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# ***Small-Scale Activity Observed with GST***

*Vasyl Yurchyshyn*

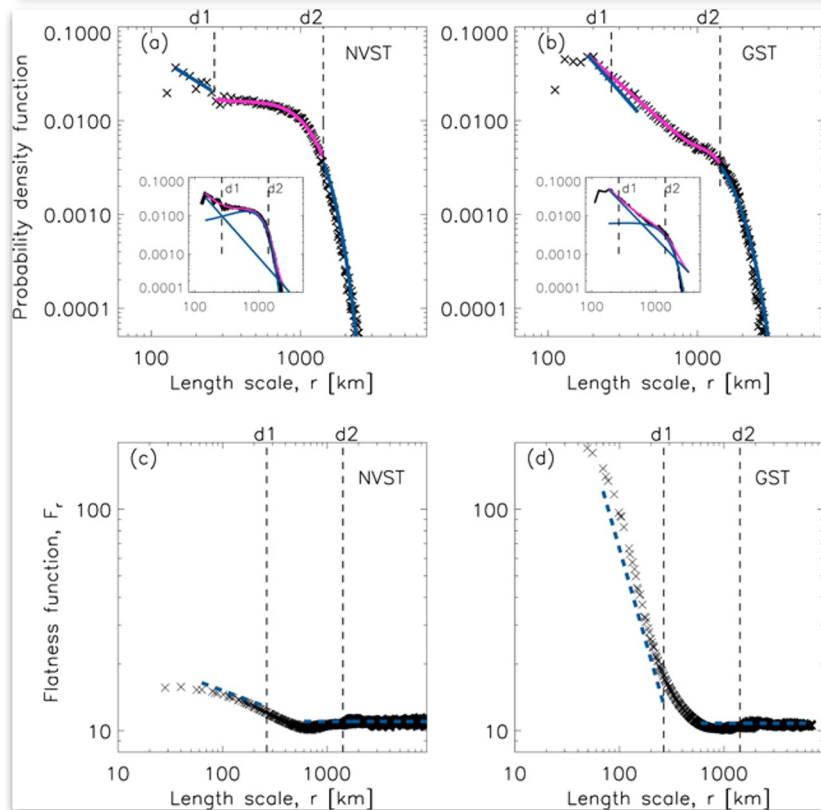
*Big Bear Solar Observatory, New Jersey Institute of Technology*



A brief review of GST publications since 2020, relevant to small-scale photospheric dynamics, chromospheric activity, and reconnection.

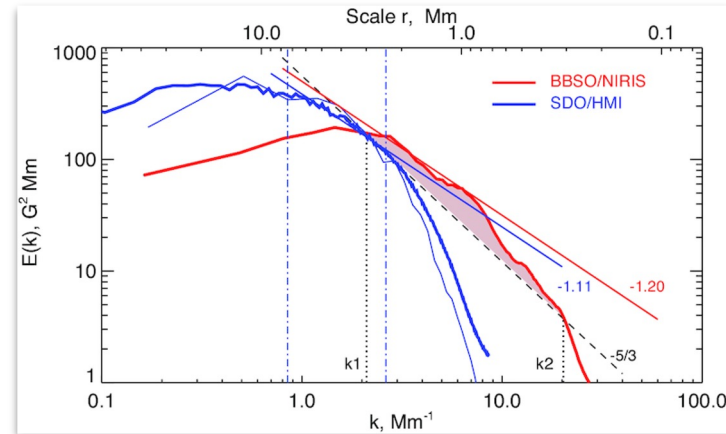
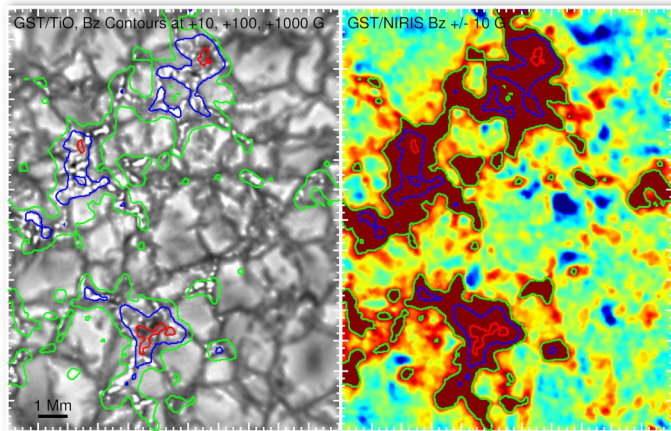
The research effort was mainly focused on understanding

- Structure of granulation
- Reconnection in Sunspot Light Bridges
- Granular flows as a driver of chromospheric jets and waves
- Origin of spicules and coronal bright points



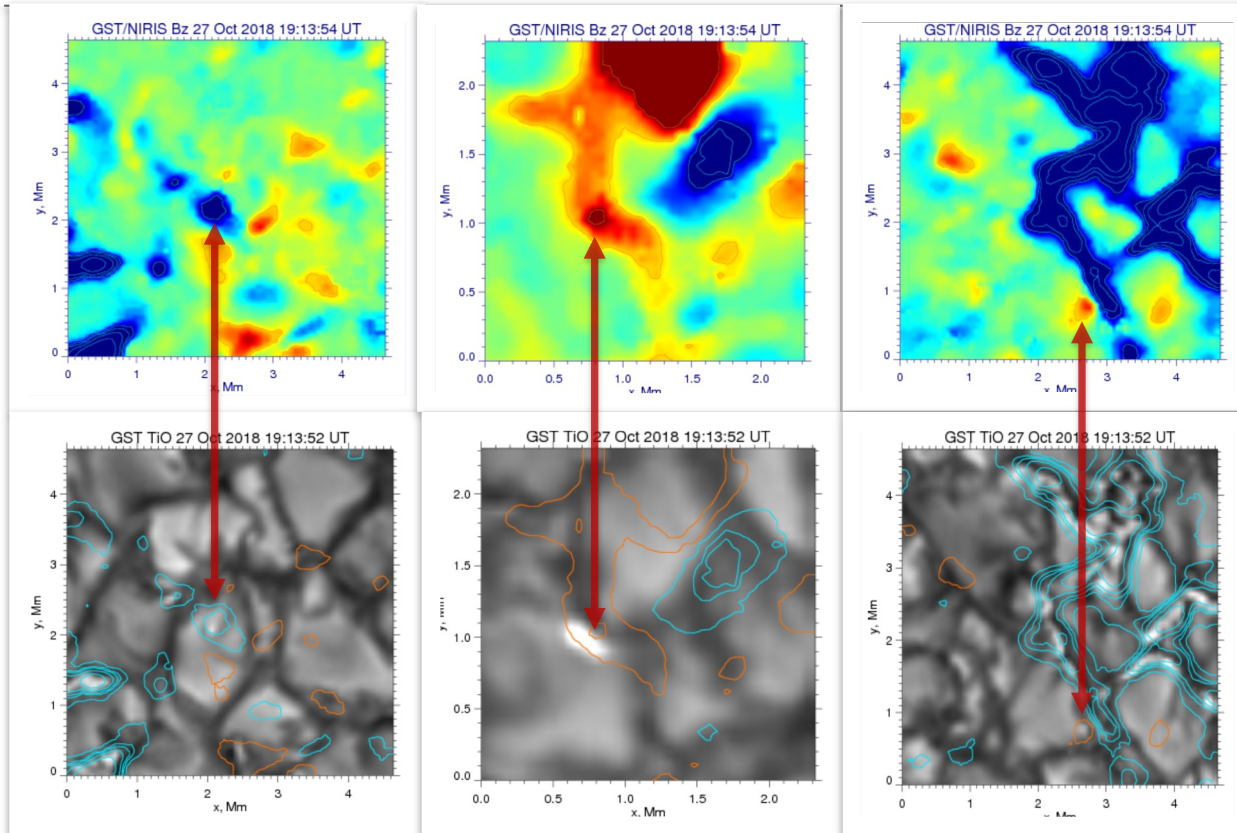
- A new granule segmentation method was developed to detect both small faint and large bright granules.
- Two critical spatial scales, 265 and 1420 km, separate QS granules into three length ranges: mini-granules (power law); small granules (combination) and granules (gaussian).
- A critical scale of 600 km was found for AR granules that separates them into two regimes: convection and turbulence.
- Comparing with the QS granules, AR granules do not display the intermediate range, likely because of the interaction between fluid motions and strong magnetic fields in active regions.
- These studies remarkable well agree with earlier findings by *Abramenko et al., 2012*, who used a less sophisticated fragmentation algorithm.

