Forward Modeling of Simulated Transverse Oscillations in Coronal Loops and the Influence of Background Emission

Speaker: Mijie Shi

KU Leuven, Belgium
Shandong University, China

Coauthors: T. Van Doorsselaere, P. Antolin, B. Li

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mijie.shi@kuleuven.be

Introduction

- **Transverse oscillations in coronal loops**
  - **Decaying**
    - Triggered by flares or CMEs
    - Large amplitude, Strong decay

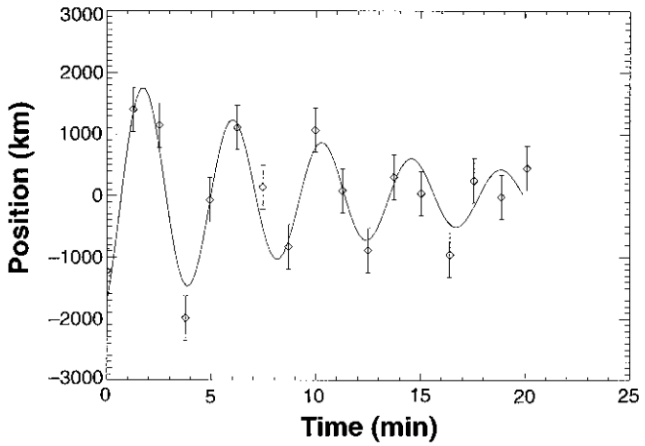


Figure from Nakariakov et al. 1999;
Also see Aschwanden at al. 1999.

  - **Decayless**
    - Not related to flares or CMEs
    - Low amplitude, No decay

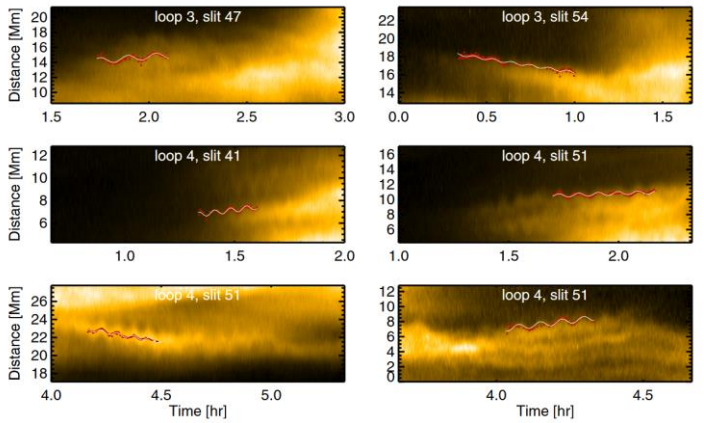
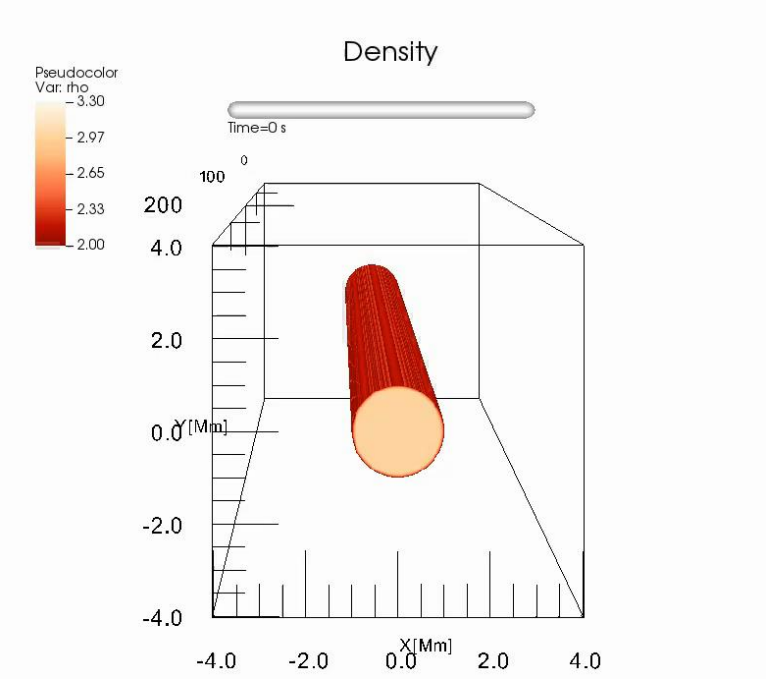


Figure from Anfinogentov et al. 2013 ;
Also see Tian at al. 2012, Wang et al. 2012.

