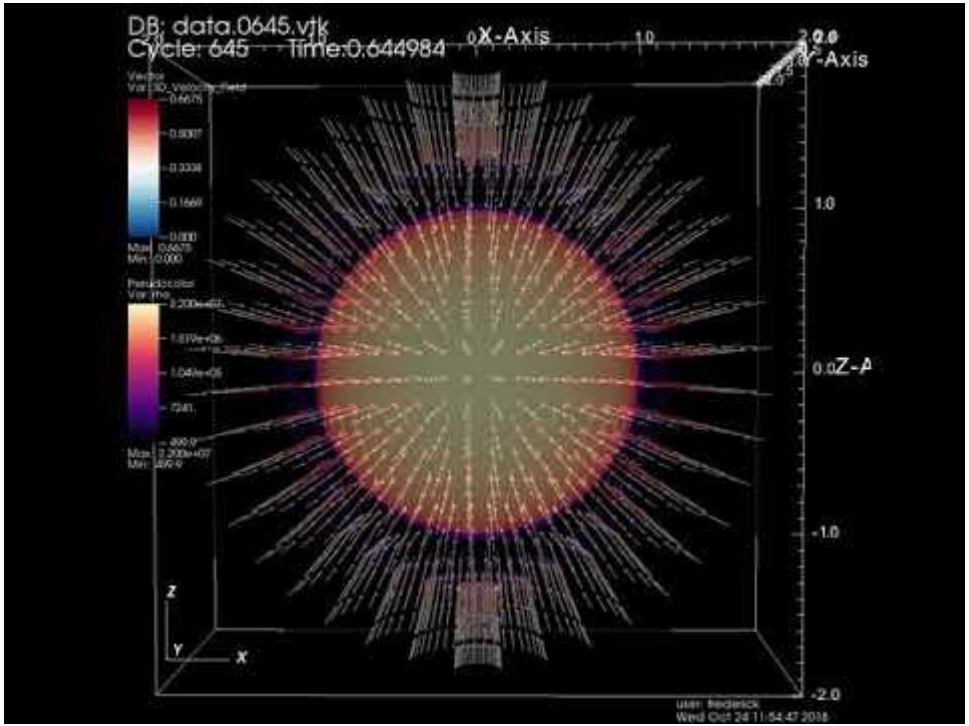


Debugging

- Issue with BCs prior to correction:
  - I was able to run the code without errors using all “outflow” BCs. This however meant that my BCs were not entirely physically accurate.
- B_field_analysis.py
  - Plots B-field components in the computational domain for a specified Θ (φ-value is arbitrary due to azimuthal symmetry).
  - Helped to think through some of the conditions I required at each boundary; I had missed conditions for r = 0 and since BCs for B_Θ assign different values varying with radius, I required a conditional expression for r < 1 and r > 1 for these BCs.
  - I also had a unfortunate issue with b-field component normalization: Neglecting to place parentheses around terms in the denominator for normalization meant I was scaling up B-field magnitude rather than scaling down.
- Correcting these errors (or incomplete conditions) allowed the code to run properly with user-defined boundary conditions.

Correction of BCs, Proper Implementation of B-field

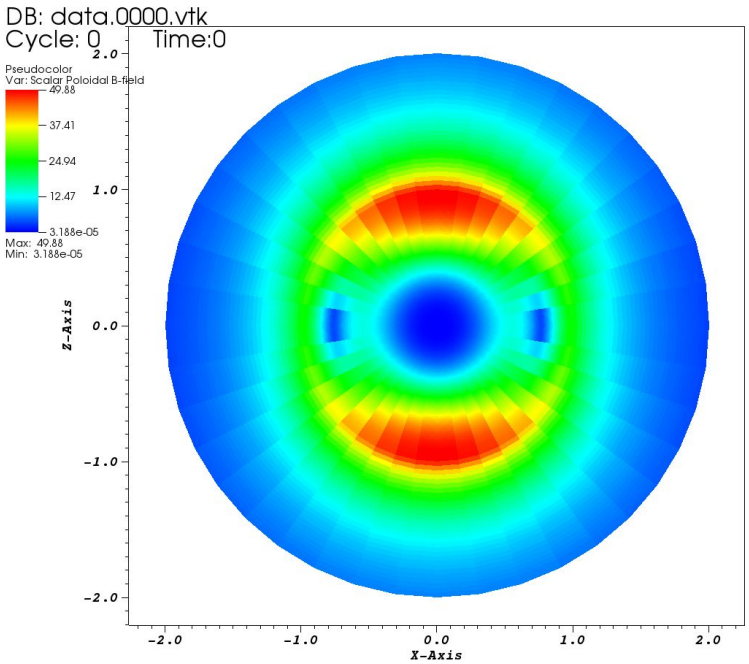
- Following correction, computation runs smoothly and free of prior errors we've encountered with negative density/pressure/energy.
- Simulation shows evolution of velocity vectors superimposed on top of density.



