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Nature of surge-like activity above sunspot light bridges: Magnetic Reconnection or Shocks?

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Contributed Talk

2. Chromospheric heating and dynamics

Nature of Surge-like Activities above Sunspot Light Bridges: Magnetic Reconnection or Shocks?

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We analyzed the surge-like oscillatory activity above sunspot light bridges using data taken by the Interface Region Imaging Spectrograph (IRIS) and the 1.6-m Goode Solar Telescope (GST). From the IRIS 2796 slit-jaw images, we detected surge-like activity above the entire light bridge at any time. The 1400 slit-jaw images reveal an oscillatory bright front ahead of the surges. The wavelength-time diagrams of the Mg II 2796.35 Å line within the surges show clear sawtooth patterns, suggesting that the oscillations are highly nonlinear and likely caused by shocks. We also find a positive correlation between the acceleration and maximum velocity of the moving front, which is consistent with numerical simulations of upward propagating slow-mode shock waves. These results, together with the fact that the oscillation period stays almost unchanged over a long duration, lead us to propose that the surge-like activity above LBs is mainly caused by shocked p-mode or magnetoacoustic waves leaked from the underlying photosphere. In observations of another sunspot, similar surge-like activity is seen in the Hα core images taken by GST. Some surges appear to reach larger distances and they are clearly associated with fast jets visible in the Halpha wing images, which occasionally occur at selected locations in the light bridge. Many of these jets are found to have an inverted Y-shape and rooted in transient brightenings with line profiles typical of UV bursts, indicating the occurrence of magnetic reconnection at the footpoints of the jets. In conclusion, our analysis clearly shows that the surge-like activity above light bridges has two components: the ever-present short surges likely to be related to the upward leakage of magneto acoustic waves from the photosphere, and the occasionally occurring long and fast surges that are obviously caused by the intermittent reconnection jets.

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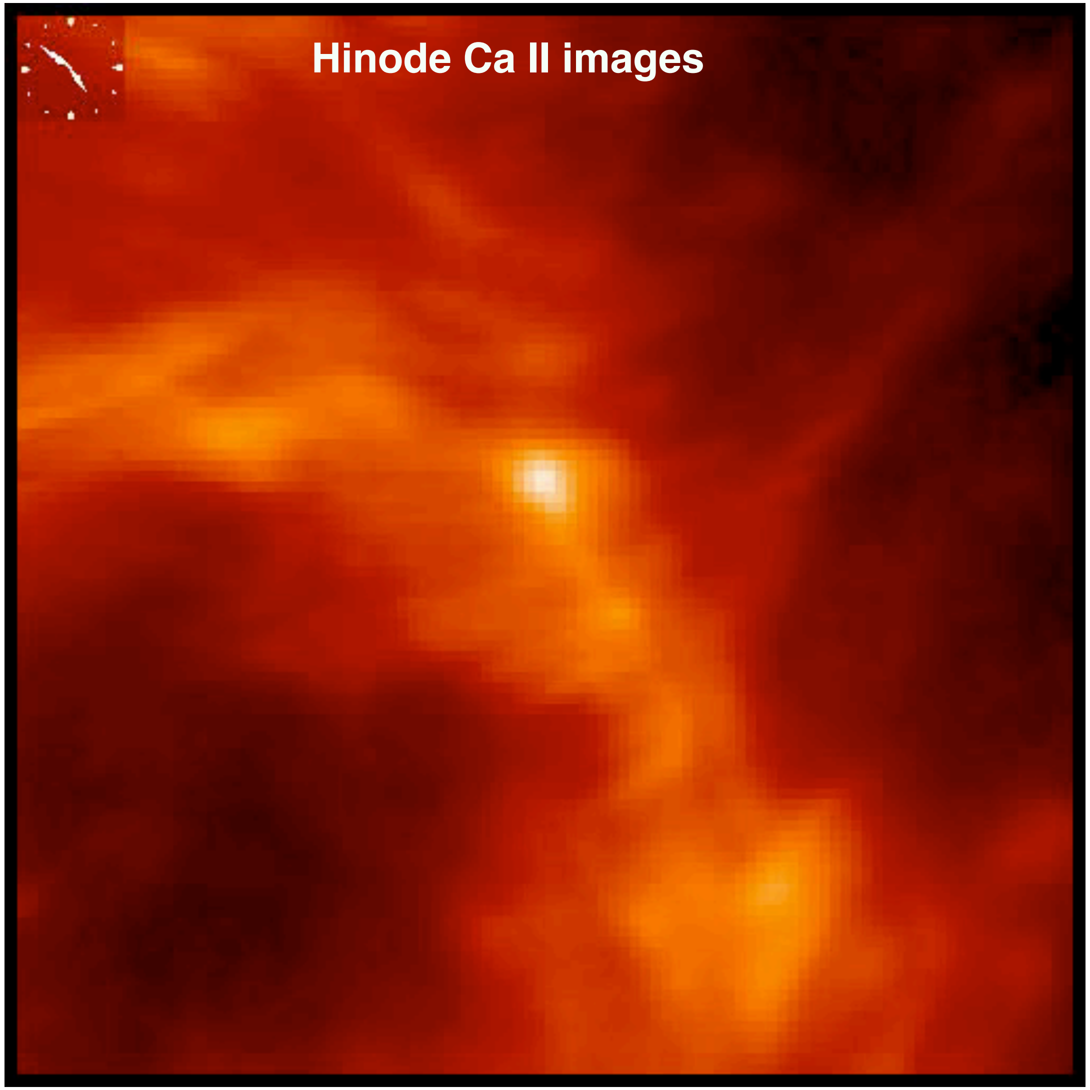
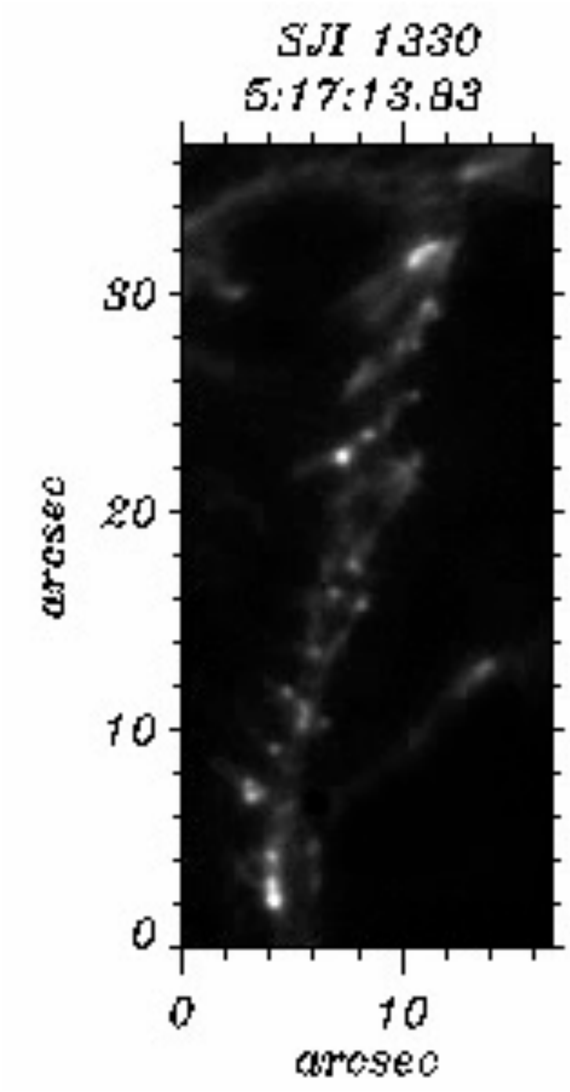
Surge-like chromospheric activity above light bridges