- **Possible generation mechanism**
  - Continuous footpoint driver (e.g., Karampelas et al. 2017)
  - Background flow (e.g., Karampelas et al. 2020)

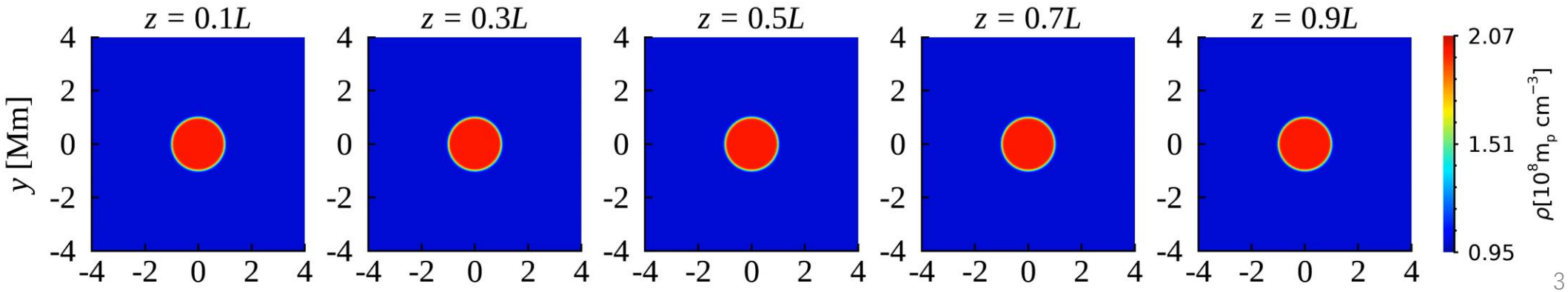
Simulation model

- **Density enhanced straight loop**
  - ➢No gravity, thermal conduction, or physical dissipation
  - ➢With radiative cooling
- **Velocity driver at footpoint**
  - ➢Dipole like periodic driver (Poscoe et al. 2010)



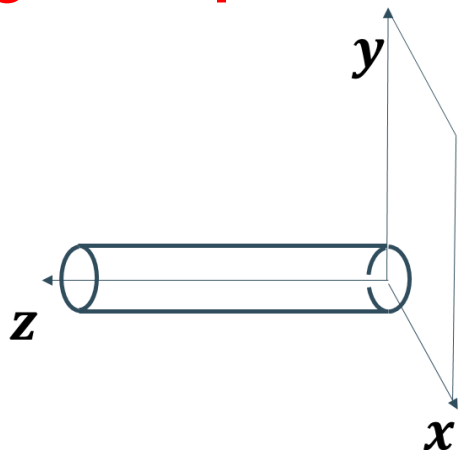
Density at the loop cross sections

t= 0 s



Forward modeling: model → observables

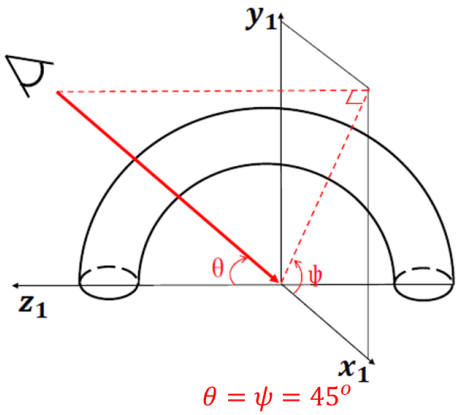
- **Straight loop → Semi-torus loop**



$$x_1 = x,$$
$$y_1 = (R + y)\sin\zeta,$$
$$z_1 = -(R + y)\cos\zeta,$$

$$\begin{bmatrix} v_{x_1} \\ v_{y_1} \\ v_{z_1} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \sin\zeta(z) & \cos\zeta(z) \\ 0 & -\cos\zeta(z) & \sin\zeta(z) \end{bmatrix} \begin{bmatrix} v_x \\ v_y \\ v_z \end{bmatrix}.$$

where $\zeta = z/R$, and $R = L/\pi$



(Yuan et al. 2016, ApJS)

