724326

# How are p-modes converted to act as a wave driver for coronal loop simulations?

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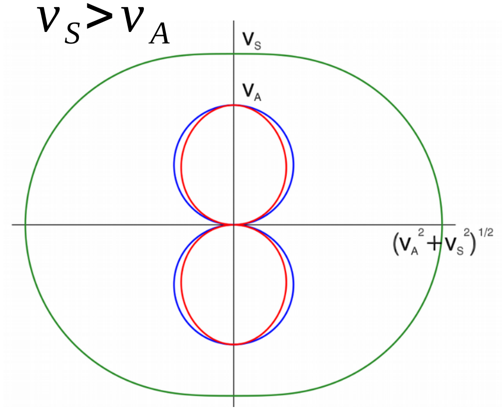
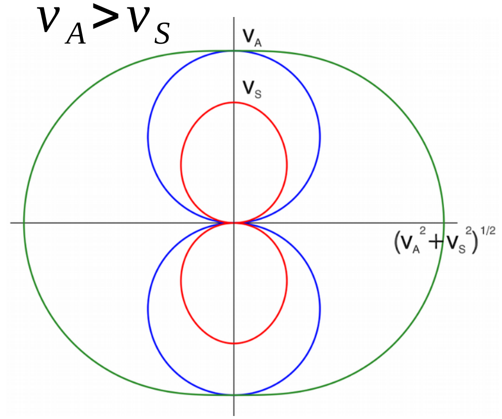
# Wave Modes

## homogeneous plasma

$v_S > v_A$



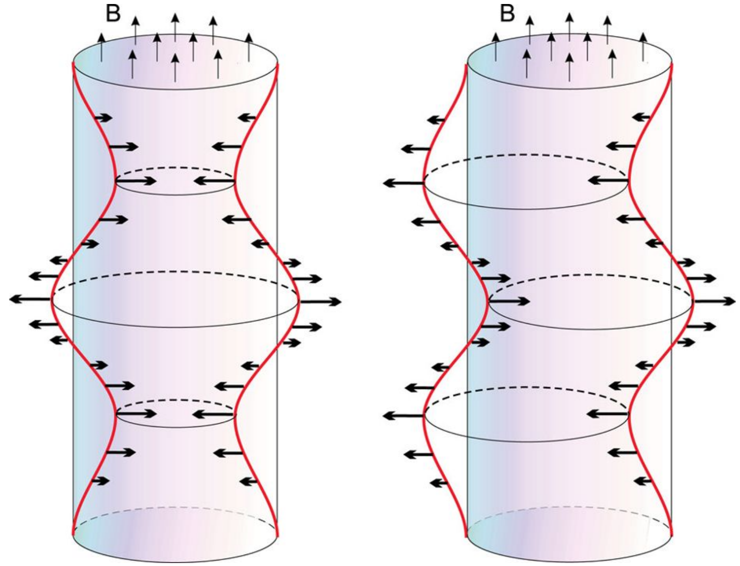

$v_A > v_S$




## cylinder

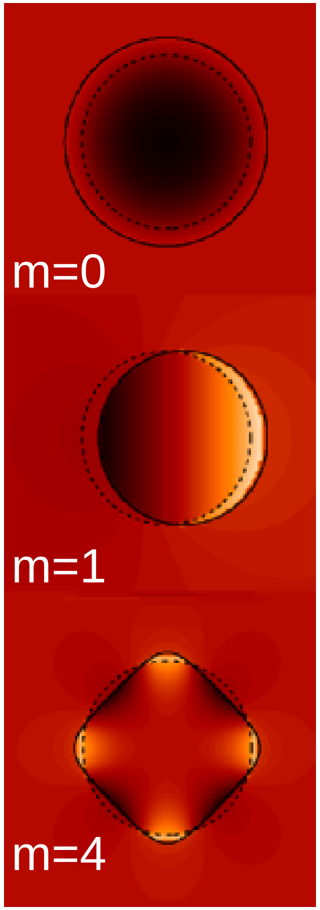
m=0
sausage mode

m=1
kink mode




*Morton et al. (2012)*

sausage, kink and fluting mode

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# Motivation

- The corona may be heated by ubiquitous waves that originate from the photosphere
- Most simulations to study coronal heating start at the corona