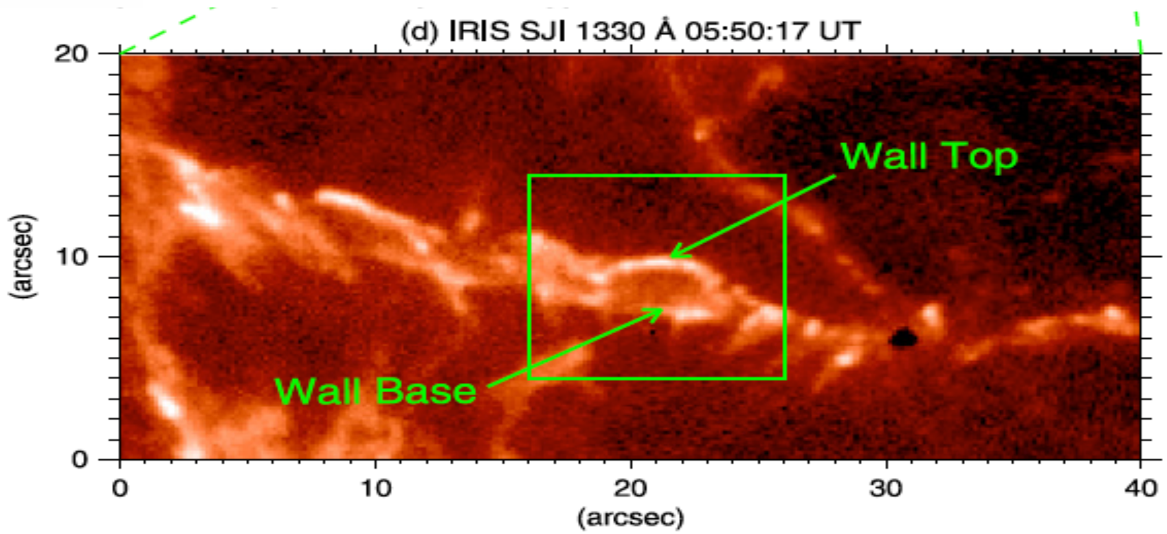
Shimizu et al. 2009

- Surge-like activity is frequently observed above light bridges in chromospheric passbands, called Hα surges, Ca II jets, plasma ejections, light wall oscillation, peacock jets (Roy 1973, Asai et al. 2001, Shimizu et al. 2009).
- Most previous studies attributed the activity to magnetic reconnection.

The bright front ahead of surges



Bharti 2015



Yang et al. 2015

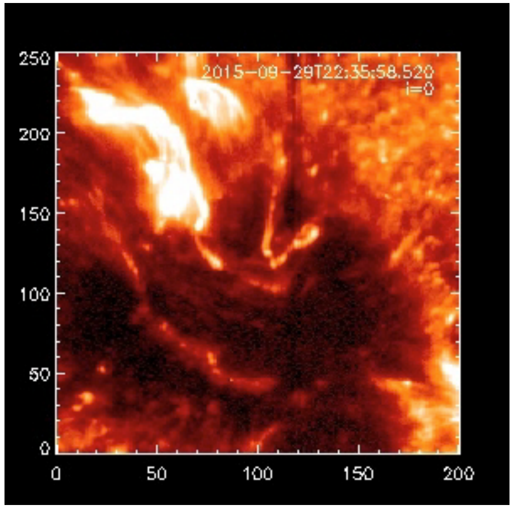
- Yang et al. 2015 and Bharti 2015 detected an oscillatory bright front ahead of surges in IRIS 1330 passband.
- Yang et al. 2015 discussed the possibility that p-mode leaked from the photosphere causes these recurrent surges.

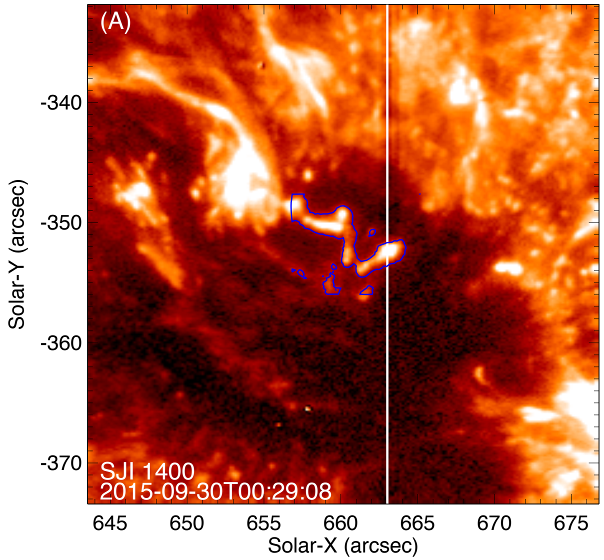
Our perspectives

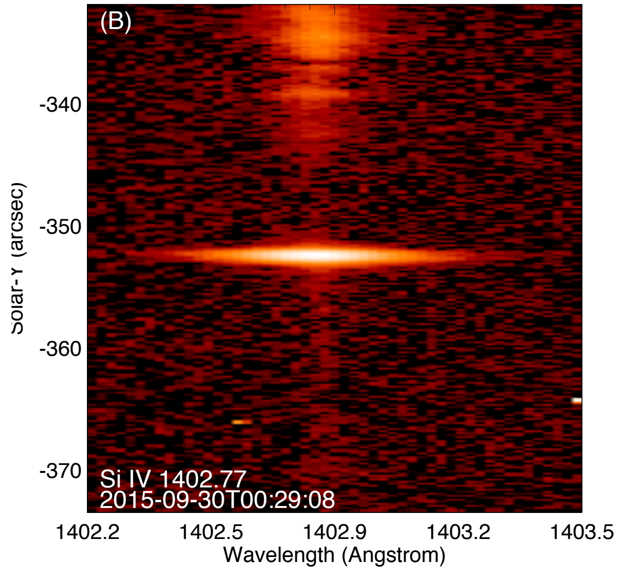
Using IRIS and GST data, we try to investigate the nature of these recurrent surges. Our observations reveal the existence of at least two types of surges above light bridges:

- Type-I: occur at all locations above light bridges during the entire observation period, might be linked to an ever-present process such as waves or shock waves;
- Type-II: occasionally occurring at some locations, might be associated with intermittent magnetic reconnection.

