# Solar jets: SDO and IRIS observations in the perspective of new MHD simulations

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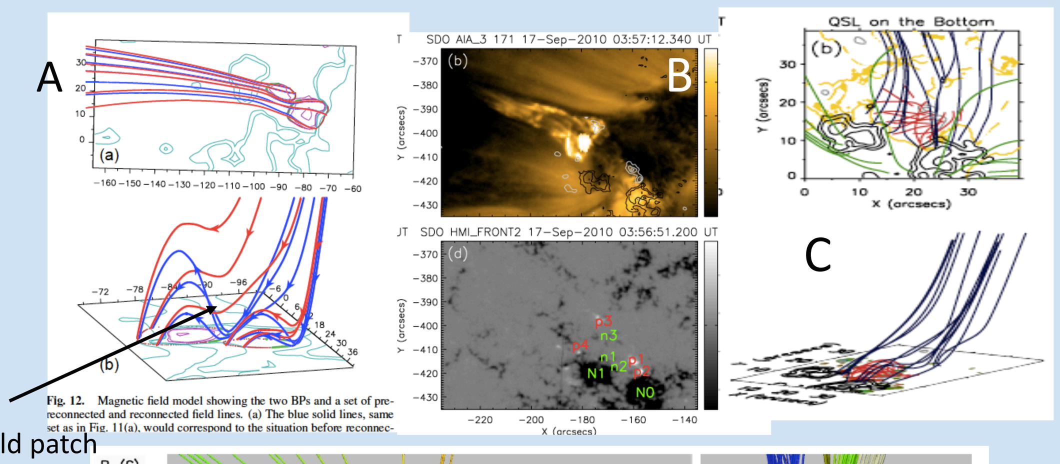
## Objective

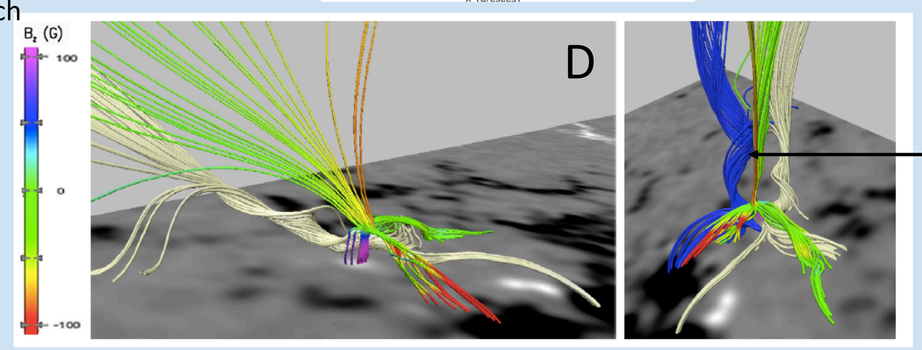
In the last decade coordinated observations of the Interface Region Imaging Spectrograph (IRIS) with the instruments on board the Solar Dynamic Observatory (SDO) allow to make a step forward for understanding the trigger of jets and the relationship between hot jets and cool surges. We observe at the same time the development of 2D and 3D MHD numerical simulations to interpret the results.

We review a few jet studies based on IRIS spectra and SDO observations and show that with the same observations, different theoretical interpretations are possible based on different approaches, e.g. non-linear force-free field extrapolation, 3D MHD data driven simulations.