**What wave driver should be used for these simulations?**

**How are p-modes converted when they reach the corona?**

$$C \simeq \frac{\pi \omega L}{v_S(\gamma+1)} \sin^2(\theta)$$

*Cally (2005)*

acoustic → magnetic

# Equilibrium Atmosphere

1.) Build divergence free magnetic field

$$\partial_x B_x + \partial_y B_y + \partial_z B_z = 0$$

2.) Calculate equilibrium pressure and density

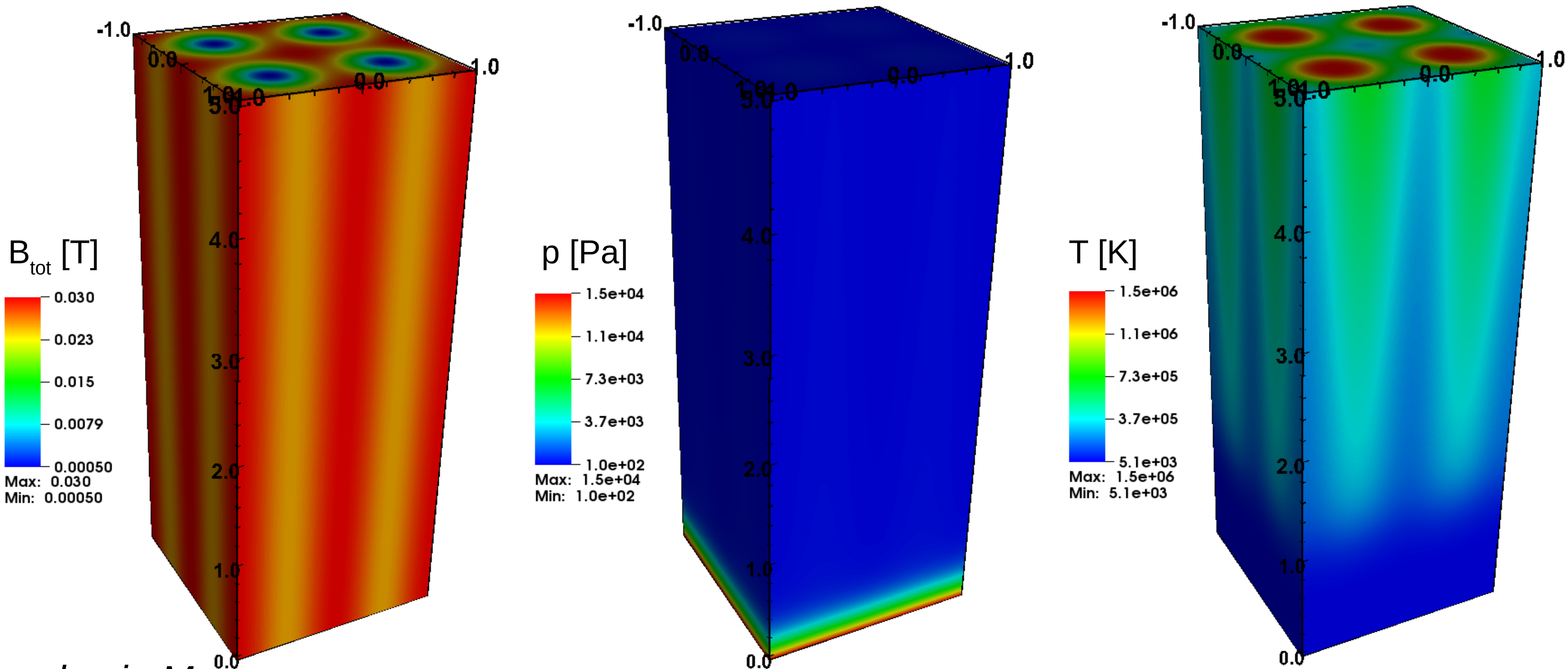
$$\underbrace{\underbrace{\frac{(\vec{B}\cdot\vec{\nabla})\cdot\vec{B}}{\mu_0}}_{\text{magnetic tension}} - \underbrace{\vec{\nabla}\left(\frac{B^2}{2\mu_0}\right)}_{\text{magnetic pressure}}}_{\text{Lorentz force}} - \underbrace{\vec{\nabla} p}_{\text{gas pressure}} - \underbrace{\rho \vec{g}}_{\text{grav. strat.}} = 0$$