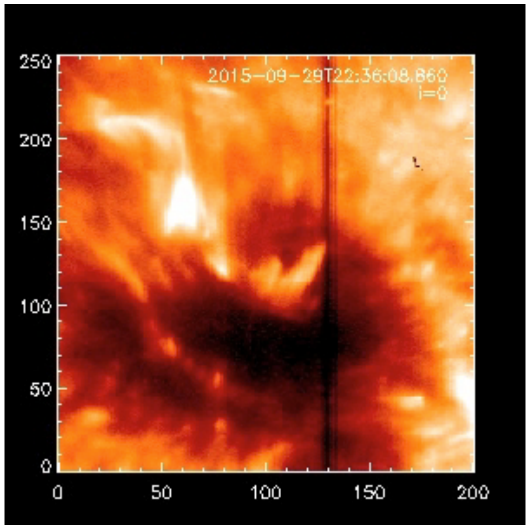
Shock Evidence I: continuous bright front

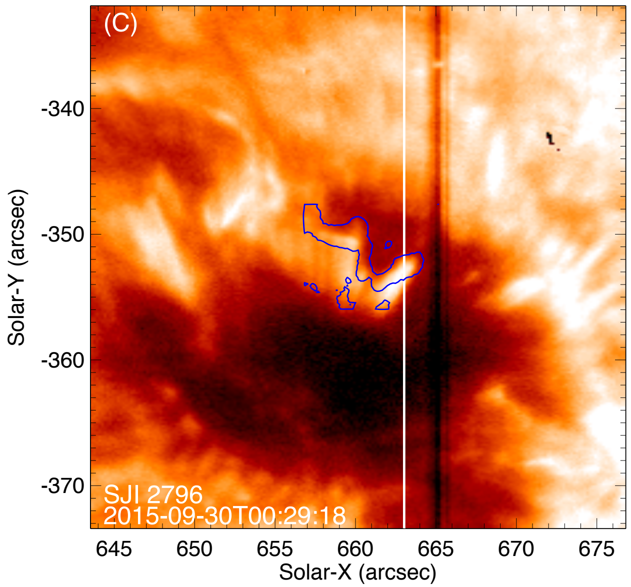


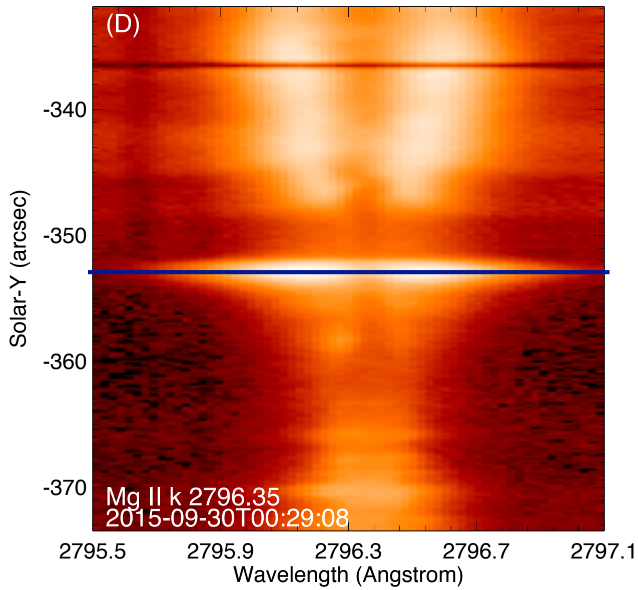




TR passband (～10^5K)

