Breaking temperature equation down

We can plot different contribution with the post-processing IDL tool

$$n_e\left[\frac{\partial T_e}{\partial t}\right] = -n_e(\mathbf{v}\cdot\nabla T_e + (\Gamma-1)T_e\nabla\cdot\mathbf{v})$$ -- vdotgradt

$-T_e(D\nabla^2 n_e + \sigma_e)$ ----------f2eplot

$+(\Gamma-1)\eta\mathbf{J}^2 + (\Gamma-1)Q_e$ --------- eta_jsq

$-(\Gamma-1)\nabla\cdot\mathbf{q}_e$ ---------- deldotq_par & deldotq_perp

$-(\Gamma-1)Q_\Delta$ ---------- f3vplot

$-(\Gamma-1)\Pi_e:\nabla\mathbf{v}$ ---------- ?? This is probably not dominant

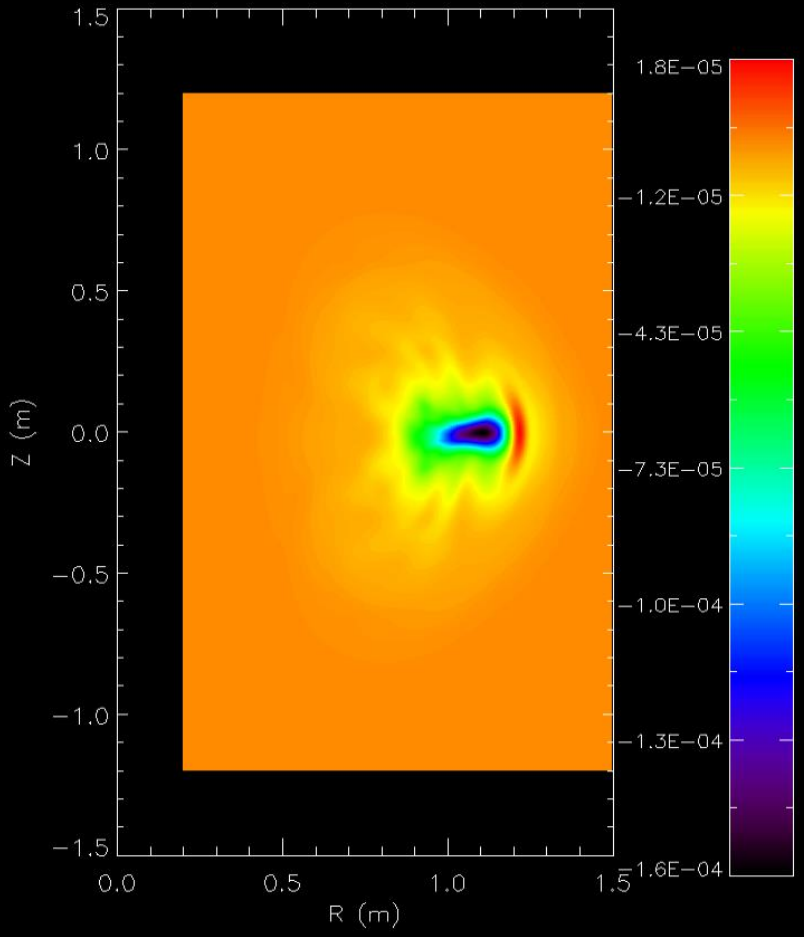
We will compare left hand side (LHS) with Right hand side (RHS) for ONE timestep

Full Case

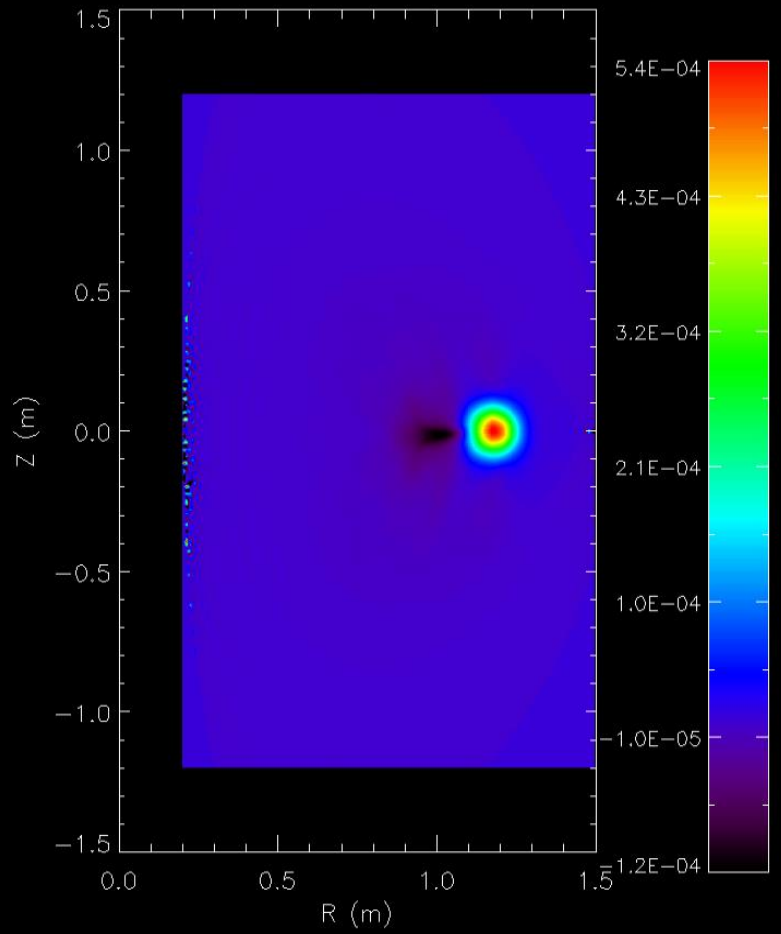
RHS = eta_jsq + vdotgradt + deldotq_par
+ deldotq_perp + f3vplot + f2eplot

Running only 1 timestep dt=0.25

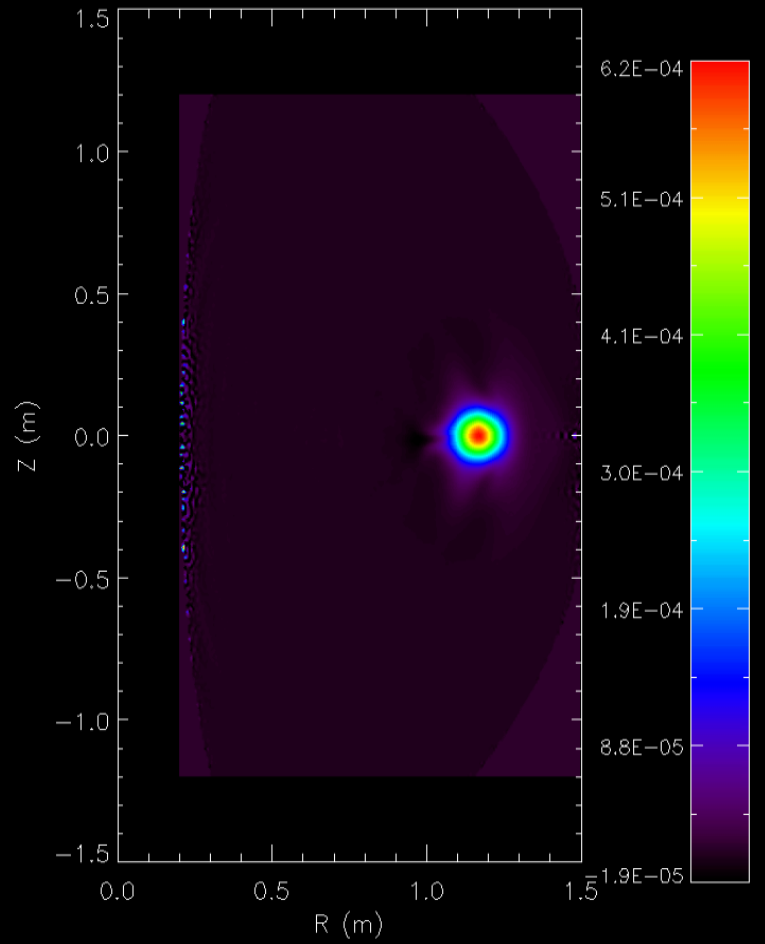
LHS: ne*[Te(t)-Te(t-dt)]/dt



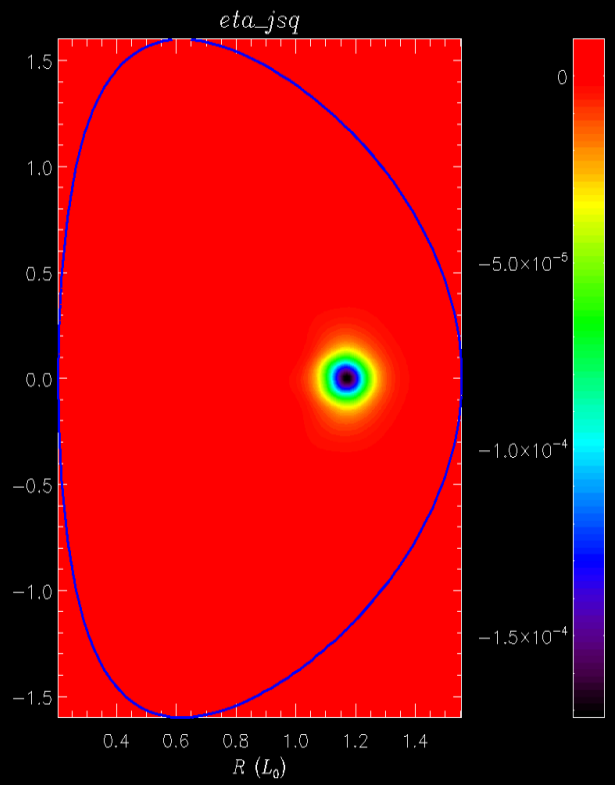
RHS:

