Magnetic Reconnection Leading to a Mini-Flare and a Twisted Jet Observed with IRIS

Reetika Joshi[1,2], Brigitte Schmieder[1], Ramesh Chandra[2], Petr Heinzel[3], Guillaume Aulanier[1], Véronique Bommier[1], James Tomin[1], Nicole Vilmer[1]

[1] LESIA, Observatoire de Paris, Université PSL, CNRS, Meudon, France
[2] Department of Physics, DSB Campus, Kumaun University, Nainital, India
[3]Astronomical Institute of the Czech Academy of Sciences,Ondrejov, Czech Republic

Overview : Mini-flare and the jet observed with IRIS

Motivation: to understand how the twist was injected into the jet using the IRIS spectrographic observations.

Observations: Interface Region Imaging Spectrograph (IRIS: spectra and slit jaw images) and Atmospheric Imaging Assembly (AIA)

Highlights: Why is there cool material over hot material in the flare site ? (Multi thermal flare model)
Where comes from the twist in the jet ? (Signature in the spectra : bidirectional flows (tilt), Dynamical model)

Solar Jets

- act as a source for transporting mass and energy from lower solar atmosphere to upper coronal heights.
- can contribute for heating the solar corona and accelerating the solar wind.
- are the key tool to probe the broad dimensions of solar heliospheric problems.

