AS-16P

Morphological evolution of solar prominences due to interchange instability in helical flux rope

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Introduction

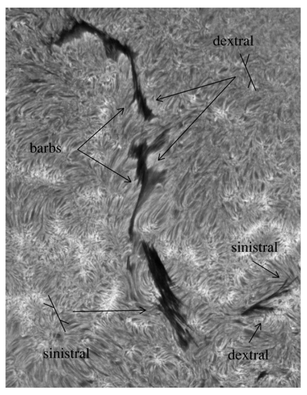


Fig.1 Example of solar filament (Hα; Parenti 2014)

Solar filaments (prominences) are often split into multiple separate parts.

It would be related to the photospheric or coronal magnetic structures hosting filaments, but the mechanism is unclear.

Aim of this study

To reveal the mechanism of splitting prominences

Numerical setups

Basic eqs.
MHD + gravity + heat conduction + radiative cooling

Numerical schemes
[MHD] 4-step Runge-Kutta + 4th-order CFD + artificial viscosity
[conduction] STS + 2nd –order CFD + slope limiter

Initial condition
Stratified at uniform $T = 2\times10^6$ K. Number density $n = 10^9$ cm^{-3}
linear force-free arcade field: B = 6 G at footpoint

■ Process to form a flux rope

Flux rope formed due to reconnection between the arcade field and opposite-polarity emerging flux at the PIL as depicted in Fig.2.

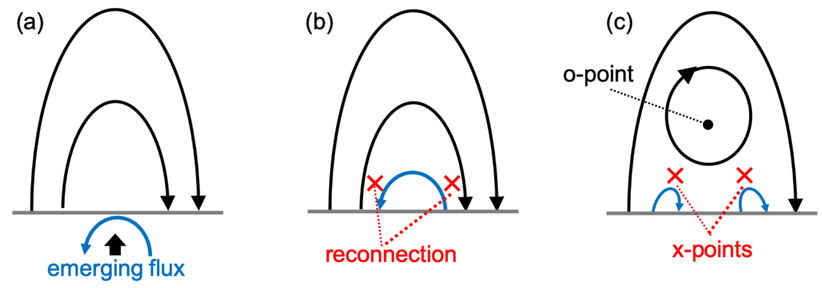
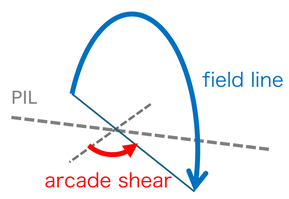


Fig.2 Schematics of the process to form a flux rope

Results

■ Parameter Survey

	case 1	case 2	case 3	case 4
Arcade shear[1]	59.4°	59.4°	75.2°	75.2°
Emergence duration[2]	16 min	24 min	12 min	24 min
Eruption	**NO**	**YES**	**NO**	**YES**



case 1 (Typical case)