- **FoMo code** https://wiki.esat.kuleuven.be/FoMo/
  - Transform to the coordinate determined by Line of Sight and Plane of Sky
  - Integrate the monochromatic emissivity along the Line of Sight

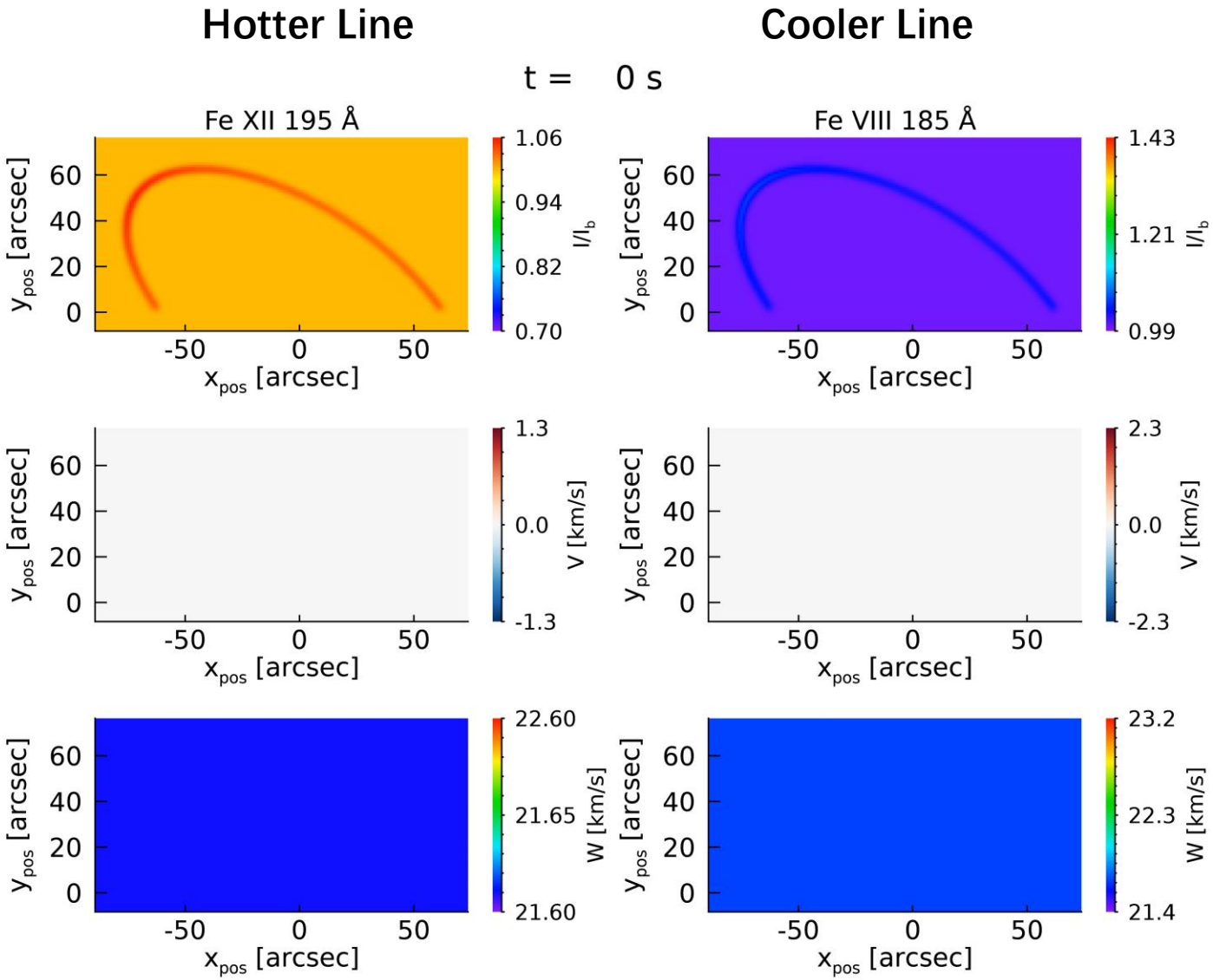
- **Background (Pixels outside the simulation domain): constant emissivity**
- **Single gaussian fit → Intensity, Doppler velocity, Doppler width**

