erc PROMINENT

NUMERICAL SIMULATIONS OF PROMINENCE OSCILLATIONS EXCITED BY AN ERUPTION

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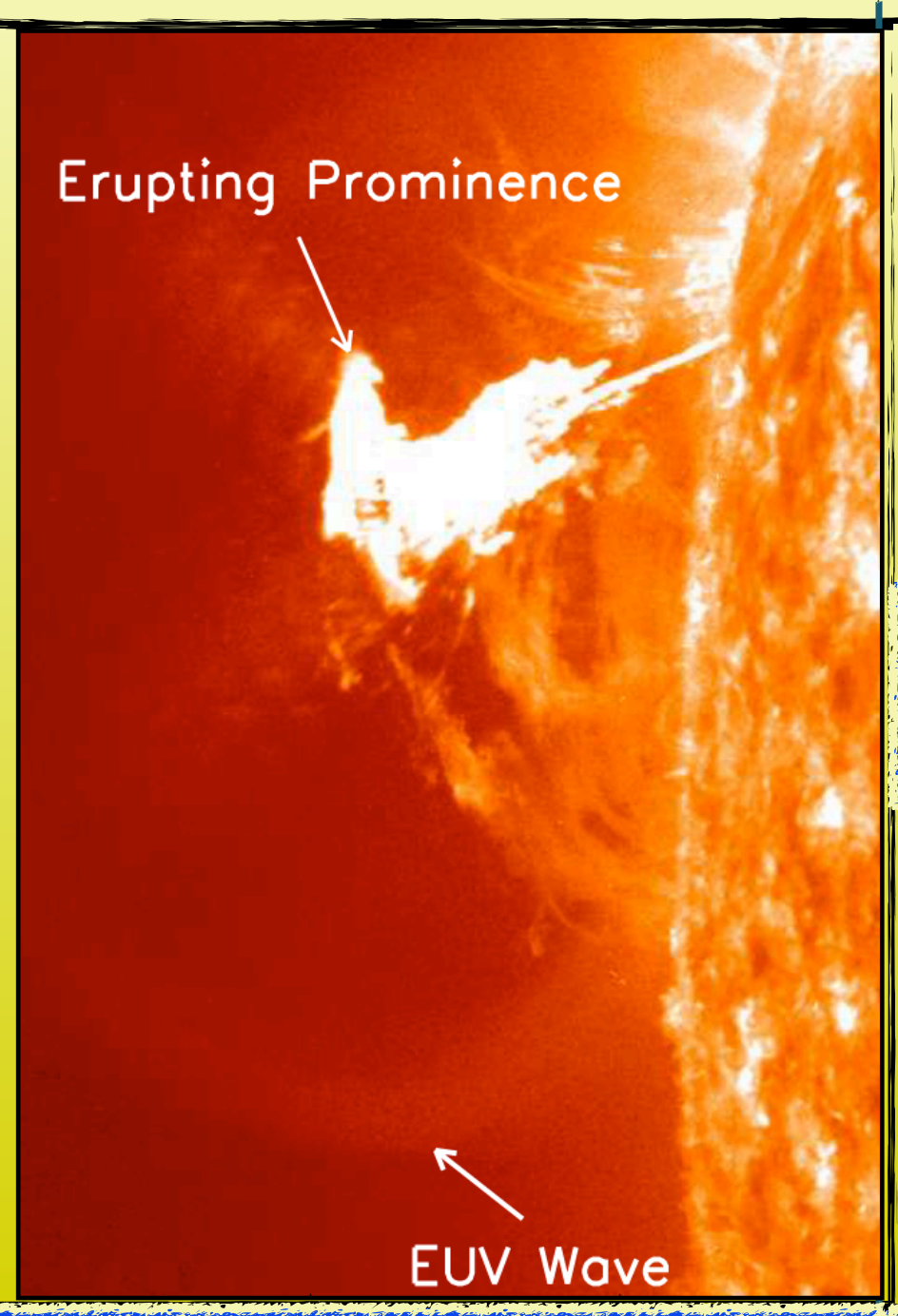
Introduction

- Prominences are clouds of cold and dense plasma suspended in the solar corona.
- Temperature 10000 *K* and density around10^{-10} *kg* m^{-3}.

