High frequency regions in the presence of coronal null points

Irantzu C. Santamaria
Tom Van Doorsselaere
Elena Khomenko
Manuel Collados

ISSI-BJ 2017
Beijing

Introduction

- Null Points are very small scale magnetic singularities present in the chromosphere and the corona
  - They cannot be observed because an extremely high spatial resolution is needed
  - But the extrapolations of photospheric magnetic fields predict them to be everywhere in the chromosphere and corona.
- Although null points are small scale features their implication in solar dynamism is of great importance: reconnection events and heating
- How do waves behave in the presence of a null point? *McLaughlin et al. (2011), Santamaria et al. (2015)*
  - $v_a = 0 \longrightarrow$ magnetic-like waves cannot propagate through the null point
    - Fast waves (low β plasma) are refracted due to the large gradient of Alfven speed
      - Before the refraction, fast magnetic waves can be converted into fast acoustic waves (β =1 contour around null points)
    - Alfven waves a guided outwards the null point aligned to the magnetic field
  - $c_s \neq 0 \longrightarrow$ only acoustic waves can cross the null point

MHD theory and computation

MANCHA code

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \boldsymbol{v}) = \left(\frac{\partial \rho}{\partial t}\right)_{diff}$$

Continuity

$$\frac{\partial (\rho \boldsymbol{v})}{\partial t} + \nabla \cdot \left[\rho \boldsymbol{v}\boldsymbol{v} + \left(p + \frac{\boldsymbol{B}^2}{2\mu_0}\right)\boldsymbol{I} - \frac{\boldsymbol{B}\boldsymbol{B}}{\mu_0}\right] = \rho \boldsymbol{g} + \left(\frac{\partial (\rho \boldsymbol{v})}{\partial t}\right)_{diff}$$

Motion

$$\frac{1}{\gamma - 1}\left(\frac{\partial p}{\partial t} + (\boldsymbol{v}\cdot\nabla)p + \gamma p(\nabla \cdot \boldsymbol{v})\right) = \cancel{Q_{rad}} + \cancel{\nabla \cdot (\kappa \nabla T)} + \left(\frac{\partial p}{\partial t}\right)_{diff}$$

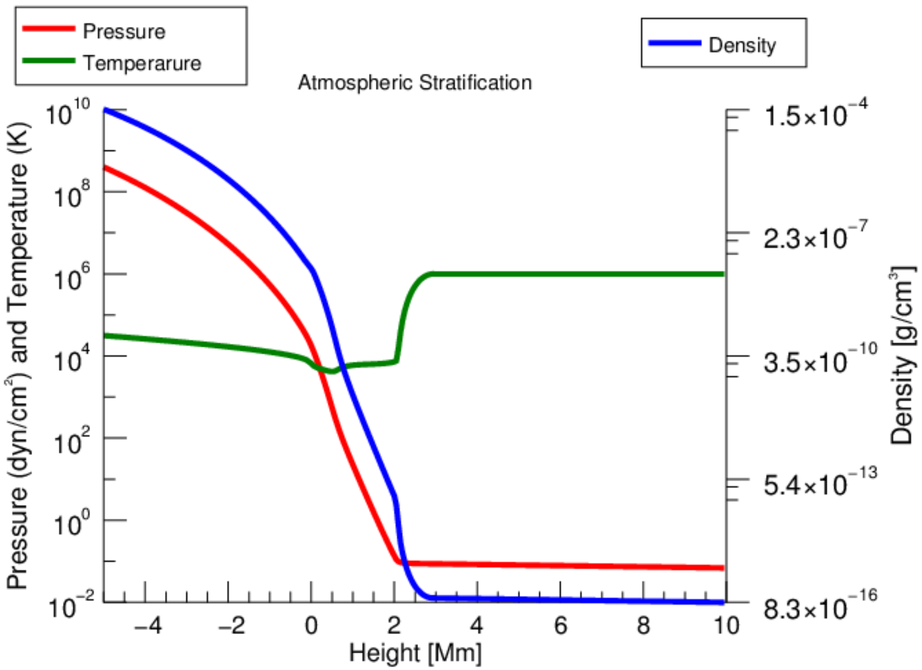
Internal energy

$$\frac{\partial \boldsymbol{B}}{\partial t} = \nabla \times (\boldsymbol{v} \times \boldsymbol{B}) + \left(\frac{\partial \boldsymbol{B}}{\partial t}\right)_{diff}$$