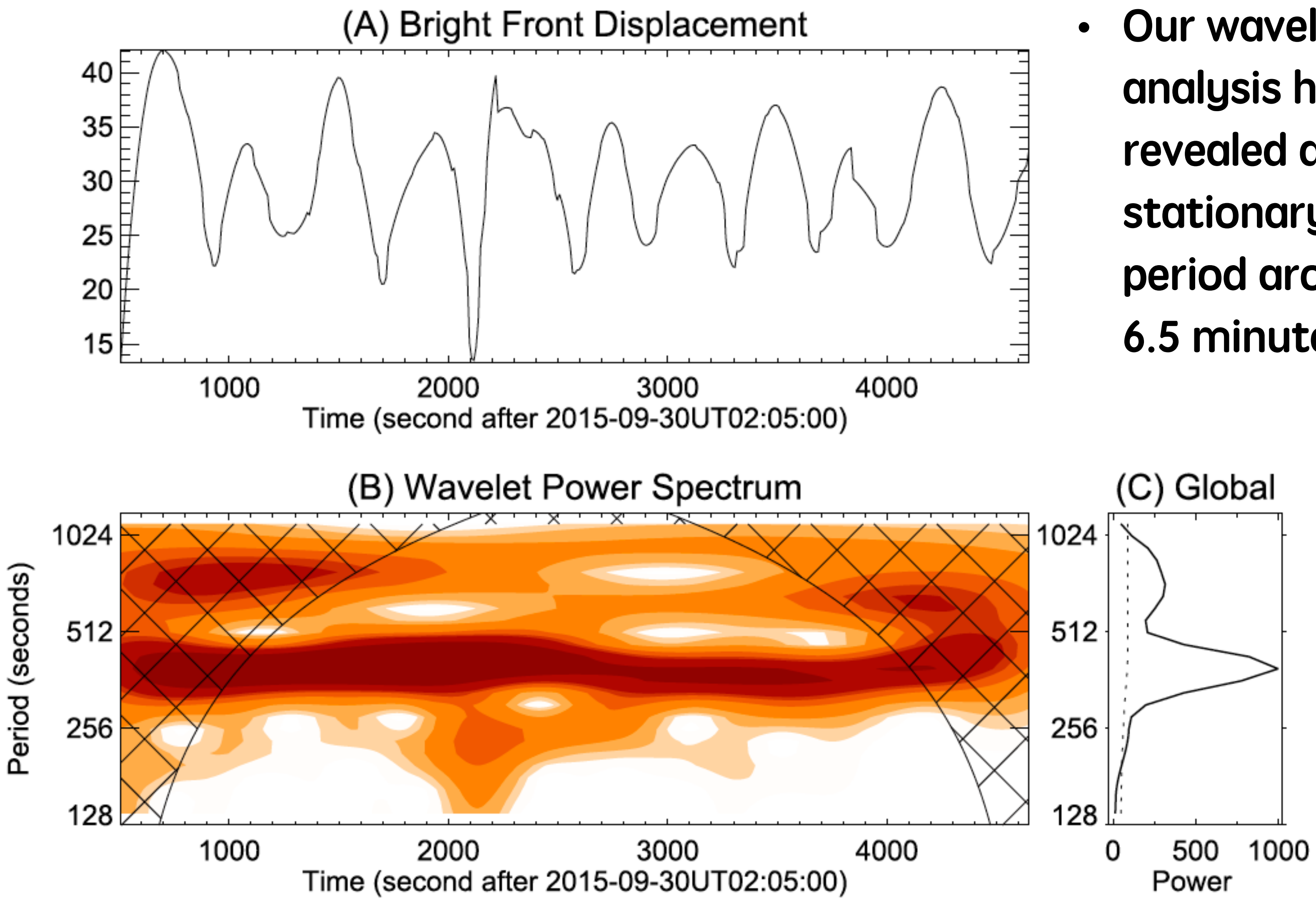






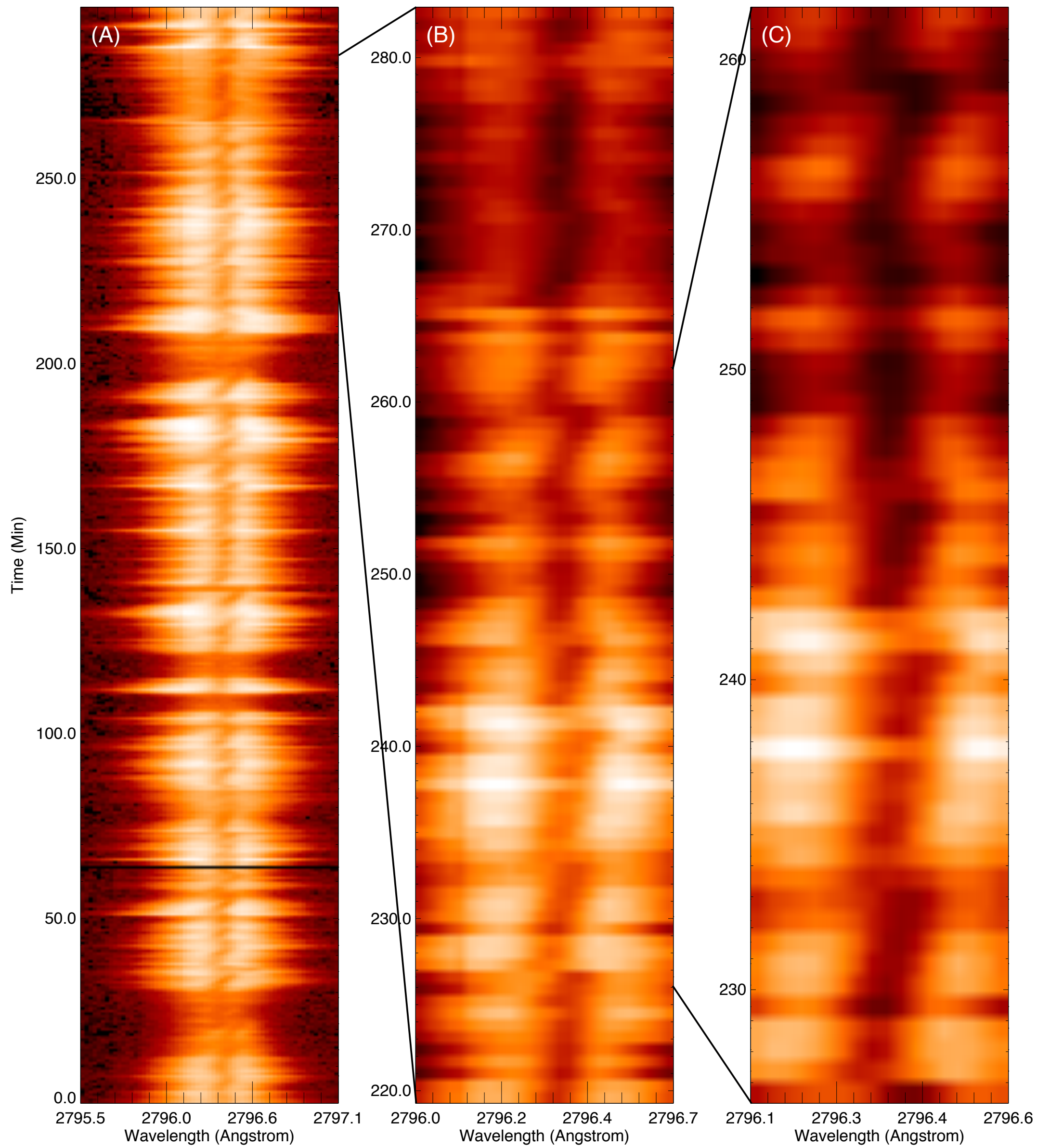
Chrom. passband (～10^4K)

Shock Evidence II： stable period for a long time



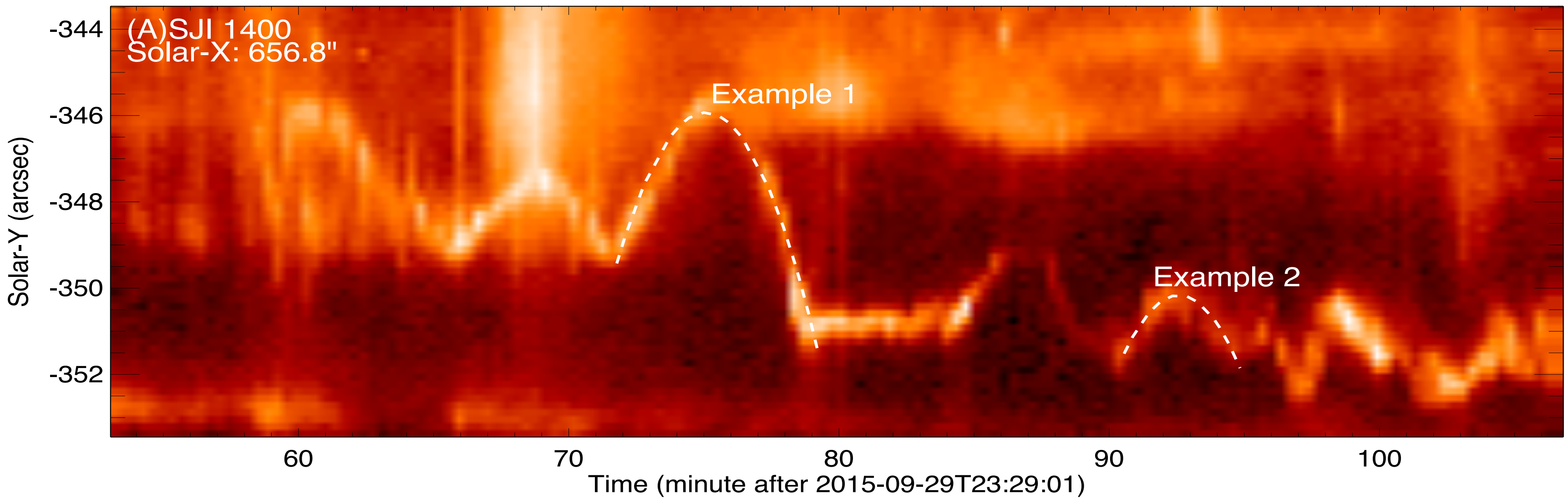
- **Our wavelet analysis has revealed a nearly stationary period around 6.5 minutes.**