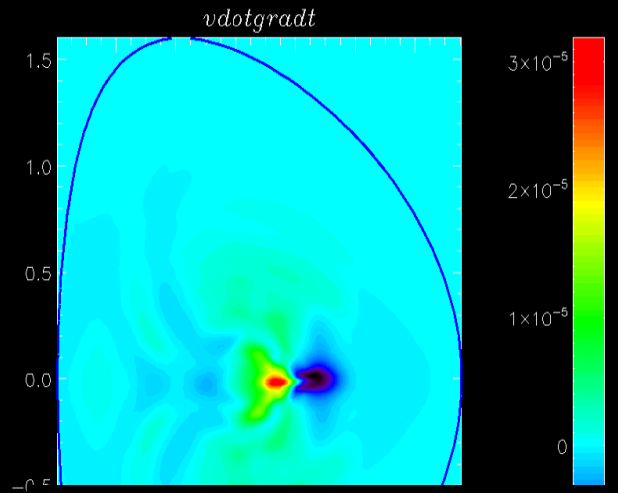


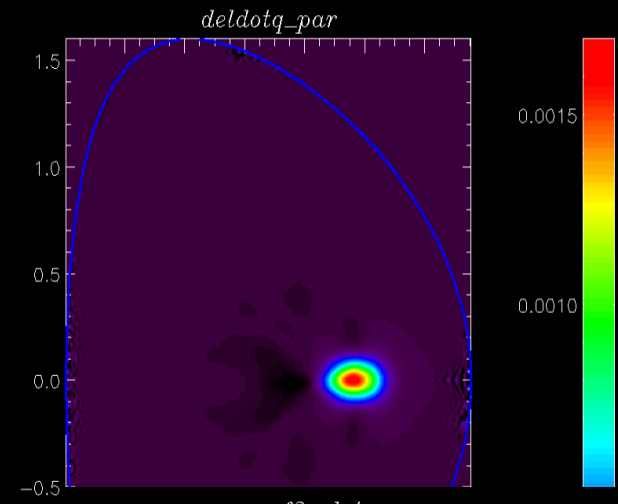
RHS - LHS

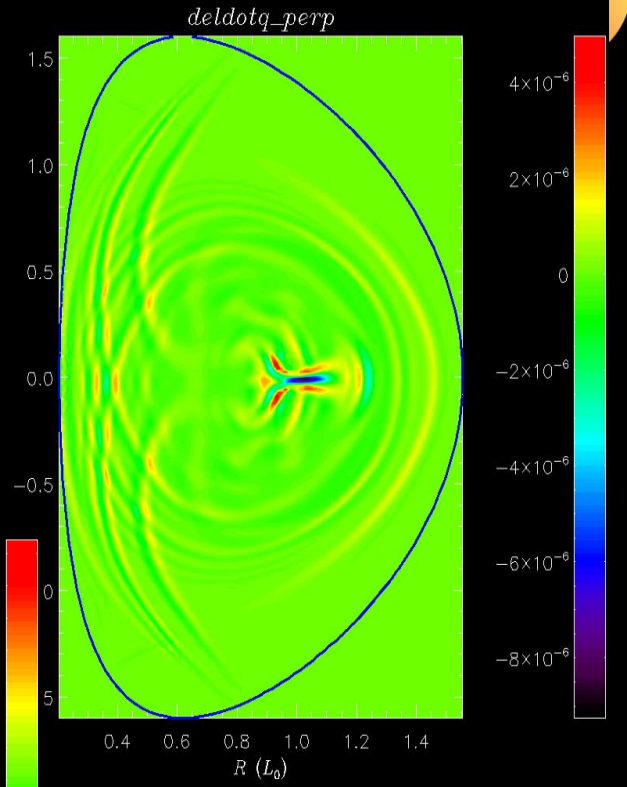


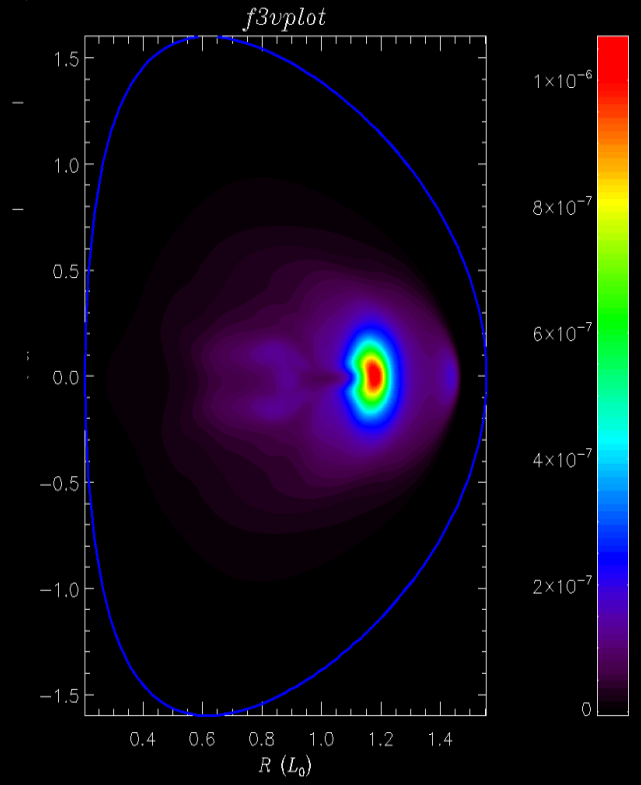
RHS = eta_jsq + vdotgradt + deldotq_par + deldotq_perp + f3vplot + f2eplot

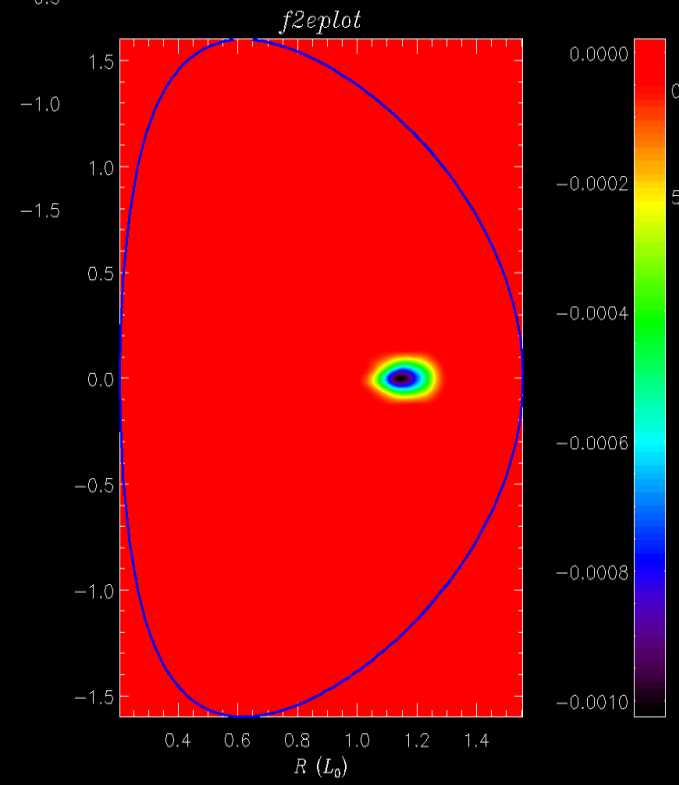












Turning off different contribution to the Te equation

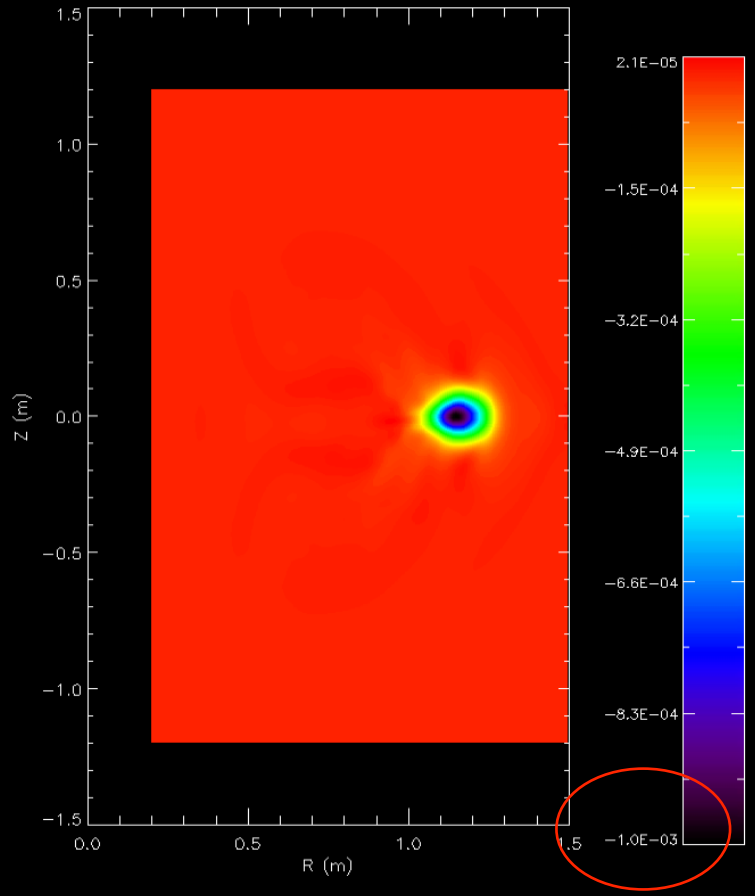
Setting $\Gamma = 1$.