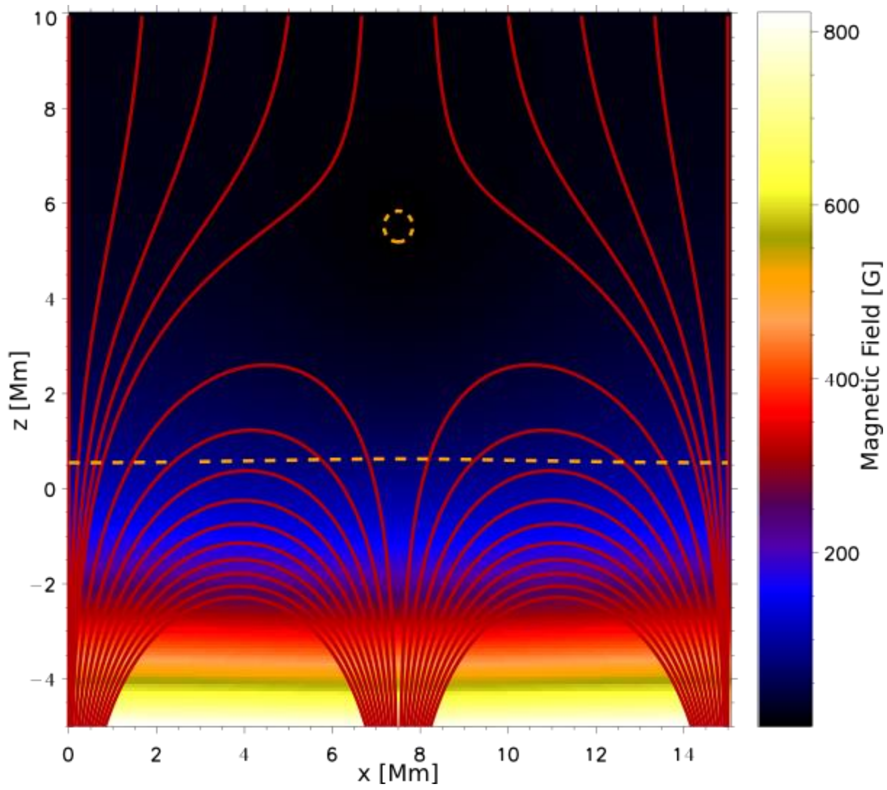
Induction

Equilibrium model

Hydrostatic model



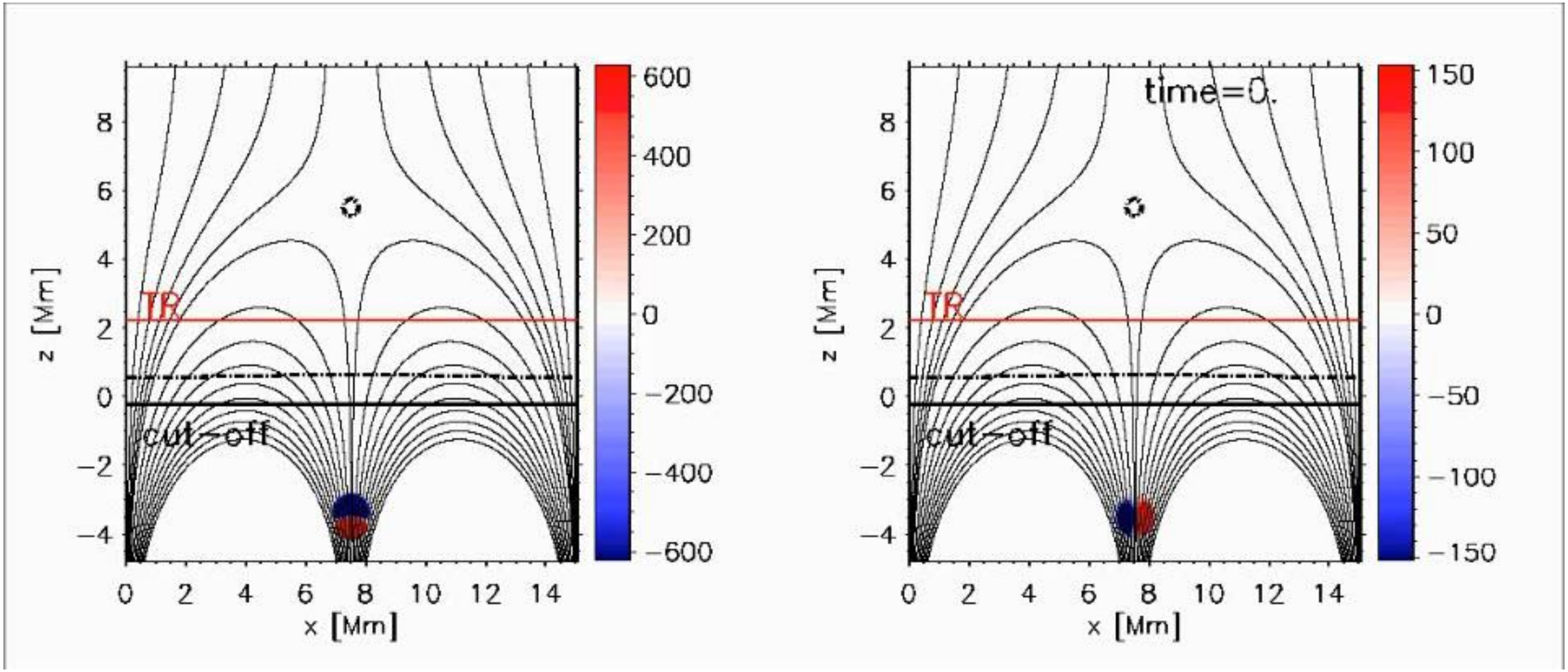
Magnetostatic model



SPIA
Solar Partially Ionized Atmosphere
KU LEUVEN

Non-linear wave behavior

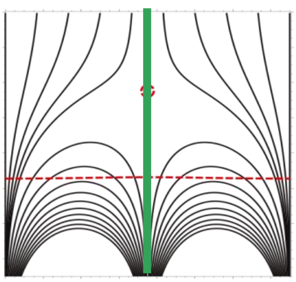
$\sqrt{\rho_0 c_{s0}} v_{long}$ $\sqrt{\rho_0 v_{a0}} v_{trans}$



Non-linear VS linear wave behavior

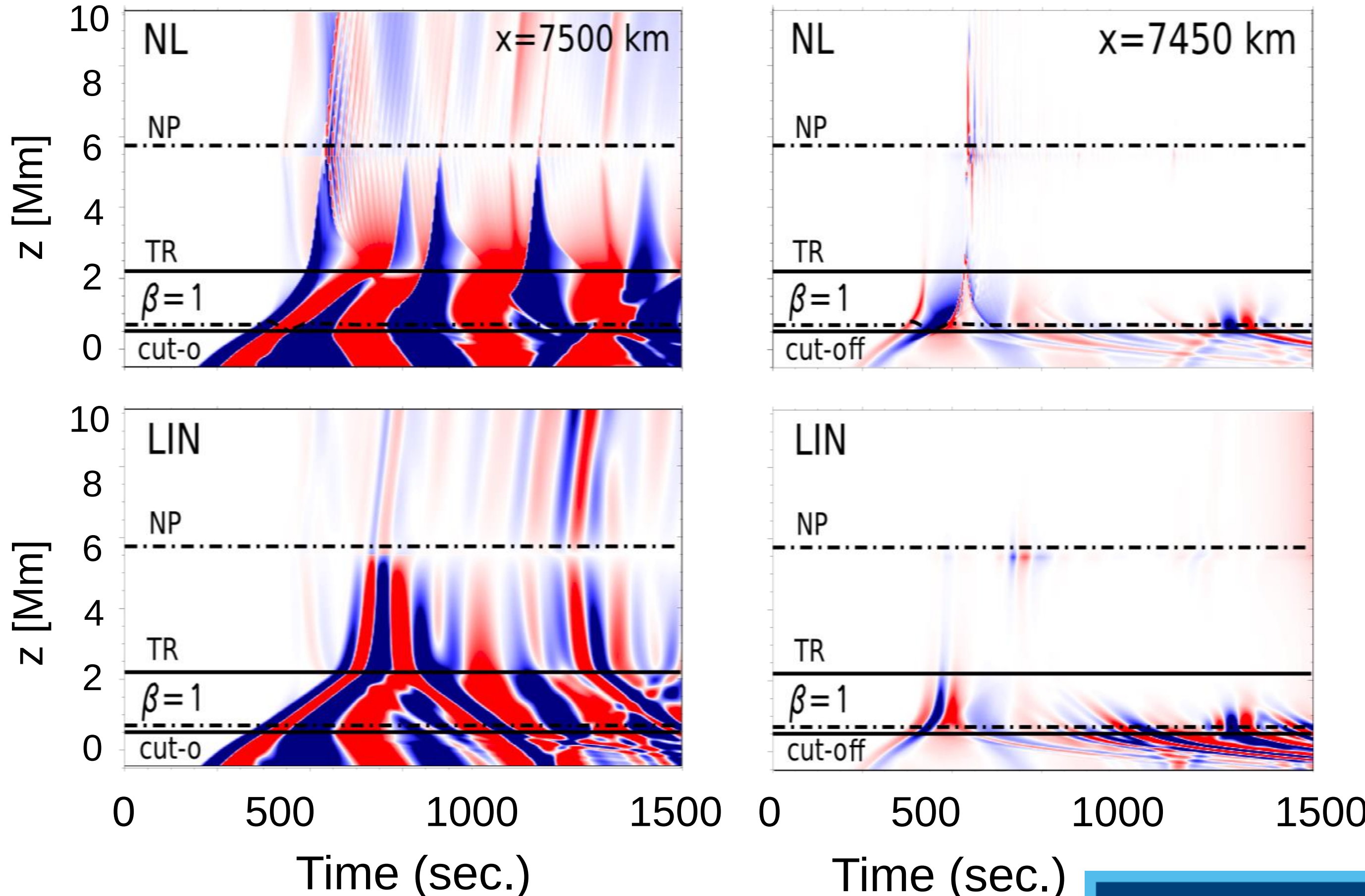
Santamaria et al. (2016)

