Waves generated by rapid reconnection

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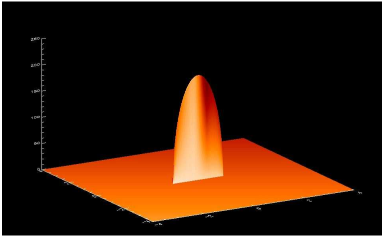
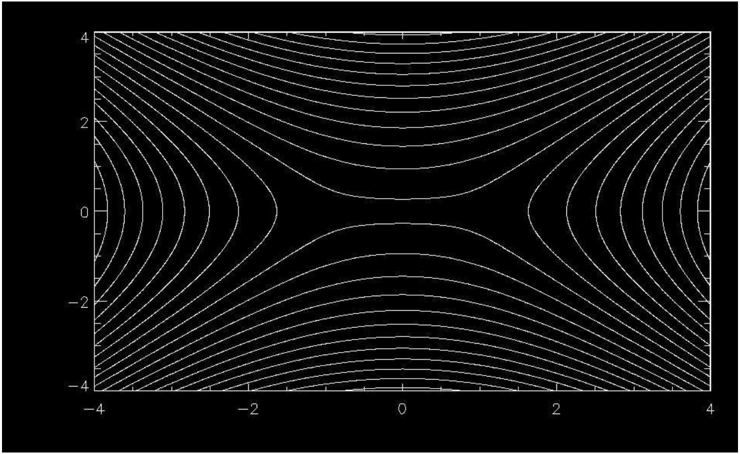


- Rapid dissipation of J sheet.
- Rapid dissipation of line J.
- Taylor relaxation and avalanches.

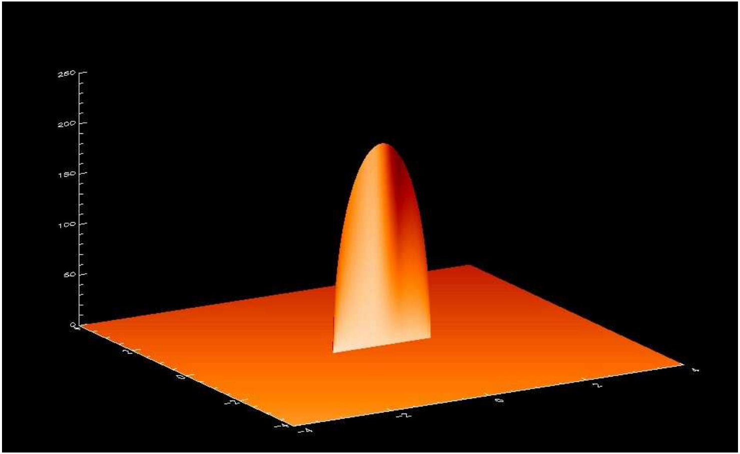
Longcope and Priest, 2007

- Initial state: finite current sheet in potential field
- Enhanced resistivity
- Current sheet disappears
- Outward linear wave triggered
- Leaves reconnection flows

Initial magnetic field



Initial current sheet



Linear equations

$$
\begin{aligned}
\frac{\partial U}{\partial t} &= \omega_A^2 r \frac{\partial C}{\partial r}, \\
\frac{\partial^2 C}{\partial t^2} &= \omega_A^2 r \frac{\partial}{\partial r}\left(r \frac{\partial C}{\partial r}\right) + \eta r \frac{\partial}{\partial r}\left(\frac{1}{r}\frac{\partial^2 C}{\partial r \partial t}\right).
\end{aligned}
$$

U is perpendicular velocity. $C = rB_\phi = -\partial A_1/\partial r$ is total current inside radius r.
Diffusion region near $r = 0$, then fast mode.
How does it evolve non-linearly?