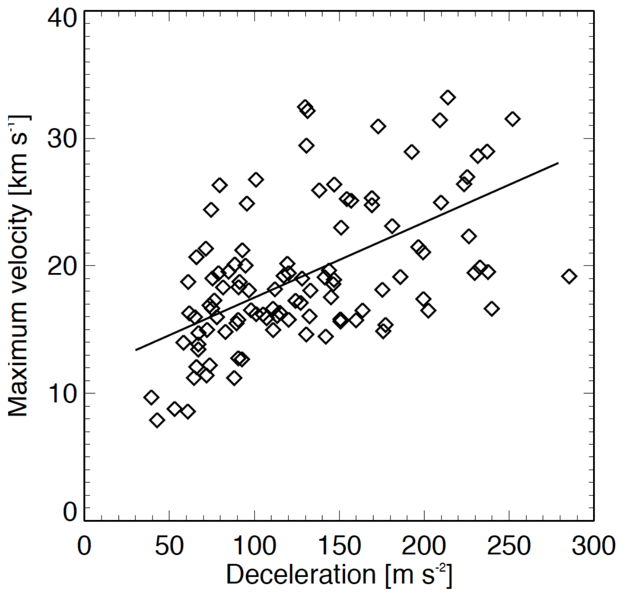
Shock Evidence III: "Z" patterns in wavelength-time diagrams of Mg II k line



- The dark line core of Mg II line repeats the following behavior: a fast impulsive blueward excursion followed by a gradual redward excursion.
- Similar behavior has been frequently observed in sunspots and cited as evidence of shock waves (Rouppe van de Voort et al. 2003; Centeno et al. 2006; Felipe et al. 2010; Tian et al. 2014)

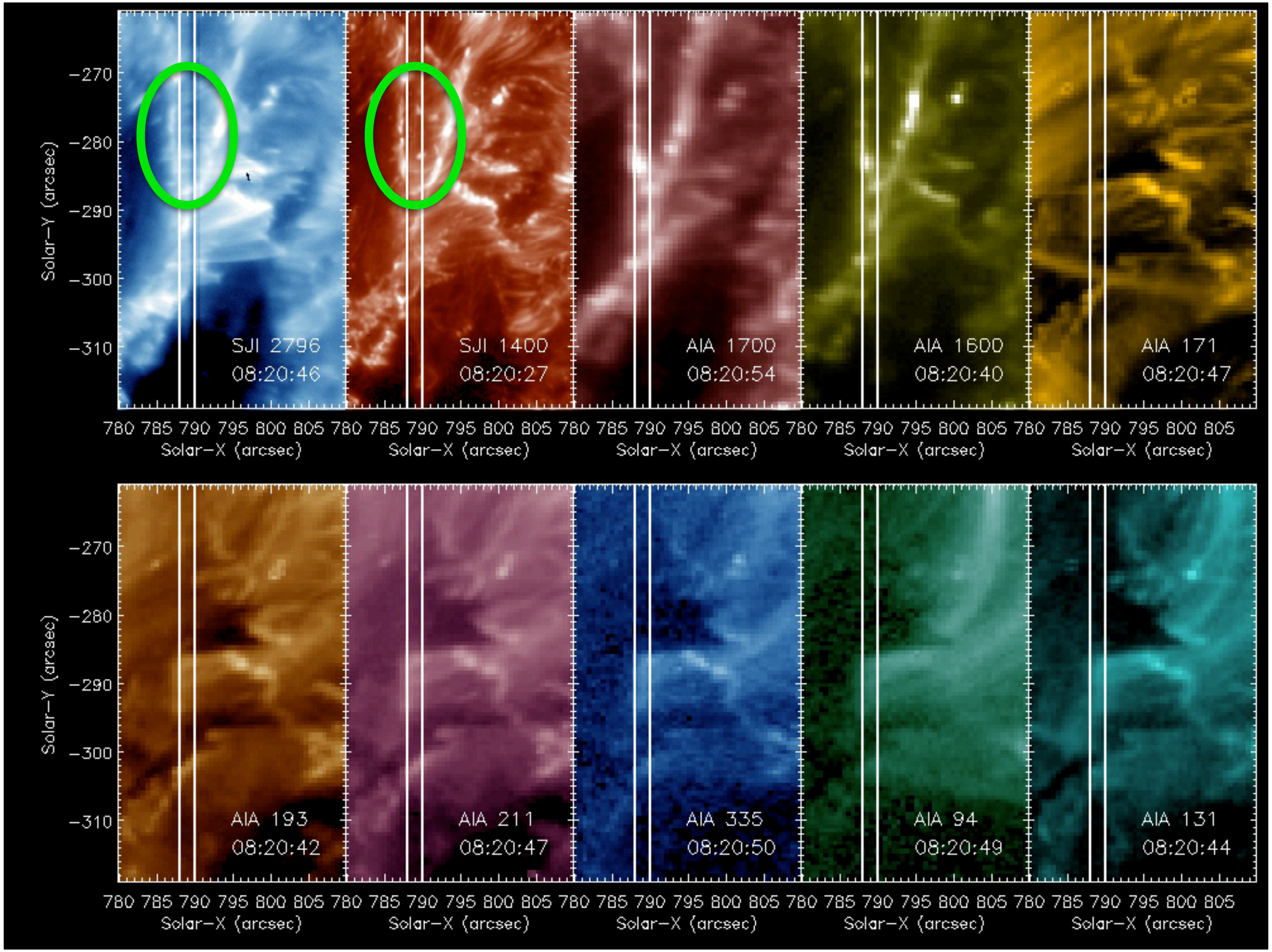
Shock Evidence IV： parabolic trajectories and positive correlation between maximum velocity and deceleration