- EUV waves are energetic waves produced by eruptions.
- Two components: fast magneto-acoustic shock wave with velocities 400-800 *km* s^{-1} (coronal Moreton or fast EUV wave) and non-wave phenomenon 100-300 *km* s^{-1} (EIT wave).



Chandra, Chen, Devi et al. 2021

Motivation

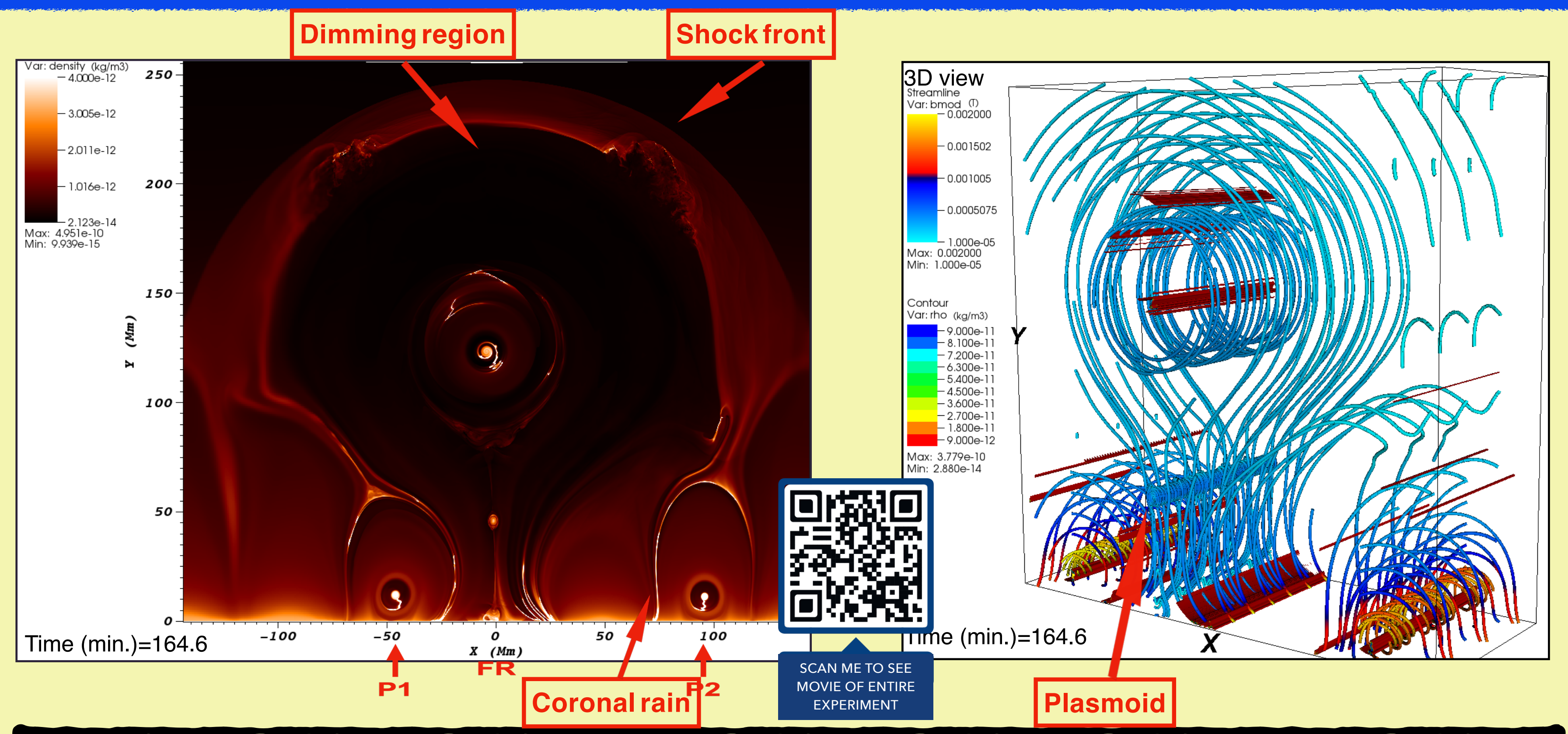
- Atmospheric Imaging Assembly (AIA) observations showed that an extreme ultraviolet (EUV) wave event, which was associated with the prominence eruption, triggered the oscillations of the nearby and distant prominences.