Non-linear equations

$$\rho \frac{D\mathbf{v}}{Dt} = -\nabla p + \mathbf{j} \times \mathbf{B}, \quad (1)$$

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{v}) = 0, \quad (2)$$

$$\frac{\partial \mathbf{B}}{\partial t} = \nabla \times (\mathbf{v} \times \mathbf{B}) - \nabla \times (\eta \nabla \times \mathbf{B}), \quad (3)$$

$$\frac{\rho^\gamma}{\gamma - 1} \frac{D}{Dt} \left(\frac{p}{\rho^\gamma} \right) = \eta j^2 + Q_{visc}, \quad (4)$$

$$p = \rho R T. \quad (5)$$

Note if p is zero initially, it can't remain zero due to Ohmic heating. In fact need p inside current sheet!

Pressure

(2Dpressure.mpeg)

Current

(2Dcurrent.mpeg)

Velocity

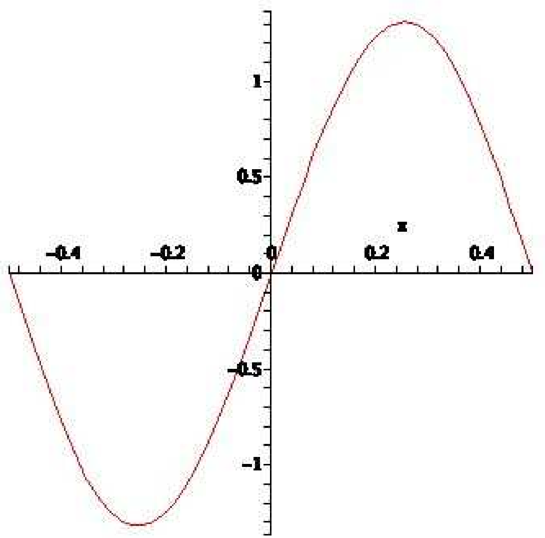
(2DmodV.mpeg)

Try a finite line current

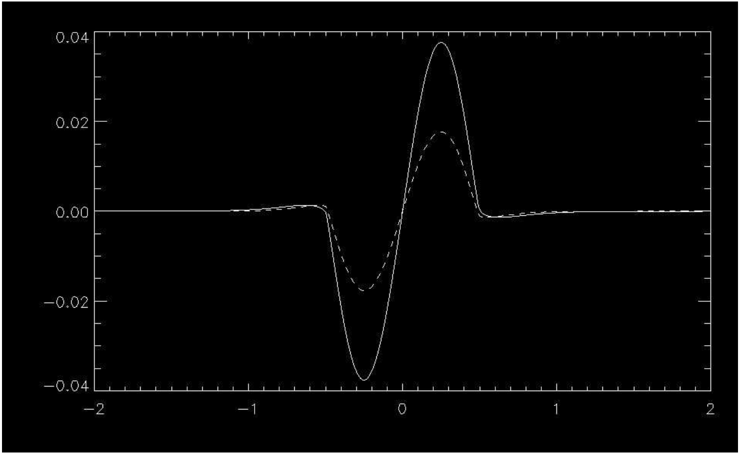
Take a cylindrical field.

- Assume axial current (goes smoothly to zero at $r = a$.)
- Calculate $B_\theta(r)$ and $p(r)$ for equilibrium.
- Note assume rapid diffusion of J.
- Pressure gradient generates an outflow.