Liu et al., 2021; 2022

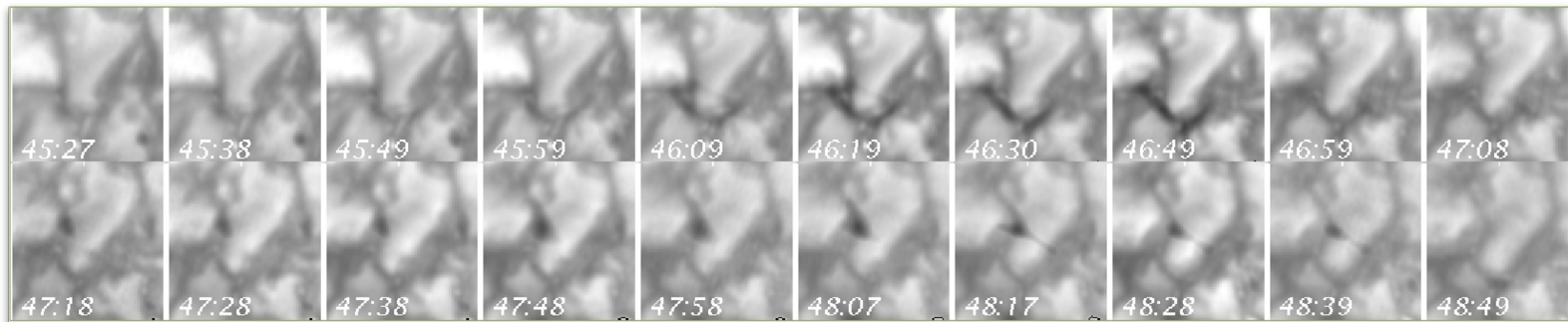
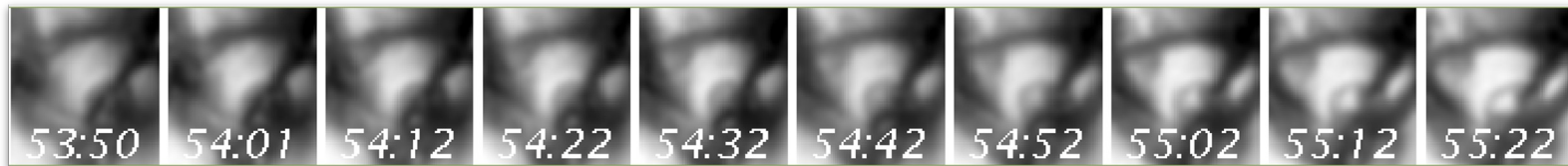


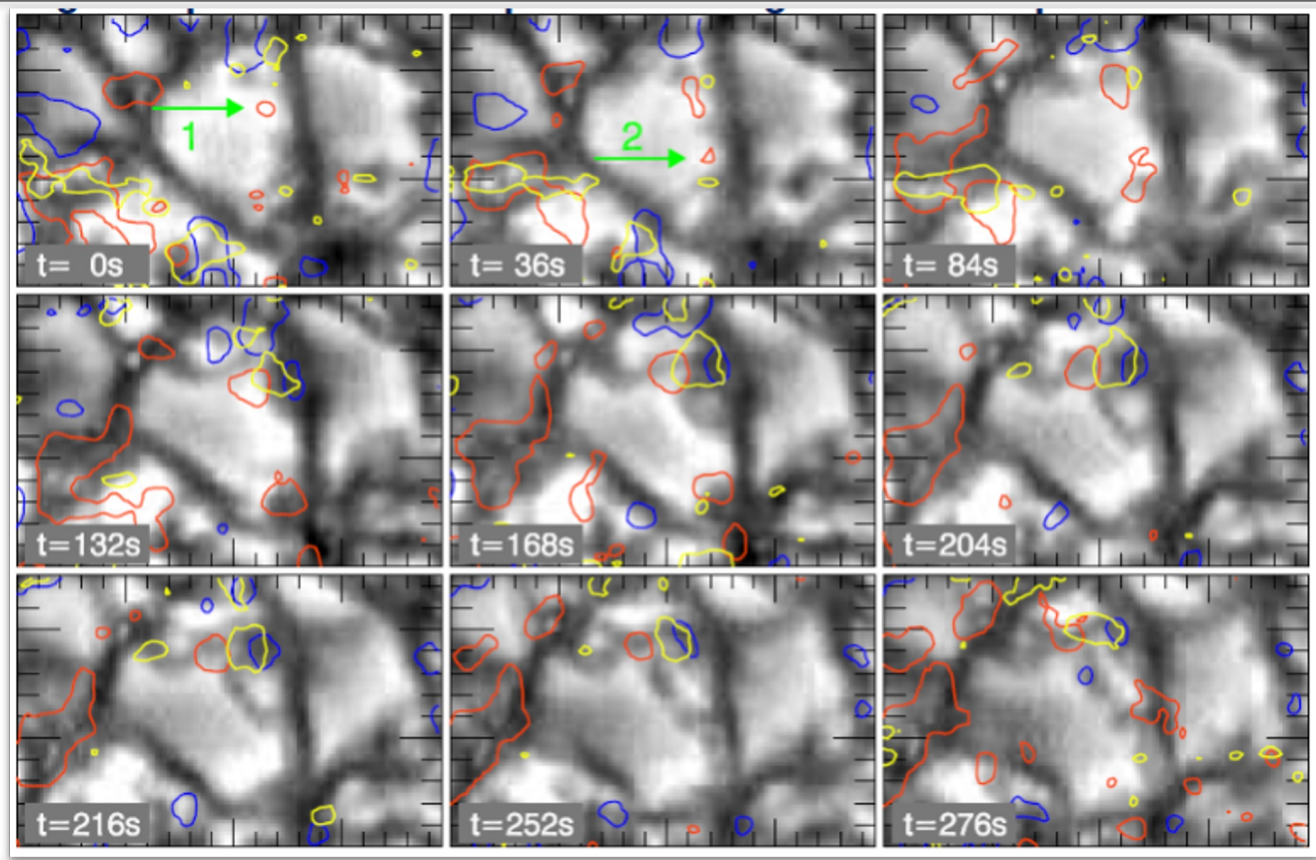
- NIRIS 200–400 km elements of 1000–2000 G field strength. When compared to the HMI spectra, the  $-1.2$  slope of the NIRIS spectrum appears to be more extended into the short spatial range until the cut-off at 0.8–0.9 Mm
- Comparison with the Kolmogorov-type spectra showed that the Kolmogorov turbulent cascade cannot account for more than 35% of the total magnetic energy observed in the scale range of 3.5–0.3 Mm
- The energy excess can be attributed to local turbulent dynamo and/or magnetic super-diffusivity that can slow down the rate of the Kolmogorov cascade leading to a shallower resulting spectrum.