Visualizing the B-field

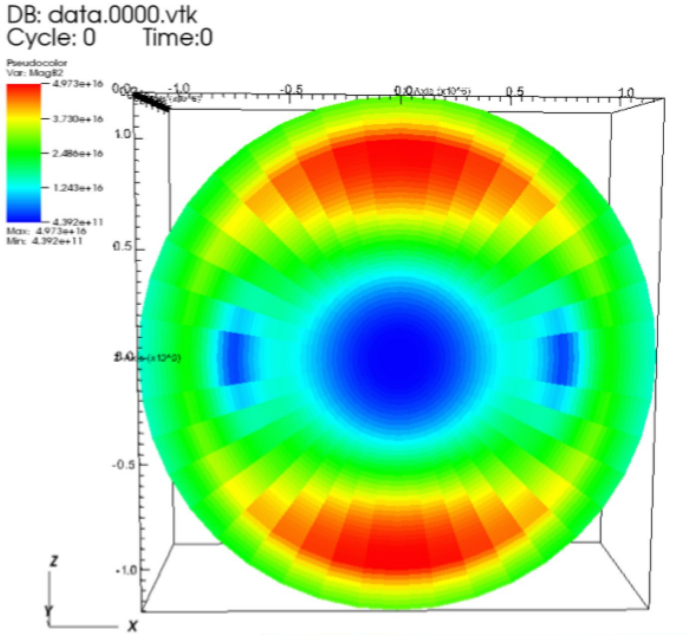
- Although the B-field should be an attribute like density or pressure that PLUTO automatically saves for each iteration so these variables can be plotted or visualized in VisIT, the data were not including B-field components.
- Created user variables which map to the B-field components
    - Option enabled in pluto.ini for defining user variables, required to define variables in ComputeUserVar() located inside Src/userdef_output.c

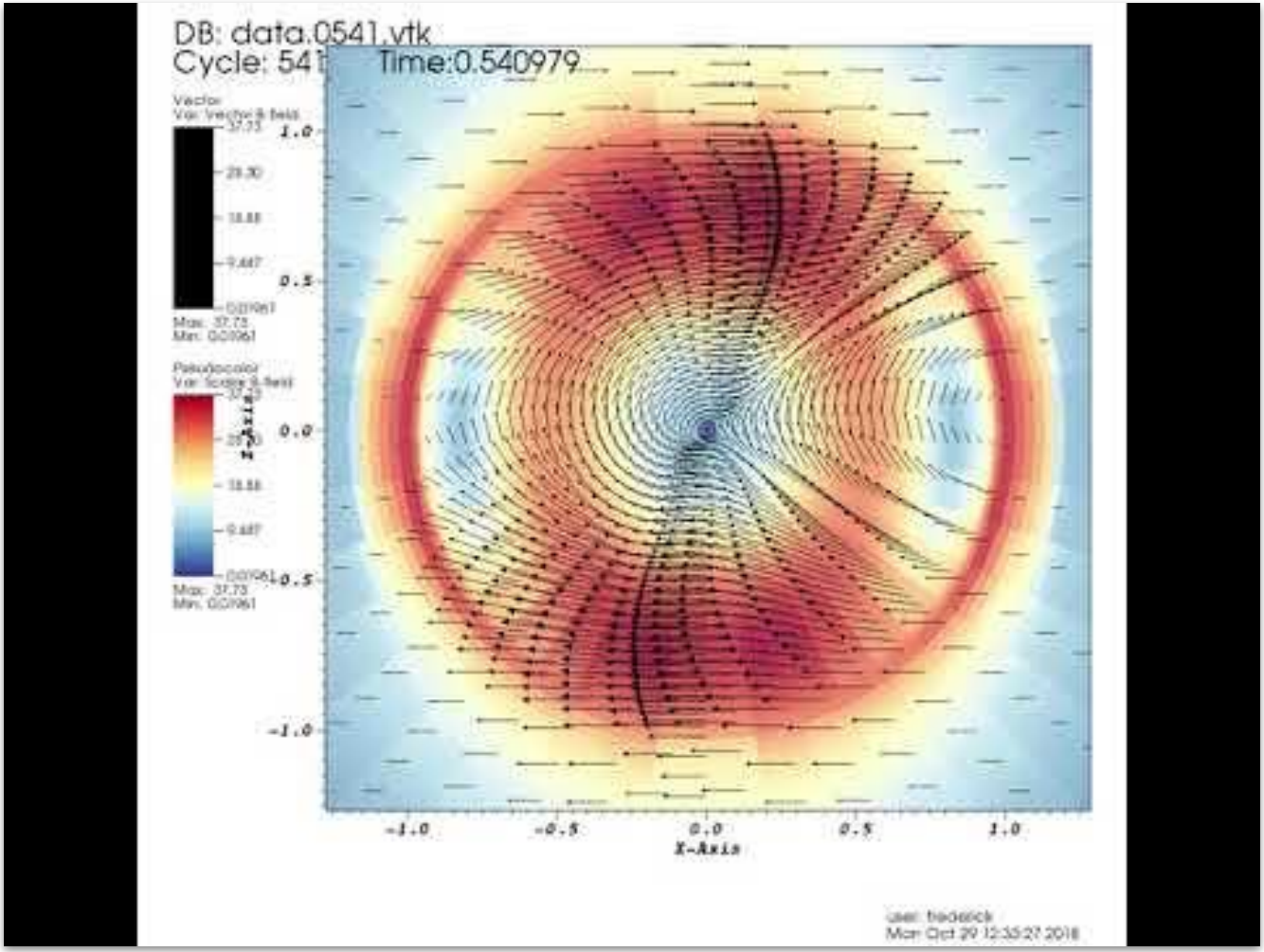
My Work



user: frederick
Mon Oct 29 11:17:52 2018

Kuhn's Work

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Min: 0.00961
Pseudocolor
Var: Scalar 3 field
Max: 37.73
Min: 0.00961
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0.0
-0.5
-1.0
Y-Axis
-1.0
-0.5
0.0
0.5
1.0
X-Axis
user: hedstrck
Mon Oct 29 12:35:27 2018