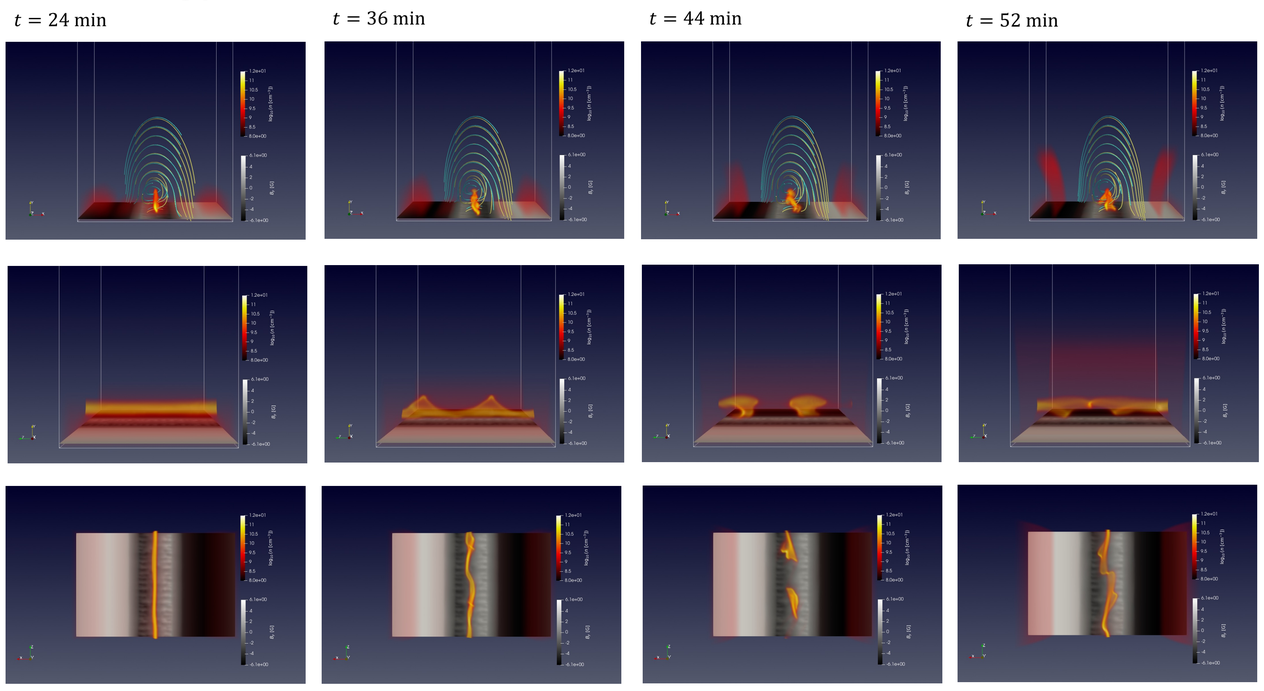


Fig. 3: Temporal evolution of prominence in case1. Orange color represents the high-density region corresponding to prominence. Different rows correspond to different view angles.