## INTRODUCTION

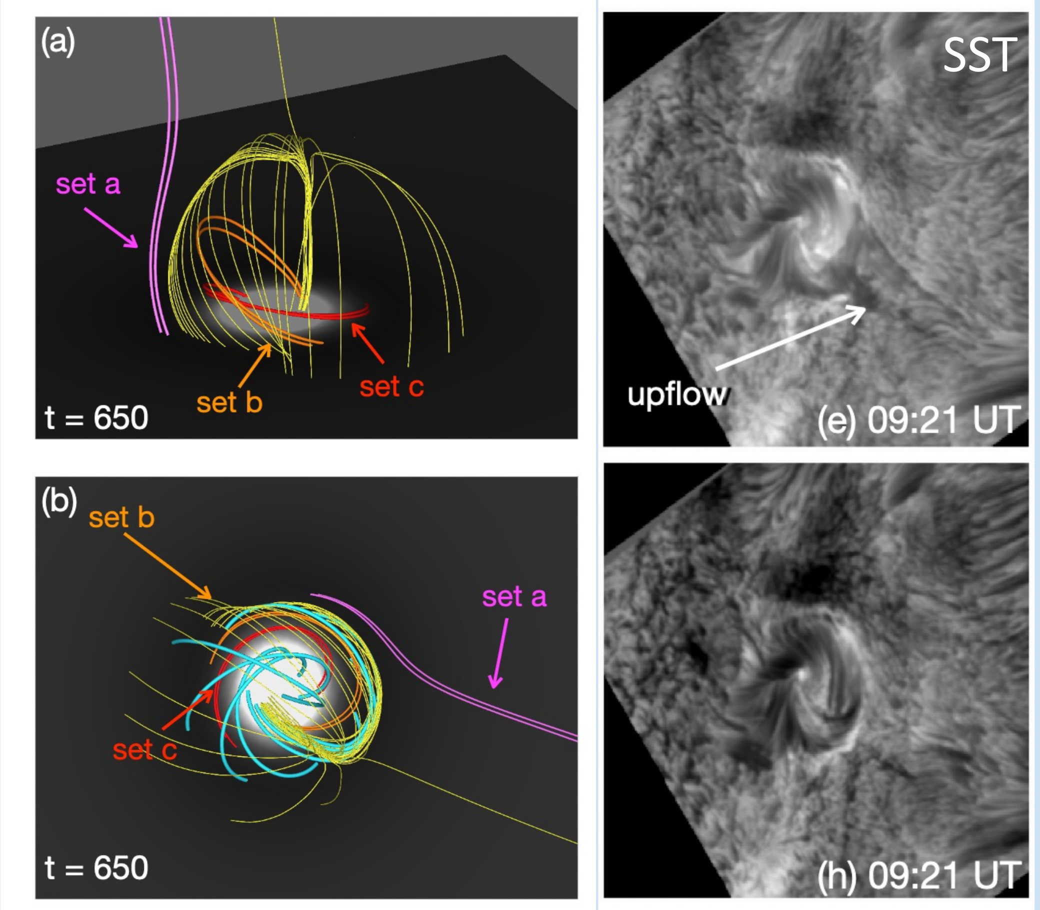
**I. Role of the magnetic configuration : bald patch or null point Cancellation and emerging flux**



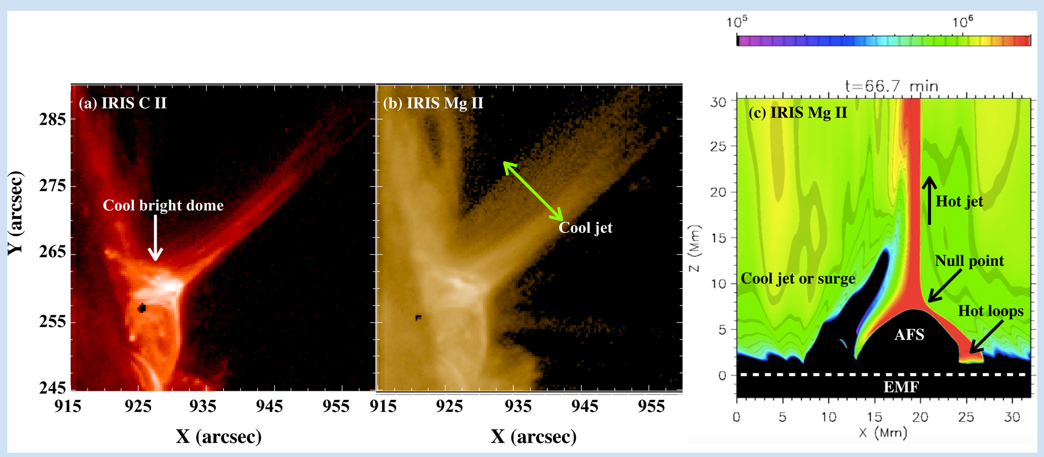

*Magnetic reconnection initiating solar jets in bald patch (BP) and in null point. from NLFF extrapolated magnetic field lines and electric currents [from Guo et al. (2013)].*
*(D) NLFF extrapolated magnetic field showing bald patch and null point [from Schmieder et al. (2013)].*

**2. 3D MHD model:** Two distinct flux systems: a circular patch of strong closed magnetic flux surrounded by weaker open flux.