3.) Calculate temperature from ideal gas law

$$T = \frac{pM}{\rho R}$$

# Equilibrium Model

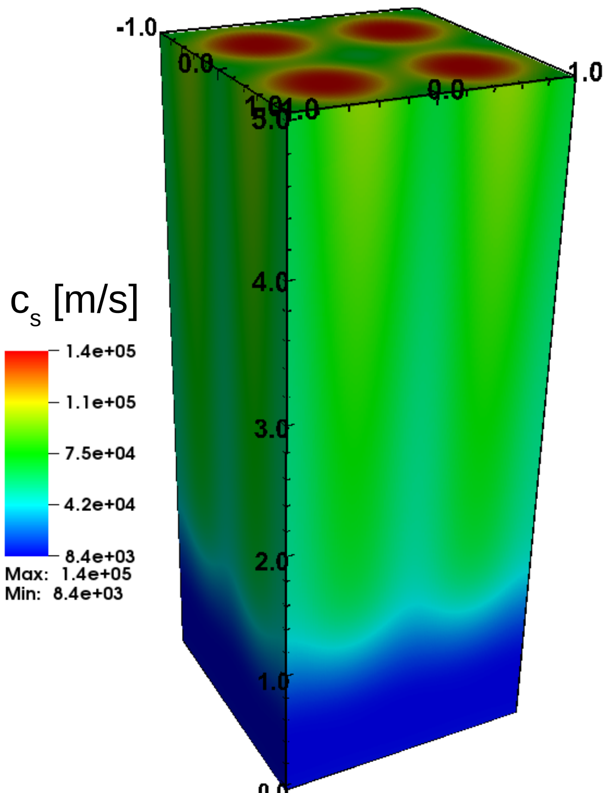
magnetic field | pressure | temperature



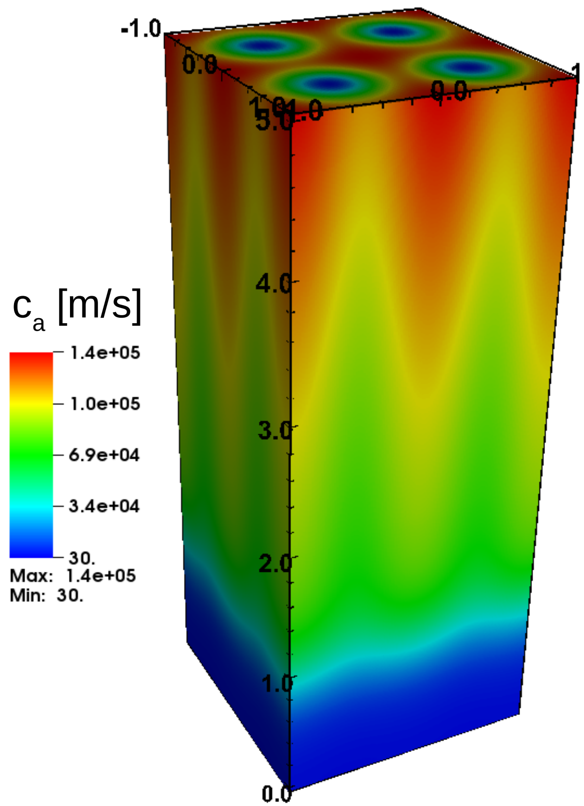

*scales in Mm*

# Equilibrium Model

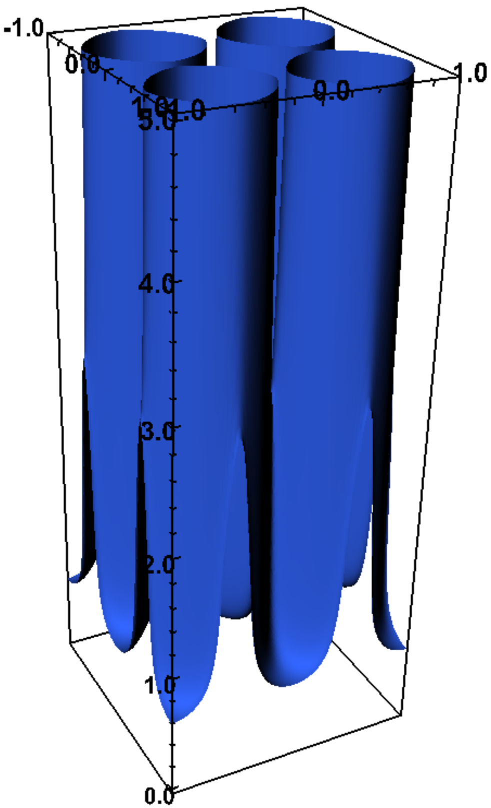
sound speed




Alfvén speed




β = 1 contour




*scales in Mm*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# Driver

*see thesis of Irantzu Calvo Santamaria (2015)*

**vertical acoustic-gravity wave**

$$v_{z,1}=V_0\exp\left(\frac{z}{2H}+k_{zi}z\right)\sin\left(\omega t-k_{zr}z\right)$$