$$n_e\left[\frac{\partial T_e}{\partial t}\right] = -n_e(\mathbf{v}\cdot\nabla T_e + \cancel{(\Gamma-1)T_e\nabla\cdot\mathbf{v}})$$
$$-T_e(D\nabla^2 n_e + \sigma_e)$$
$$\cancel{+(\Gamma-1)\eta\mathbf{J}^2} \cancel{+(\Gamma-1)Q_e}$$
$$\cancel{-(\Gamma-1)\nabla\cdot\mathbf{q}_e}$$
$$\cancel{-(\Gamma-1)Q_\Delta}$$
$$\cancel{-(\Gamma-1)\Pi_e:\nabla\mathbf{v}}$$

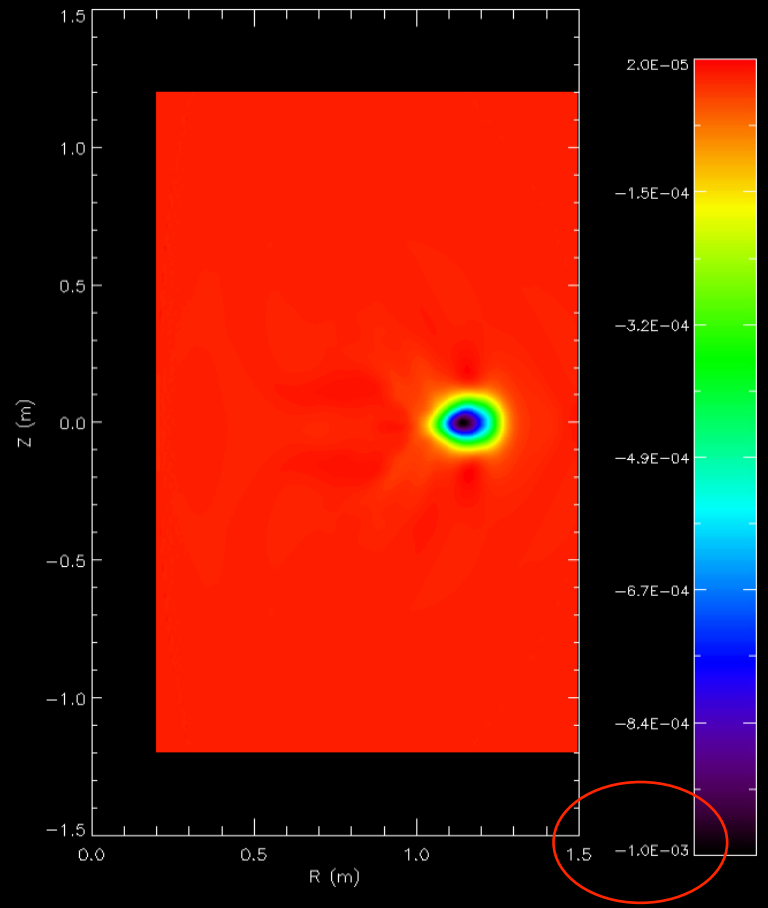
For this case, both sides are almost identical!

GREEN TERMS SEEM TO BE WORKING WELL

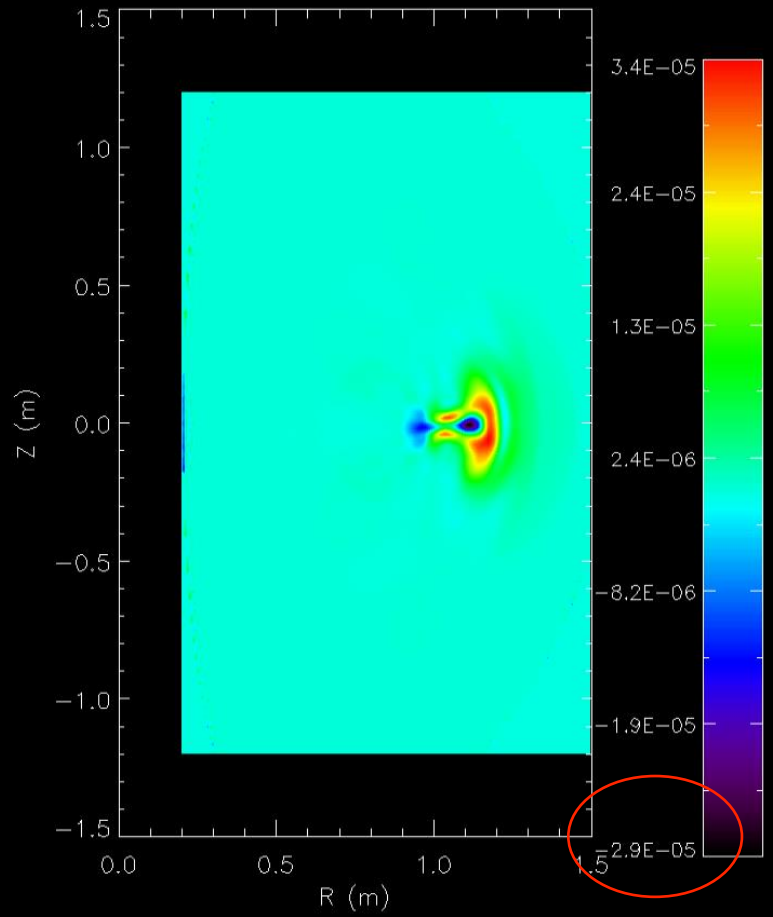
LHS: ne*[Te(t)-Te(t-dt)]/dt



RHS:



RHS - LHS

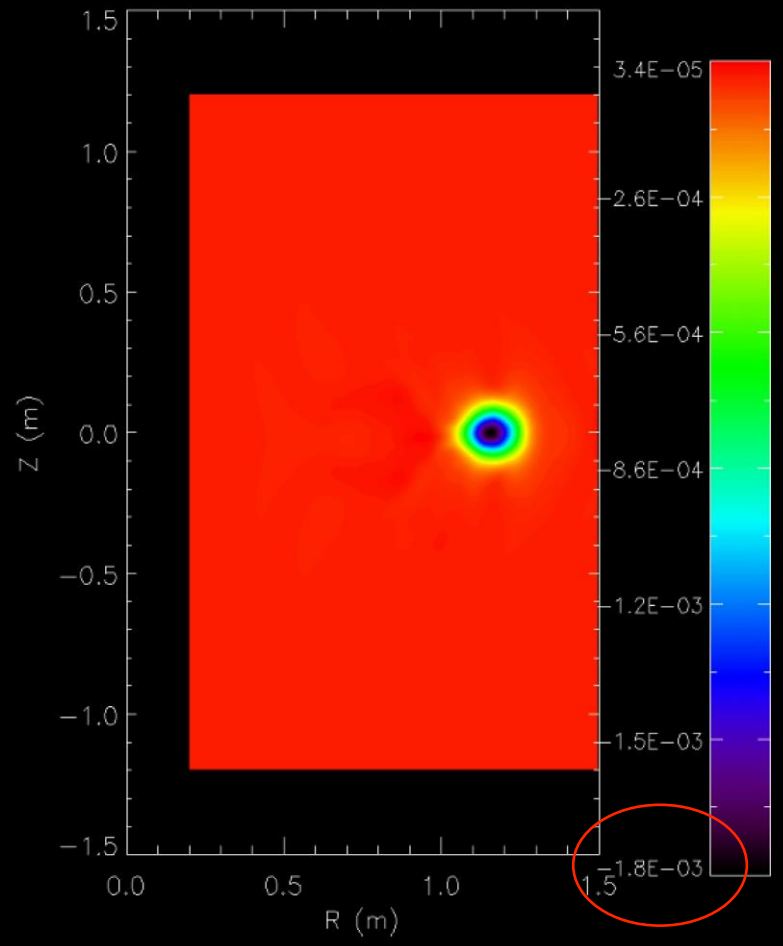


Setting kappa=0 (kappar, kappat, kappa0)