Devi, Chandra, Joshi et al. (2022)

Aims

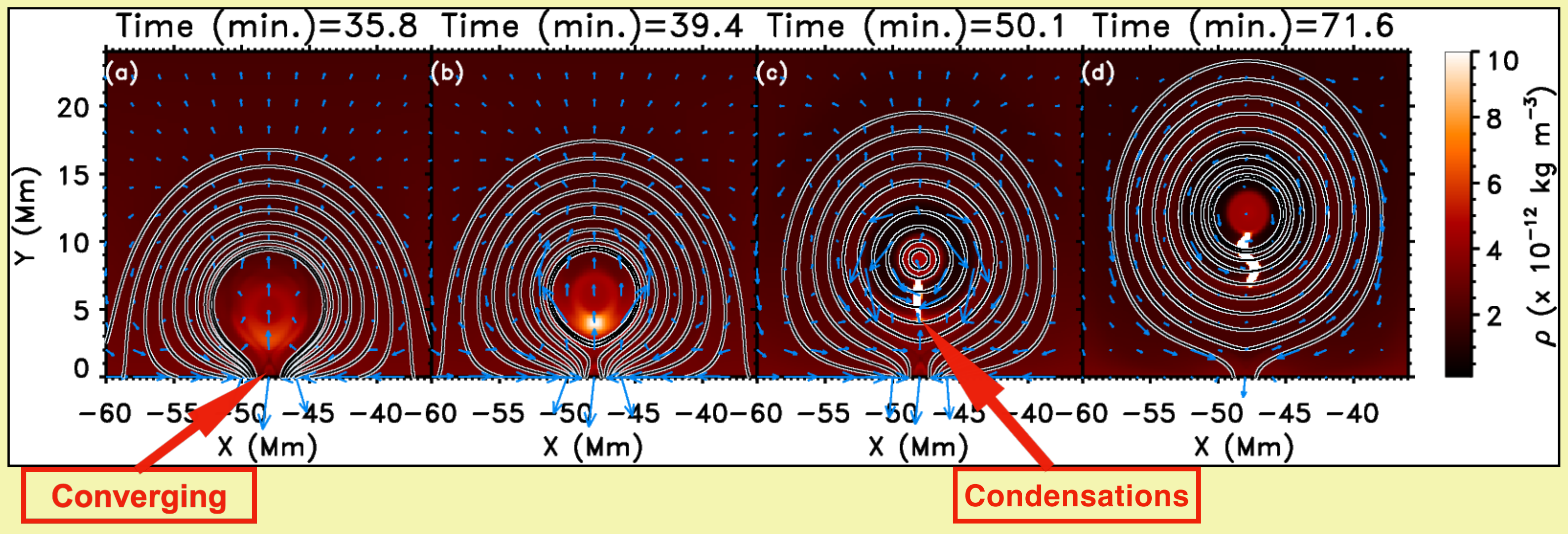
- To study the triggering mechanism of prominence oscillations by the eruptive event using the 2.5D numerical experiment.
- To investigate the effects of radiative cooling, background heating, and thermal conduction on the evolution of prominences and eruption.

Methods



SCAN ME TO SEE MOVIE OF ENTIRE EXPERIMENT

- 2.5D numerical simulations with the MHD code **MPI-AMRVAC**.
- The initial atmosphere is the gravitationally stratified solar corona permeated by the periodic sheared arcade magnetic field structure. The magnetic field strength at the bottom is 20 *G*.
- Full vertical extension of the numerical domain 480 *Mm*. Adaptive mesh refinement (AMR) is used with the maximum refinement level 31*km*.
- Two prominences are differently located with respect to the eruptive event (P1 at -48 *Mm* and P2 at 96 *Mm*).