Non-linear
A=0.2



Linear
A=10^{-5}

$\sqrt{\rho_0 c_{s0}} v_{long}$ $\sqrt{\rho_0 v_{a0}} v_{trans}$

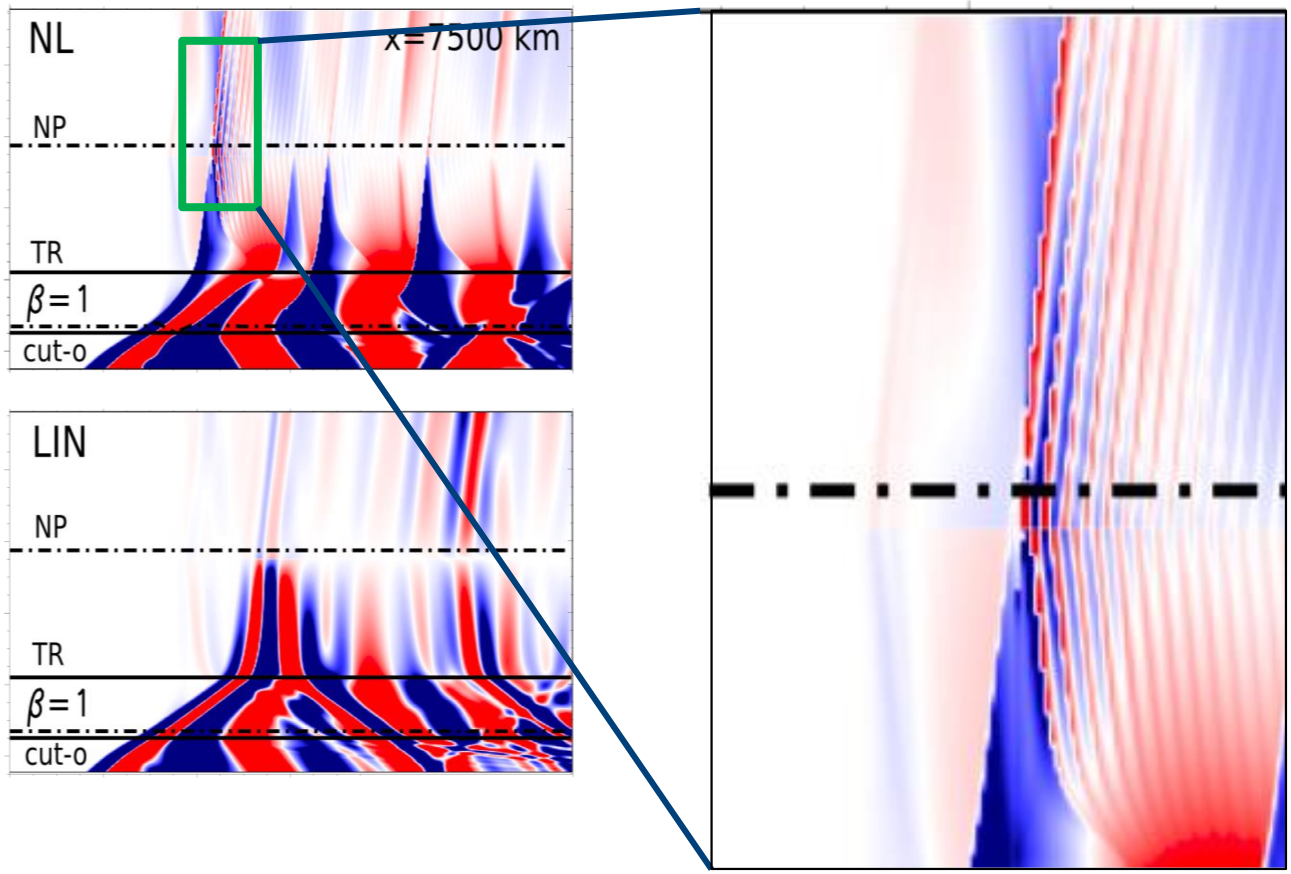


Non-linear VS linear wave behavior

$\sqrt{\rho_0 c_{s0}} v_{long}$

Non-linear
A=0.2

Linear
$A=10^{-5}$



SPIA
Solar Partially Ionized Atmosphere

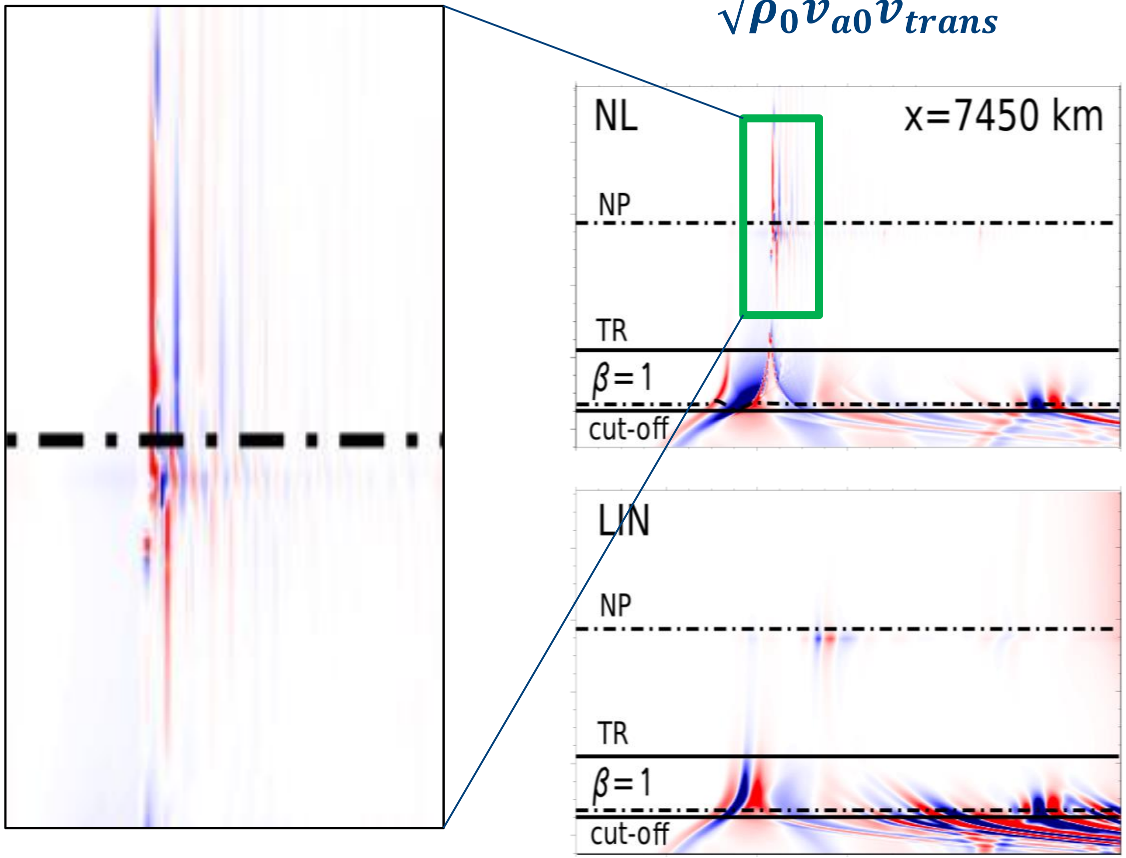
KU LEUVEN

Non-linear VS linear wave behavior

Non-linear
A=0.2

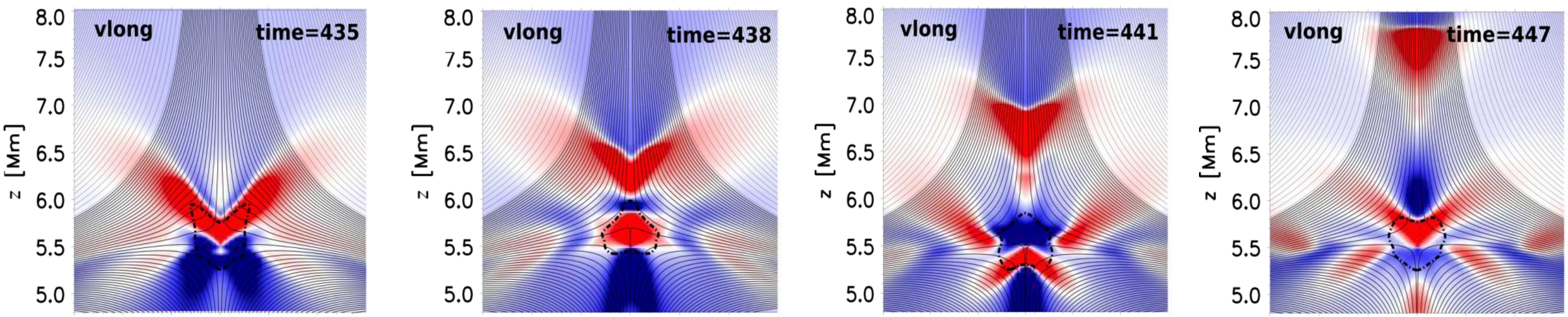
Linear
$A=10^{-5}$

$\sqrt{\rho_0 v_{a0}} v_{trans}$



Non-linear VS linear wave behavior

$\sqrt{\rho_0 c_{s0}} v_{long}$

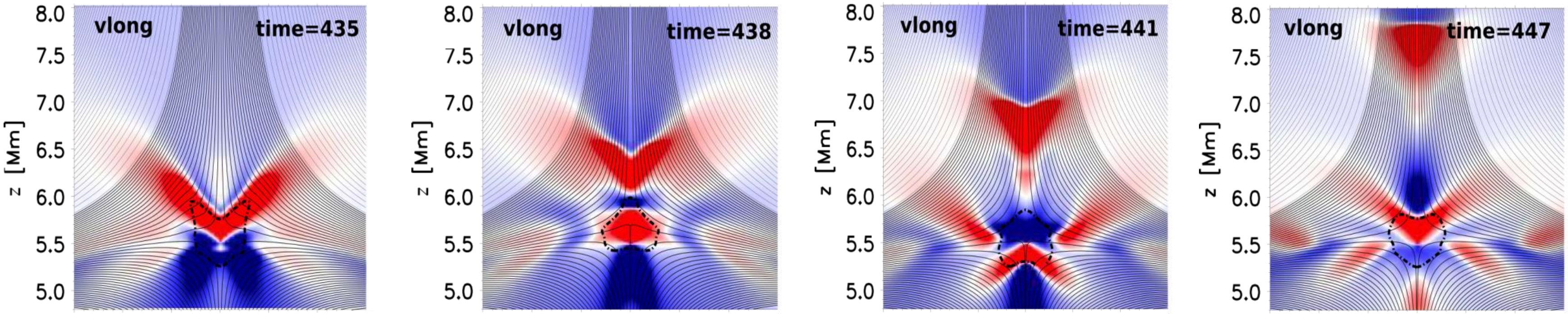


SPIA
Solar Partially Ionized Atmosphere

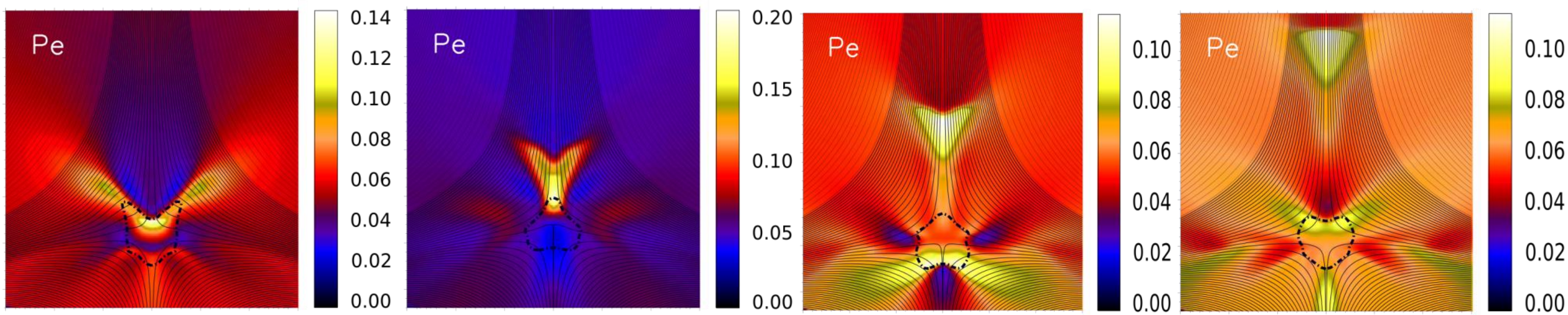
KU LEUVEN

Non-linear VS linear wave behavior

$\sqrt{\rho_0 c_{s0}} v_{long}$



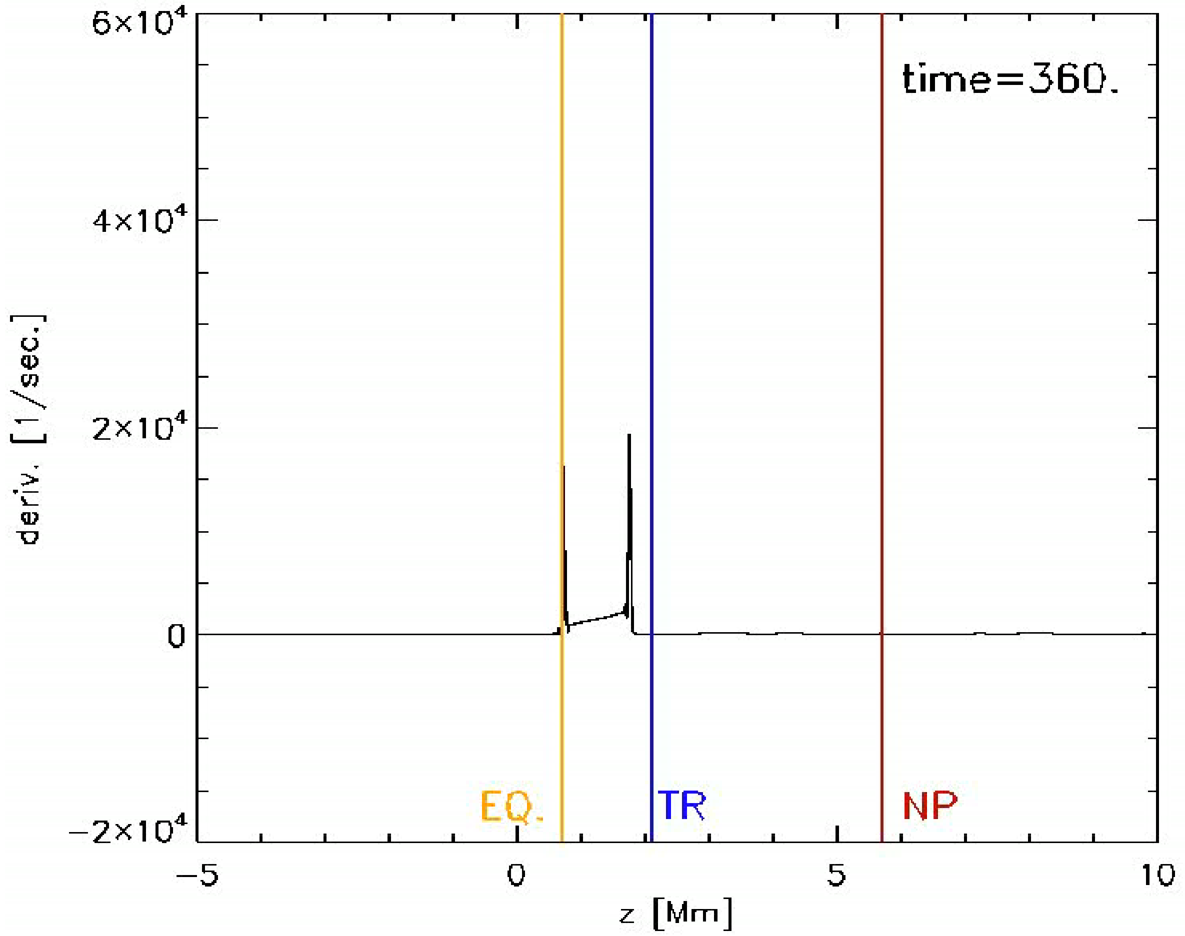
Total pressure



SPIA