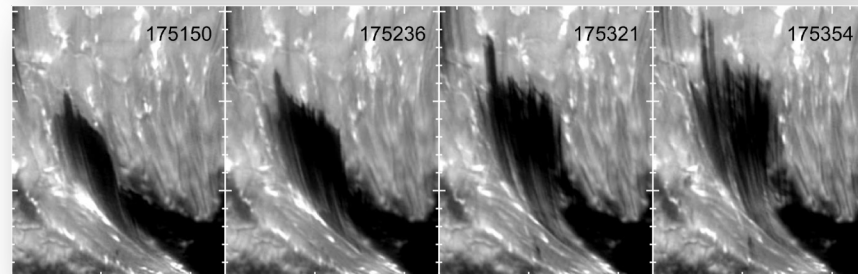
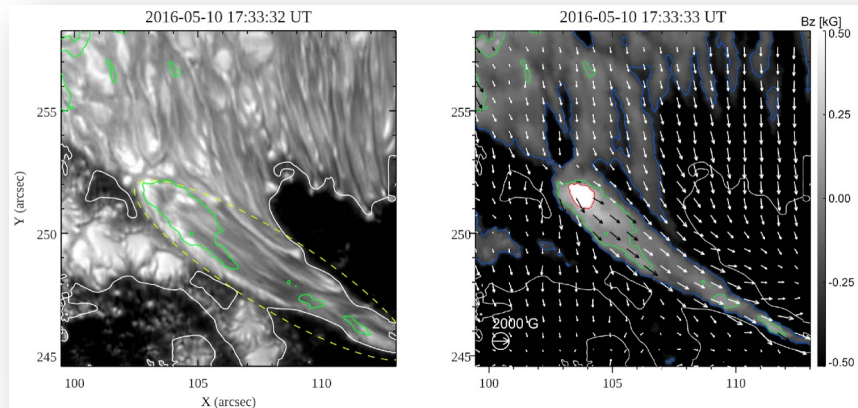
*Abramenko and Yurchyshyn (2020)*



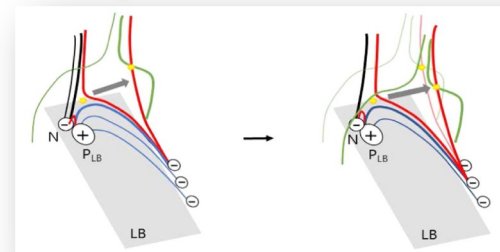
- GST NIRIS Bz scaled between  $\pm 30$  G.
- Blue / Red mark positive / negative polarity
- Contours at  $\pm 10, 30, 100, 200$  G levels
  
- GST/TiO Photosphere with over-plotted Bz contours





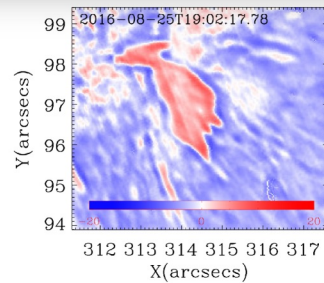
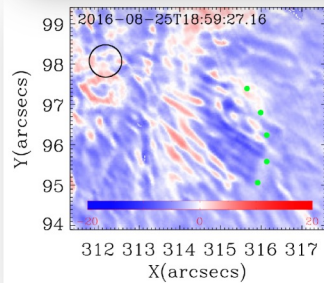
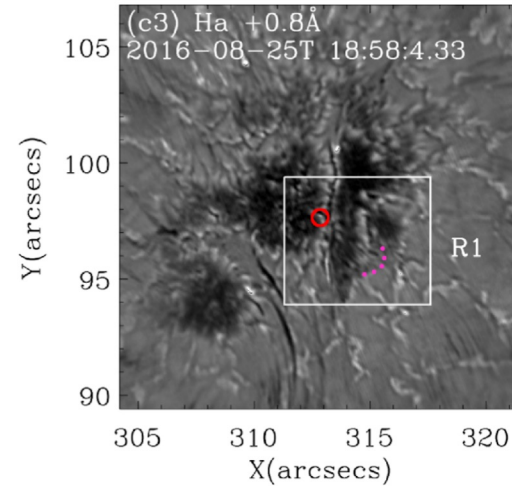
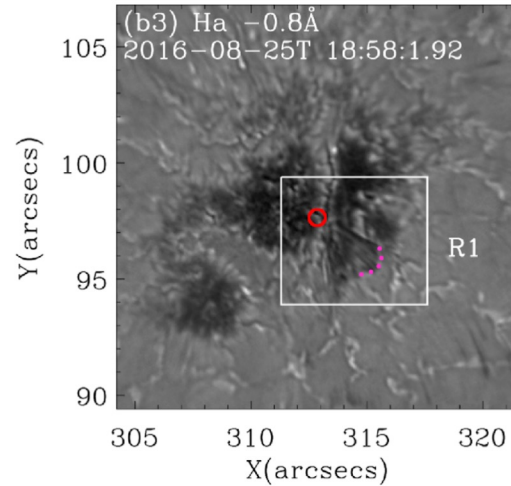
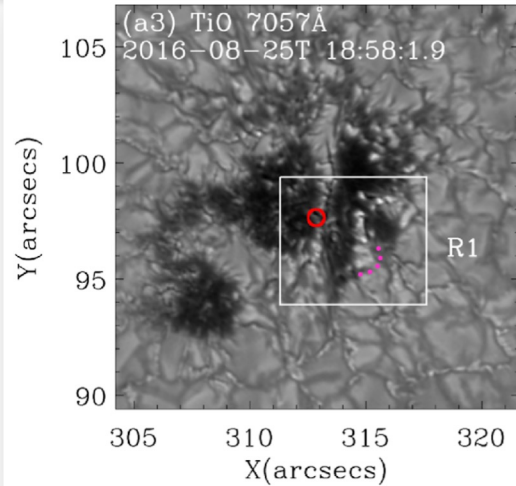


- Magnetic flux emergence in a LB that is of opposite polarity to that of the sunspot
- Recurrent jet-like ejections with brightenings were observed at the cancellation site, showing apparent horizontal extension at a projected speed of up to  $18.4 \text{ km s}^{-1}$  to form a fan-shaped appearance
- Based on these observations, authors suggested that the fan-shaped ejections may have resulted from slipping reconnection between the new flux emerging in the LB and the ambient sunspot field