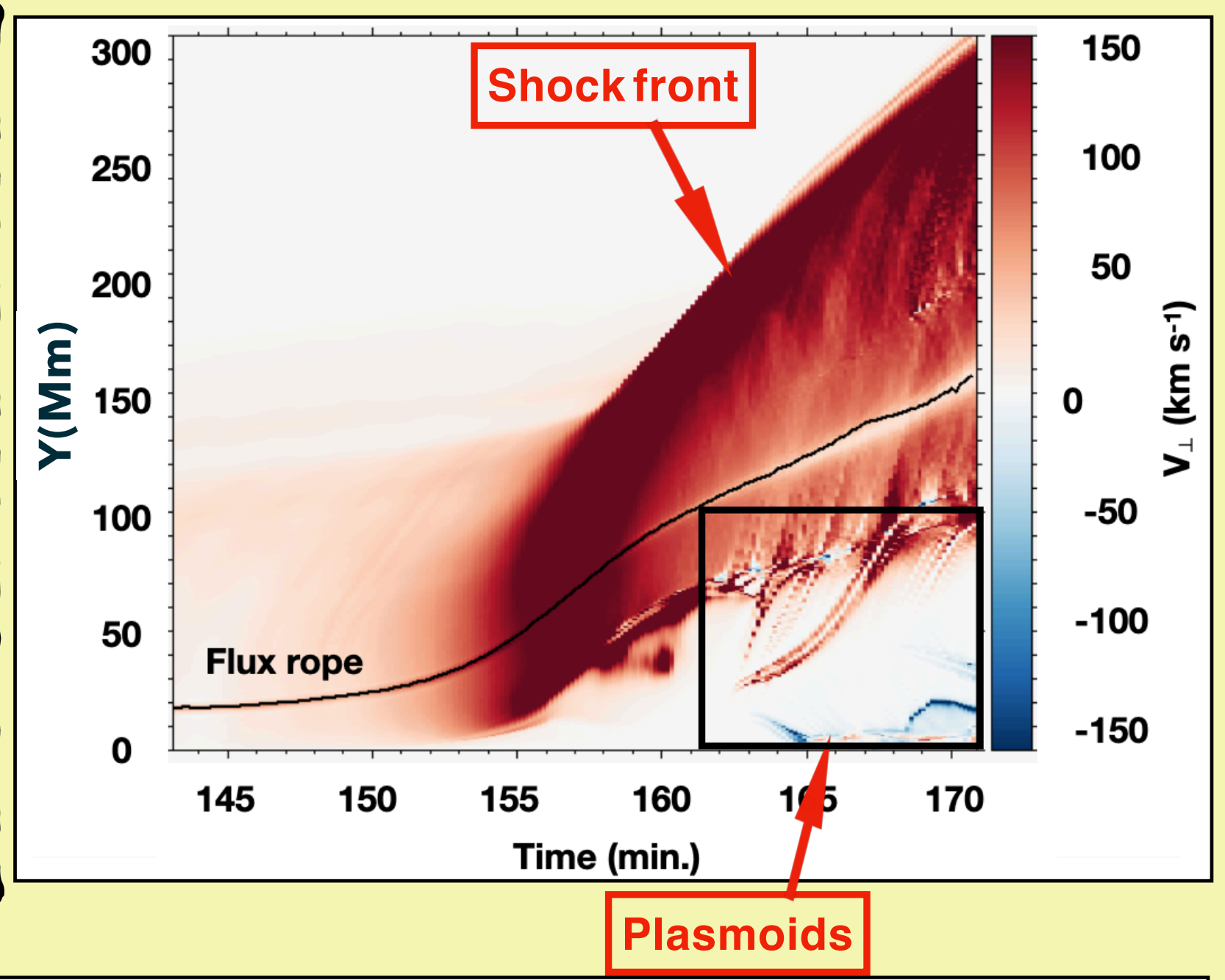


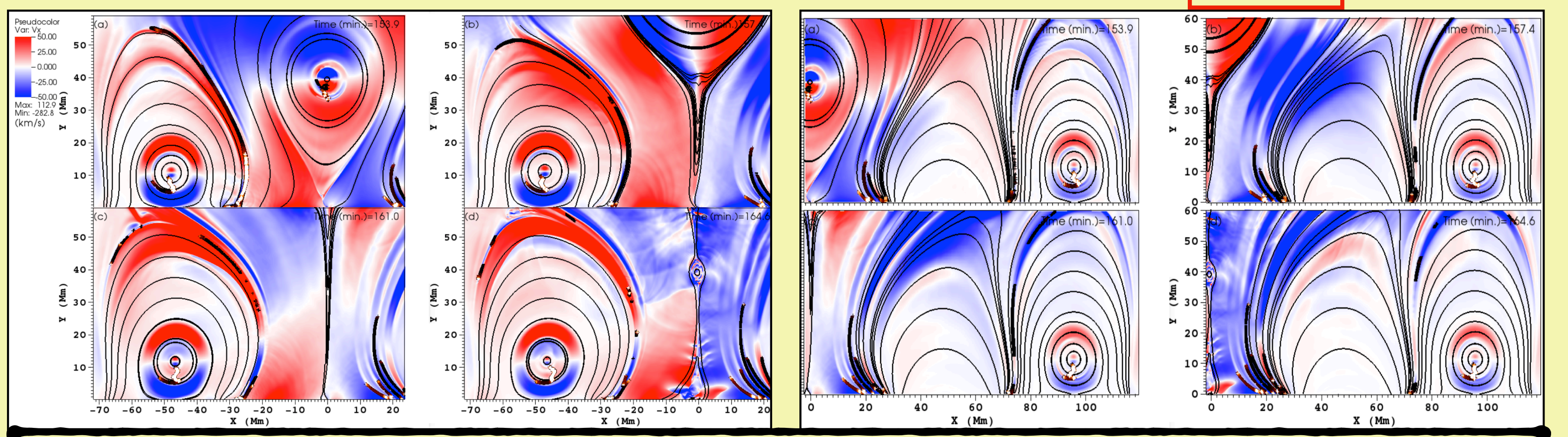
- The prominence-hosting flux ropes are formed using the converging footpoint motions, *Vx* = 12 *km* s^{-1}.
- In-situ prominences formation is based on the levitation-condensation model: Kaneko & Yokoyama, 2015; Jenkins & Keppens, 2021; Brughmans, Jenkins, Keppens (under review). Initially, background heating and radiative losses are compensated. The magnetic flux ropes lift the plasma from the bottom (i.e., denser) layers. Condensations occur in the dipped regions at 50 minutes due to thermal instability (***panel c***). The prominences slightly oscillate around the bottom of the magnetic dips after the condensation formation (***panel d***).
- The flux ropes and prominences formation phase is finished at 66.7 minutes. Both prominences have identical evolution before the eruption formation.
- The eruptive flux rope (EFR) is formed with the converging footpoints motions from 66.7 minutes.
- During the eruption formation, condensations occur in the overlying magnetic arcades. These condensations drain along the magnetic field as coronal rain.