Solar Partially Ionized Atmosphere

KU LEUVEN

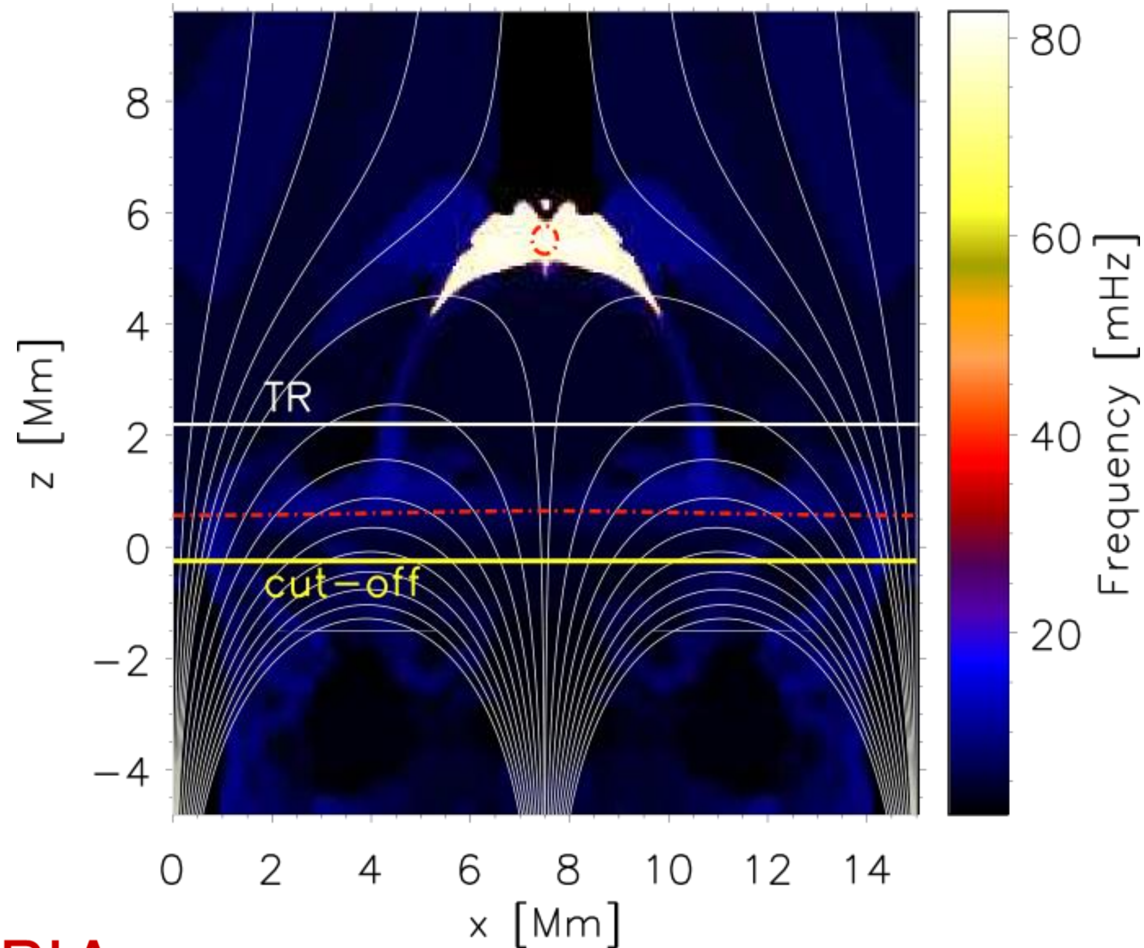
Non-linear VS linear wave behavior



SPIA
Solar Partially Ionized Atmosphere
KU LEUVEN

Non-linear VS linear wave behavior

Dominant frequency distribution

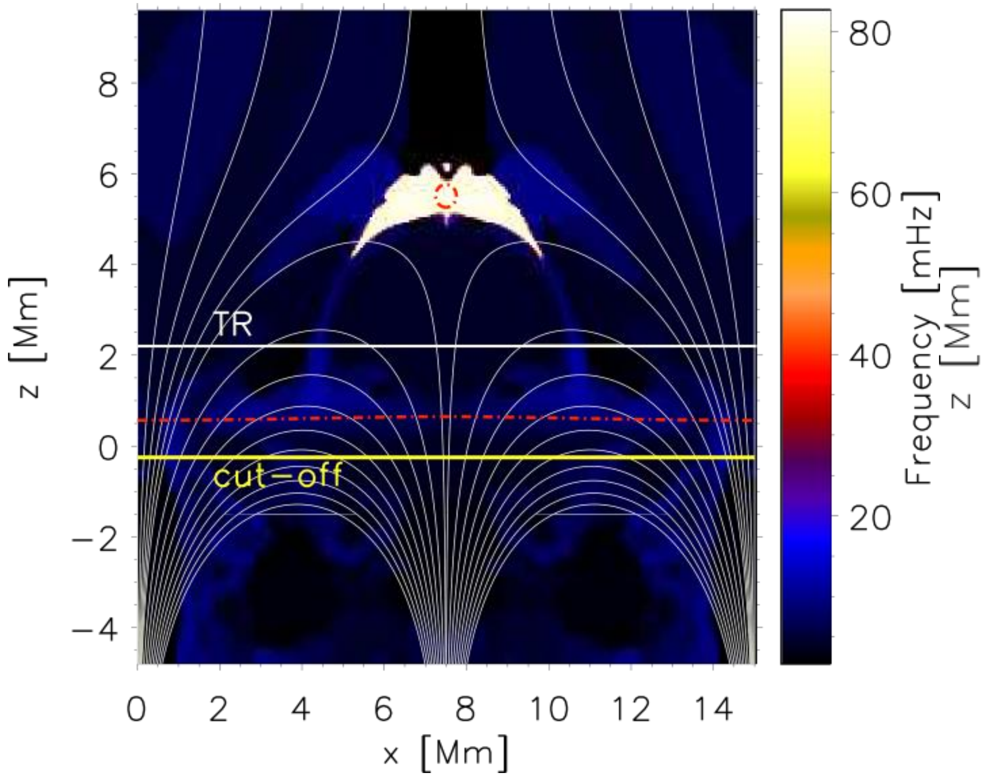


SPIA
Solar Partially Ionized Atmosphere
KU LEUVEN

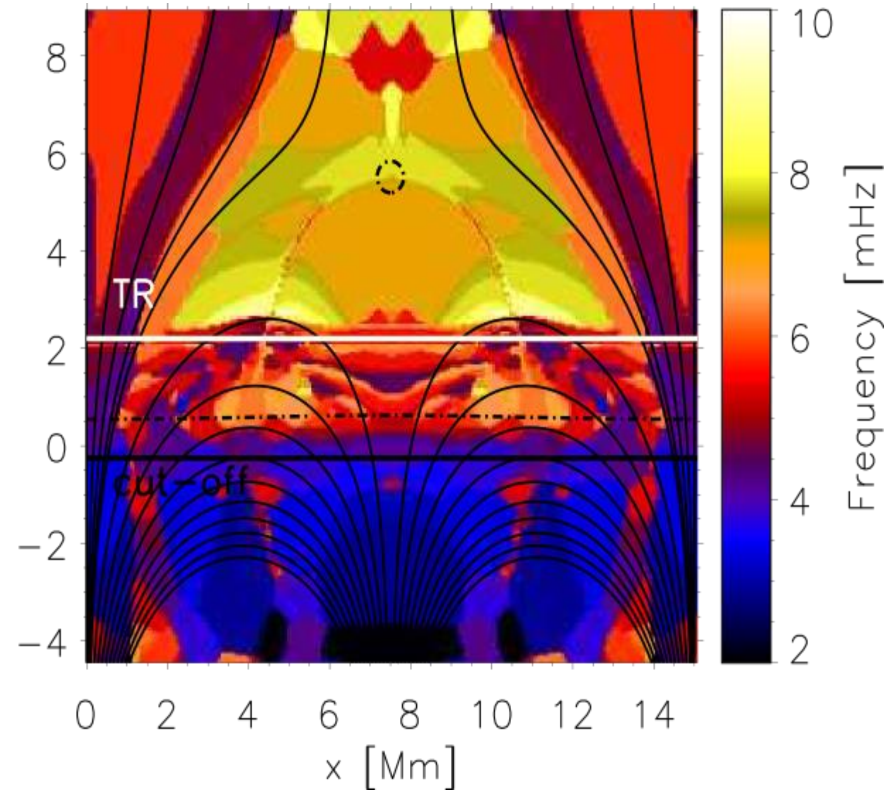
Non-linear VS linear wave behavior

Dominant frequency distribution

Non-linear



Linear

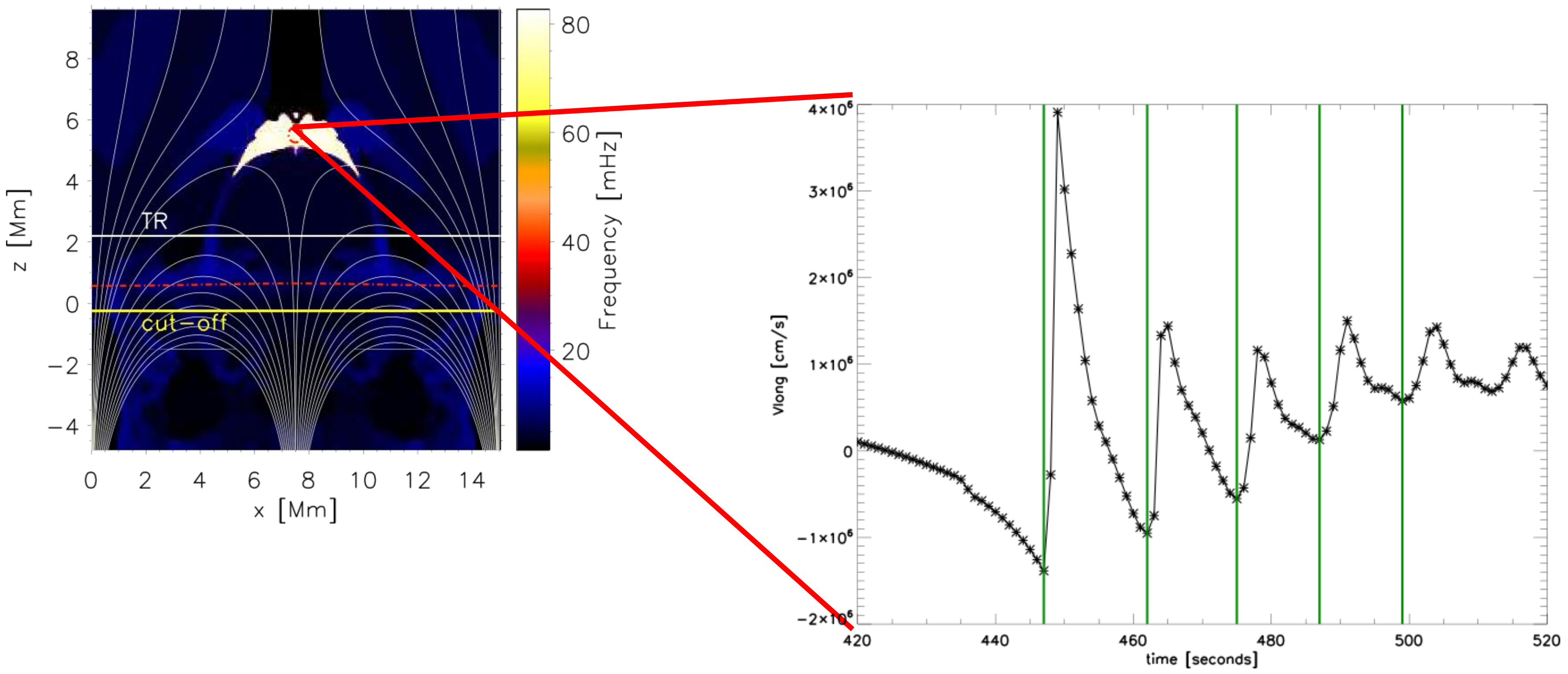


SPIA
Solar Partially Ionized Atmosphere

KU LEUVEN

Non-linear VS linear wave behavior

Dominant frequency distribution



High frequencies around the null point (preliminary results)

Can we relate the high frequency jets with any observational feature?

High frequencies around the null point (preliminary results)