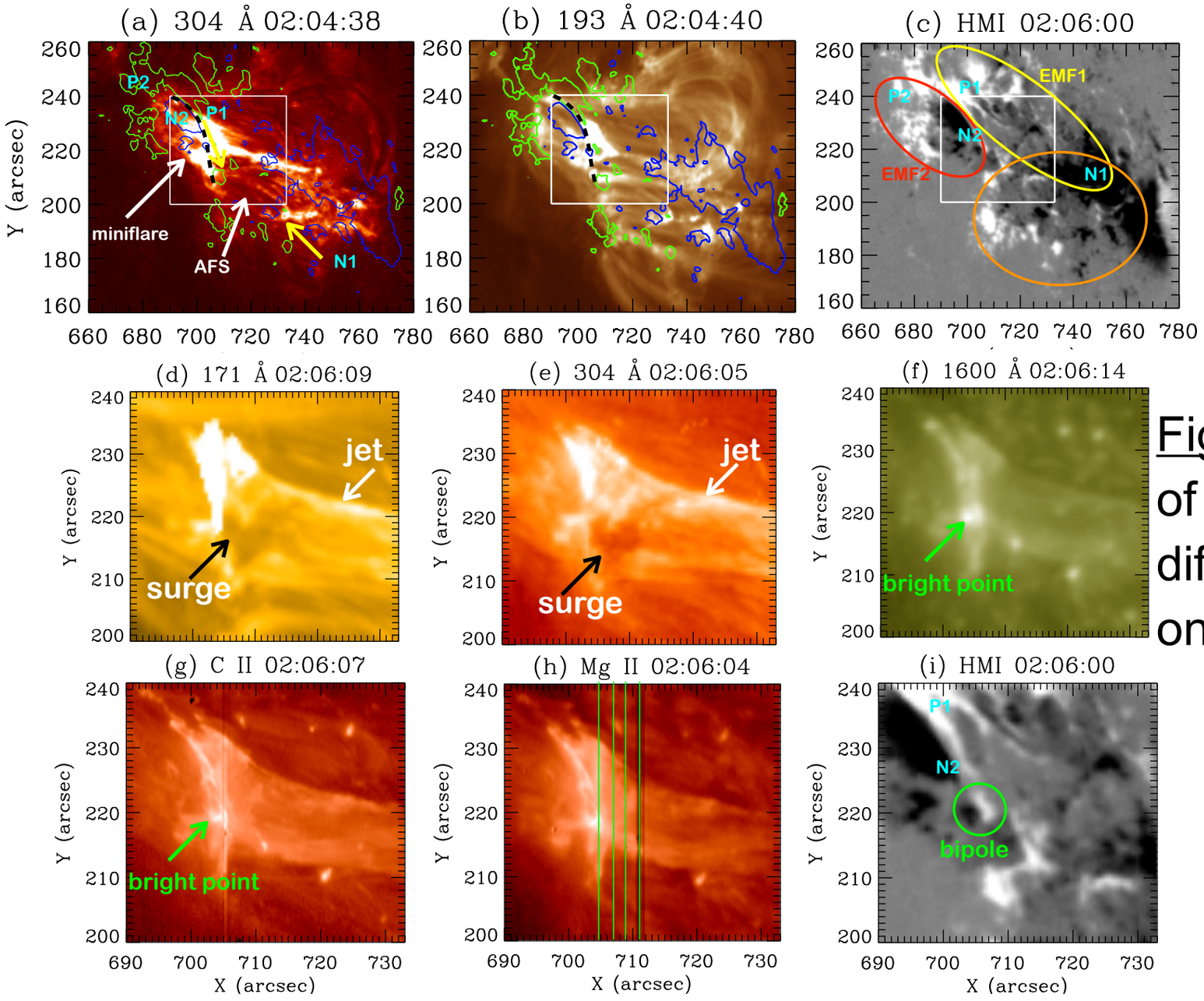

Fig1: Multiwavelength observations of a solar jet and mini-flare in different AIA and IRIS wavebands on March 22, 2019.

