Numerical study of MHD modes in coronal loops

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Objectives

Analyse the capability of different type of perturbations to excite slow and sausage modes in coronal loops. We define:

- local energy deposition, and,
- global energy deposition.

Introduction

The **coronal seismology** combines the measurement of temporal and spatial signatures of (magnetohydrodynamics) MHD waves and oscillations together with their theoretical modelling to infer coronal mean plasma properties. In the particular case of the **coronal loops**, the **fast sausage mode** and the **standing slow mode** are the most commonly studied due to their compressibility which makes them susceptible to be observed.

Method and model

We perform 2.5D axisymmetric simulations evolving the ideal MHD equations. Initially, the dense and hot coronal loop is in equilibrium with corona and chromosphere [1]. Then, we perturb it with an instantaneous energy deposition of the order of $\sim 10^{27}$erg (microflare).

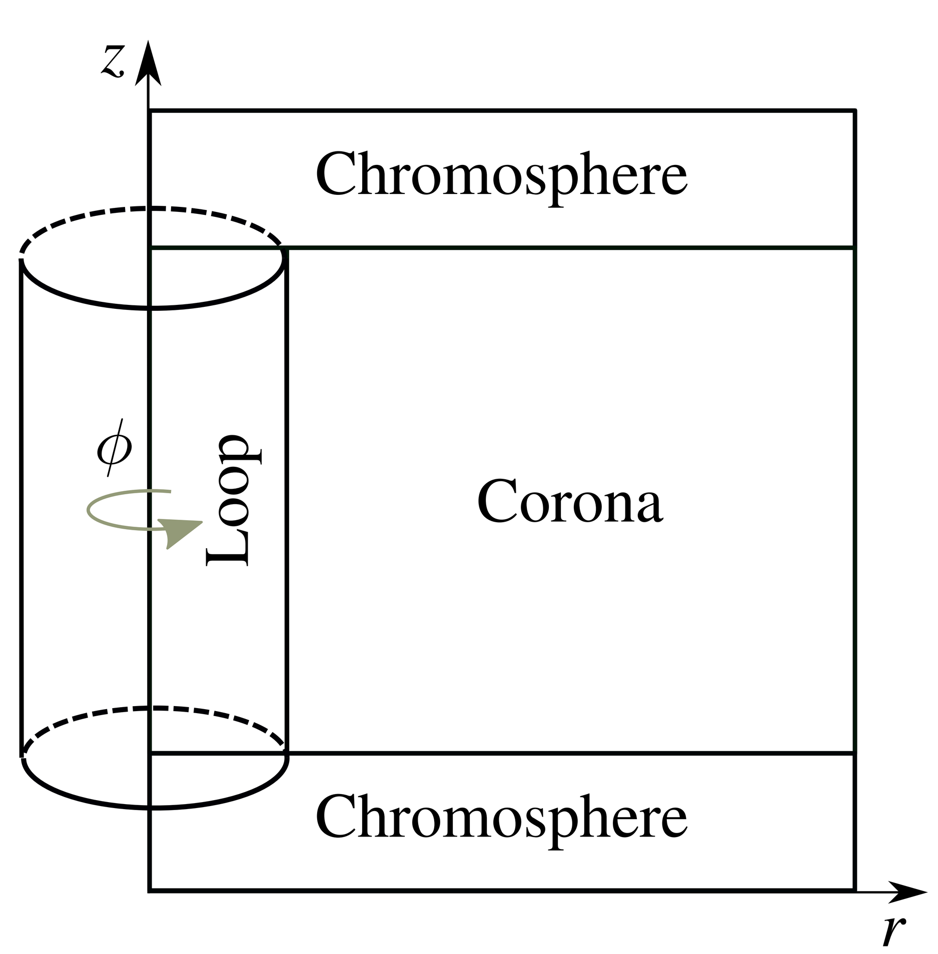
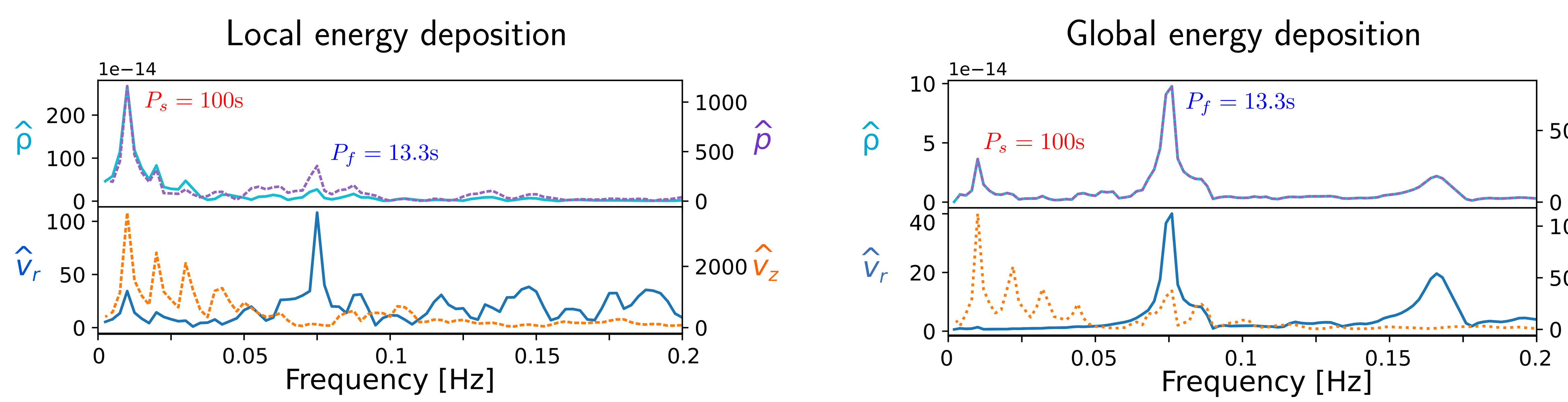