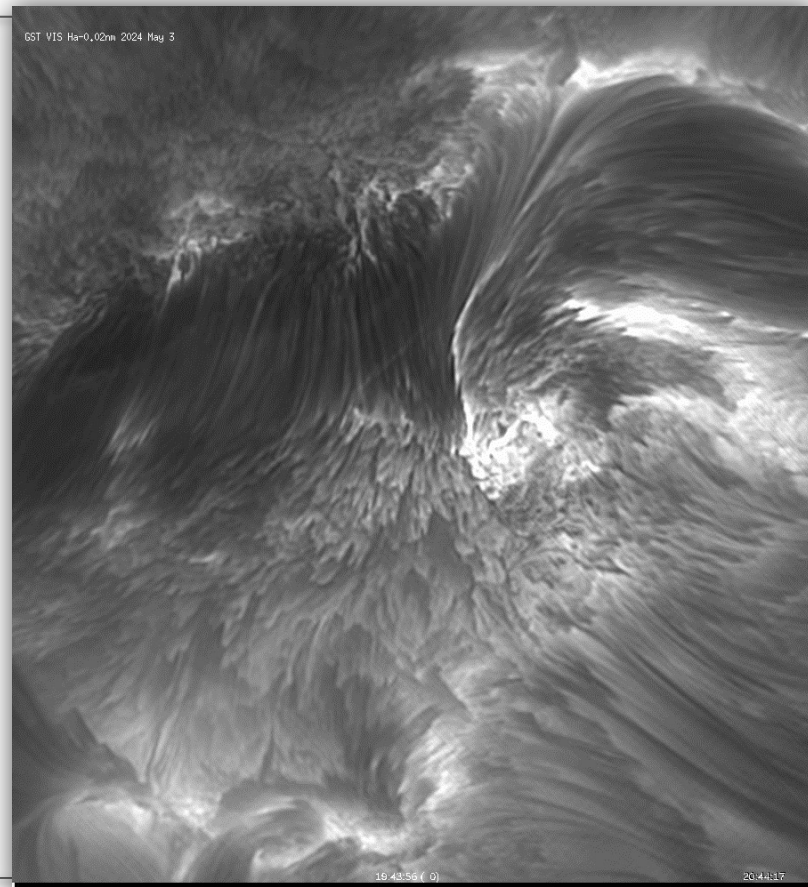
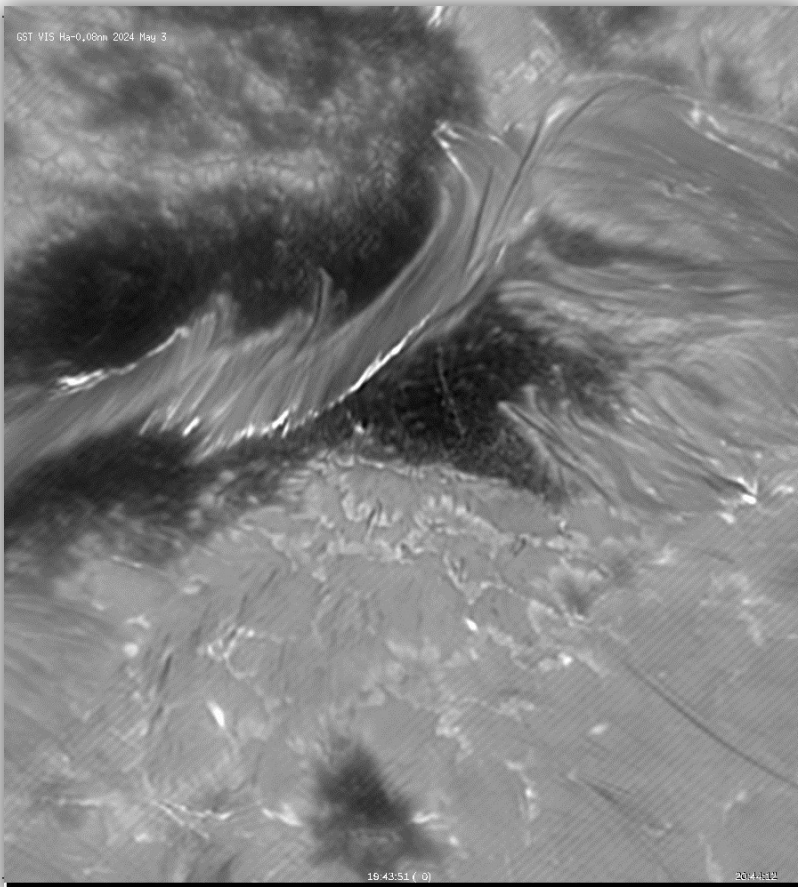


*Lim et al., 2020*





- Multi-wavelength analysis indicates that the fan-shaped jet could result from magnetic reconnection across the highly diverging field low in the chromosphere, leading to an apparent slipping motion of the jet material along the LB.
  - No opposite magnetic polarity was detected at the base of the jet
- Liu et al., 2022*

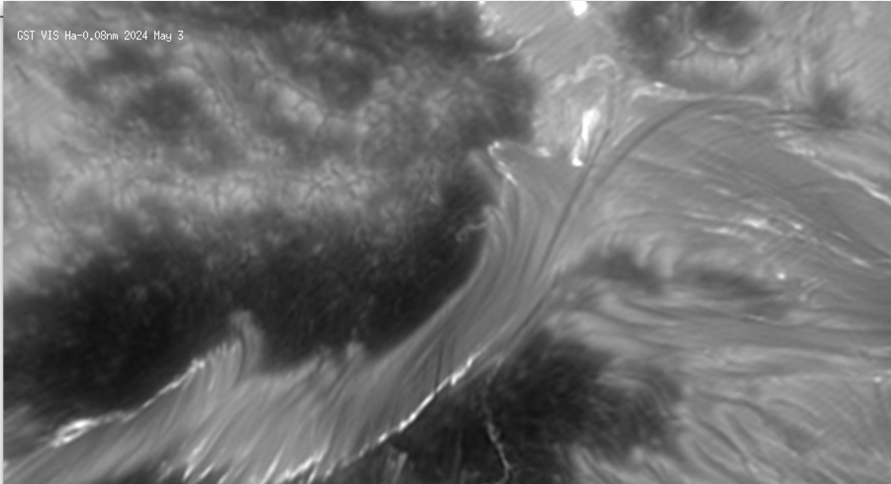




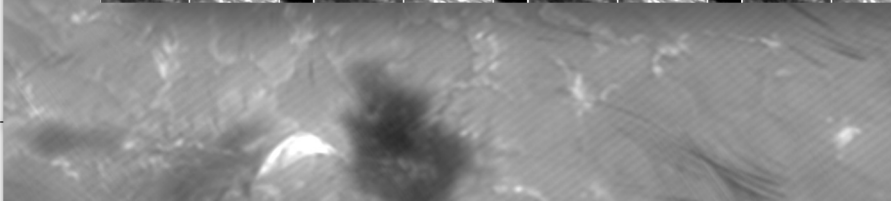
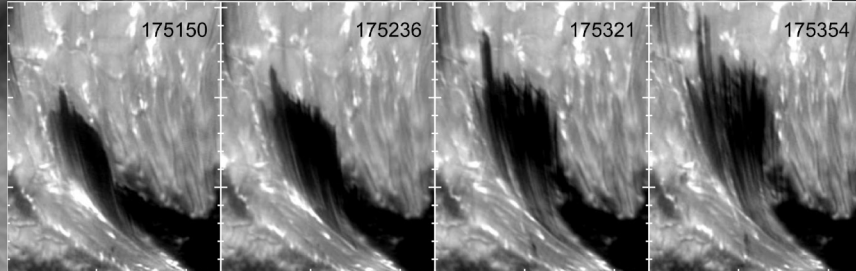
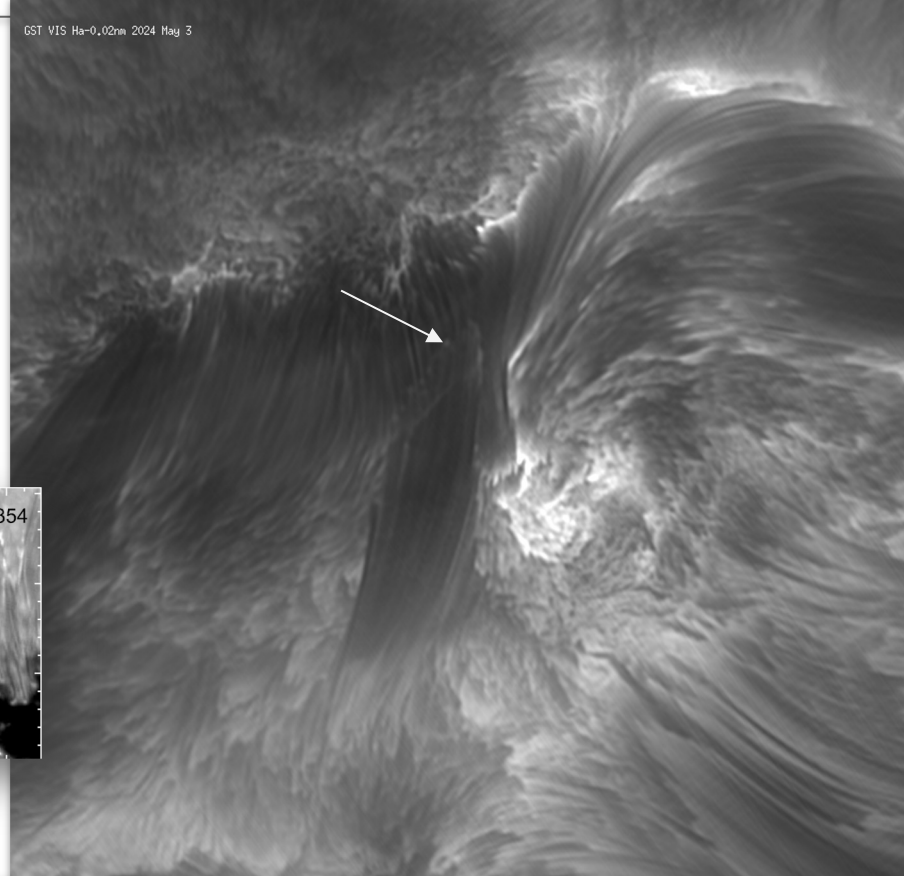
# Chromospheric Jets may Compress Plasma