Results: Plane of Sky images

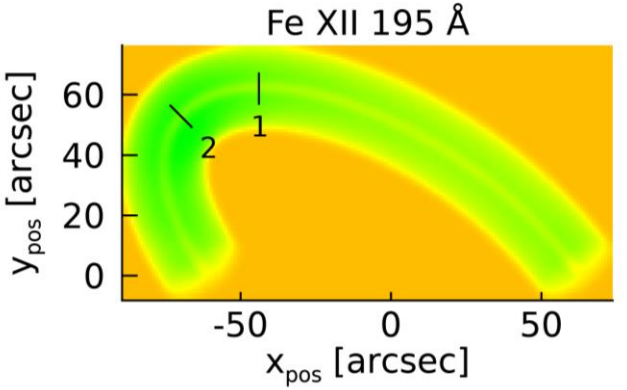
Intensity

Doppler velocity

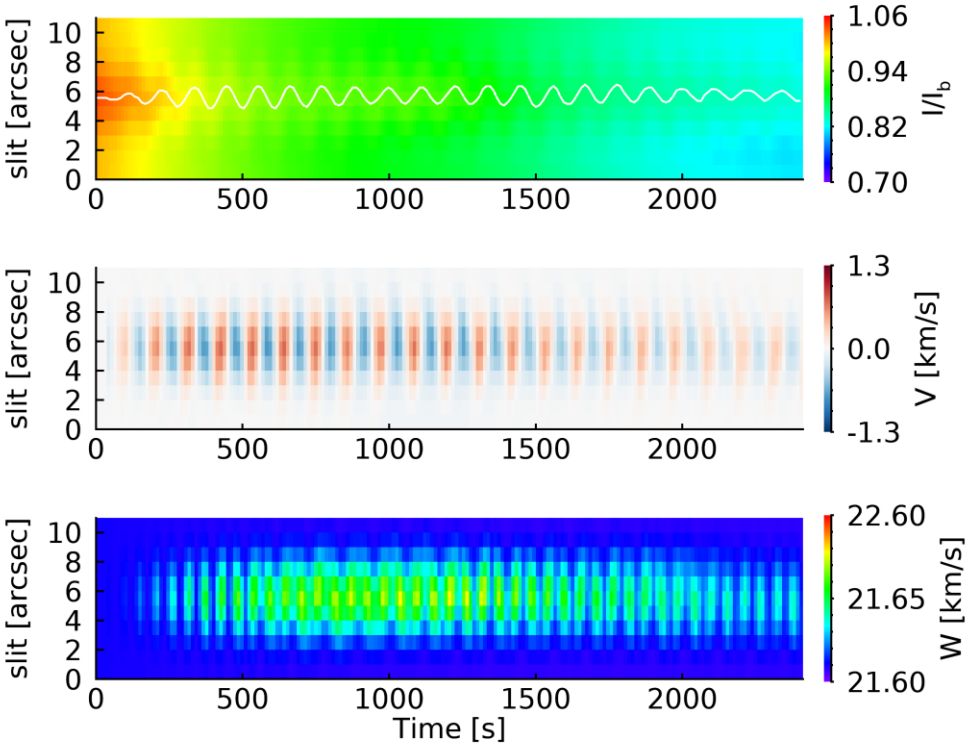
Doppler width



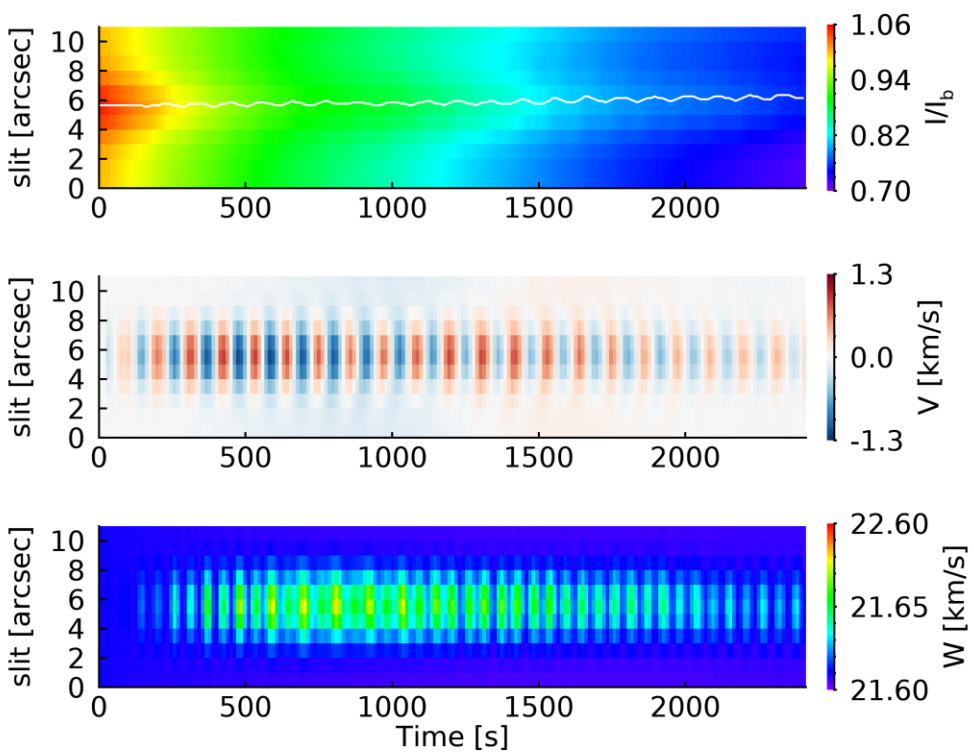
Results: Slit-cut (195 Å line)