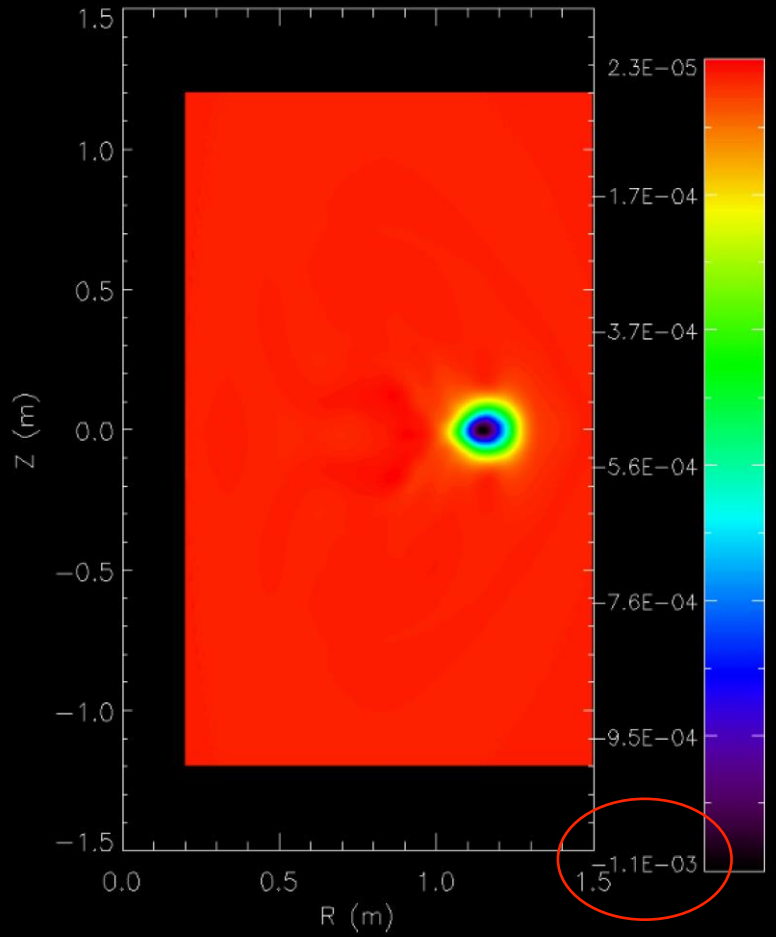
$$n_e\left[\frac{\partial T_e}{\partial t}\right] = -n_e(\mathbf{v}\cdot\nabla T_e + (\Gamma-1)T_e\nabla\cdot\mathbf{v})$$
$$-T_e(D\nabla^2 n_e + \sigma_e)$$
$$+(\Gamma-1)\eta\mathbf{J}^2 + (\Gamma-1)Q_e$$
$$-\cancel{(\Gamma-1)\nabla\cdot\mathbf{q}_e}$$
$$-(\Gamma-1)Q_\Delta$$
$$-(\Gamma-1)\Pi_e:\nabla\mathbf{v}$$

We have problems for this case. The magnitude is very significant

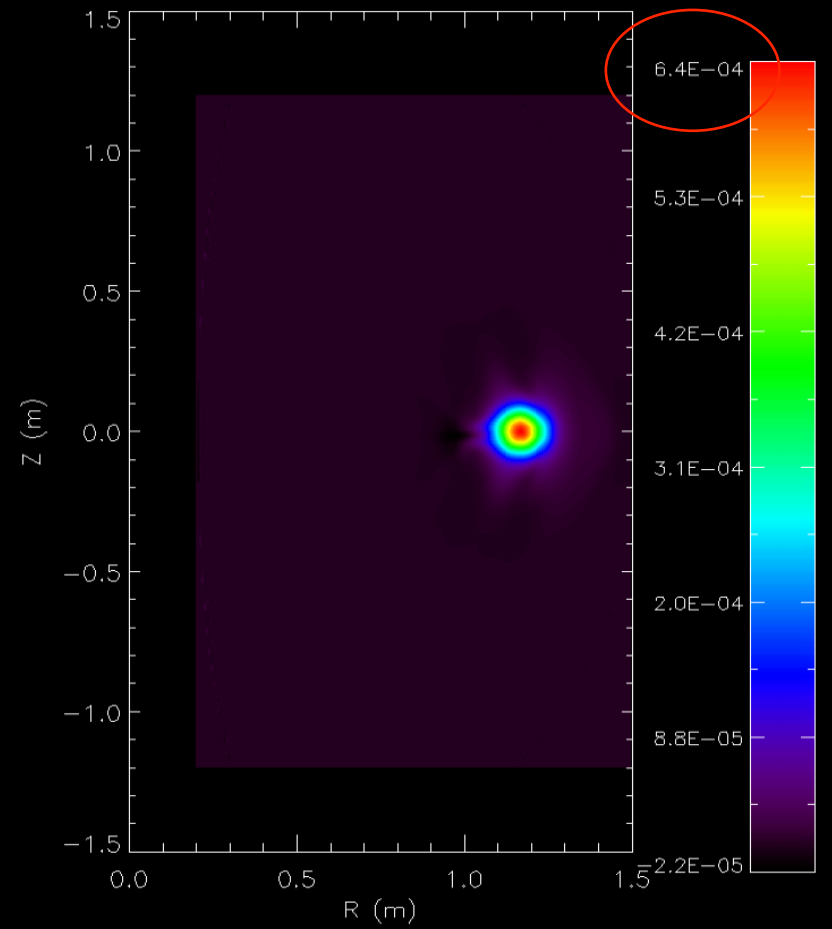
LHS: ne*[Te(t)-Te(t-dt)]/dt



RHS:



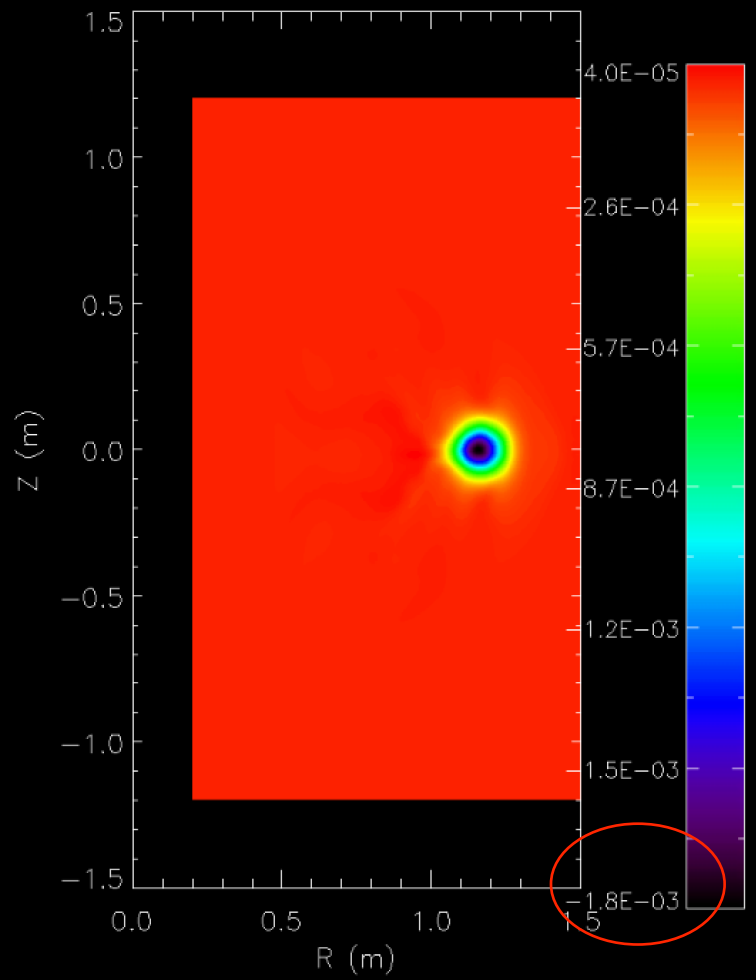
RHS - LHS

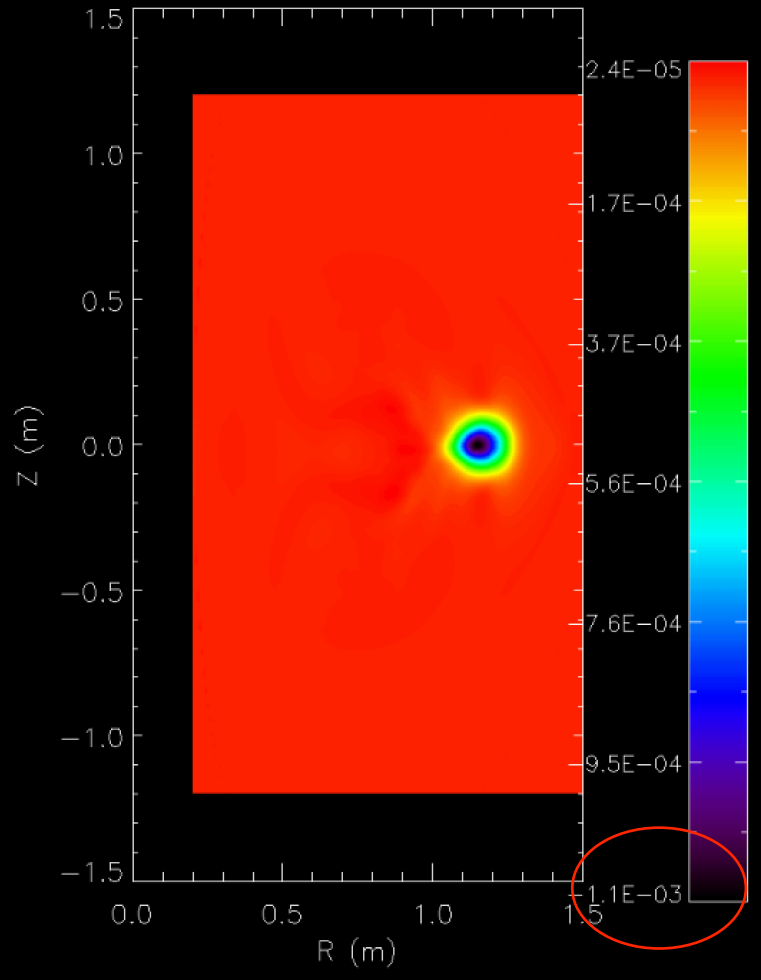


kappa=0. Amu/c=0

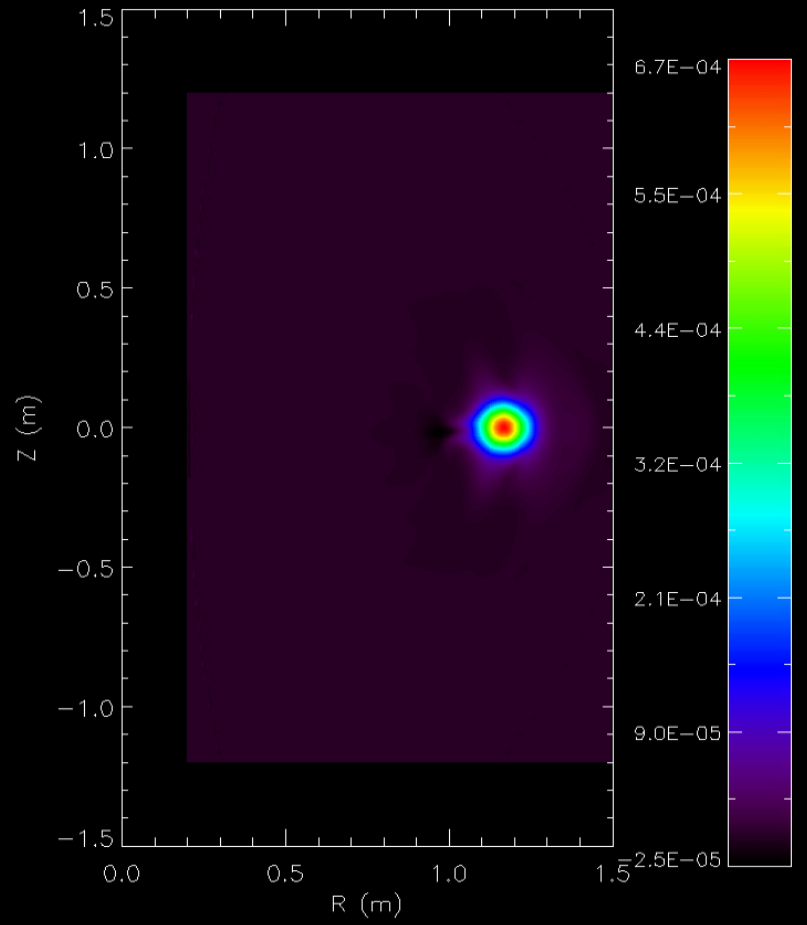
Still have the same difference

$$n_e\left[\frac{\partial T_e}{\partial t}\right] = -n_e(\mathbf{v}\cdot\nabla T_e + (\Gamma-1)T_e\nabla\cdot\mathbf{v})$$
$$-T_e(D\nabla^2 n_e + \sigma_e)$$
$$+(\Gamma-1)\eta\mathbf{J}^2 + (\Gamma-1)Q_e$$
$$-\cancel{(\Gamma-1)\nabla\cdot\mathbf{q}_e}$$
$$-(\Gamma-1)Q_\Delta$$
$$-(\Gamma-1)\Pi_e:\nabla\mathbf{v}$$





RHS - LHS



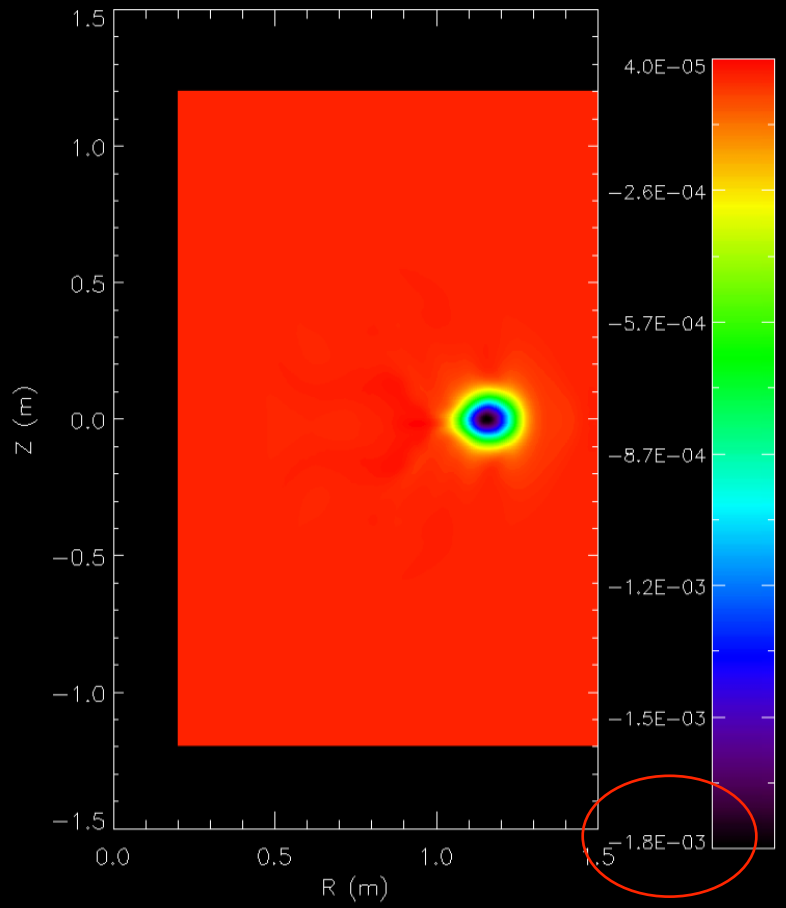
Kappa=0. amu/c=0. eta=0 (eta_fac=0)

$$n_e\left[\frac{\partial T_e}{\partial t}\right] = -n_e(\mathbf{v}\cdot\nabla T_e + (\Gamma-1)T_e\nabla\cdot\mathbf{v})$$
$$-T_e(D\nabla^2 n_e + \sigma_e)$$
$$+\cancel{(\Gamma-1)\eta\mathbf{J}^2} + (\Gamma-1)Q_e$$
$$-\cancel{(\Gamma-1)\nabla\cdot\mathbf{q}_e}$$
$$-\cancel{(\Gamma-1)Q_\Delta}$$
$$-(\Gamma-1)\Pi_e:\nabla\mathbf{v}$$

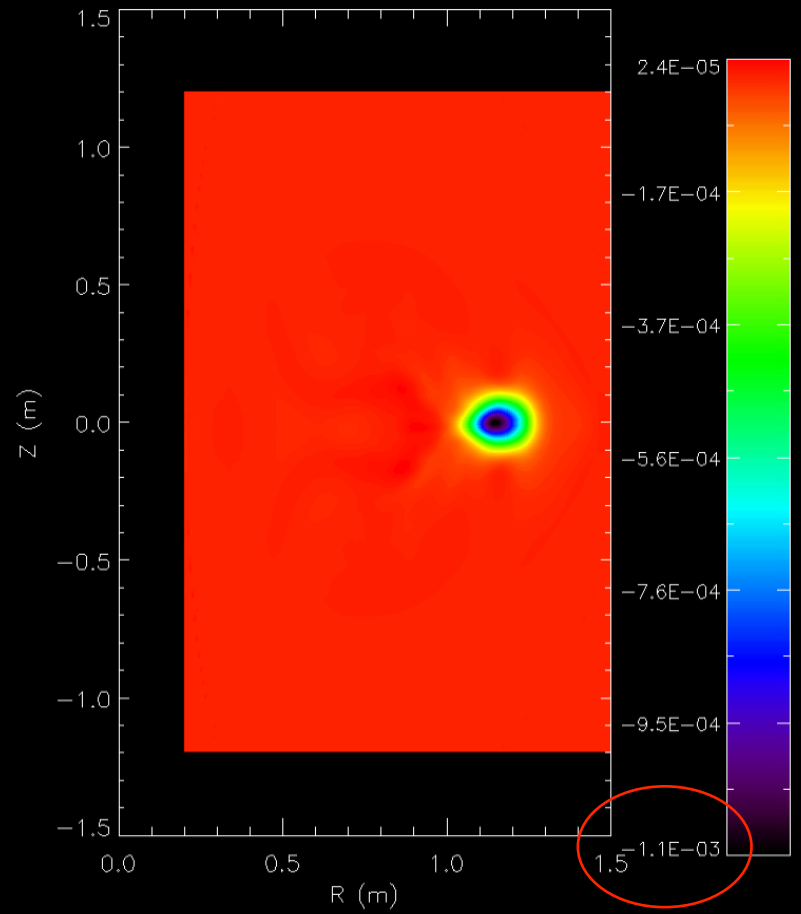
Some of the red terms are causing this discrepancy (?)