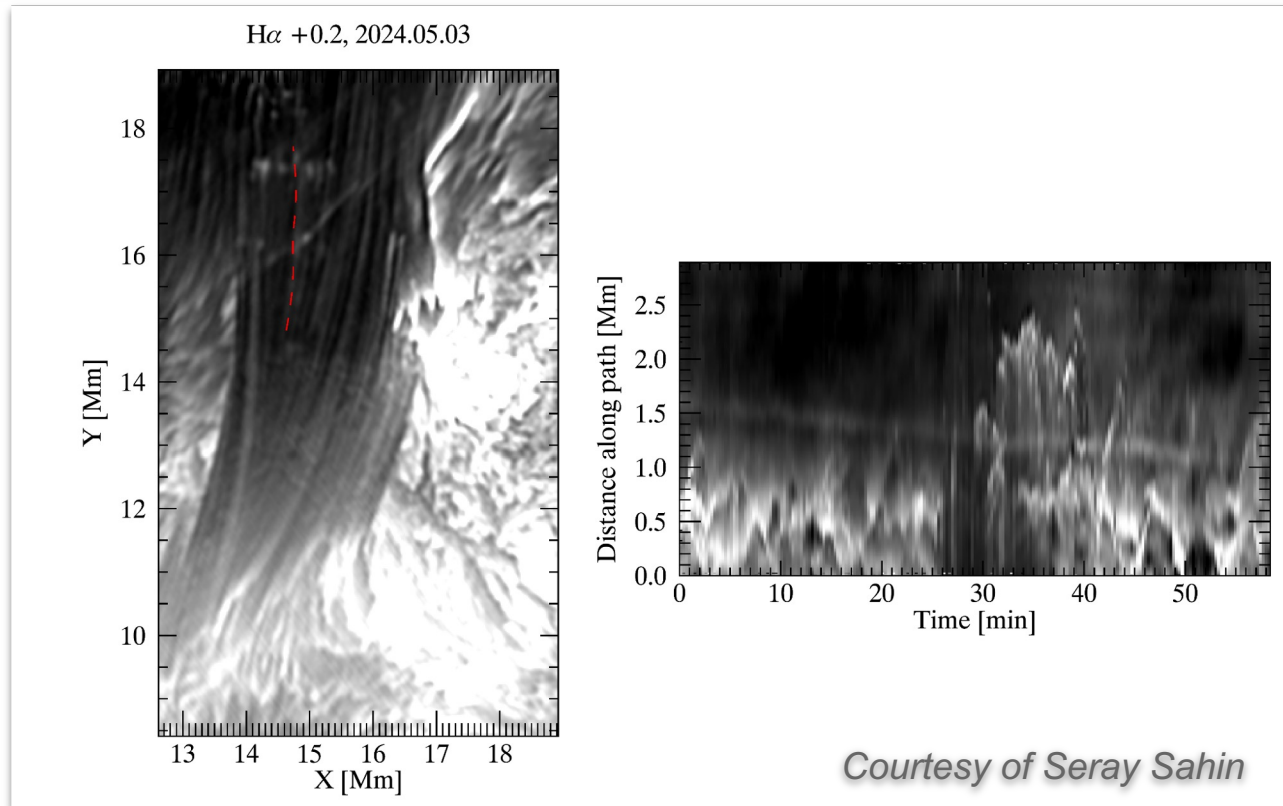


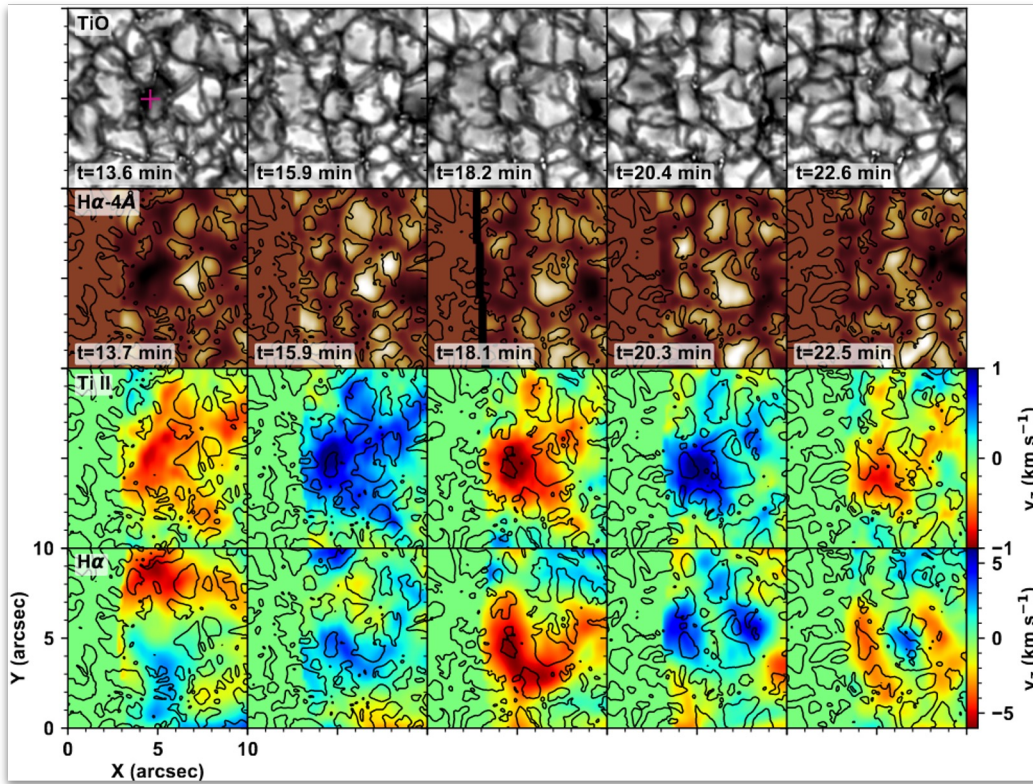
GST VIS Ha-0.08nm 2024 May 3



GST VIS Ha-0.02nm 2024 May 3

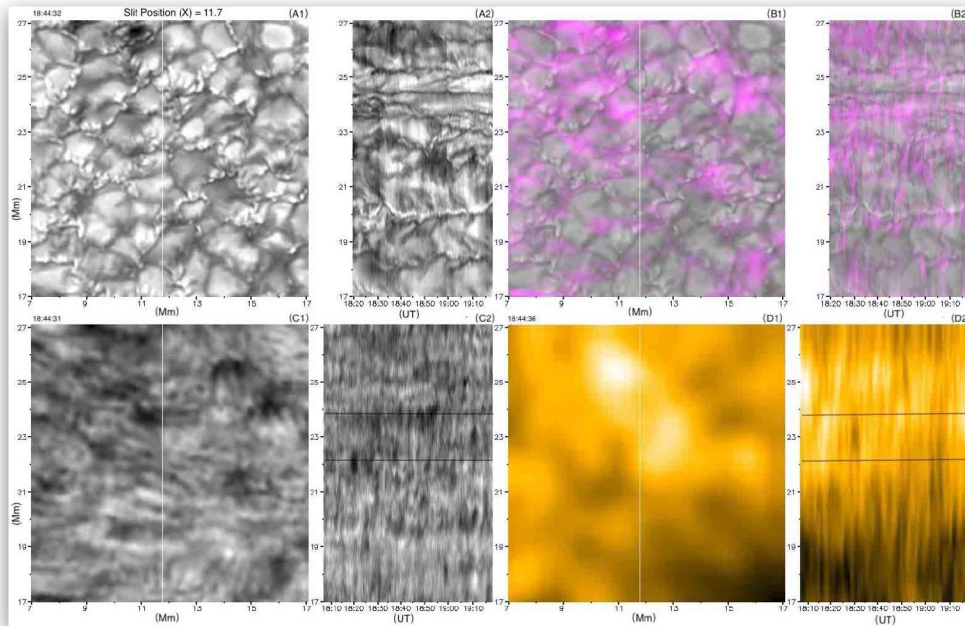




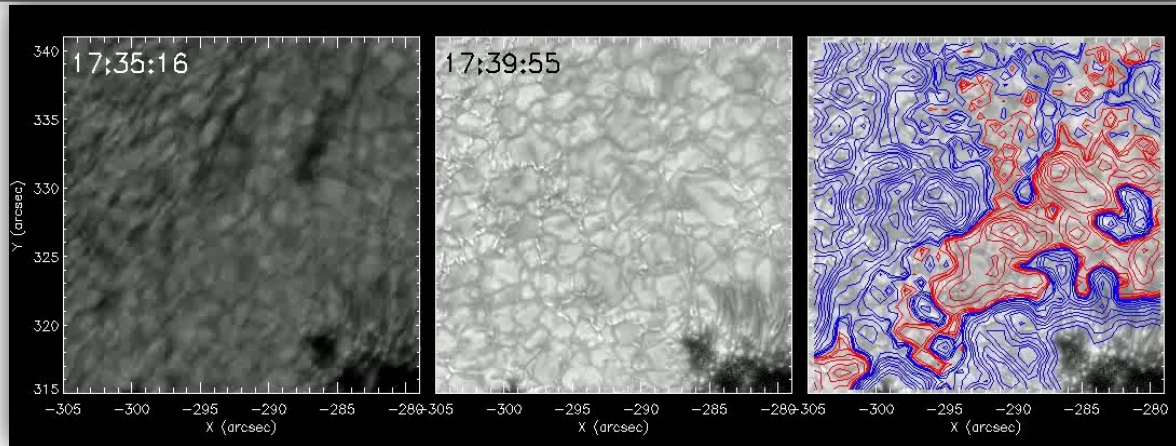


- FISS H $\alpha$  and Ca II 8542 Å observations of wave excitation by a new type of event: rapidly changing granules
- Granules in the internetwork region that undergo rapid dynamic changes such as collapse, fragmentation, or submergence appears to be associated with the occurrence of transient oscillations in photospheric and chromospheric layers with dominant periods of about 4 min.
- Ca II-0.5Å raster images also show repetitive brightenings at the location of the rapidly changing granules that are considered the manifestation of shock waves

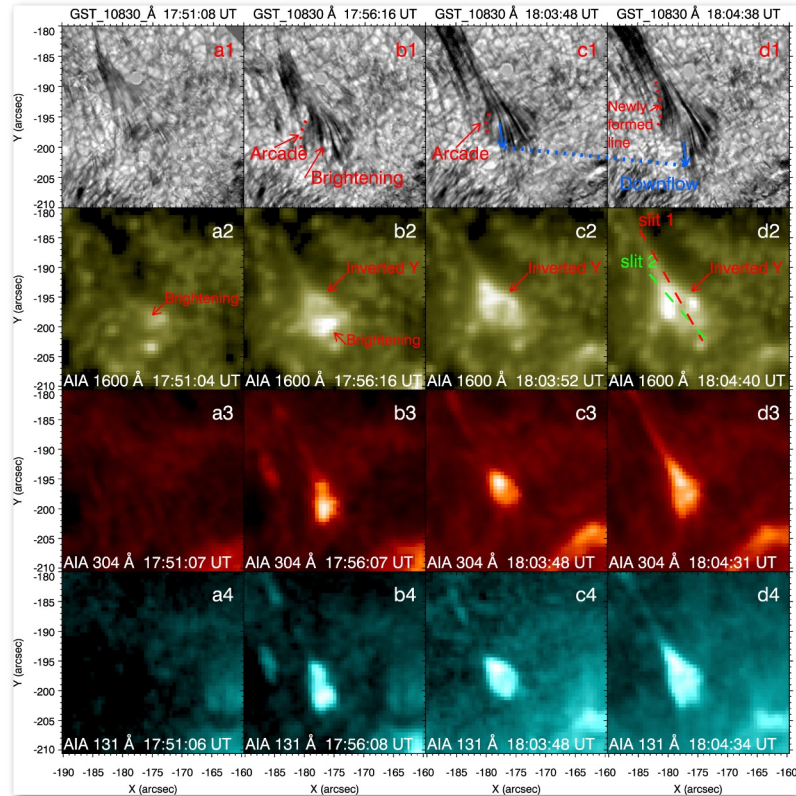
*Kwak et al., 2020*



- Repeated injections of 10830 Å material from inter-granular lanes with a period of ~ 5 minutes
- EUV emissions was found to be periodically modulated with similar periods of ~ 5 minutes