Results

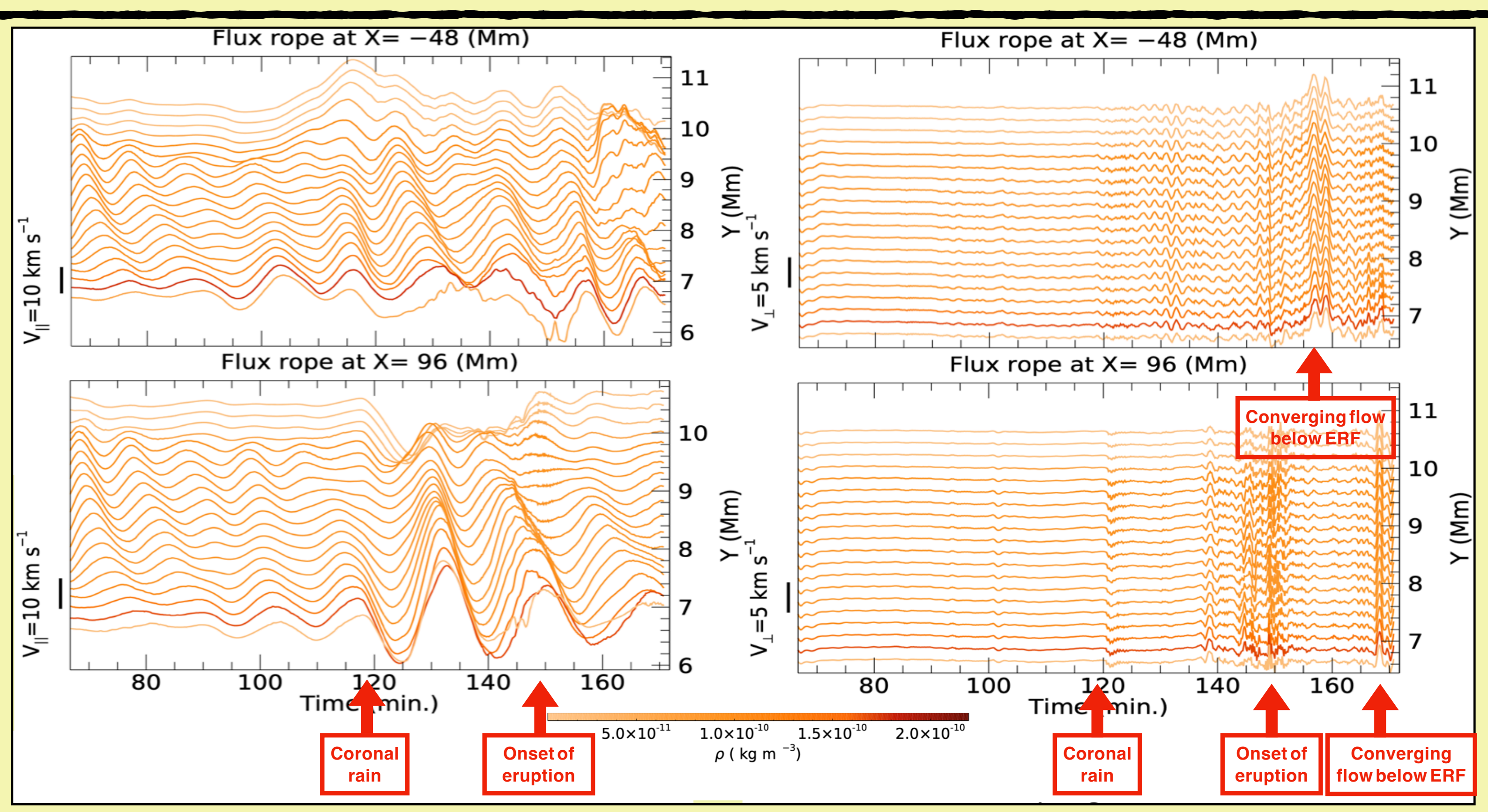
- Flux rope becomes unstable at 148 minutes. EFR propagates with a certain inclination with respect to the vertical axis. This asymmetry results in the rotational plasma motions around the EFR core.

- When EFR is accelerated, a shock front also forms. This is followed by the region of the increased density and dimming region.
- Below EFR, the elongated current sheet forms and becomes fragmented at 162 minutes. Plasmoids move downward and upward.
- Condensations also occur inside the EFR and show the rotational motions.





- The interaction of EFR with the nearby prominence. ***Panel a***: P1 inclined to the left due to the shock front; ***panels b,c***: P1 inclined to the right due to the converging flows below EFR; ***panel d***: the perturbations due to the plasmoids instability.
- The interaction of EFR with the distant prominence. ***Panel a***: the shock front interacts with the nearby magnetic arcades, strongly pushing them to the right; ***panel b***: the shock front interacts with the magnetic arcades overlying P2; ***panel c***: the converging perturbation below EFR also reaches P2; ***panel d***: the perturbations due to the plasmoids instability seem to be unable to affect the distant prominence.



Summary

- Both prominences are affected by the condensations that form due to the thermal instability in the overlying magnetic arcades. These condensations drain to the bottom of the numerical domain along the magnetic field as coronal rain and trigger the large-amplitude longitudinal oscillations in both prominences.
- The eruption produces the shock wave, which propagates in the solar corona affecting the magnetic environment around EFR.
- The prominence in the vicinity of the eruption is mainly affected by the developing shock wave and strong converging motions in the direction of the current sheet below the rising flux rope. These trigger the small-amplitude transverse oscillations.
- The distant prominence is only slightly affected by the shock wave. The converging flow below the rising flux rope plays a more important role, producing the perturbation of the transverse velocity 5 *km* s^{-1}.

References

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