MHD jet Model based on Pariat 2015 (Joshi et al 2024)

**3. 3D MHD model of emerging flux for hot jet and cool surge**




With IRIS observations, it was demonstrated that cool and hot jets are present simultaneously (Joshi et al 2020a). *IRIS jet observed in C II on April 4, 2017, showing a bright dome signature of emerging flux with a null point.*

The emerging flux models of Nobrega et al 2016 explains that the chromosphere is raising arround the hot jet creating a surge.

Reference: Schmieder B. 2022 Frontiers

## IRIS spectra- HMI Jz

On 22 March 2019: a case –study of a twisted jet:
- where comes the twist?
- what is the magnetic configuration of the jet ?
Is there a null point or bald patches?

## Observations

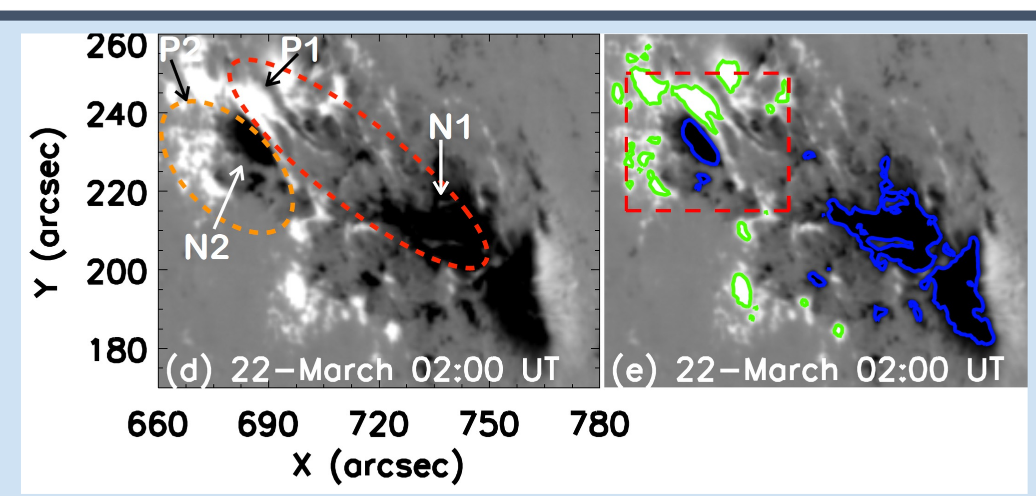



*Fig. 1; HMI longitudinal magnetograms of AR NOAA 12736 showing the evolution of the magnetic polarities. The jet reconnection is occurring between the two large emerging flux areas EMF1 (P1, N1) and EMF2 (P2, N2) encompassed in the two ovals. The emergence of the EMFs is materialized by the extension of the two ovals between these two times. The blue and green contours are for negative, and positive magnetic field polarities with label 300 Gauss (Joshi et al 2020b).*