- Both EUV emissions and strength of the magnetic field are remarkably stronger near the injection area
- Peaks of the EUV emission time profiles were found to be in sync with oscillatory peaks of the stronger magnetic field in the region
- Observations present strong support to the idea that coronal heating is powered by magneto-acoustic waves



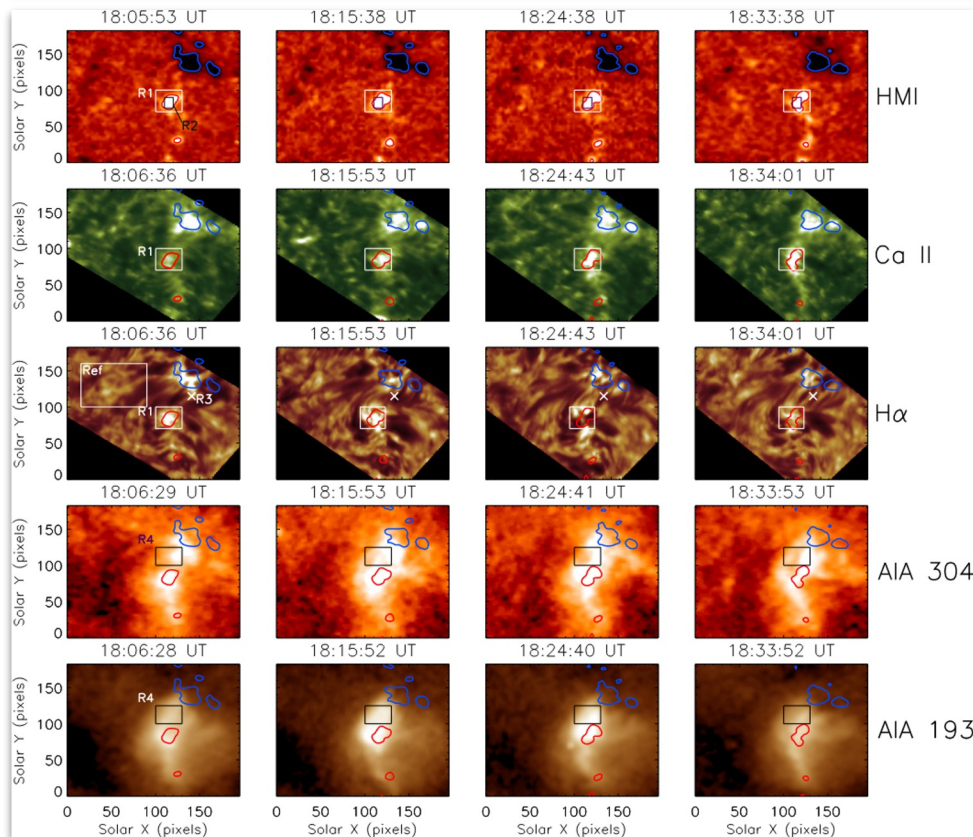
- The events were at the polarity inversion lines with their roots in intergranular lanes
- Two events were repetitive microjets, lasting 50 and 27 min, the other two were singular, lasting ~5 minutes. The recurrence was quasiperiodic with a period of ~5 minutes
- Transient cospatial EUV brightenings were only observed for the longer duration microjets, which were associated with active expanding granules and flux cancellation
- Reconnection may generate multi temperature plasma, including cool ejections at chromospheric temperatures
- Ongoing reconnection may be modulated by p-mode oscillations inside the Sun



