

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

Reetika Joshi<sup>1,2</sup>, Brigitte Schmieder<sup>1</sup>, Ramesh Chandra<sup>2</sup>, Petr Heinzel<sup>3</sup>, Guillaume Aulanier<sup>1</sup>, Véronique Bommier<sup>1</sup>, James Tomin<sup>1</sup>, Nicole Vilmer<sup>1</sup>

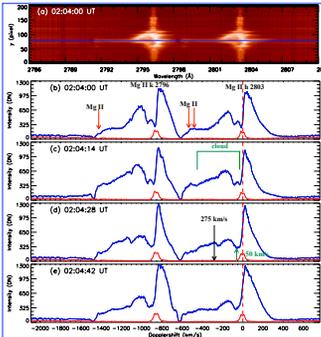
<sup>1</sup>LESIA, Observatoire de Paris, Université PSL, CNRS, Meudon, France

<sup>2</sup>Department of Physics, DSB Campus, Kumaun University, Nainital, India

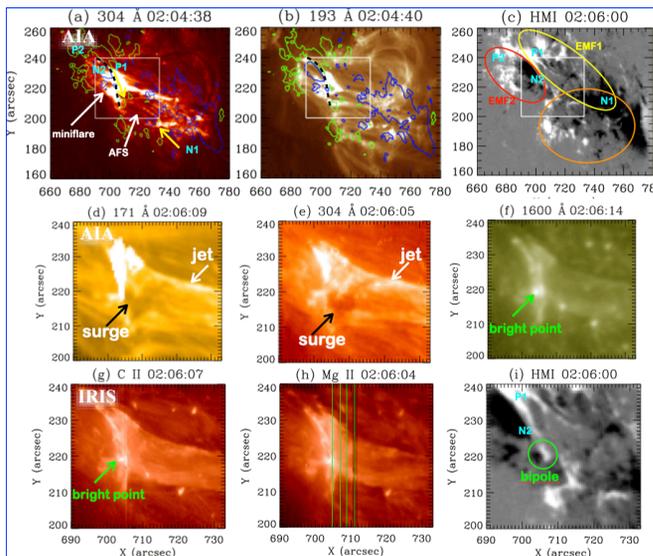
<sup>3</sup>Astronomical Institute of the Czech Academy of Sciences, Ondřejov, Czech Republic

IRIS spectra

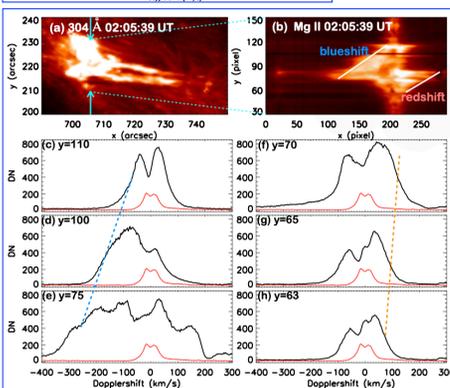
**Summary:** The magnetic reconnection occurs between two emerging magnetic flux (EMF) in a bald patch region observed in HMI vector magnetograms. A transfer of twist was operating between a neighbouring flux rope to the jet. Analysis of IRIS spectra of Mg II, C II, and Si IV ions allows us to study the dynamics and the stratification of the flare atmosphere during the magnetic reconnection phase at the jet base in a bald patch (BP) region. The twist was confirmed by tilt of the IRIS spectra well observed in Mg II and Si IV. Strong asymmetrical Mg II and C II line profiles with extended blue wings observed at the reconnection site are interpreted by the presence of two chromosphere temperature clouds: one explosive cloud with blueshift at -290 km/s and one cloud with smaller Dopplershift (around -36 km/s). These ejections are in the opposite direction of the jet and explained by trapped cool material between the two EMFs. The detection of X-ray emission by FERMI/GBM simultaneously with the excess in the Balmer continuum supports the idea of bombardment of non thermal electrons during the reconnection even for a B6.7 class flare.