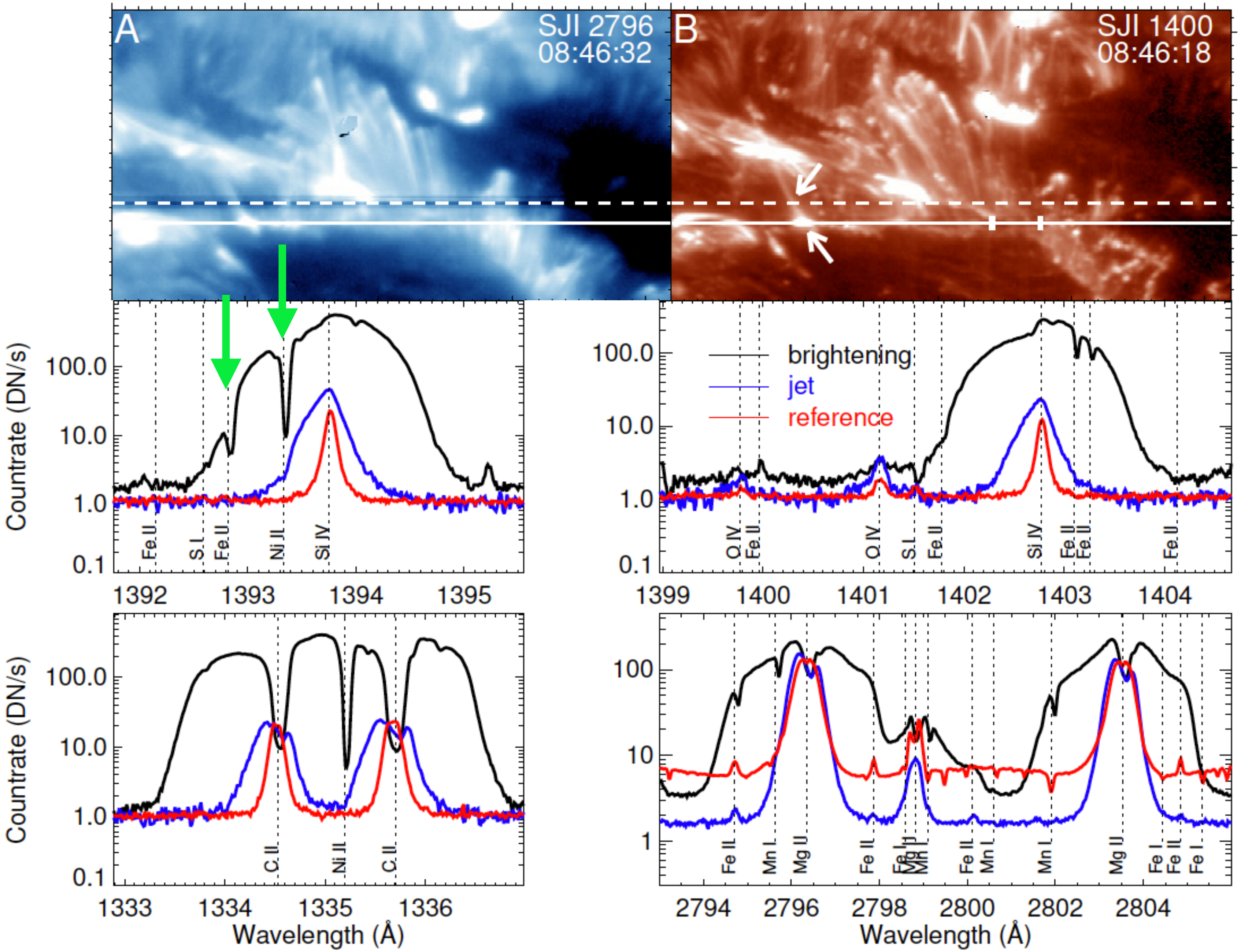


- The bright font in IRIS 1400 passband follows a parabolic path;
- Positive correlation between the maximum velocity and deceleration agrees with shock wave simulations (Hansteen et al. 2006; De Pontieu et al. 2007).

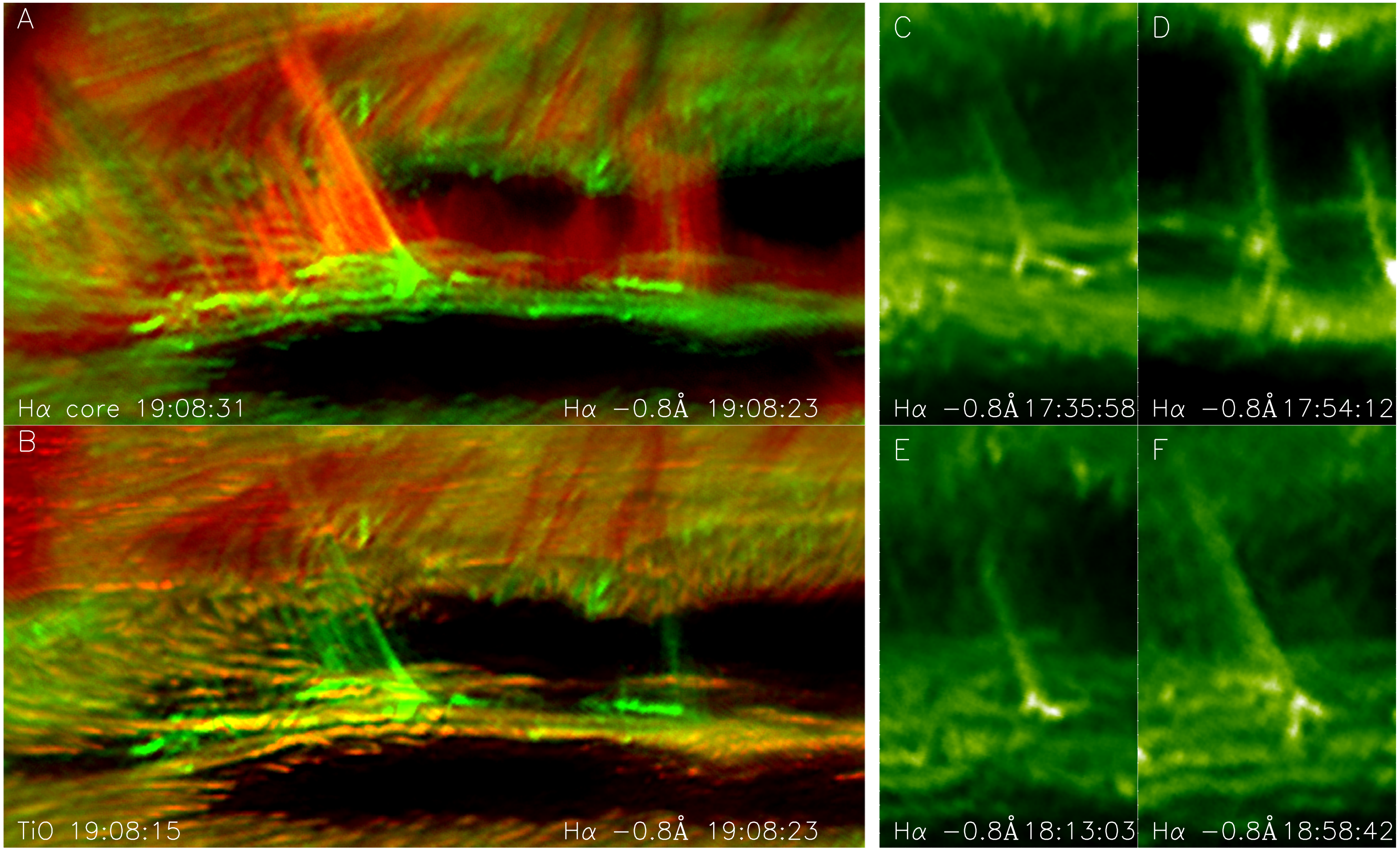
Reconnection Evidence I: numerous narrow and collimated jets from light bridges