**Jet spectra: Mg II, CII, Si IV**

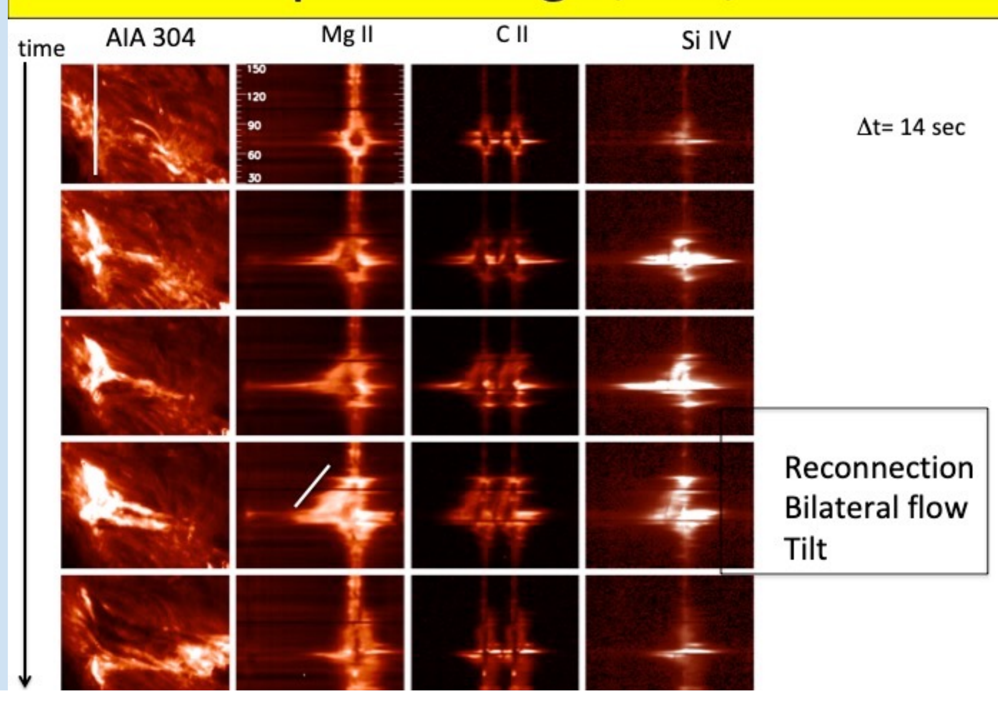



*Fig 2. Jet reconnection base (UV burst or mini-flare) and jet evolution between 01:57 UT to 02:09UT (left: AIA 304 Å, middle and right: IRIS spectra). The inclined white line indicates the twist at the jet base.*