Can we relate the high frequency jets with any observational feature?

Similar periods are observed in flaring loops (van Doorsselaere et al., 2011). BUT this short period oscillations are associated to fast sausage modes…

High frequencies around the null point (preliminary results)

Can we relate the high frequency jets with any observational feature?

Similar periods are observed in flaring loops (van Doorsselaere et al., 2011). BUT this short period oscillations are associated to fast sausage modes…

Why not slow shock waves?

High frequencies around the null point (preliminary results)

Can we relate the high frequency jets with any observational feature?

Similar periods are observed in flaring loops (van Doorsselaere et al., 2011). BUT this short period oscillations are associated to fast sausage modes…

Why not slow shock waves?

When do the high frequencies appear?

High frequencies around the null point (preliminary results)

Can we relate the high frequency jets with any observational feature?

Similar periods are observed in flaring loops (van Doorsselaere et al., 2011). BUT this short period oscillations are associated to fast sausage modes…

Why not slow shock waves?

When do the high frequencies appear?

Dependence on the amplitude of the perturbation?

High frequencies around the null point (preliminary results)

Can we relate the high frequency jets with any observational feature?

Similar periods are observed in flaring loops (van Doorsselaere et al., 2011). BUT this short period oscillations are associated to fast sausage modes…

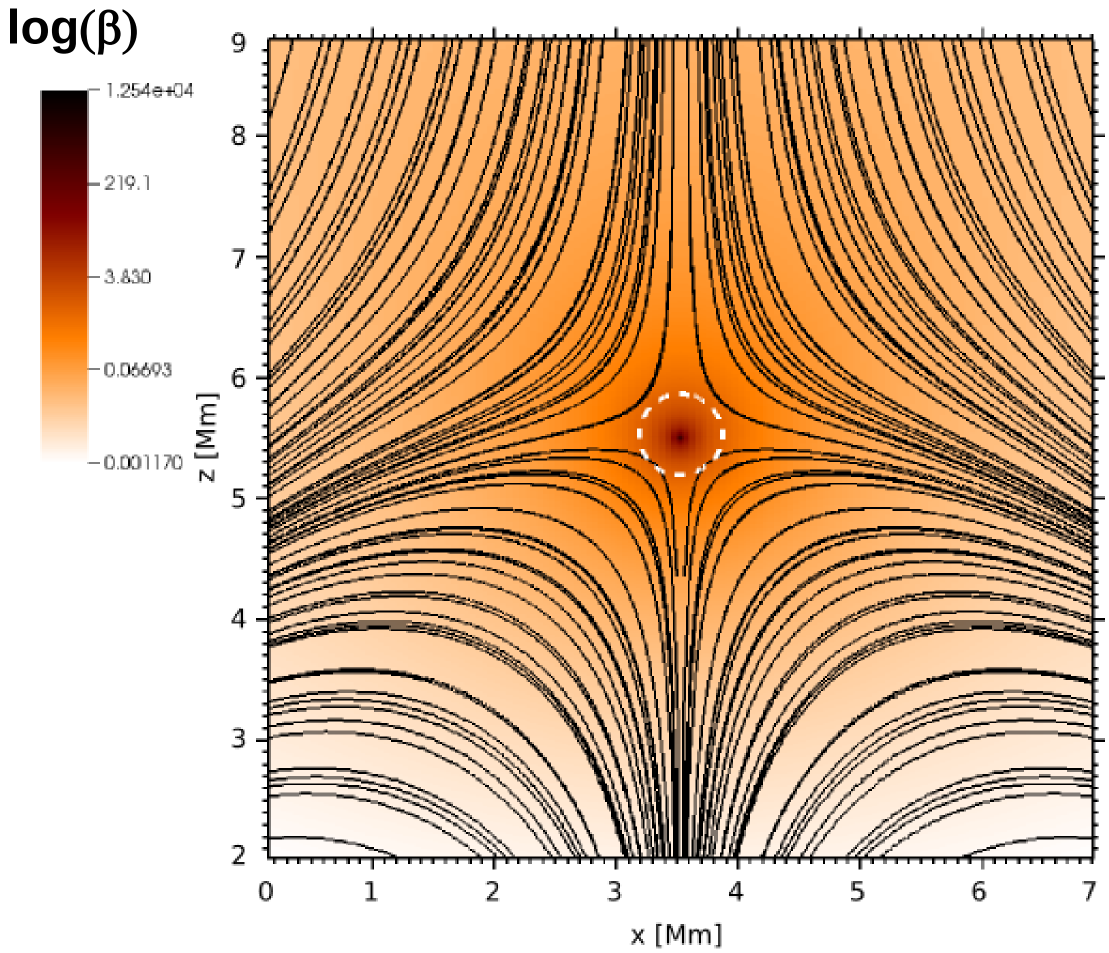
Why not slow shock waves?

When do the high frequencies appear?