$$p_1=V_0\,p_0|P|\exp\left(\frac{z}{2H}+k_{zi}z\right)\sin\left(\omega t-k_{zr}z+\phi_P\right)$$

$$\rho_1=V_0\rho_0|R|\exp\left(\frac{z}{2H}+k_{zi}z\right)\sin\left(\omega t-k_{zr}z+\phi_R\right)$$

$T=100\,s$ → $\omega=0.0628\,Hz$

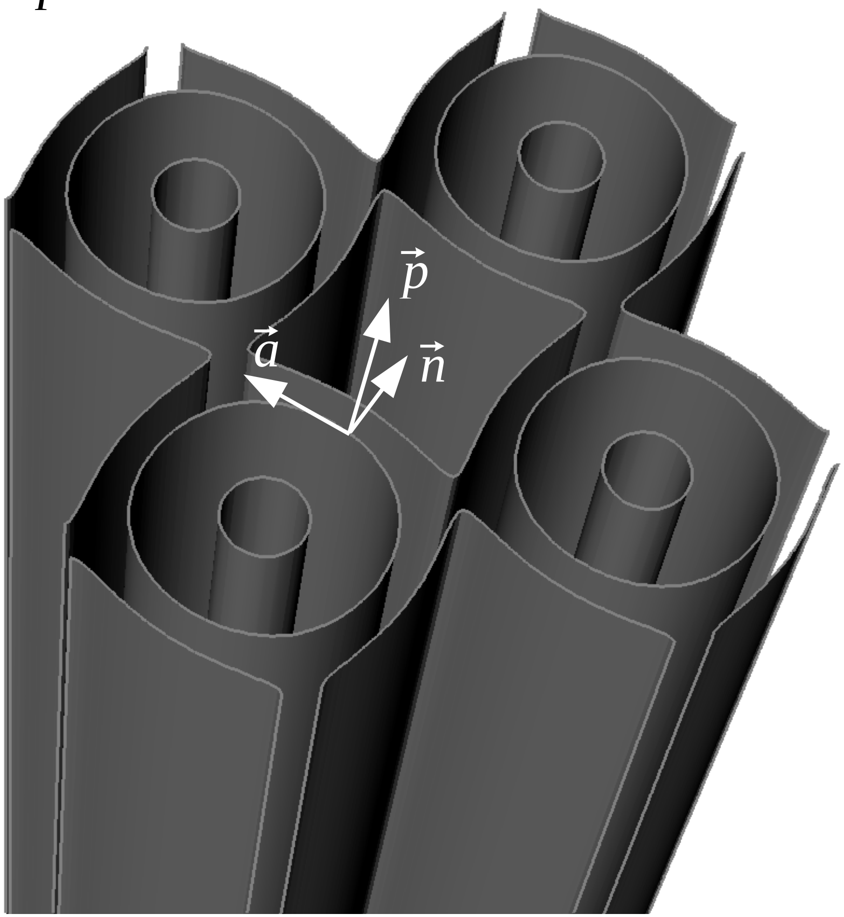
$V_0=10^{-2}\,m/s$

$$k_z=k_{zr}+ik_{zi}=\frac{\sqrt{\omega^2-\omega_c^2}}{v_S}$$

# Decomposition into Components

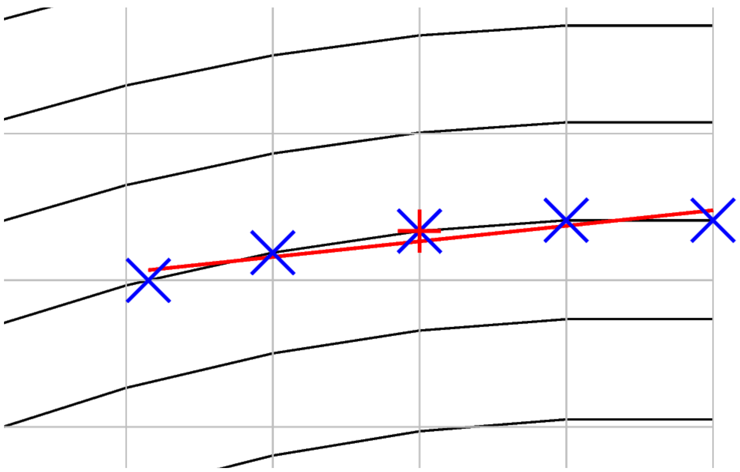
*as suggested by Mumford, Fedun & Erdélyi (2015)*