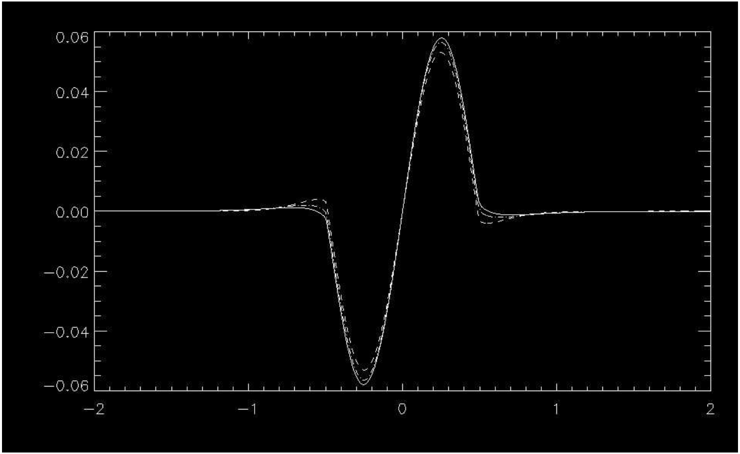
Initial pressure gradient



Velocity profiles at two times



Velocity profile and estimate

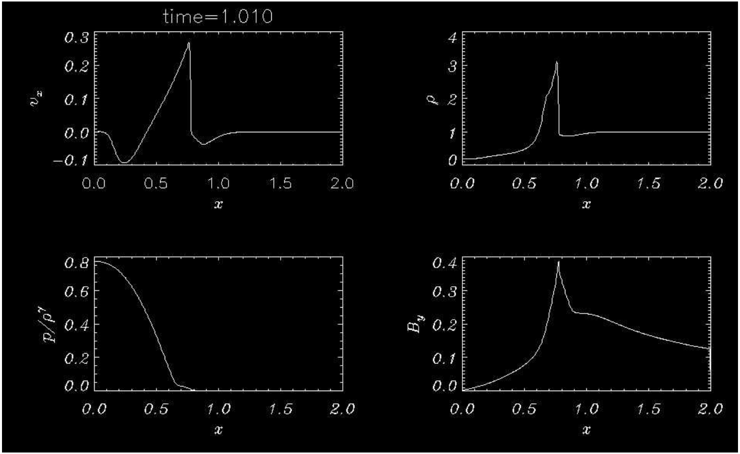


Check "LineVelocity magnitude".

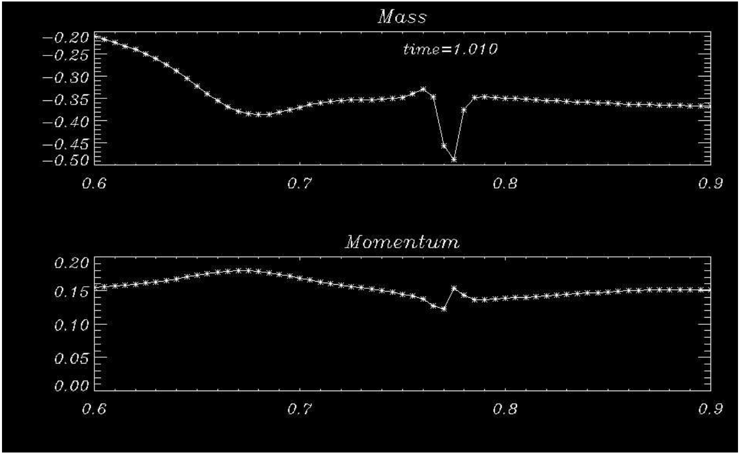
Line current: Velocity cut

(Velocity.mov)

Perpendicular fast shock



Shock: Internal structure



Taylor Relaxation: Two loops

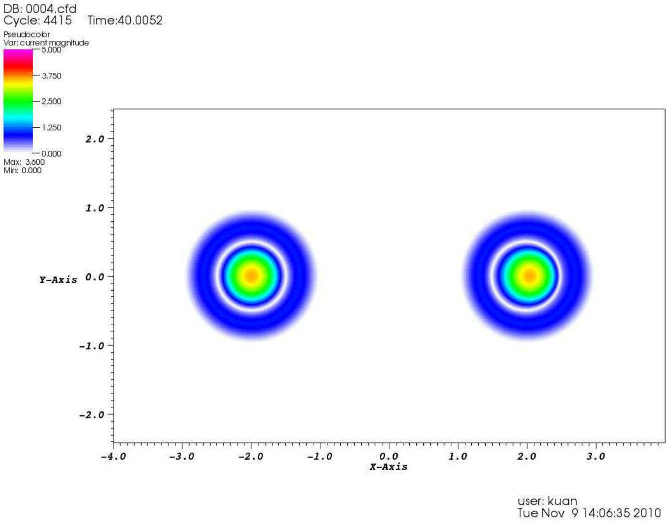
- Taylor relaxation can heat coronal loops.
- Ideal MHD kink instability gives reconnection and heat.
- This models a nanoflare.
- High temperature and field restructuring.
- Can one event trigger another in nearby stressed loop?
- Start with two loops.
- First instability sends out fast waves to destabilise second loop?