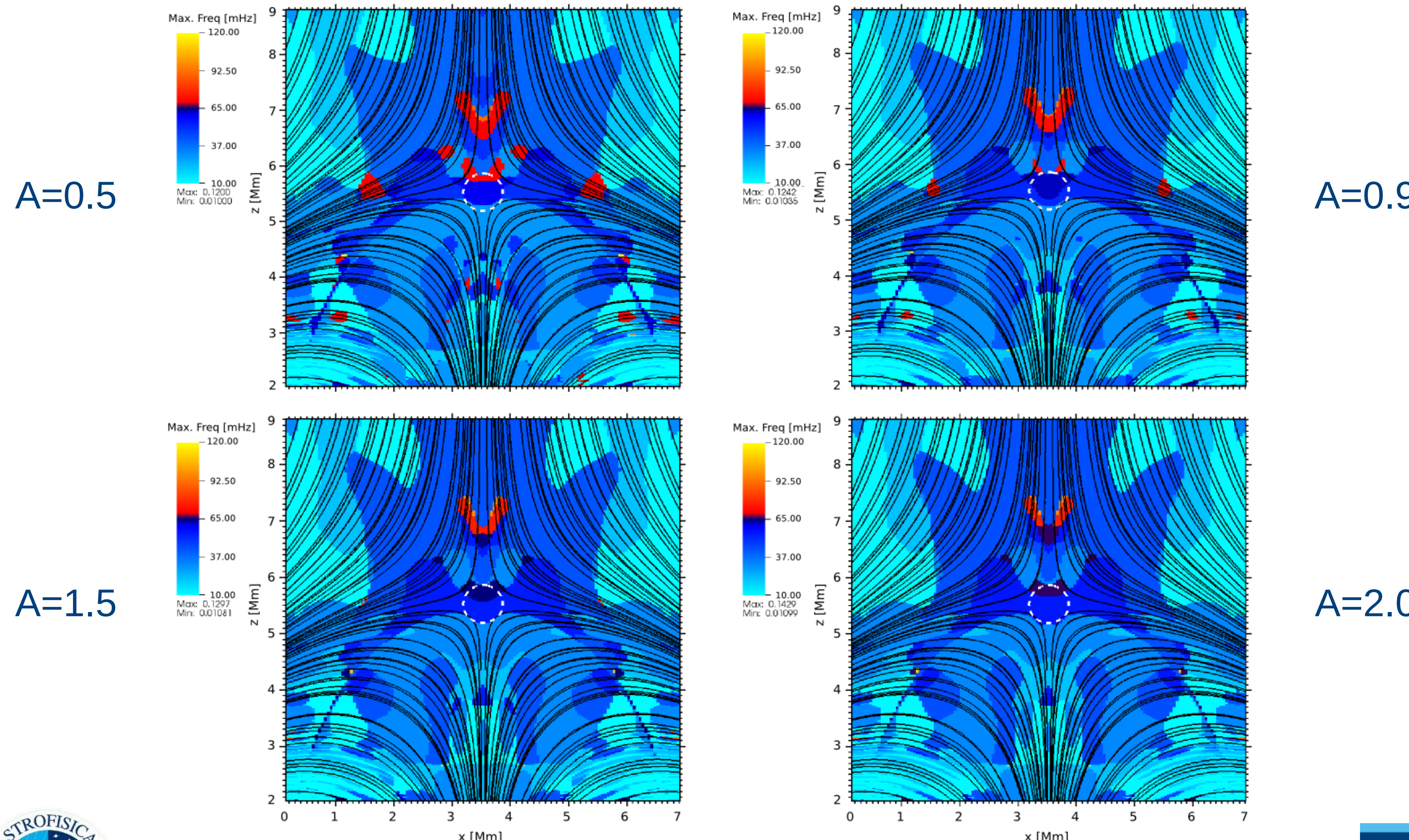
Dependence on the amplitude of the perturbation?

Or on the atmospheric/magnetic properties?

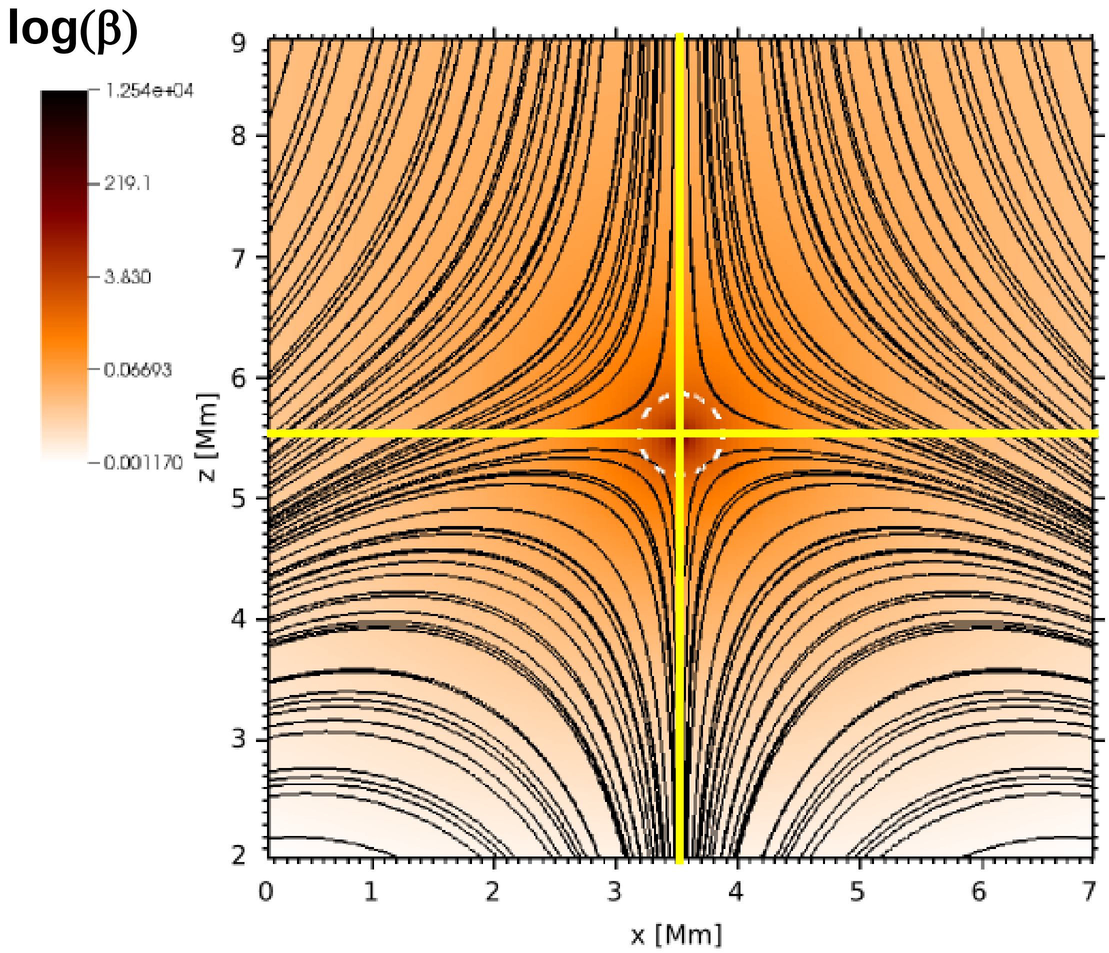
High frequencies around the null point (preliminary results)



High frequencies around the null point (preliminary results)