$\vec{p}\perp\vec{n}\perp\vec{a}$



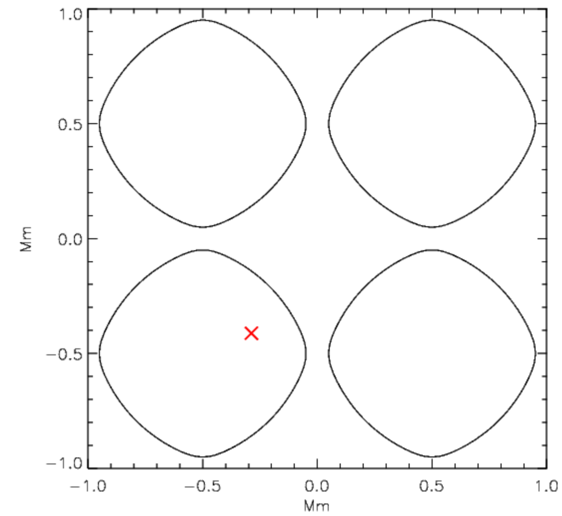

$\vec{p}||\vec{B}_0$

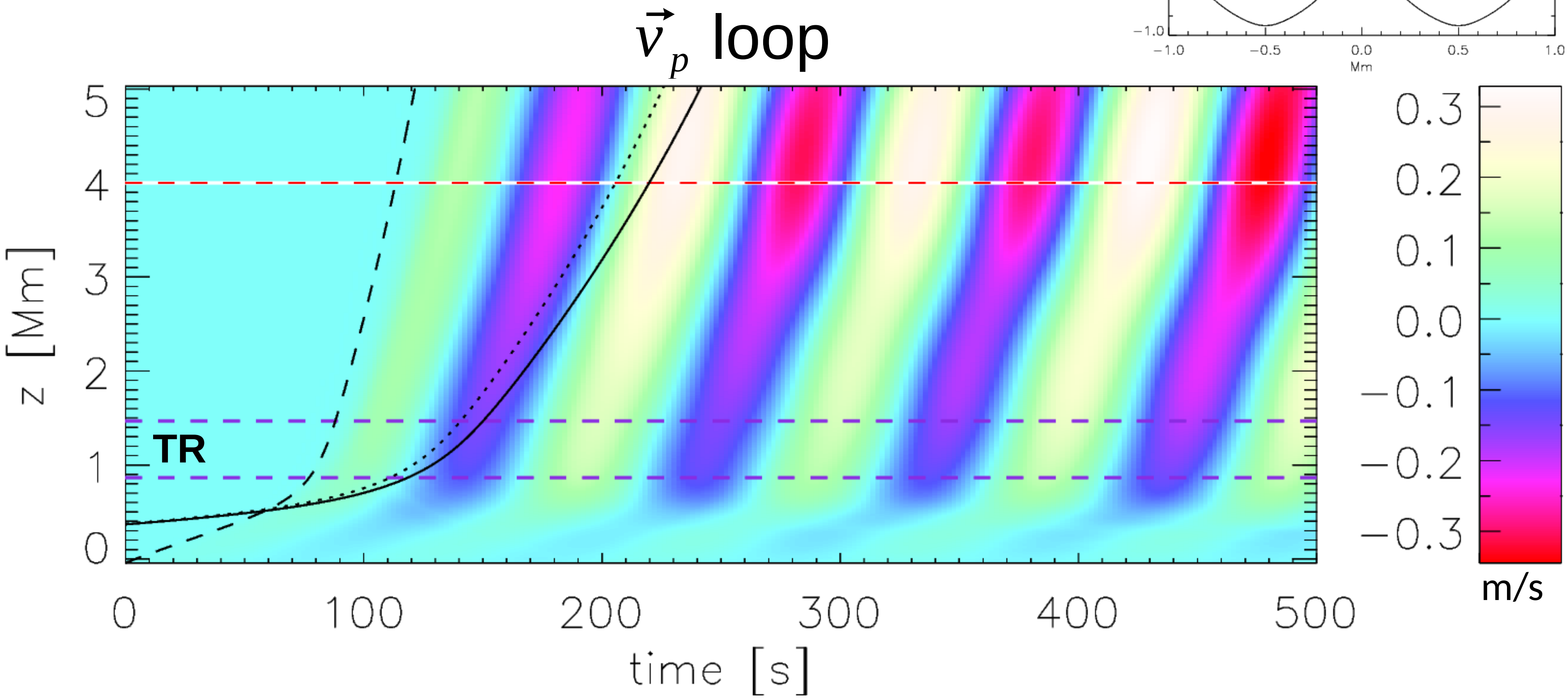
$\vec{a}:$



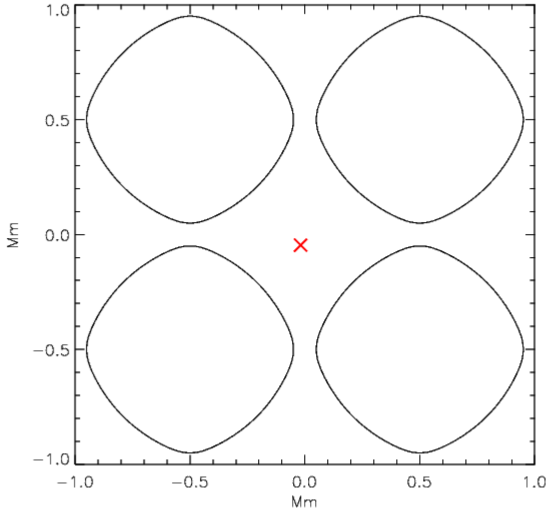
$\vec{n}=\vec{a}\times\vec{p}$

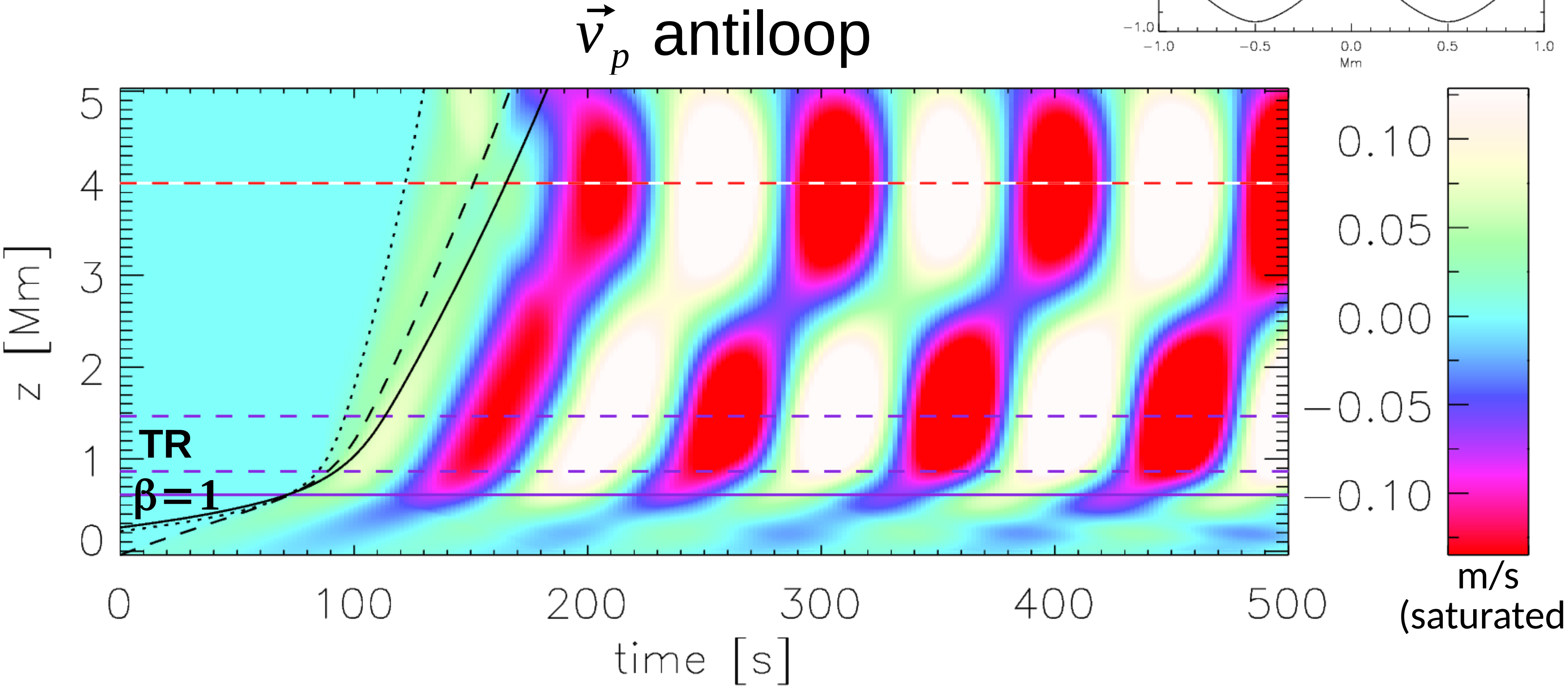
# Propagation of Parallel Component in a Vertical Field