Detection of high flows speed : 300 km/s by the cloud model method

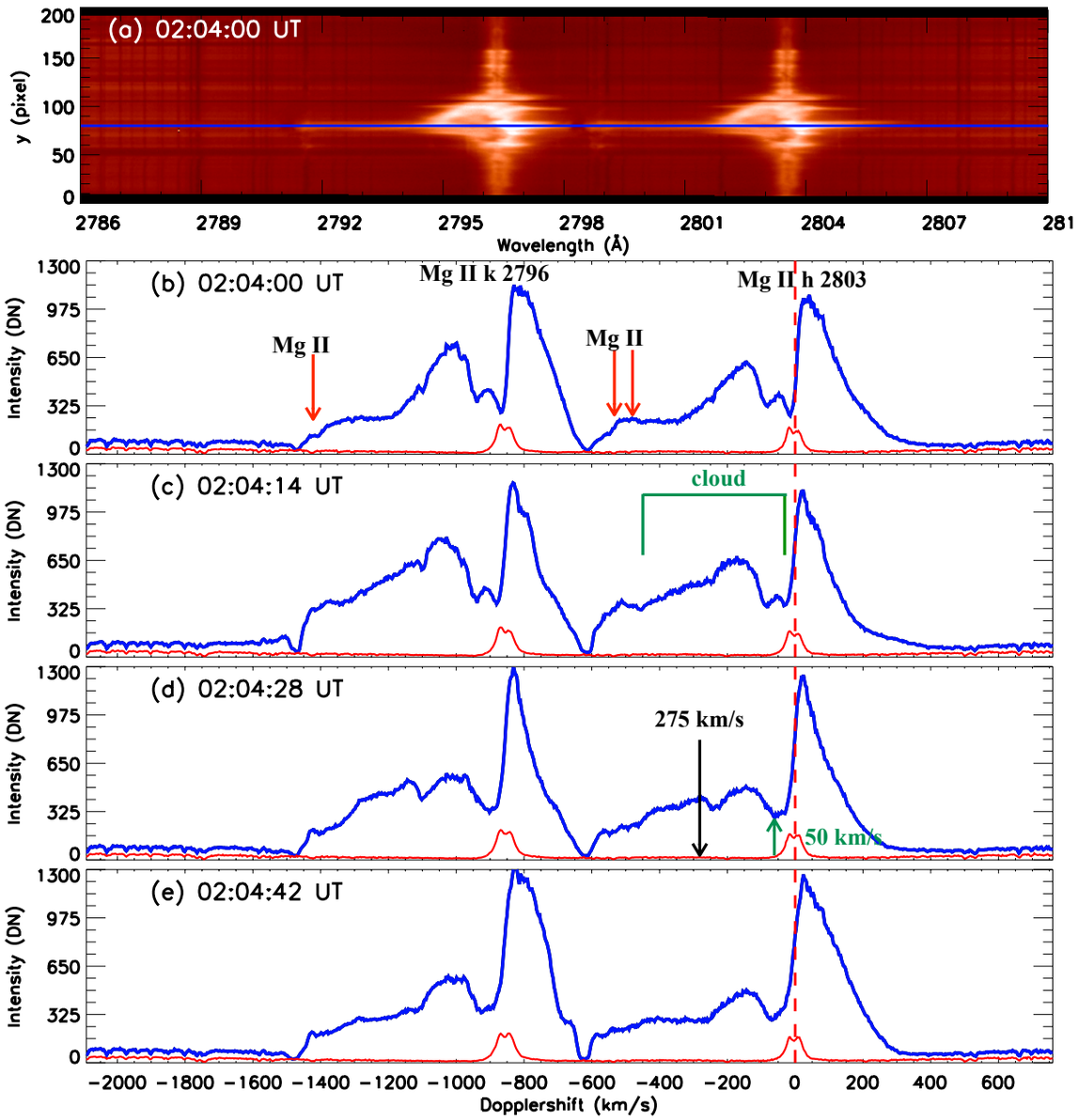

Fig2: Panel a: Mg II spectra before the UV burst. Panels b–e: evolution of the Mg II k and h line profiles.