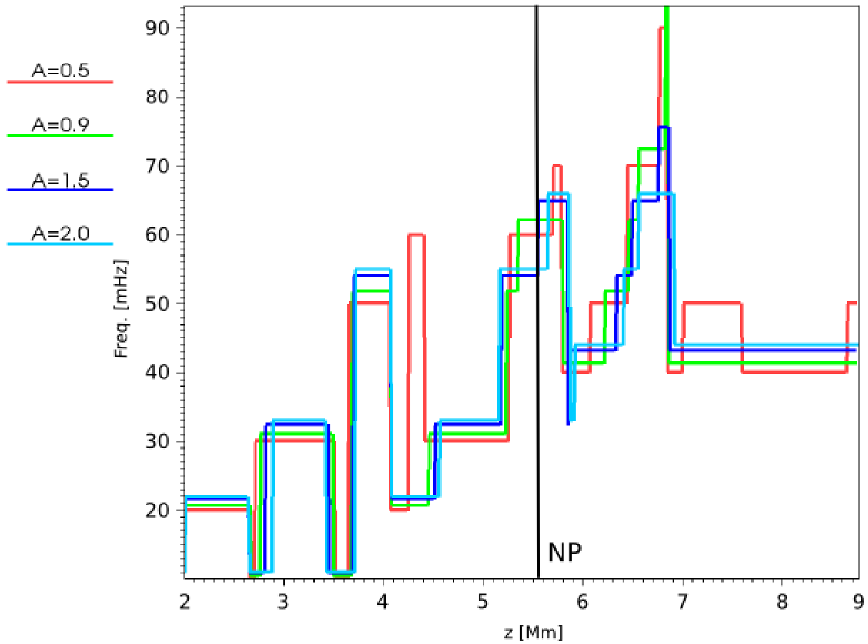


High frequencies around the null point (preliminary results)

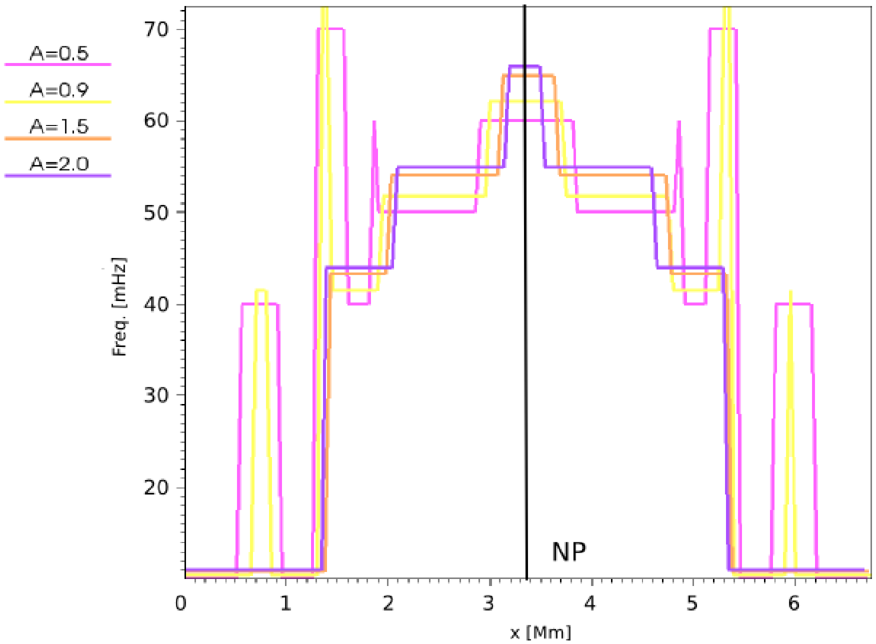


High frequencies around the null point (preliminary results)

Vertical Cut



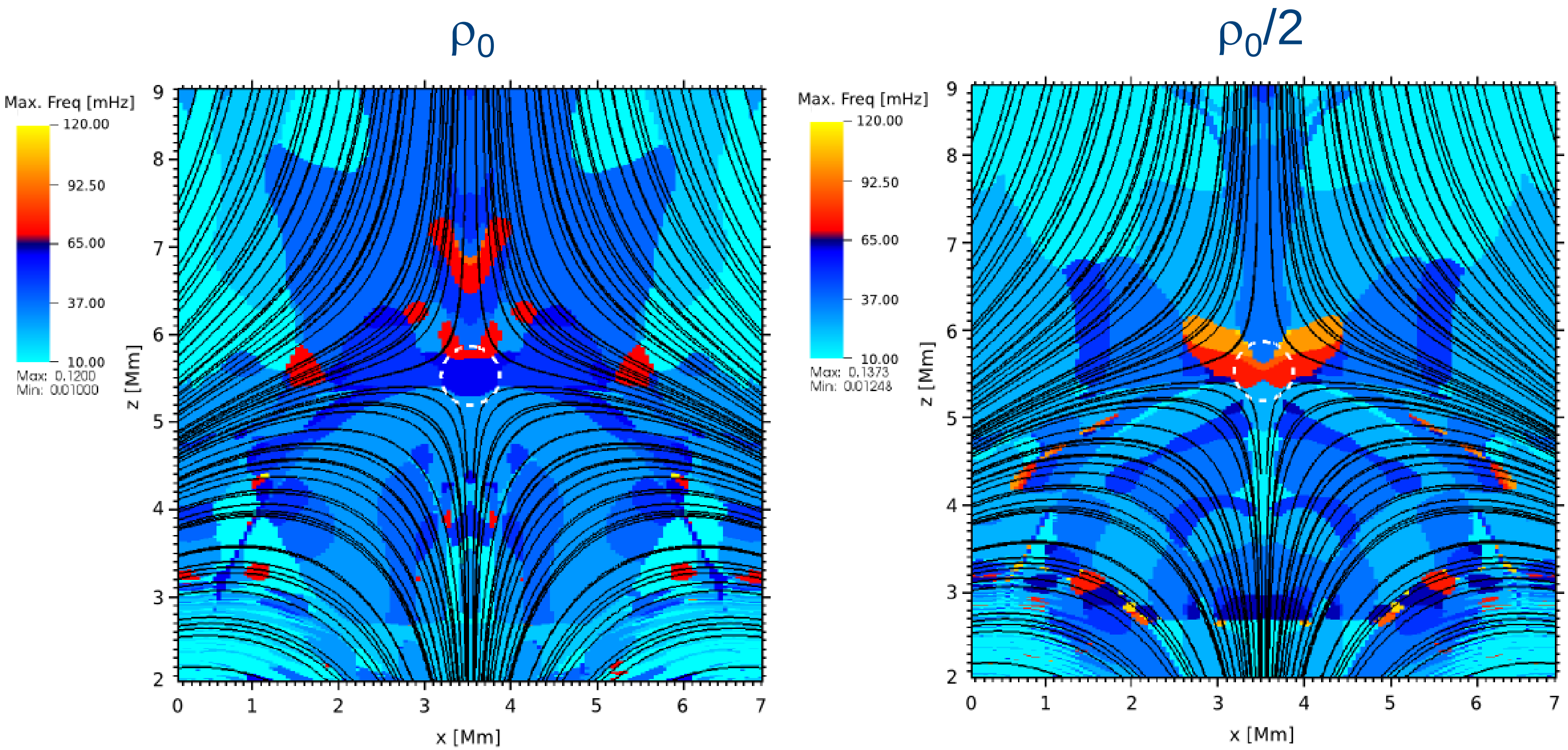
Horizontal Cut



SPIA Solar Partially Ionized Atmosphere

KU LEUVEN

High frequencies around the null point (preliminary results)



High frequencies around the null point (preliminary results)

- Frequency distribution does not change with the driver amplitude
- Frequency distribution changes with the background atmosphere

High frequencies around the null point (preliminary results)

- Frequency distribution does not change with the driver amplitude
- Frequency distribution changes with the background atmosphere

RESONANT CAVITY?

High frequencies around the null point (preliminary results)

- Frequency distribution does not change with the driver amplitude
- Frequency distribution changes with the background atmosphere

RESONANT CAVITY?

Magnetic or acoustic RC?

Still lots of open questions…

Summary

- A jet-like phenomenon is developed in the null point that might be related to the secondary shock waves created in the null point. Similar results by McLaughlin et al. (2009), but different shock nature and driving mechanism. No frequency information in their study.
- High frequency (80 mHz) region is found around the null point: secondary shock waves
- Frequency distribution does not change with the amplitude of the pulse
- Frequency distribution changes with the atmospheric density=> Resonant cavity?

TO BE CONTINUED…

SPIA Solar Partially Ionized Atmosphere

KU LEUVEN

Thanks!