Still have the same difference

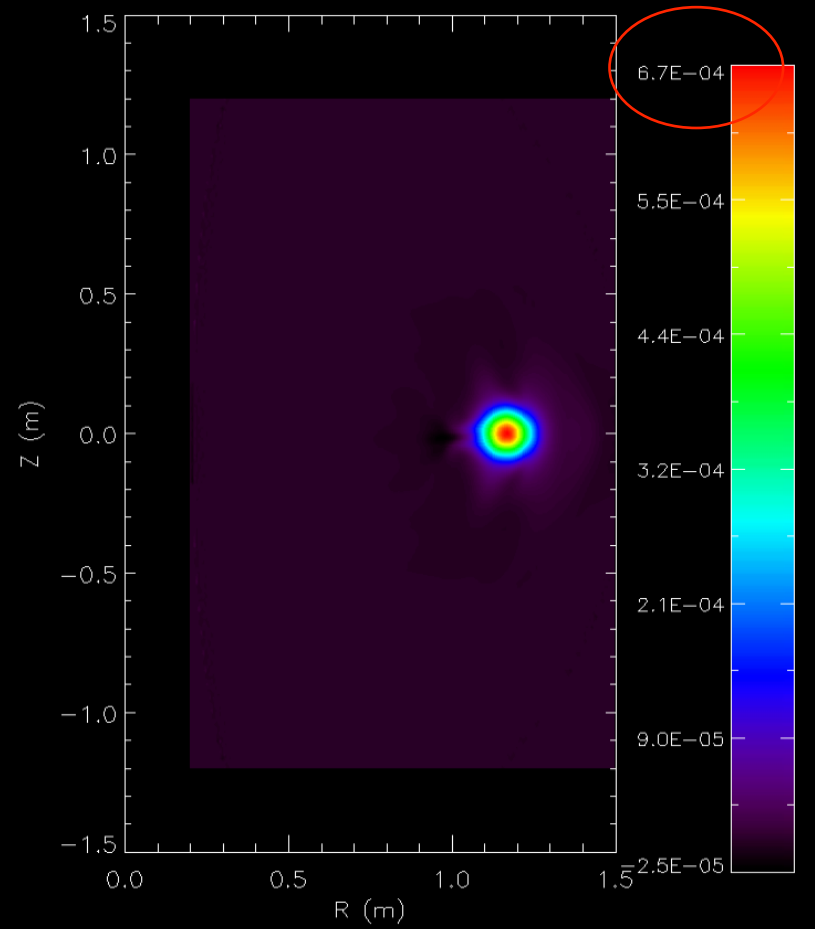
LHS



RHS



RHS - LHS



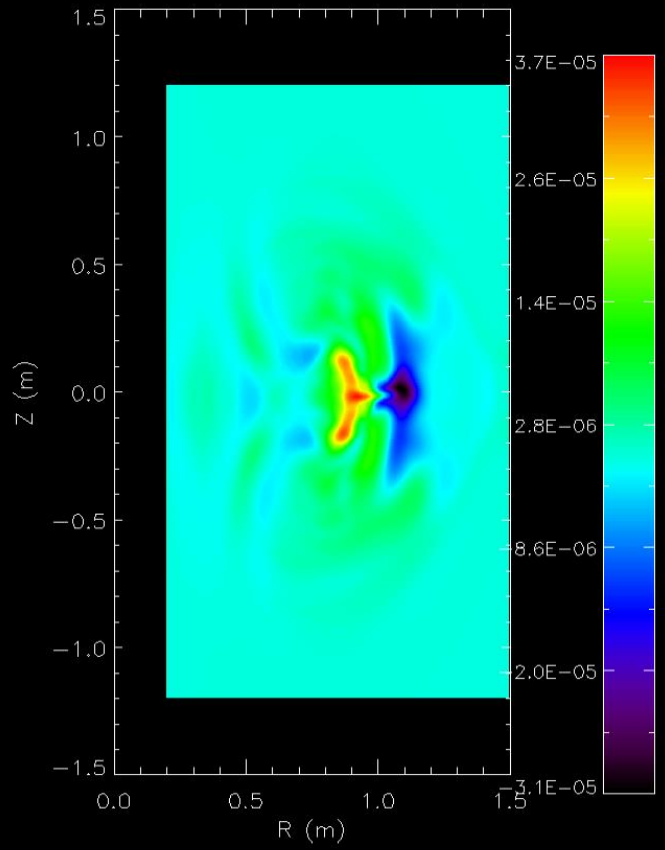
Kappa=0. amu/c=0. eta=0 (eta_fac=0). Kprad = 0 (turning off radiation)

$$n_e\left[\frac{\partial T_e}{\partial t}\right] = -n_e(\mathbf{v}\cdot\nabla T_e + (\Gamma-1)T_e\nabla\cdot\mathbf{v})$$
$$-T_e(D\nabla^2 n_e + \cancel{\sigma_e})$$
$$\cancel{+(\Gamma-1)\eta\mathbf{J}^2} + \cancel{(\Gamma-1)Q_e}$$
$$\cancel{-(\Gamma-1)\nabla\cdot\mathbf{q}_e}$$
$$\cancel{-(\Gamma-1)Q_\Delta}$$
$$-(\Gamma-1)\Pi_e:\nabla\mathbf{v}$$

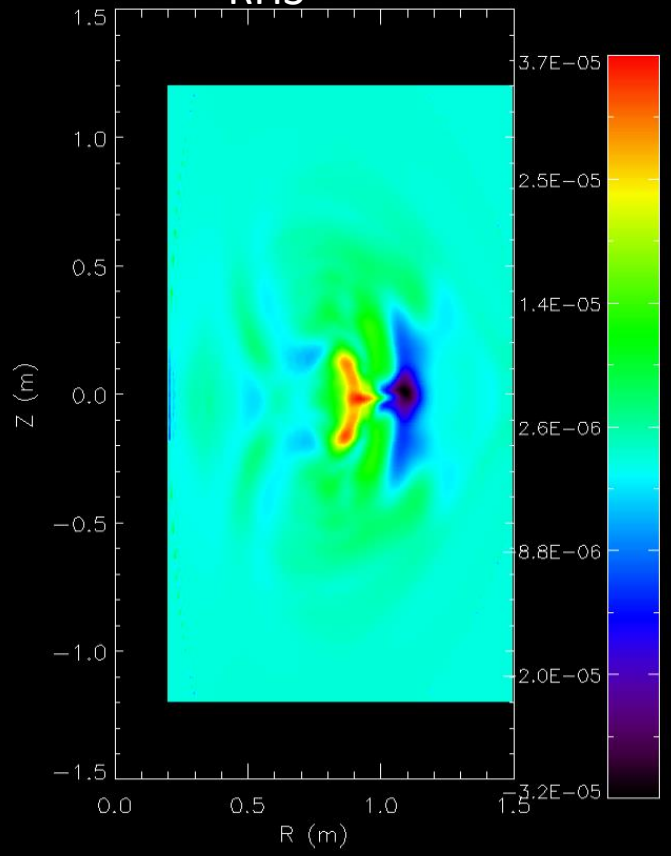
GREEN TERMS SEEM TO BE WORKING WELL

Seems to be working!