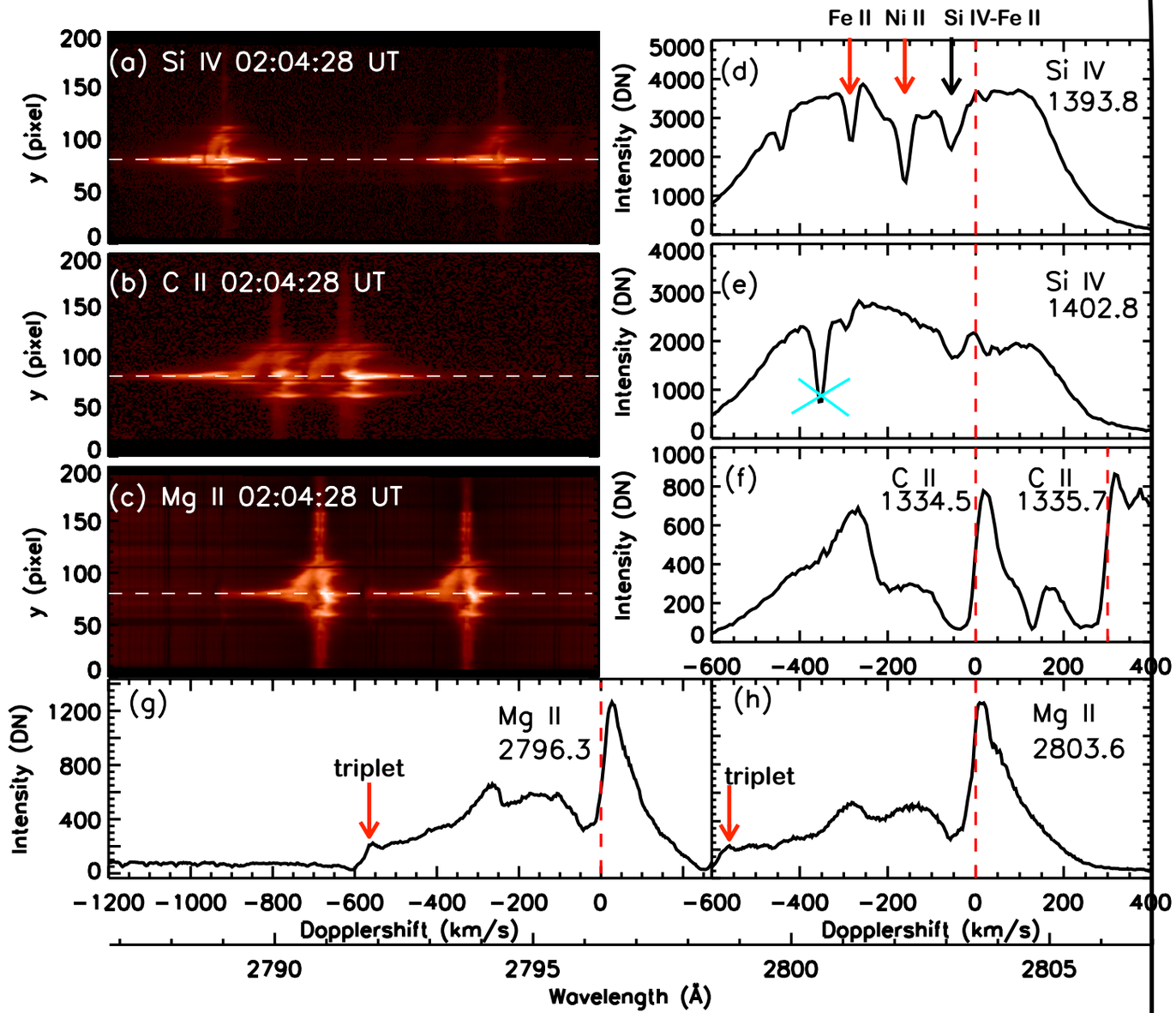

Fig3: Spectra and profiles of the jet base (UV burst) in Si IV, C II, and Mg II lines.