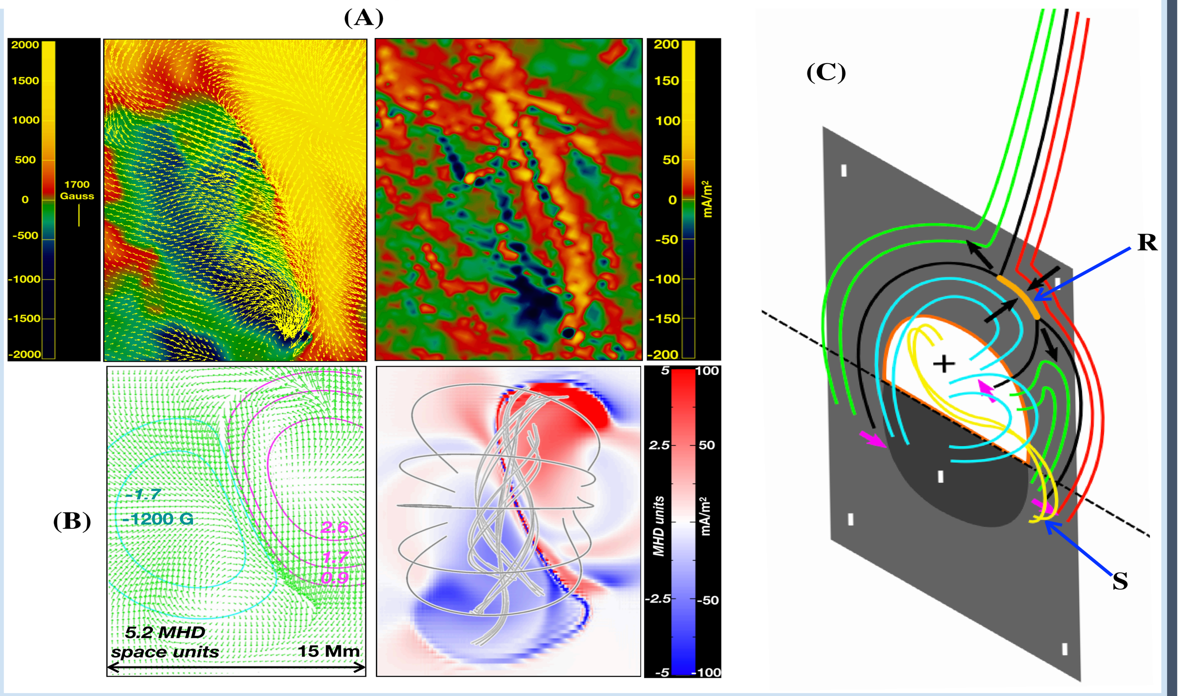


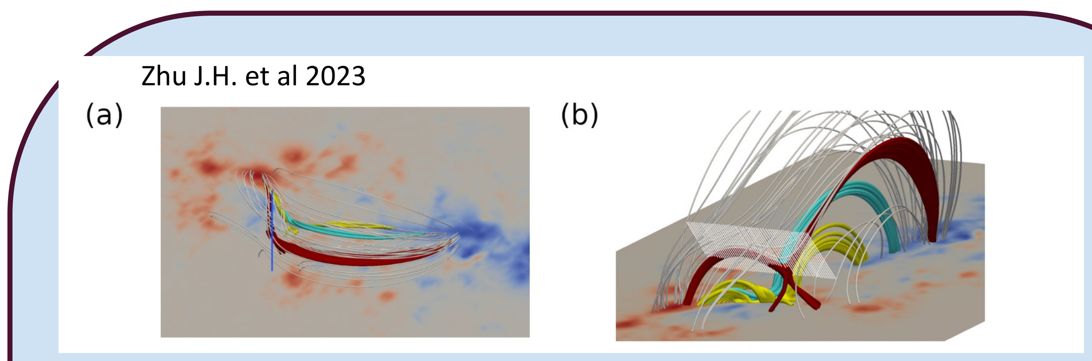

*Fig 3: Large flux rope detected in the HMI magnetic vector map computed with UNNOFIT code (Bommier, 2016) in the field of view of the red box in Fig 1 e.*
*(A) Magnetic field Bz overlaid by arrows of the horizontal magnetic field (the yellow (dark) blue areas show the positive (negative) magnetic field polarity) and electric current density map Jz.*
*(B) Comparison with the OHMMHD simulation of a flux rope. The vector pattern of observations and model looks the same as they are strongly nearly parallel to the PIL and converging together in the bottom part to the site of reconnection S.*
*(C) Schematic view of magnetic field lines in the jet bald patch MHD simulation; in yellow is drawn the flux rope with a sigmoid shape [adapted from Wyper et al. (2019)]. The reconnection is at R in the study of Wyper et al. (2019) but, a reconnection at S will be a better fit to the Joshi et al. (2020b) observations*

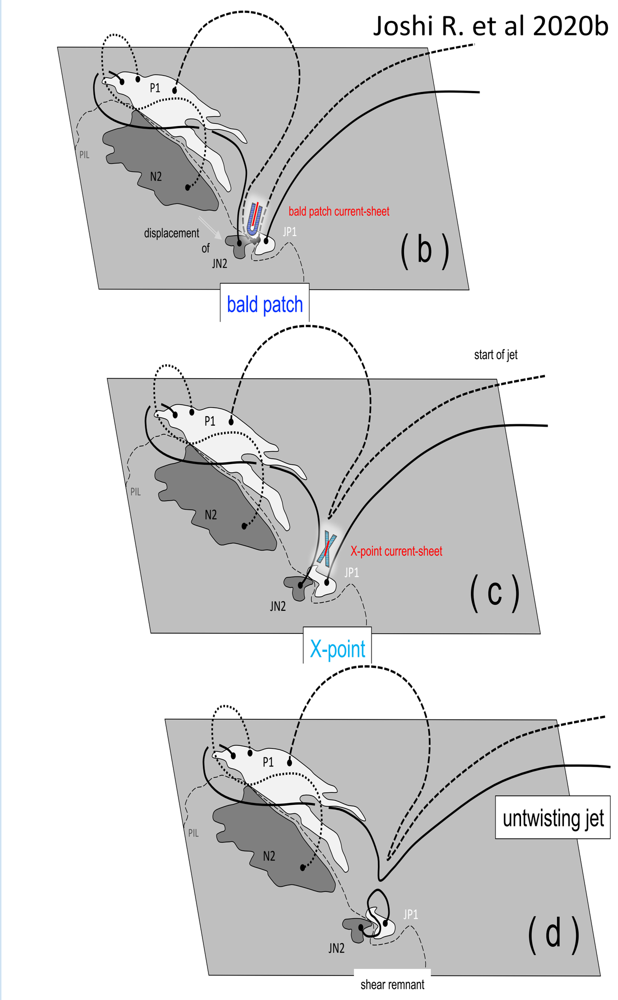
Reference: Joshi Reetika, Schmieder, Aulanier, Bommier, Chandra, 2020b A&A, 642, A169