Taylor relaxation: Temperature

(Case8temperature.mpg)

Taylor relaxation: Fieldlines

(Case3fieldlines.mpeg)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Pseudocolor
Var: current magnitude
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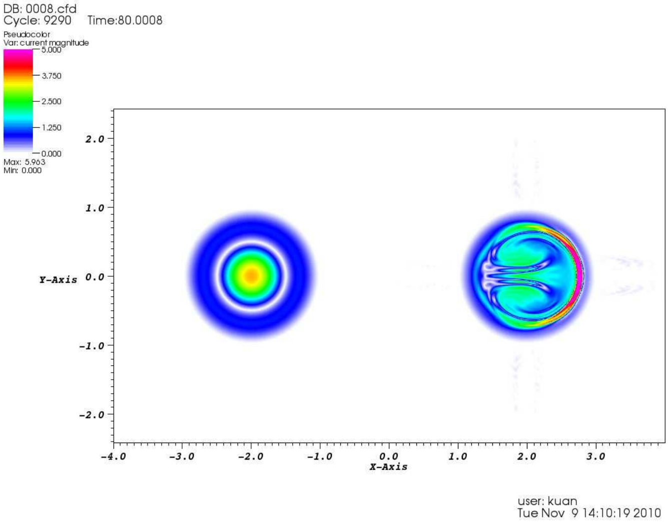
3.750
2.500
1.250
0.000
Max: 3.600
Min: 0.000
2.0
1.0
Y-Axis 0.0
-1.0
-2.0
-4.0
-3.0
-2.0
-1.0
0.0
X-Axis
1.0
2.0
3.0
user: kuan
Tue Nov 9 14:06:35 2010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Min: 0.000
2.0
1.0
Y-Axis 0.0
-1.0
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-4.0 -3.0 -2.0 -1.0 0.0 1.0 2.0 3.0
X-Axis
user: kuan
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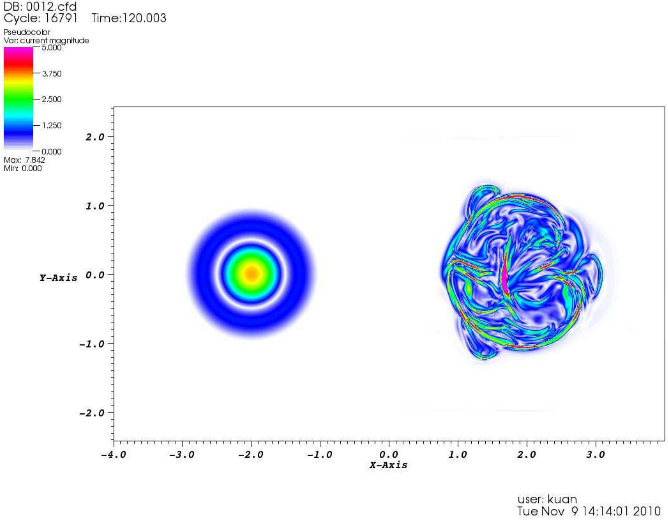