Twisted Flux Rope

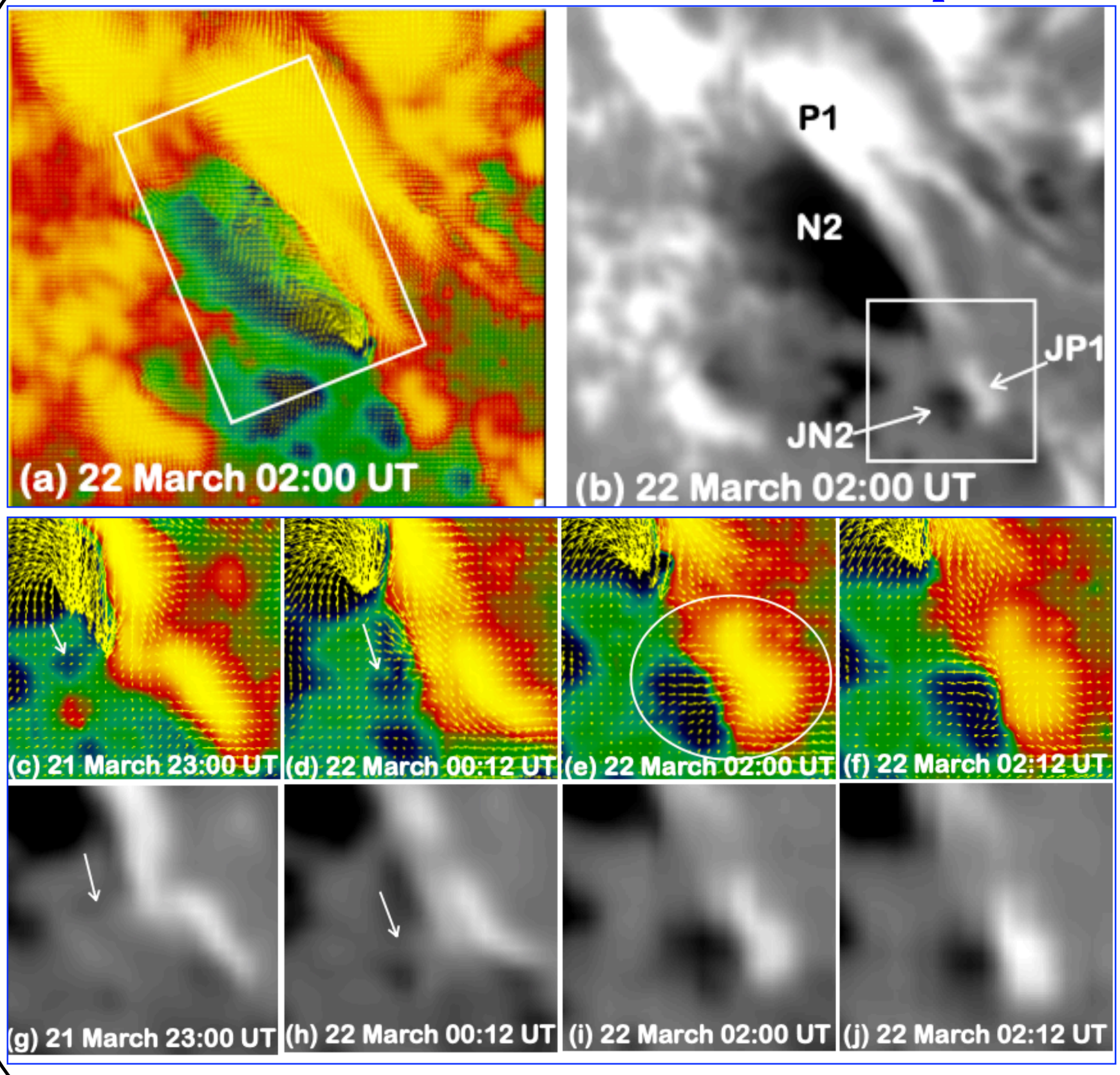

Fig4: Panel (a): Vector magnetic field configuration.