# Propagation of Parallel Component in a Vertical Field

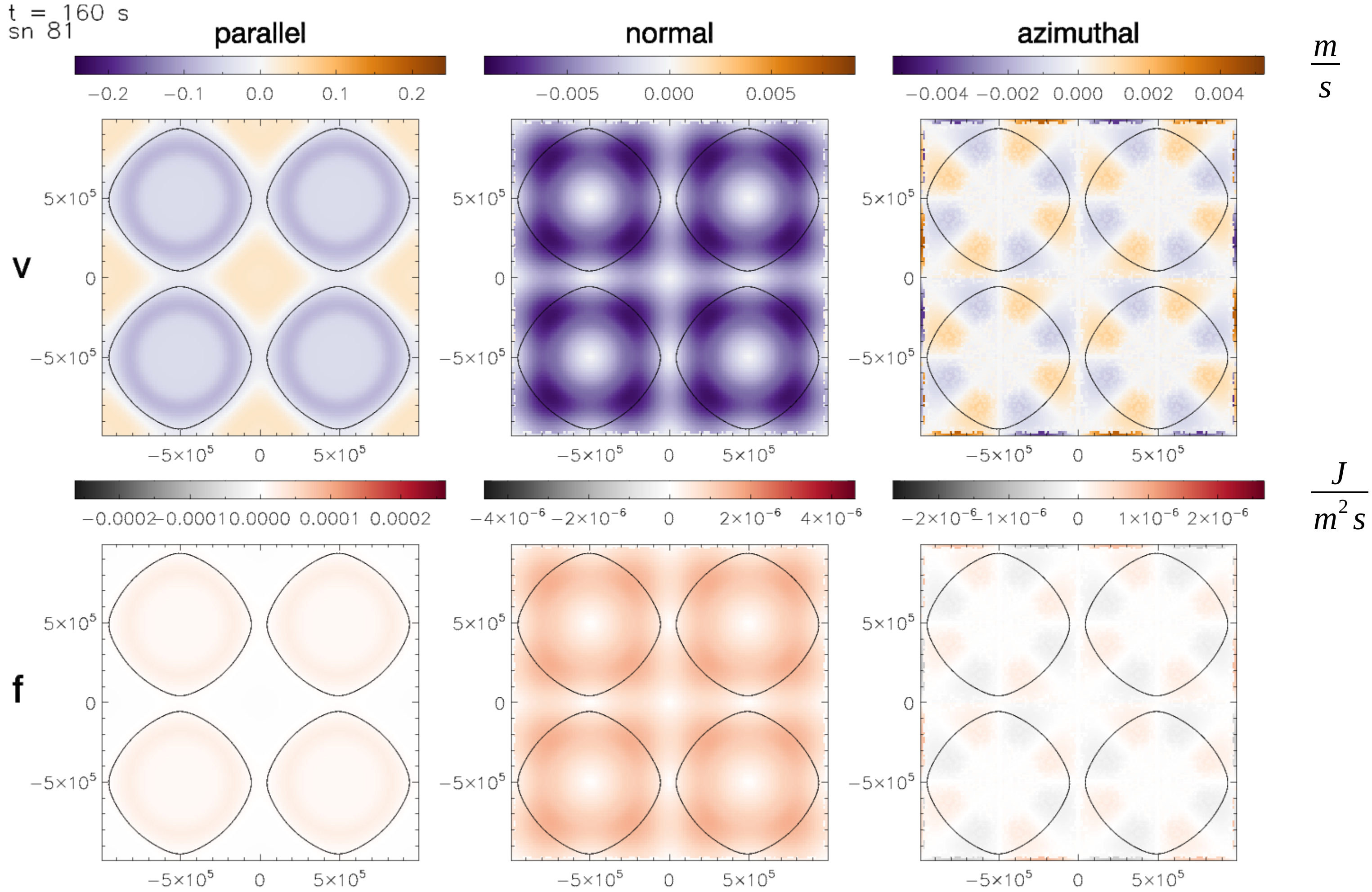


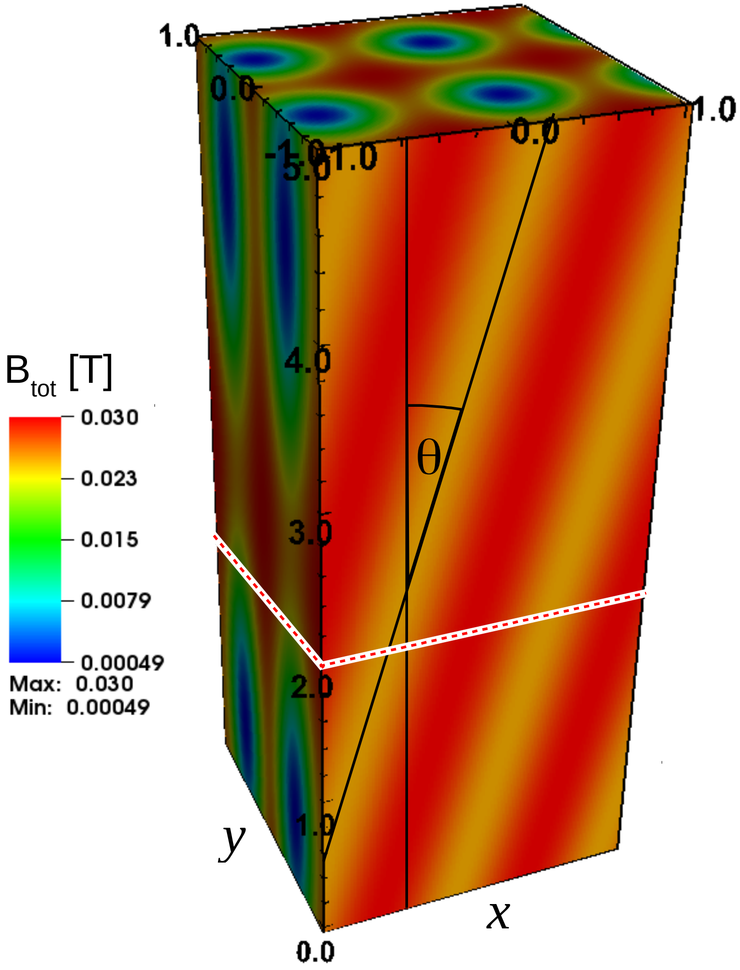
# Horizontal Cut at 4 Mm for a Vertical Magnetic Field