Slit 1



Slit 2



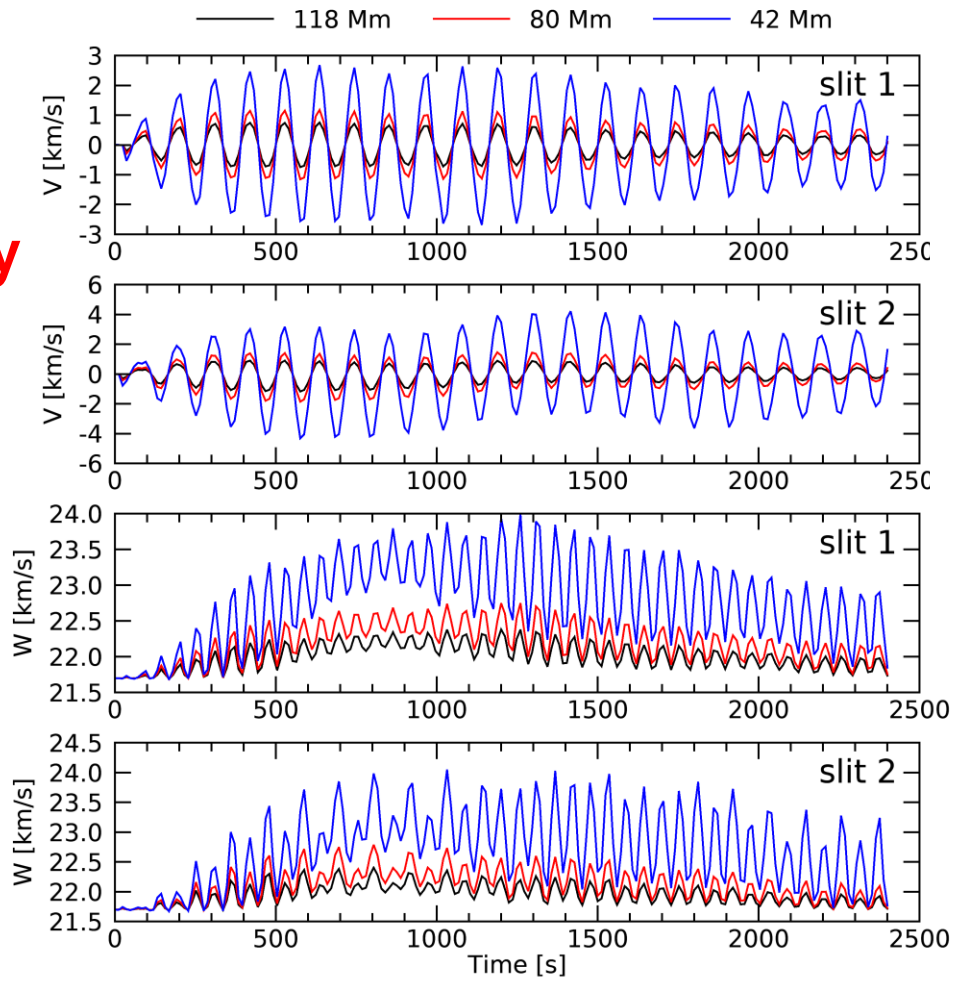
Intensity

Doppler velocity

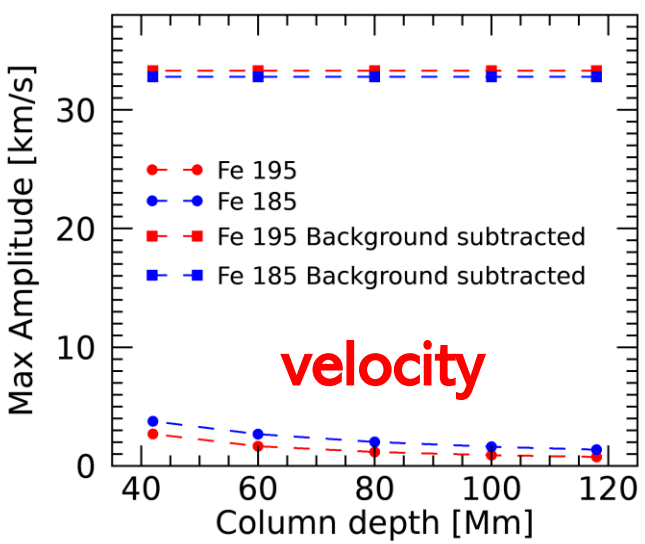
Doppler width

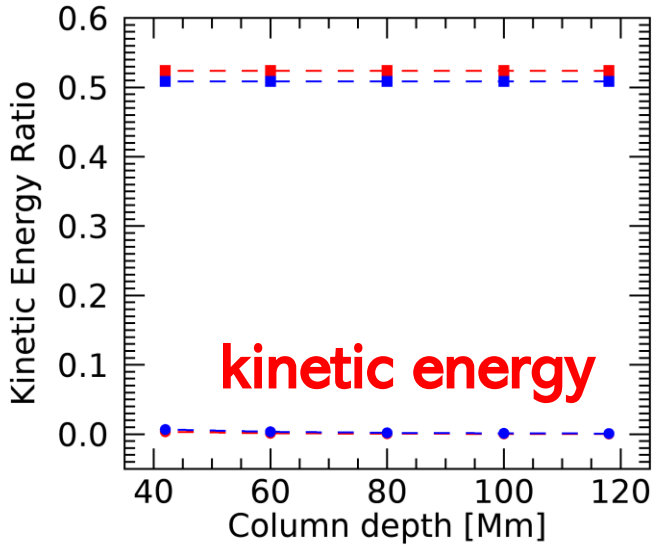
Influence of background emission

Different Background column depths



Background subtracted results





✓ **Background emission significantly reduces the observed velocity and energy**

Summary

- We perform 3D simulations studying the heating effects of kink waves in the presence of radiative cooling
- We forward-model the observables of a semi-torus loop and provide some observational signatures of transverse oscillations.
- Our results show that Doppler velocity underestimates the real velocity due to the background emission.

Please see https://arxiv.org/abs/2109.02338 for more details.

mijie.shi@kuleuven.be