Panel (b): LOS magnetic configuration including the two bipoles P1-N2, JP1-JP2.

Panel (c–e): zoomed view of vector magnetic field configuration.

Panel (f–h): zoom view of LOS magnetic field configuration.

Transfer of Twist: Comparison with Numerical Simulation

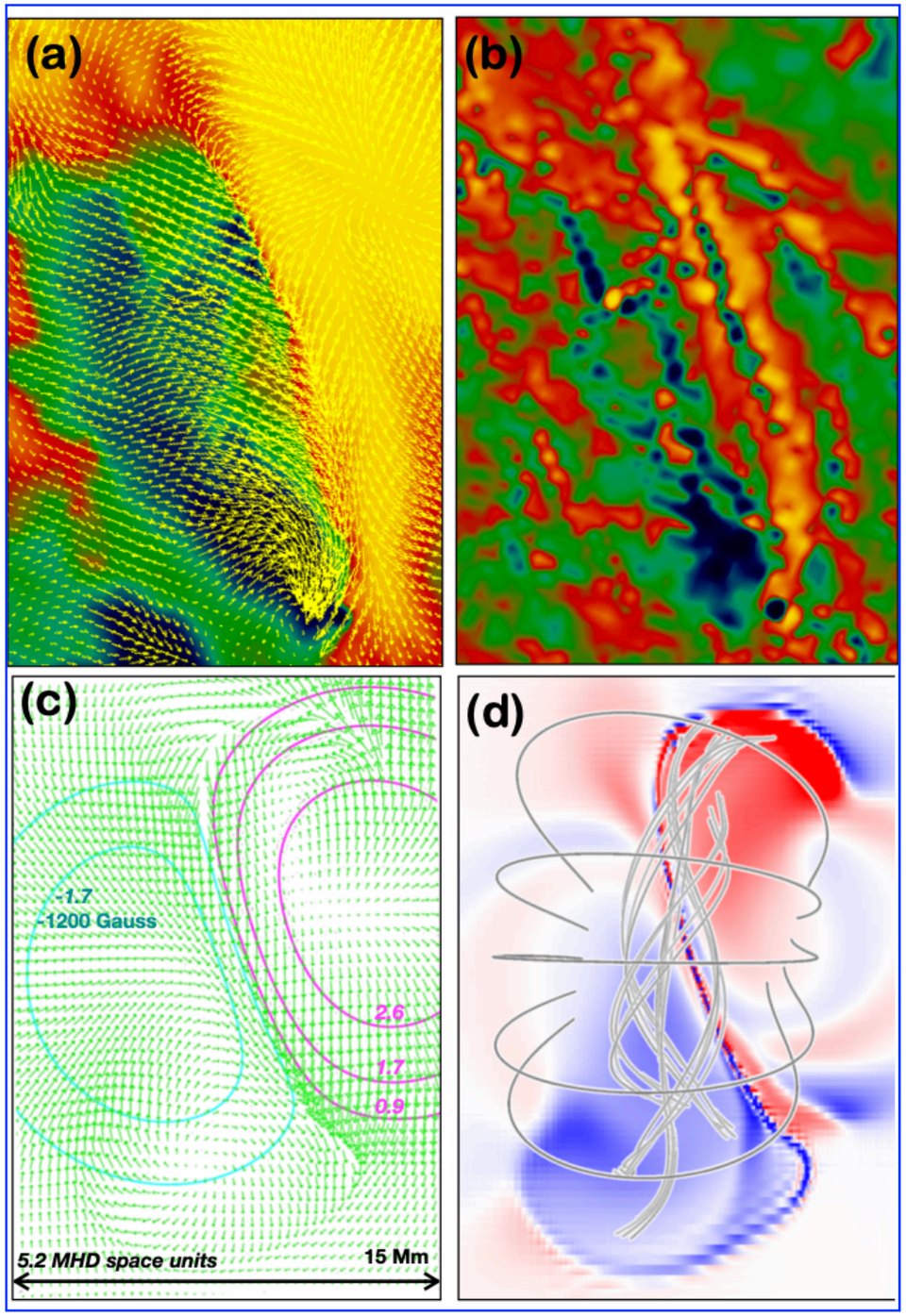

Fig5: Panel (a-b): Vector magnetic field and current density maps. Panel (c-d): MHD simulations which show that FR has very strong electric currents.