velocity perturbation

magnetic energy flux



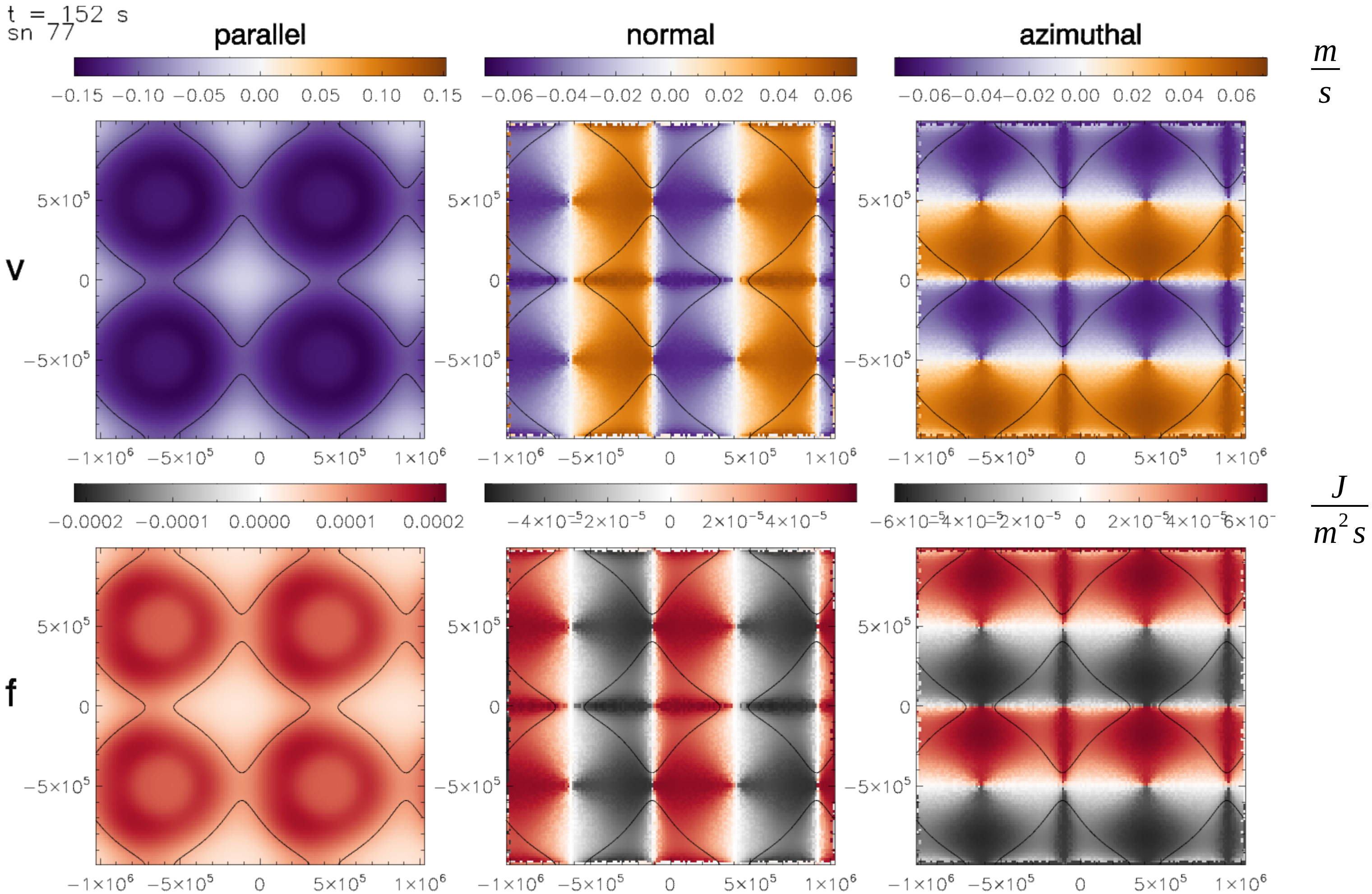
# Model with Inclined Magnetic Field



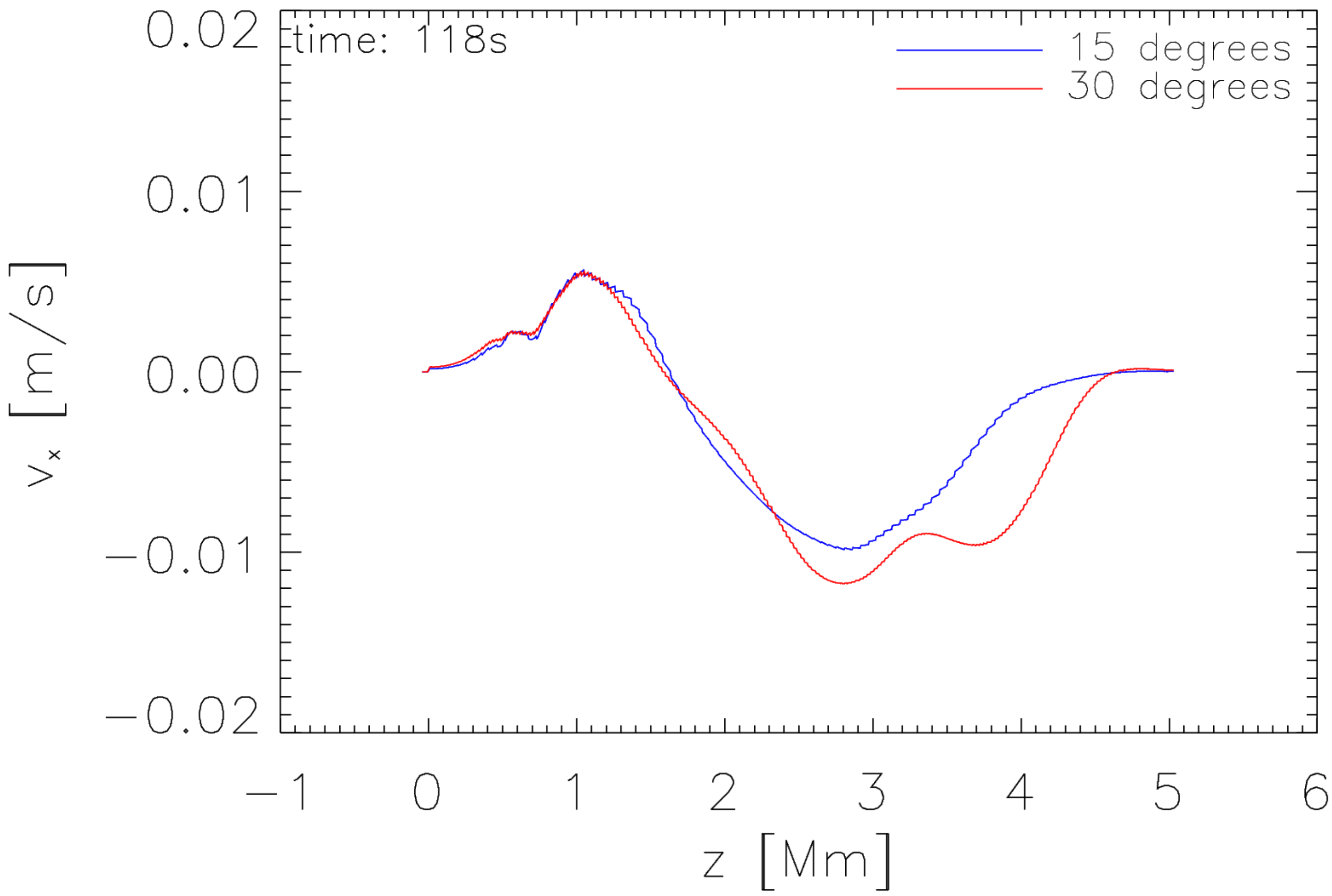
# Horizontal Cut at 2 Mm for a 15° Inclined Magnetic Field