- The event consists of multi temperature components observed in the 10830 Å, 1700 Å, 1600 Å. However, they are neither co-temporal nor co-spatial. The chromospheric counterpart displays fine structures. The widths of isolated threads range from 140 km to 250 km. The thin dark threads are rooted in the intergranular lanes.
- The jet displays an inverted Y structure. The activity begins in the low-temperature passbands (10830 and 1600 Å).
- The underlying photospheric activity includes flows, flux emergence and cancellation. The horizontal magnetic field is enhanced during the jet indicating the existence of a bald-patch magnetic topology.

Wang, Y. et al., 2021



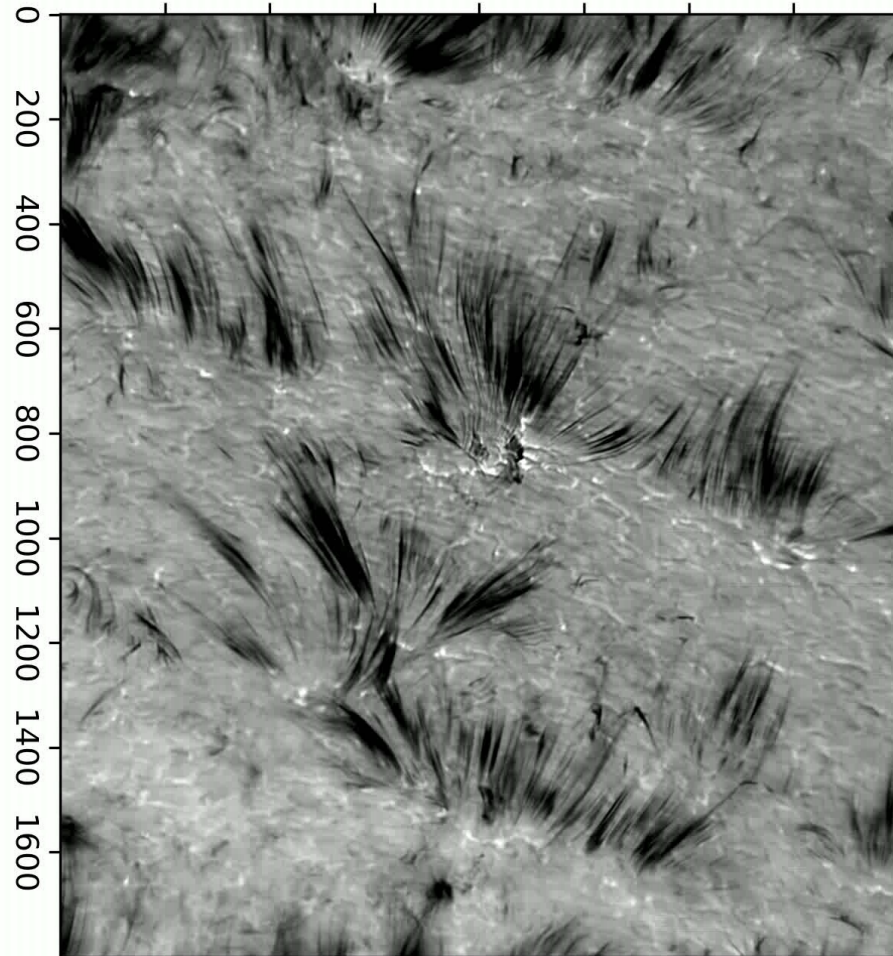


- FISS data allowed to study temporal variations of the coronal and chromospheric emission from CBP for the first time since Habbal & Withbroe (1981) work.
- H $\alpha$  and Ca II data allowed to trace changes of both intensities and Doppler velocities, and most importantly, of the hydrogen temperature based on a novel, recently developed inversion technique by Chae et al. (2020).
- The delay in the response of the chromospheric counterpart of the CBP could suggest that the heating occurs at coronal heights with a consequent heating of the CBP chromospheric counterpart.
- The study did not find evidence of additional heating due to magnetic reconnection associated with flux emergence.