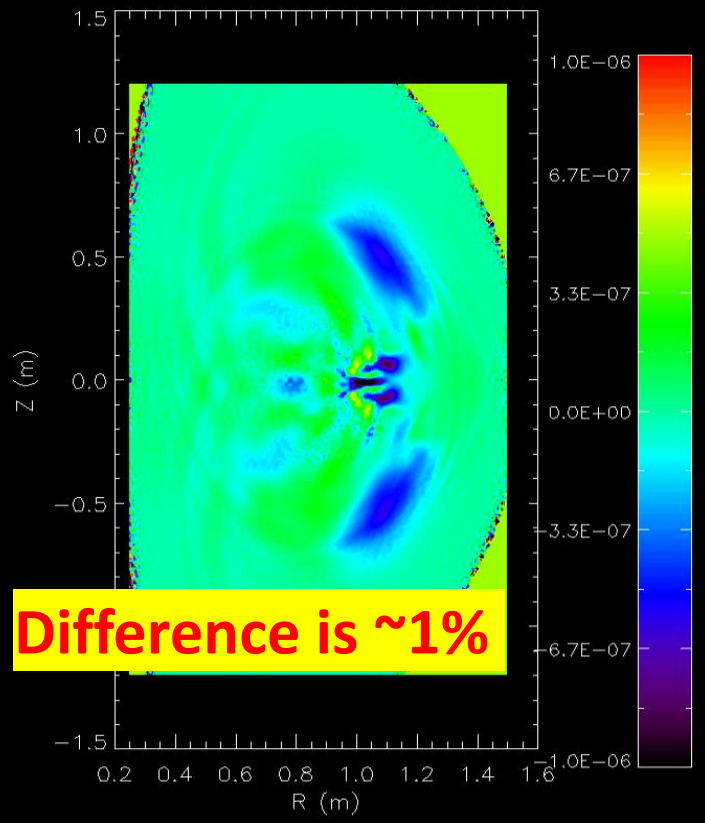
LHS



RHS



RHS - LHS



Difference is ~1%

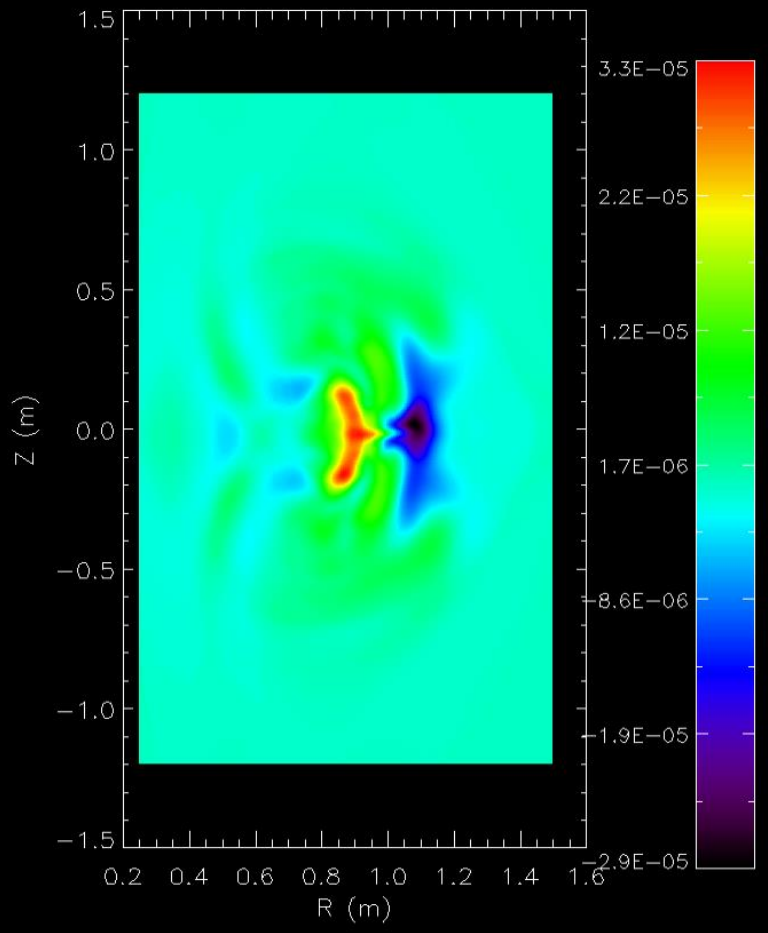
KPRAD=0. kappa=0

$$n_e\left[\frac{\partial T_e}{\partial t}\right] = -n_e(\mathbf{v}\cdot\nabla T_e + (\Gamma-1)T_e\nabla\cdot\mathbf{v})$$
$$-T_e(D\nabla^2 n_e + \sigma_e)$$
$$+(\Gamma-1)\eta\mathbf{J}^2 + (\Gamma-1)Q_e$$
$$-(\Gamma-1)\nabla\cdot\mathbf{q}_e$$
$$-(\Gamma-1)Q_\Delta$$
$$-(\Gamma-1)\Pi_e:\nabla\mathbf{v}$$

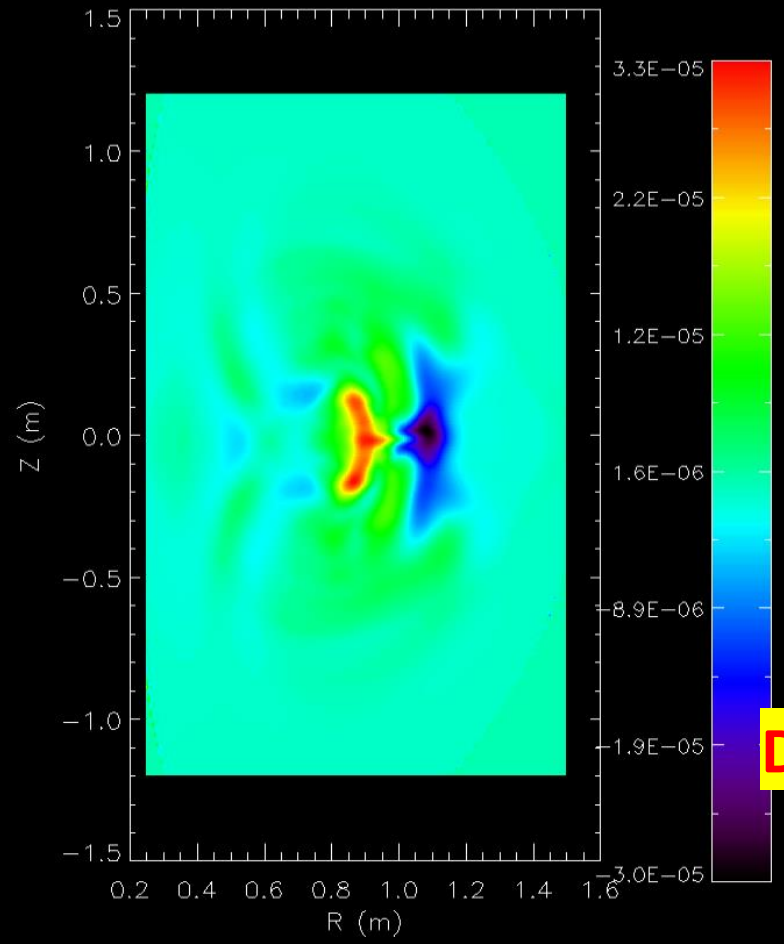
Seems to be working!