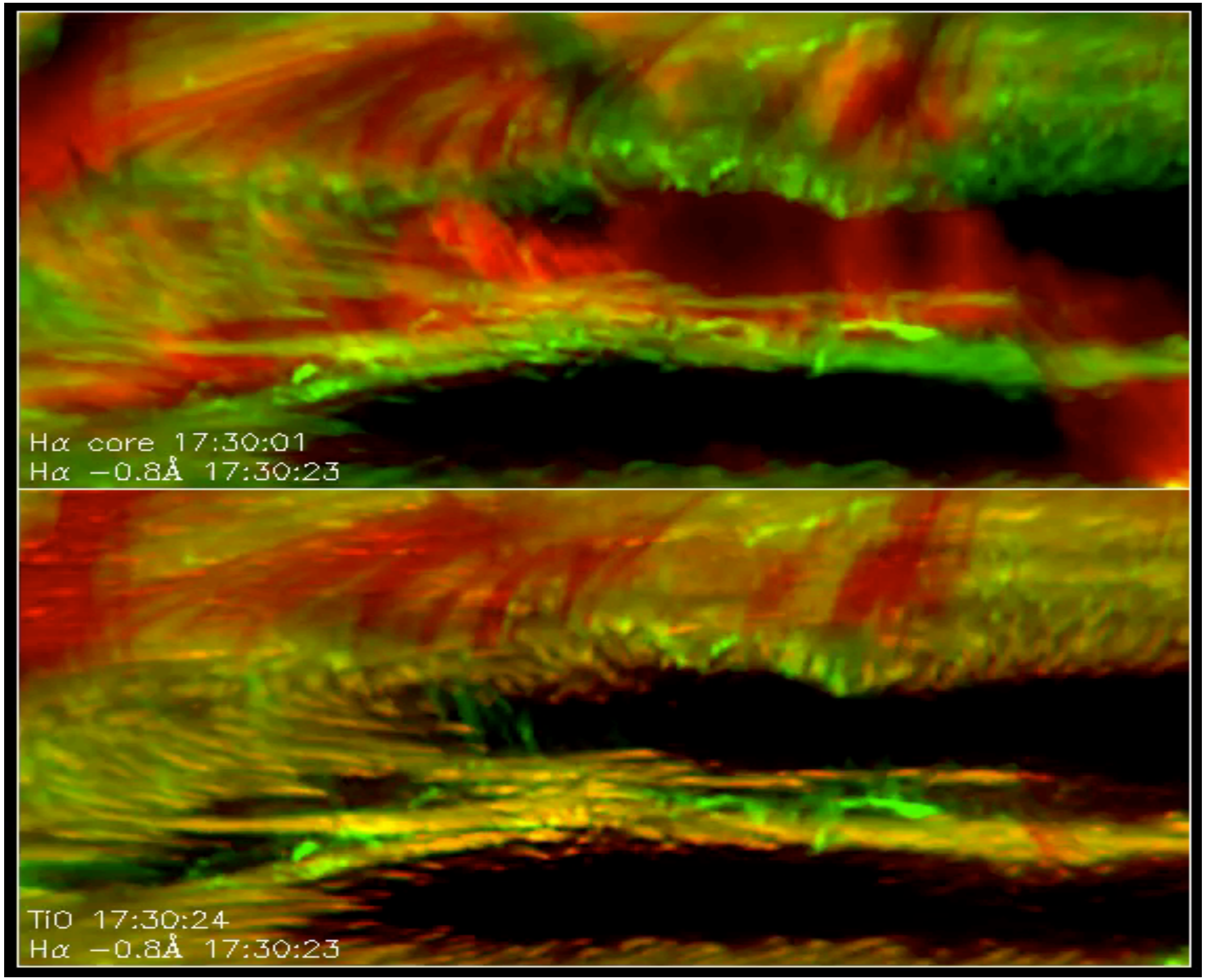
Reconnection Evidence II：Line profiles at footpoint brightenings similar to those of IRIS bombs/UV bursts