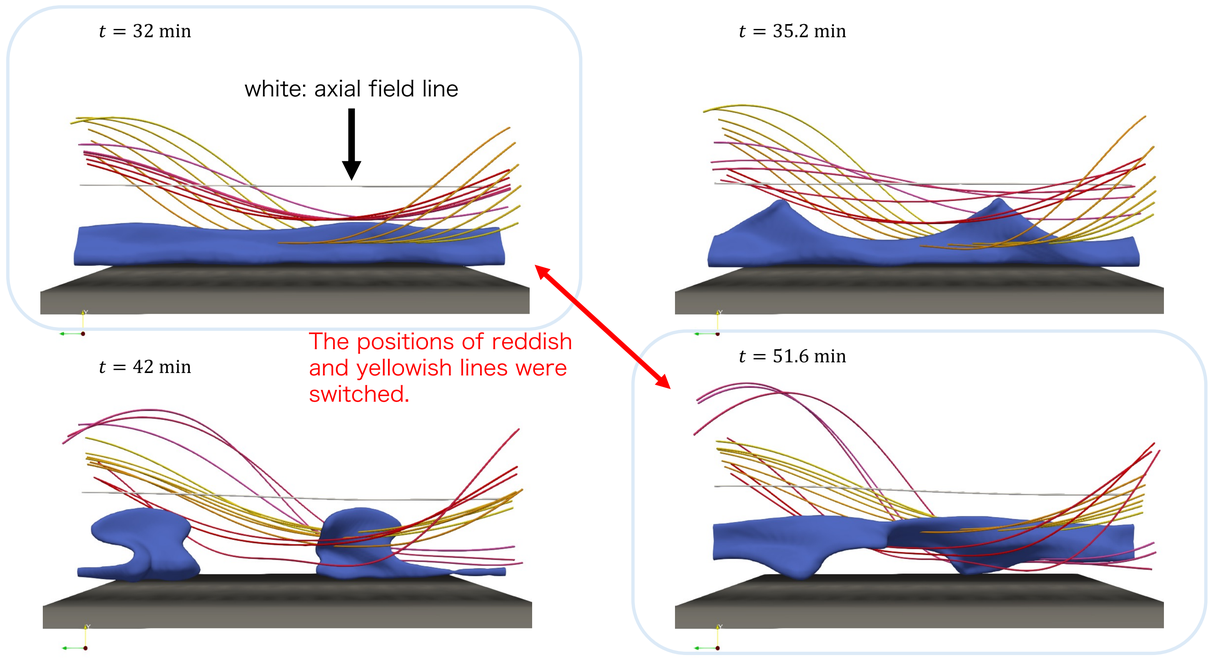


Fig. 4: Lines: magnetic field lines. Blue color: isocontour at T=0.3 MK. The identical field lines were tracked over time. The same color represents the same field lines. At $t = 32$ min, reddish field lines were close to the flux rope axis, whereas yellowish field lines were apart. At $t = 51.6$ min, the positions of reddish and yellowish lines were replaced, indicating interchange instability.

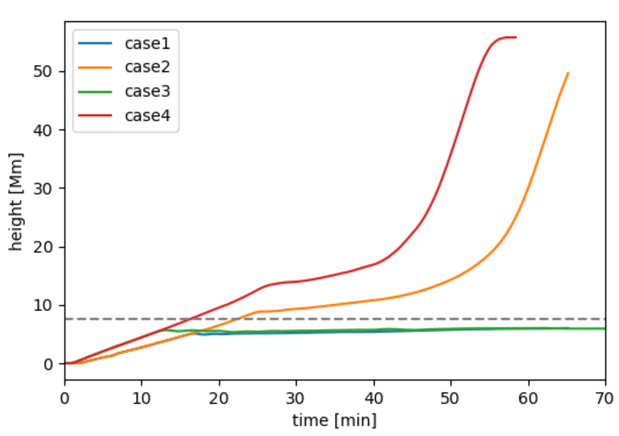


Fig. 8 Temporal evolution of axial height of the flux ropes. The flux ropes in cases 2 and 4 erupted after exceeding the critical height of torus instability.

case 2 (larger emerging flux)

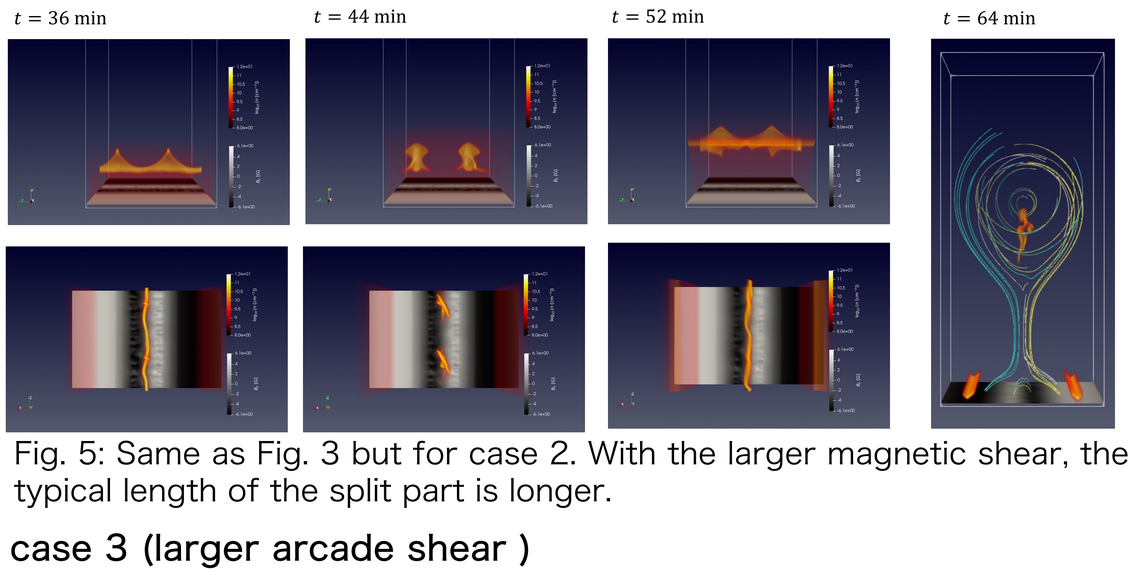


Fig. 5: Same as Fig. 3 but for case 2. With the larger magnetic shear, the typical length of the split part is longer.