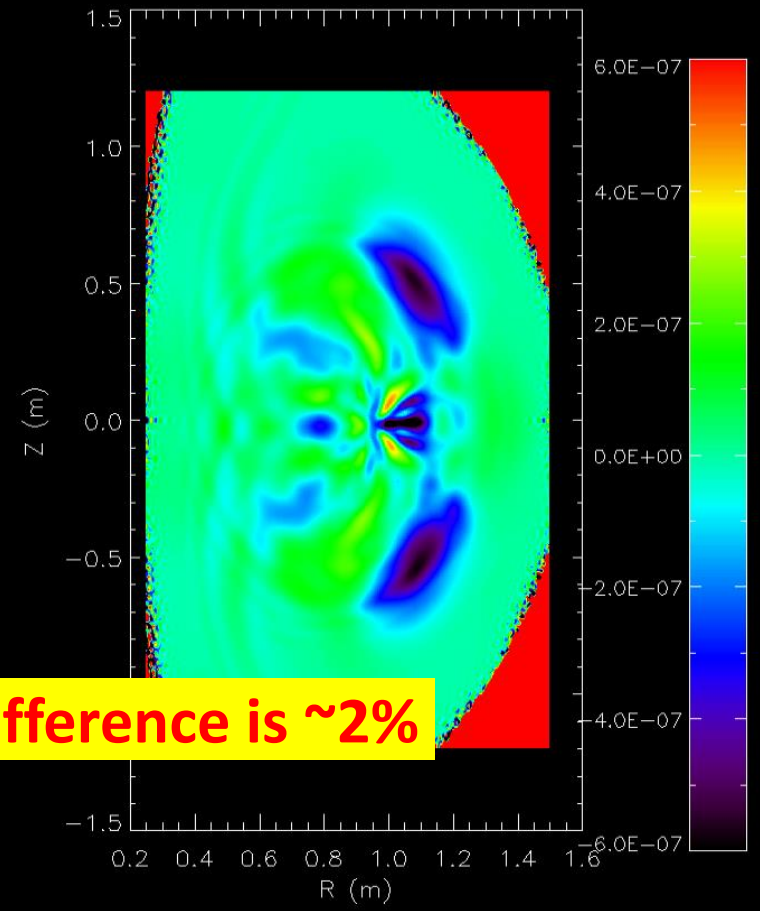
GREEN TERMS SEEM TO BE WORKING WELL

LHS



RHS





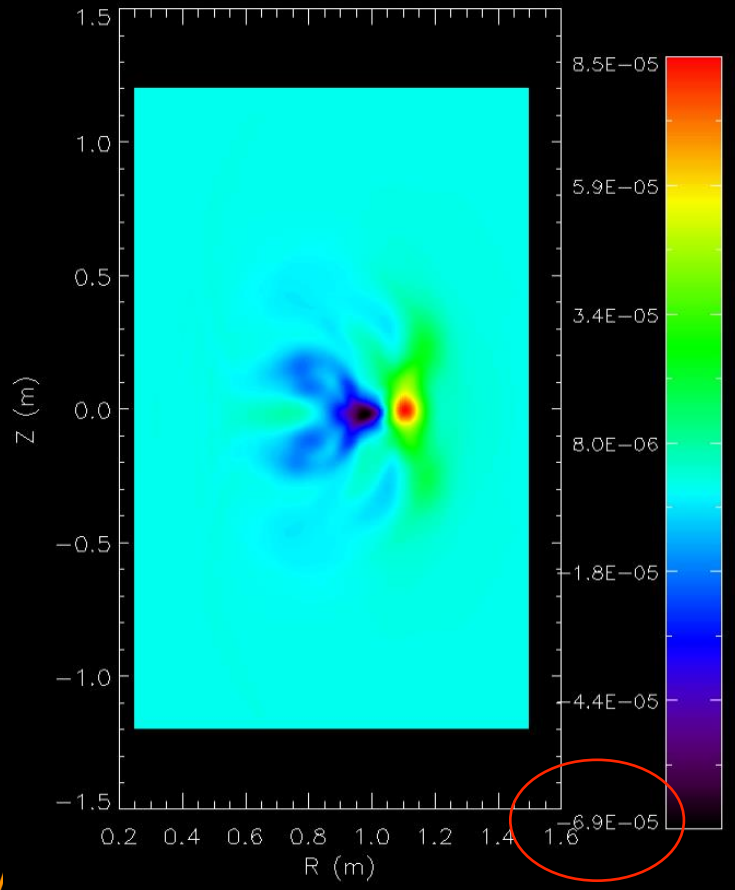
Difference is ~2%

Just KPRAD=0

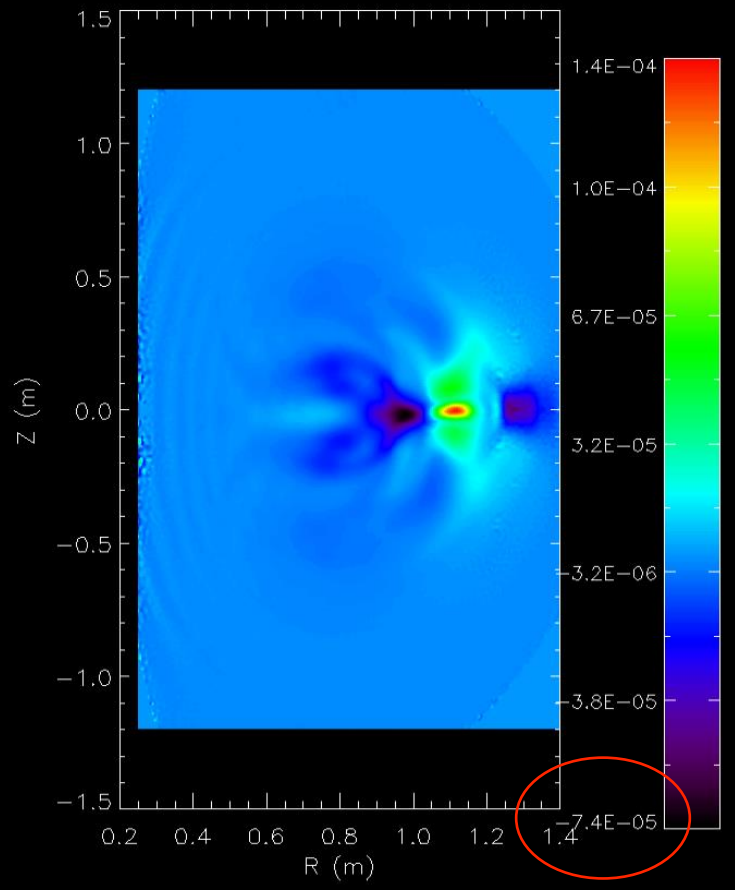
$$n_e\left[\frac{\partial T_e}{\partial t}\right] = -n_e(\mathbf{v}\cdot\nabla T_e + (\Gamma-1)T_e\nabla\cdot\mathbf{v})$$
$$-T_e(D\nabla^2 n_e + \cancel{\sigma_e})$$
$$+(\Gamma-1)\eta\mathbf{J}^2 + \cancel{(\Gamma-1)Q_e}$$
$$-(\Gamma-1)\nabla\cdot\mathbf{q}_e$$
$$-(\Gamma-1)Q_\Delta$$
$$-(\Gamma-1)\Pi_e:\nabla\mathbf{v}$$

We have again significant differences!!

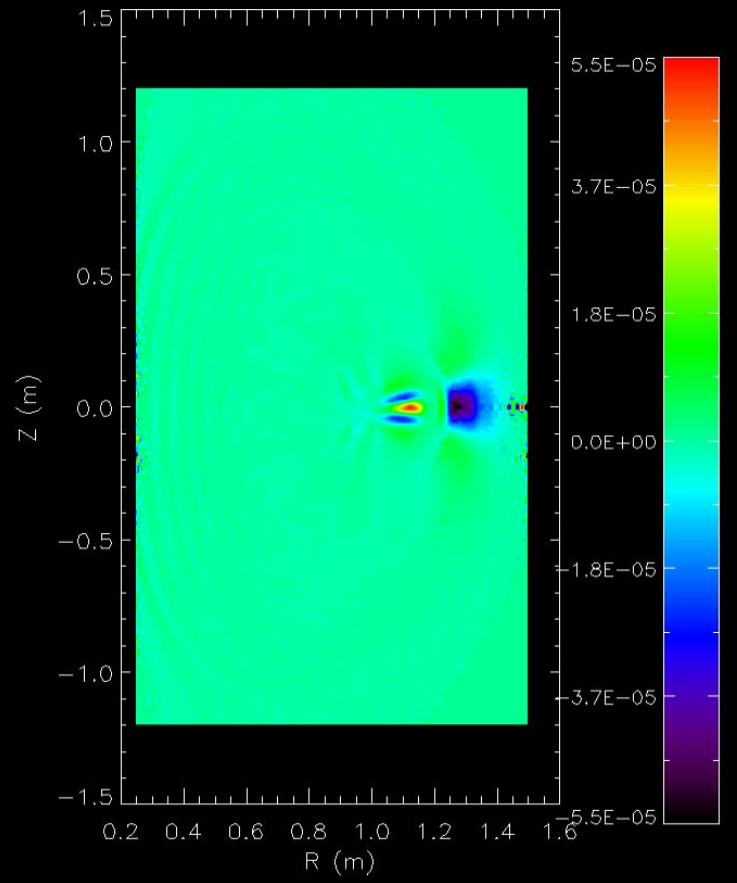
LHS



RHS



RHS - LHS

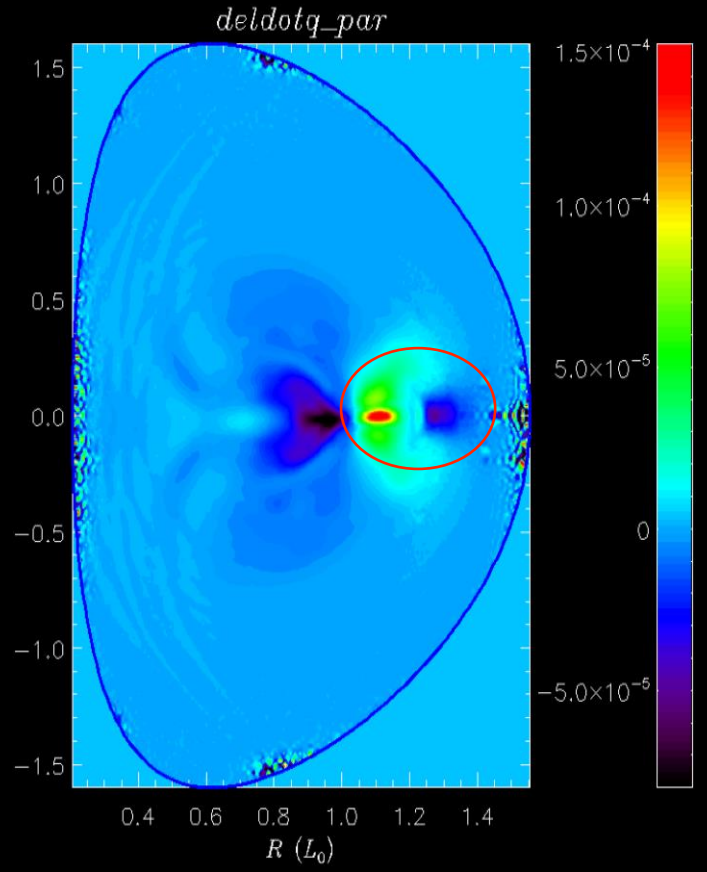


Just KPRAD=0

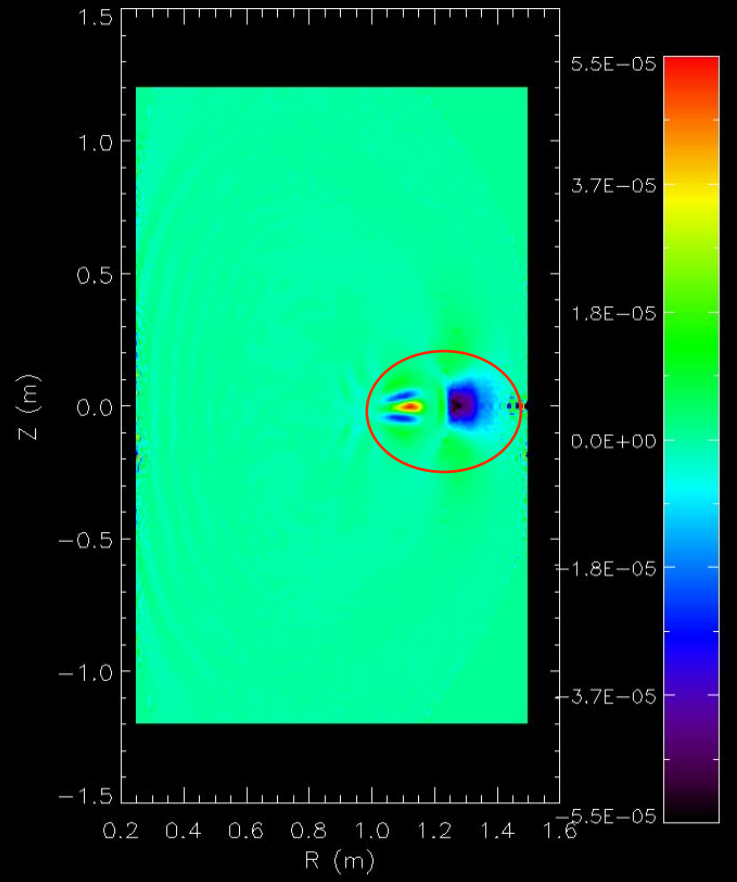
$$n_e\left[\frac{\partial T_e}{\partial t}\right] = -n_e(\mathbf{v}\cdot\nabla T_e + (\Gamma-1)T_e\nabla\cdot\mathbf{v})$$
$$-T_e(D\nabla^2 n_e + \sigma_e)$$
$$+(\Gamma-1)\eta\mathbf{J}^2 + (\Gamma-1)Q_e$$
$$-(\Gamma-1)\nabla\cdot\mathbf{q}_e$$
$$-(\Gamma-1)Q_\Delta$$
$$-(\Gamma-1)\Pi_e:\nabla\mathbf{v}$$

We have again significant differences!!

Deldotq_par has similar pattern than the difference term



RHS - LHS



In summary

$$n_e\left[\frac{\partial T_e}{\partial t}\right] = -n_e(\mathbf{v}\cdot\nabla T_e + (\Gamma-1)T_e\nabla\cdot\mathbf{v})$$
$$-T_e(D\nabla^2 n_e + \cancel{\sigma_e})$$
$$+(\Gamma-1)\eta\mathbf{J}^2 + \cancel{(\Gamma-1)Q_e}$$
$$-(\Gamma-1)\nabla\cdot\mathbf{q}_e$$
$$-(\Gamma-1)Q_\Delta$$
$$-(\Gamma-1)\Pi_e:\nabla\mathbf{v}$$

Red terms have to have some problems