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Min: 0.000
Y-Axis
X-Axis
user: kuan
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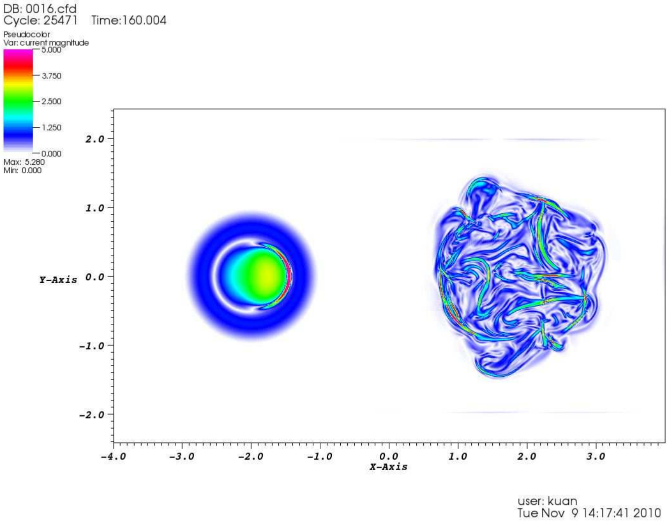
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X-Axis
user: kuan
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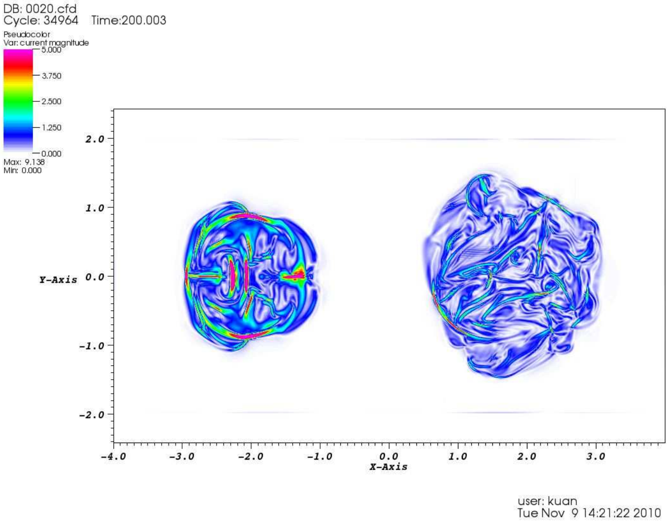
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0.000
Max: 9.138
Min: 0.000
2.0
1.0
Y-Axis 0.0
-1.0
-2.0
-4.0
-3.0
-2.0
-1.0
0.0
X-Axis
1.0
2.0
3.0
user: kuan
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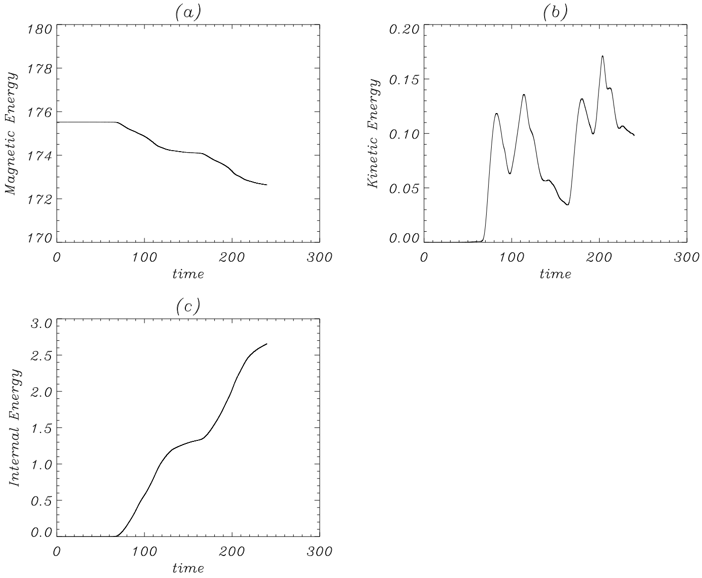
Magnetic, kinetic and internal energies



Taylor relaxation: Two loops

(newcase1cd.mp4)

Taylor relaxation: Two loops and velocity cut

(vx.mpg)