case 3 (larger arcade shear)

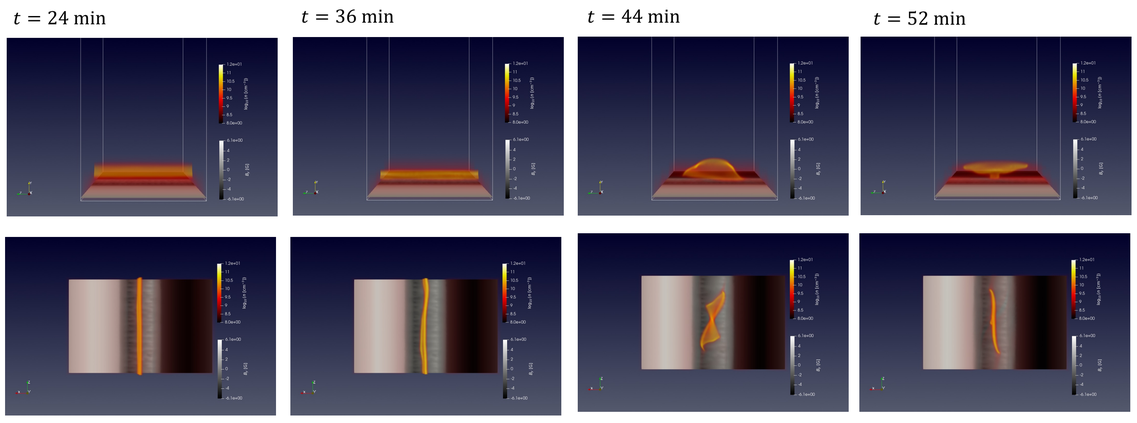


Fig. 6: Same as Fig. 3 but for case 3. With the larger magnetic shear, the typical length of the split part is longer.

case 4 (larger arcade shear & larger emerging flux)

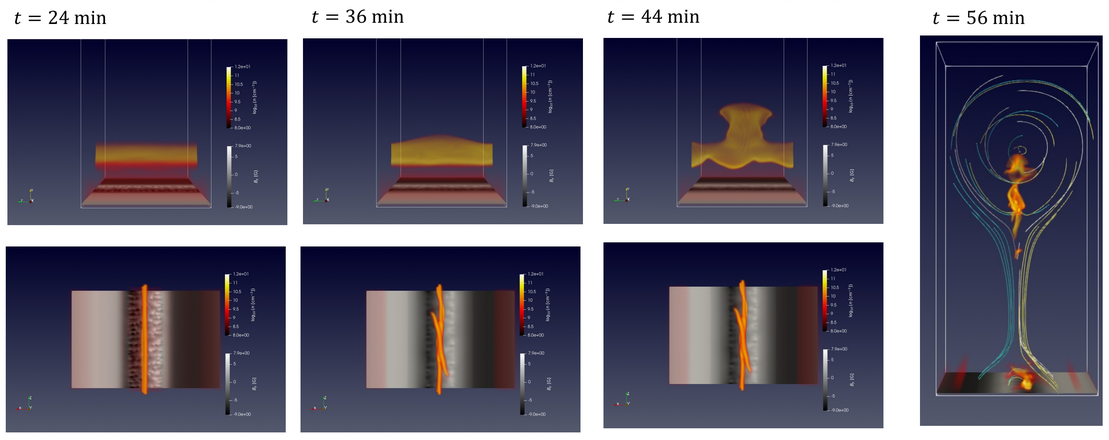


Fig. 7: Same as Fig. 3 but for case 3. With the larger magnetic shear, the typical length of the split part is longer.

Summary & Discussion

In our MHD simulations, the prominences were once split into multiple parts. Later, the split parts were merged to reconstruct a single thread again. We found that the interchange instability grew inside the helical flux rope. The splitting and merging of prominence were associated with the interchange instability. Our results suggest that the prominences' morphological evolution can be caused by interchange instability of the coronal magnetic flux rope.