Reconnection Evidence III: The inverted Y-shape structure



Two types of surges



~~Reconnection or Shocks~~

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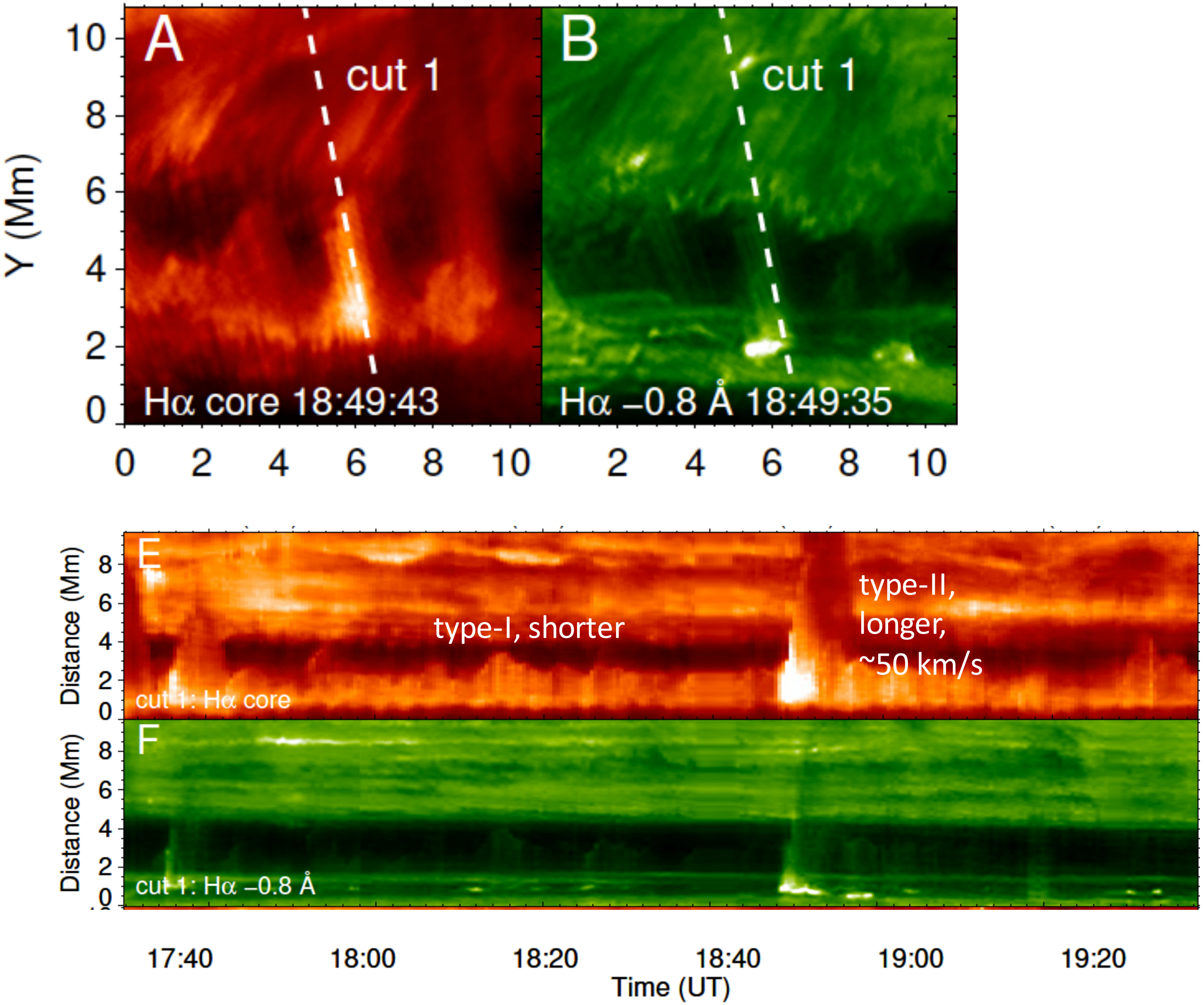
Reconnection and Shocks

Base on IRIS SJI observations, Hou et al. (2017) came to a similar conclusion.

Two types of surges



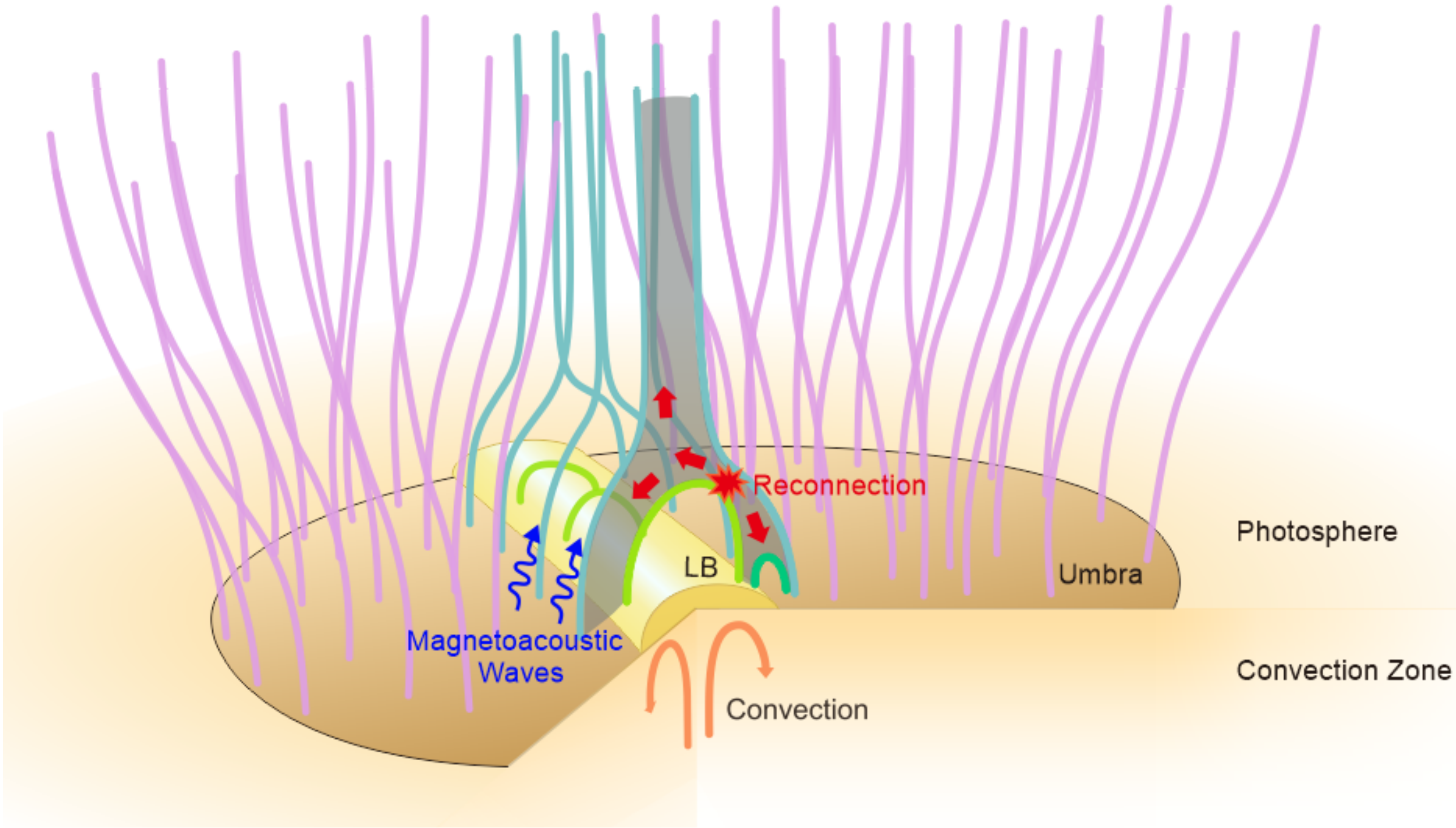
Type–I surges:

- occur at all locations above light bridges
- reach lower height
- smaller velocity (10∼30 km/s)
- might be driven by shocks

Type–II surges:

- occasionally occurring at some locations
- reach higher altitudes
- move at higher speeds (∼100 km/s)
- caused by magnetic reconnection

Summary: Two types of surges



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Zhang, J., Tian, H., He, J.-S., Wang, L.-H. 2017, ApJ, 838, 2

Tian, H., Yurchyshyn, V., Peter, H., et al. 2018, ApJ, 854, 92

THANKS!