Figure 1:Scheme of the coronal loop, corona and chromosphere.

Perturbations

In the Quiet Sun, the $\tau_{rad} \ll \tau_{cond}$, on the other hand, in an Active Region, the $\tau_{cond} \ll \tau_{rad}$. In the QS, given a typical energy disturbance in the loop, it will be contained in a localised region of the loop. But in AR, the perturbation cannot be cooled by radiation in times of the conductive times and the disturbance spreads throughout the entire loop. We call *Local energy deposition* to the perturbation in the first case, and *Global energy deposition* in the second one.



Fourier amplitude of density, pressure and radial and longitudinal velocities measured at loop top.

Important Result

The **local** and **global** energy depositions trigger a mode pattern of mainly **two coupled frequencies** which is strongly dominated by the **slowest one** in the first case and by the **fast magnetosonic one** in the second case.

Importance of β parameter

We analyse the importance of β parameter in the excitation of sausage modes by global energy depositions in three coronal loop configurations:

	Cases		
	Reference	Case I	Case II
T [MK]	3.1	4.3	4.1
B [G]	51	45	58
β	0.4	0.7	0.4
Energy [10^{27} erg]	1.5	1.5	37

Table 1:Temperature, magnetic field, β parameter and energy values for the different cases.

Then, we compare the relative importance between the fast and the slow components, performing the rate between the fast and slow FT intensities for the density variable:

	Cases		
	Reference	Case I	Case II
Rate	2.7	2.2	5.0

Table 2:Rate between the fast FT intensity and the slow FT intensity for the density variable.

Given global energy deposition, we note that:

1. If the deposited energy is the same, but the parameter β is larger, the fast signal increases by almost the same amount as the slow one.
2. If the parameter β is the same, but the energy deposited is larger, there is a substantial increase of the fast signal over the increase of the slow one.

Conclusion

We found that a global energy deposition in a loop triggers slow and fast frequency coupled oscillations, but where fast mode dominates, that is, this type of deposition is able of producing **a sausage mode**. **This suggests that the rarity of this type of mode is due to the requirement that the heat conduction effect should be the dominant one, according to the active region loops (hot and short)**.

References

[1] V. M. Nakariakov, V. F. Melnikov, and V. E. Reznikova. Global sausage modes of coronal loops. , 412:L7–L10, December 2003.

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