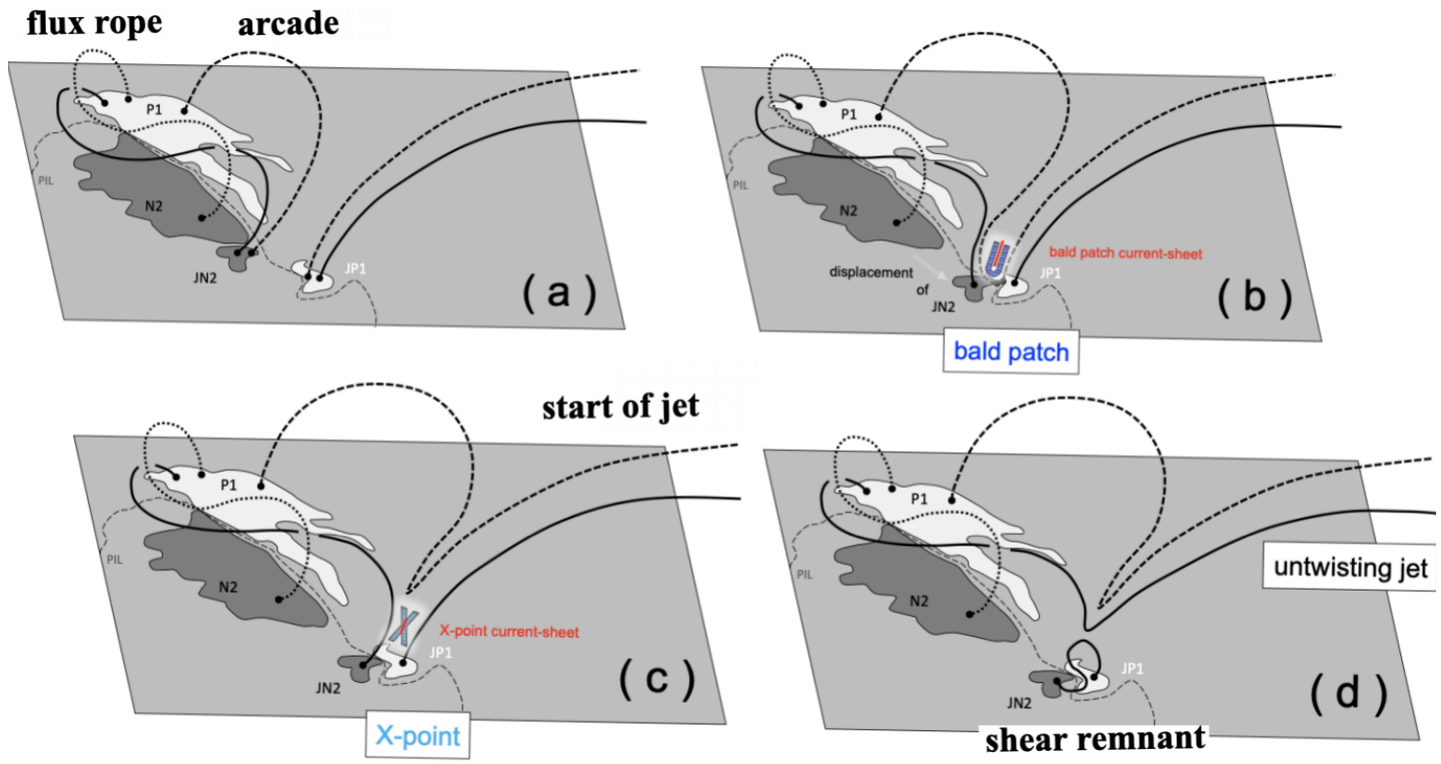

Fig6: Sketch of the formation of the jet and twist transfer

Panel (a): magnetic configuration before the reconnection

Panel (b): formation of the BP current sheet

Panel (c): X-point current sheet

Panel (d): the untwisting jet after the reconnection

Bombardment by energetic electrons

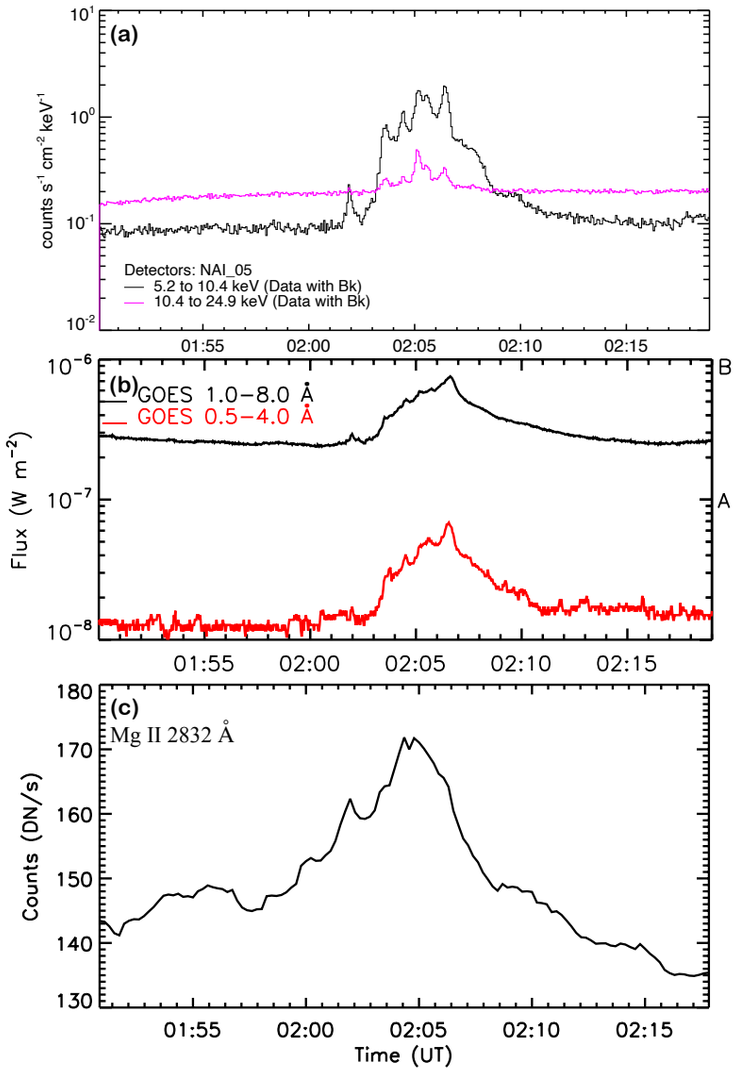

Fig7: Intensity variation at flare site observed in FERMI, GOES, and IRIS.
Panel(a): Soft X-ray (< 20 keV) correspondence in FERMI/GBM observations.
Panel (b): GOES light curve for the B6.7 class mini-flare
Panel (c): Light curve in Mg II SJIs.