velocity perturbation

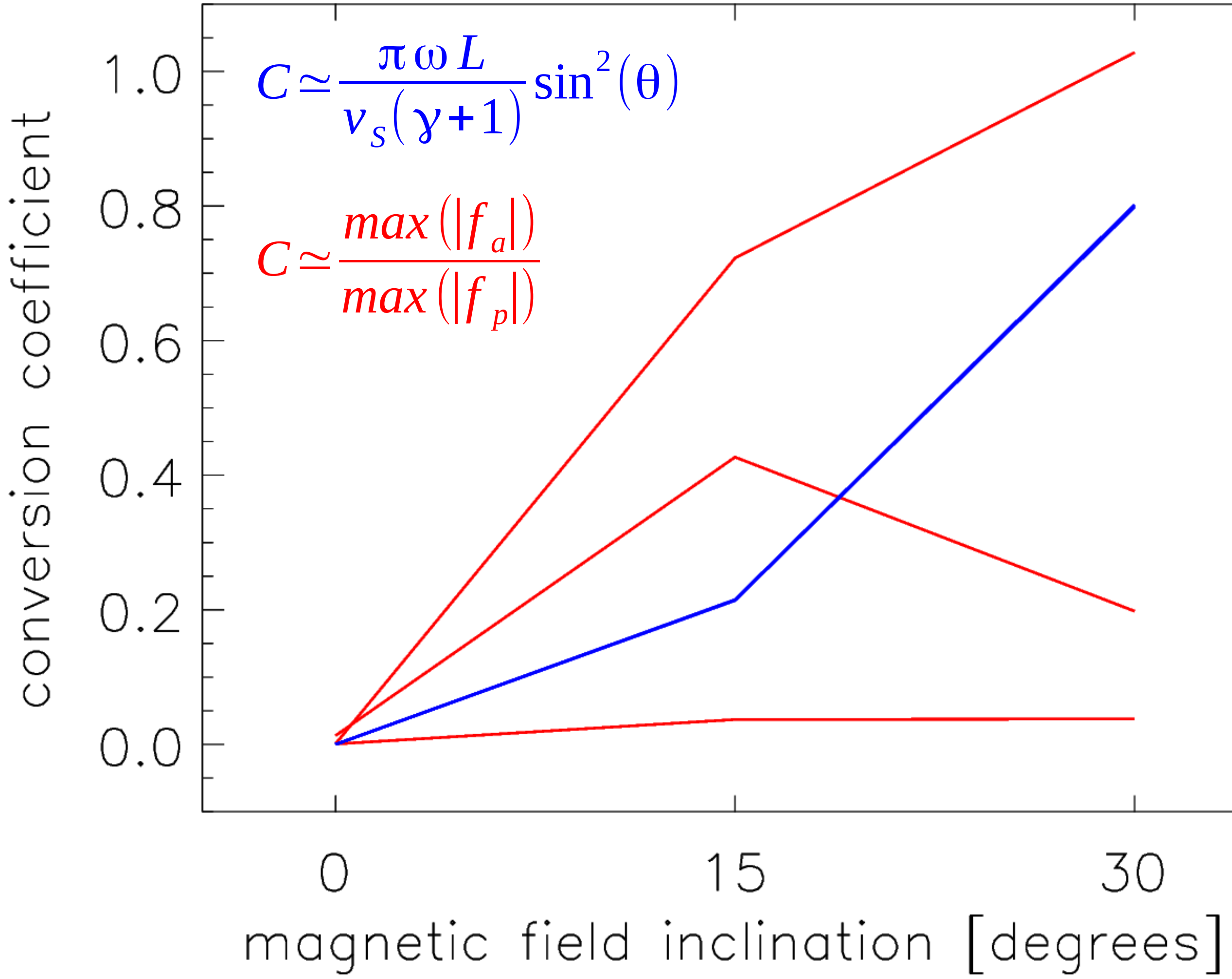
magnetic energy flux



# Kink Oscillation for Inclined Field Lines



# Mode Conversion



# Summary and Conclusions

- Vertical field:
  - Mainly vertical perturbations
  - Sausage mode superimposed with m=4 fluting mode
- Inclined field:
  - Mainly perturbations parallel to magnetic field
  - Kink mode appears
- Conversion from acoustic to magnetic waves for horizontally stratified atmosphere behaves differently than according to the theory for a plane parallel atmosphere

# Outlook

- Investigate wave properties more thoroughly
- Use different driver periods
- Position loops randomly
- Model with diverging field lines