**Fig3:** Panel a: Mg II spectra at 02:04:00 UT along the slit position 1 before the UV burst. Panels b-e from top to bottom: evolution of the Mg II k and h line profiles. The horizontal green brace denotes the low-intensity value of the Mg II blue peak, a signature of the possible presence of an absorbing (red arrow in panel d) and emitting radiation cloud along the LOS. The reference profiles are shown in red. The vertical red dashed lines in panels b-e show the position of rest wavelength at 2803.6 Å.

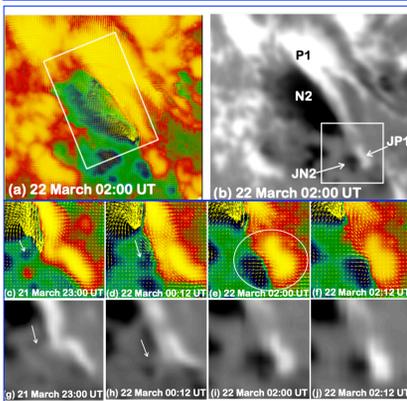


**Fig1:** Solar jet and surge observed in different AIA/EUV channels on March 22 2019 in NOAA AR 12736. Panels (a-b): mini flare in AIA 304 Å and 193 Å passbands overlaid with the HMI magnetic field contours of strength  $\pm 300$  Gauss. Panel (c): longitudinal magnetic field configuration observed with HMI consisting of emerging magnetic fields (EMFs). Panels (d-f): three different AIA channels zooming on the jet base and surge. Panels (g-h): IRIS SJI 1330 Å and SJI 2796 Å observations. Panel (i): zoom of the magnetic configuration at the jet base along the PIL between P1 and N2 and the bipole where the reconnection takes place, corresponds to the bright point.



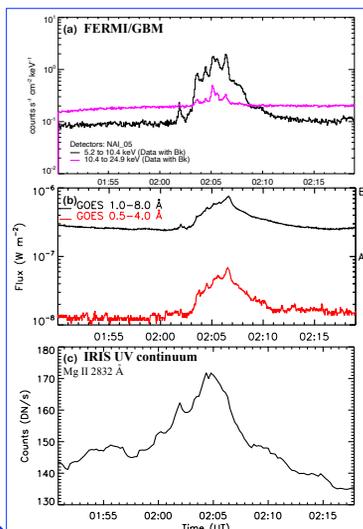
## Bidirectional flows

**Fig4:** Panel (a): Mini flare and bright jet with two branches inserting a cool dense surge. Panel (b): The Mg II k line spectra corresponding to the slit position 1. The red and blue shift wings are shown by the white tilted lines on the left (blueshift) and right (redshift) in the spectra. Panels (c-e): the blue shift profiles shown by the tilted blue dashed line corresponding to strong blueshifts (-300 to -100 km/s). Panels (f-h): the red shift profiles from 80 to 100 km/s.

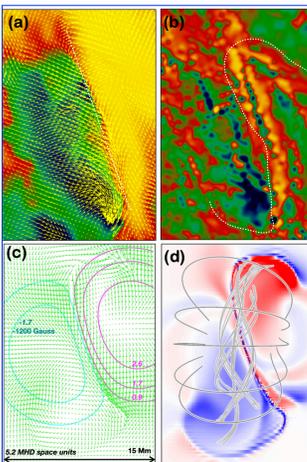


## Evidence of flux rope

**Fig5:** Panel (a): Vector magnetic field configuration. Panel (b): LOS magnetic configuration at the AR 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.



**Fig2:** Intensity variation at the flare site observed in FERMI/GBM, GOES, and IRIS. Panel (a): Soft X-ray (less than 20 keV) correspondence in FERMI/GBM observations. There are fewer small peaks observed with hard X-ray correspondence ( $>20$  keV, pink curve). Panel (b): GOES light curve for the B6.7 class solar flare, shows the flare peaks at  $\sim 02:06$  UT with small peaks corresponding to GBM peaks. Panel (c): Intensity light curve at the bright point in Mg II 2832 Å SJI.



## Numerical simulations-vector B

**Fig6:** Panel (a-b): Vector magnetic field and current density maps computed with the UNNOFIT code. Panel (c-d): MHD simulations which show that FR has a very strong electric currents, with current flowing from red to blue. 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.

## Publications

These results are published by 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).