Sandwich atmosphere model for mini flare

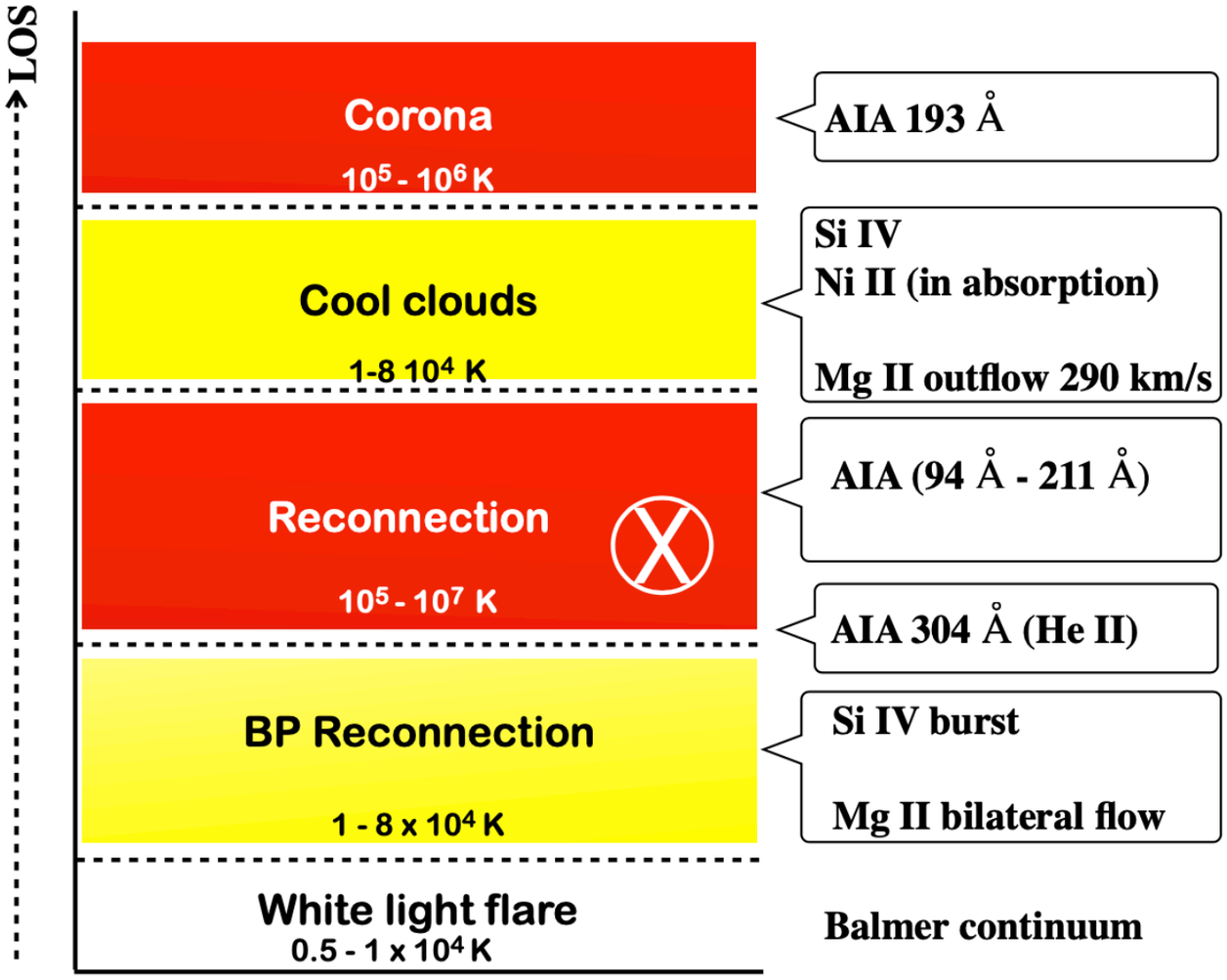

Fig8: Model of multi-layers of the mini flare atmosphere during the jet reconnection in a BP region.

Results

- A part of the flux rope formed a small bipole with a bald patch (BP) region, which dynamically became an X-current sheet during reconnection.
- A strong extension of the blue wing in Mg II decreased over a distance (from –300 km/s to a few km/s). This is the signature of the transfer of the twist to the jet.
- The reconnection would start in the low atmosphere in the BP reconnection region and extend at an X-point along the current sheet.
- The nonthermal HXR emission is related to the enhancement of the Balmer continuum emission, as a signature of a significant excess in heating. This supports the scenario of hydrogen recombination in flares after a sudden ionization at chromospheric layers.

Publications

These results are published as:

Joshi, Reetika, Schmieder, B., Aulanier, G., Chandra, R., Bommier, V., **2020, A&A 642, A169**,

Joshi, R., Schmieder, B., Tei, A., et al., **2021, A&A 645, A80,**

Joshi R., Schmieder, B., Heinzel, P., Tomin, J., Chandra, R., Vilmer, N., et al., **2021 A&A (accepted)**,

and are presented in the **Ph.D. thesis** by Reetika Joshi (September 2021) .