## Results

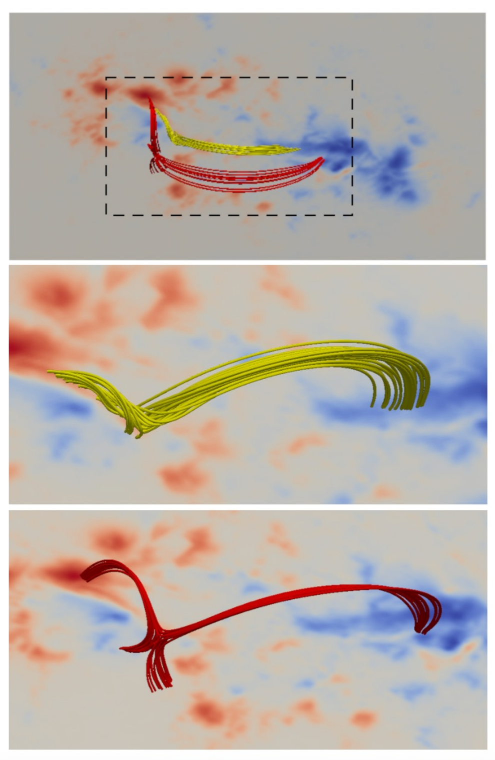
On 22 March 2019. from a data driven model
- the twist comes from the twisted filament
- Both the bald patch and the null point exist.

## Data-driven model



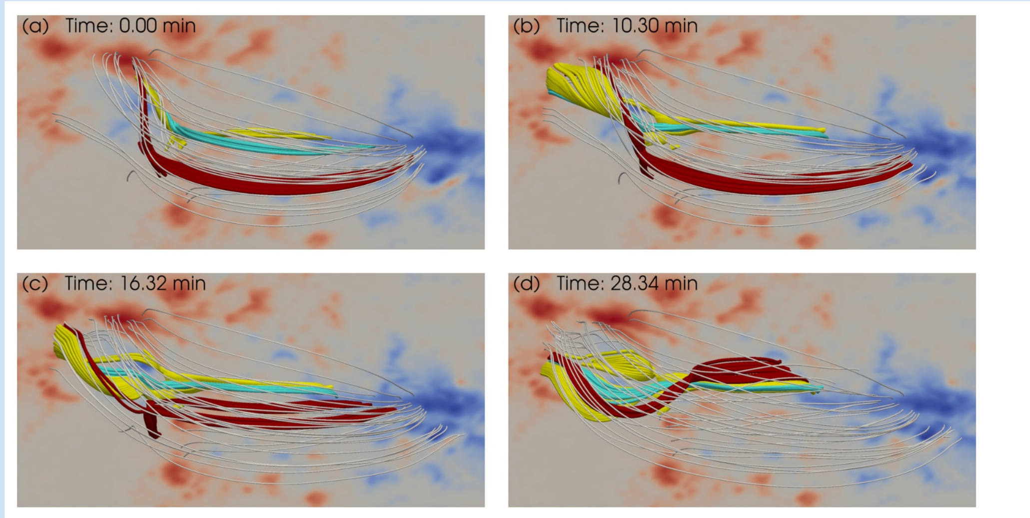

NLFF Extrapolation



*Left: Sketch of the formation of the jet and transfer of the twist from the flux rope to the jet during reconnection in the bipole P1 and N2 (see Fig1)*
*(b) magnetic configuration before the reconnection, and formation of the Bald patch current sheet,*
*( c) X-point current sheet,*
*(d) the untwisting jet after the reconnection*

*Right: Sample magnetic field lines in the NLFFF model showing different magnetic structures. The background shows the vertical magnetic field Bz. The rectangle region contains the two main structures founded and is zoomed in (b) and (c) with a different view. (b) A flux rope structure colored by yellow field lines lying above a bald patch near the photosphere in the north region. (c) A null point structure in the X-shaped current sheet colored by red field lines in the south region.*

**Numerical MHD SIMULATION**




*Magnetic field evolution in the zero-β simulation. (a)–(d) Four typical moments of the simulation. Red field lines represent the null point structure and the reconnection site. Cyan and yellow field lines depict the flux rope structure and gray ones represent the ambient field lines. The flux rope in the north region slowly moves southwards, rotates counterclockwise and interacts with the field lines connected to the null point. The reconnection outflow and flux rope material move along the long spine of null point connected to a remote region at the west side. (d) Magnetic field lines after the rotation of the flux rope and interactions between the flux rope and X-shaped current. The reconnection process ends at this moment*
*Reference: Zhu JiaHao, Guo Yang, Mingde Ding, Schmieder 2023. submitted*

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