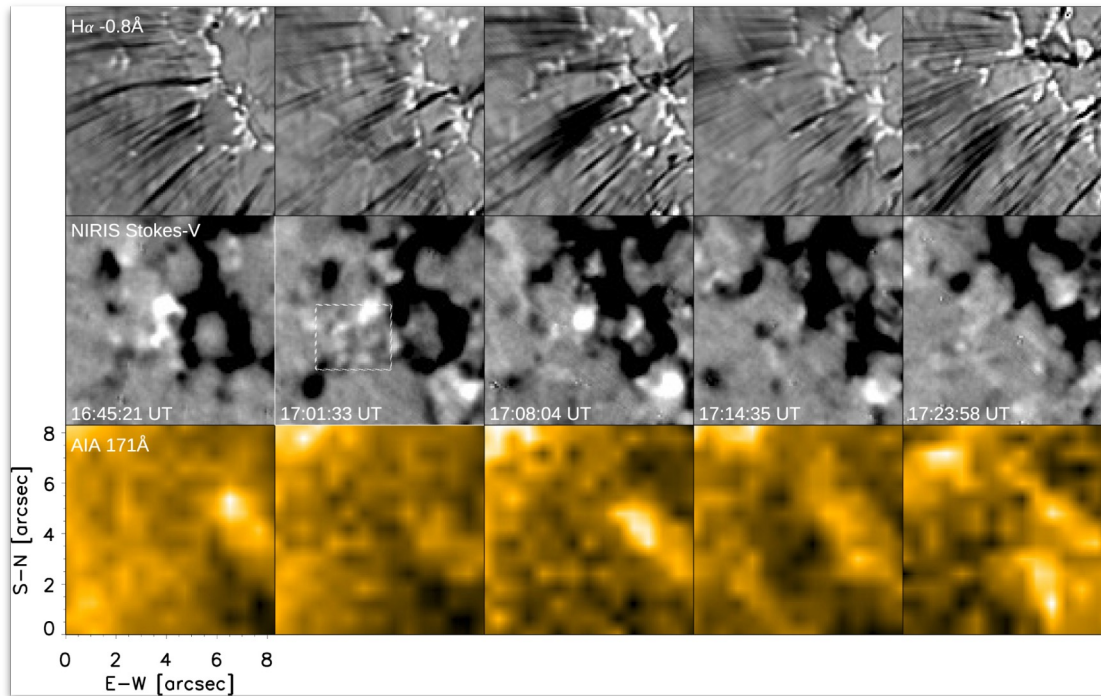
*Madjarska et al., 2021*



# GST/VIS Ha-0.8A, cadence 1s, span 4min



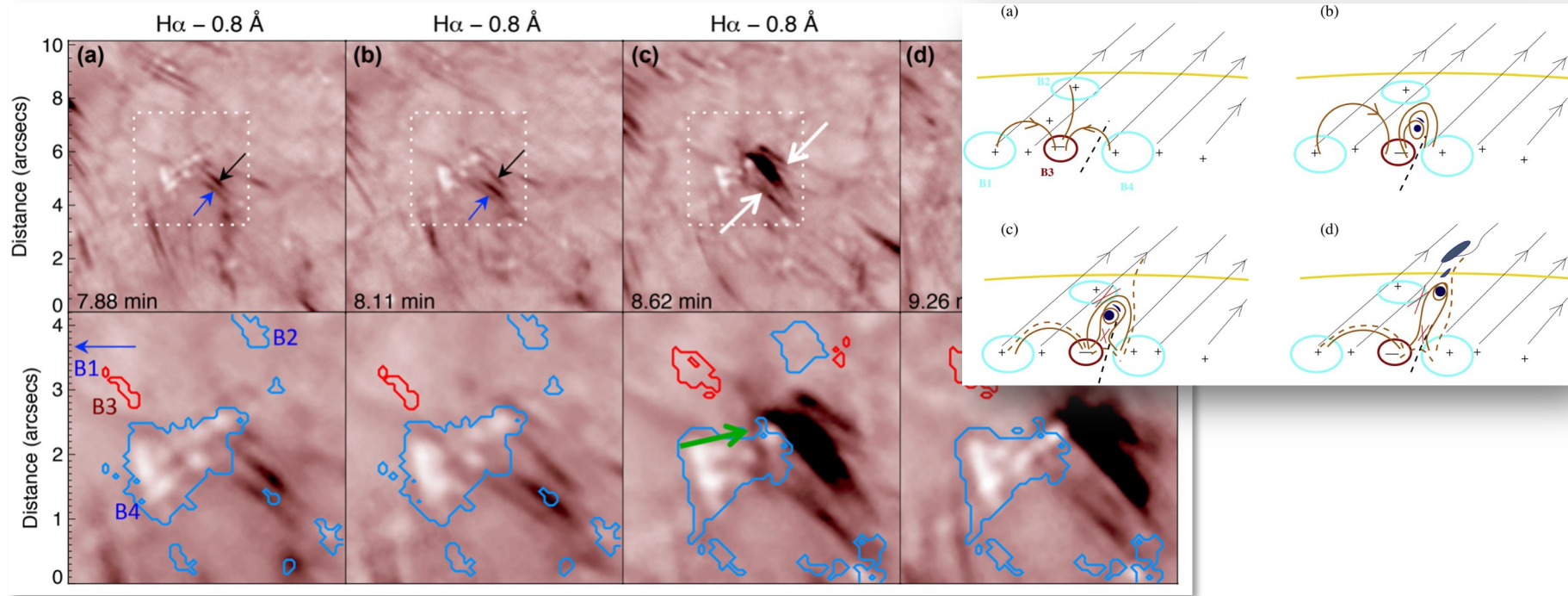
*Courtesy of Xu Yang (BBSO)*



- Net decrease in vertical magnetic flux is  $10^{18} \text{ Mx Mm}^{-2} \text{ hr}^{-1}$ , comparable to that in the QS. The energy released in CH is at the same rate as in QS
- Energy released in photospheric cancellations is sufficient for coronal heating. The free energy budget in CHs is sufficient for coronal heating and solar wind acceleration
- 7 out of 88  $H\alpha$  spicules have an AIA 171 Å counterpart
- 61 of 88 enhanced spicules are rooted near the network field cluster. Interactions between network and IN fields are closely associated with the spicule and jet-like eruptions

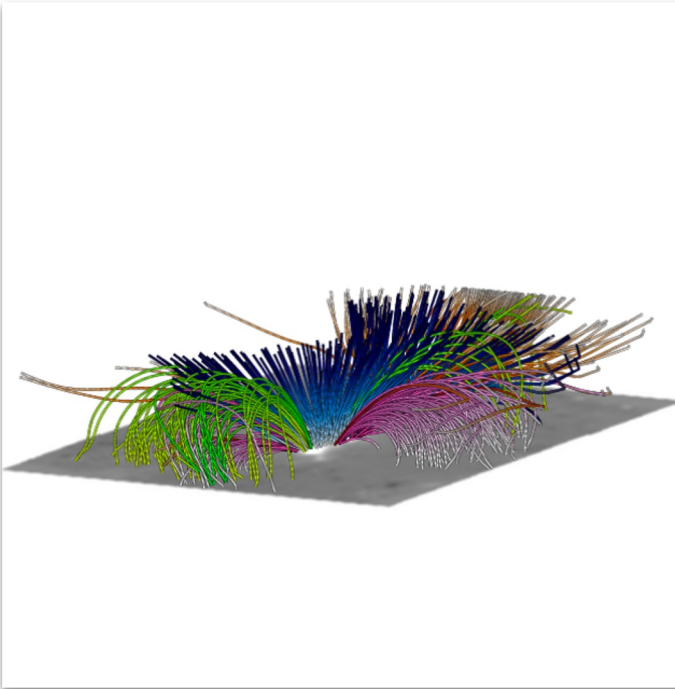
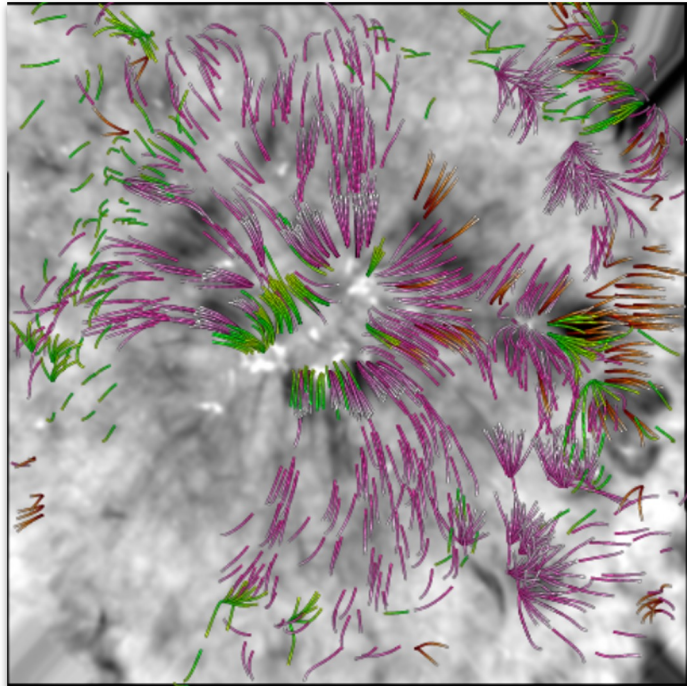
Wang, J. et al., 2022

# Microfilament Eruptions?



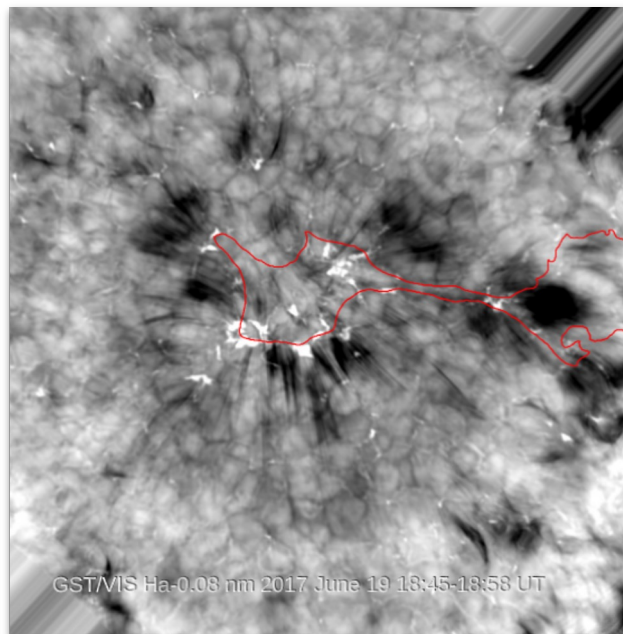
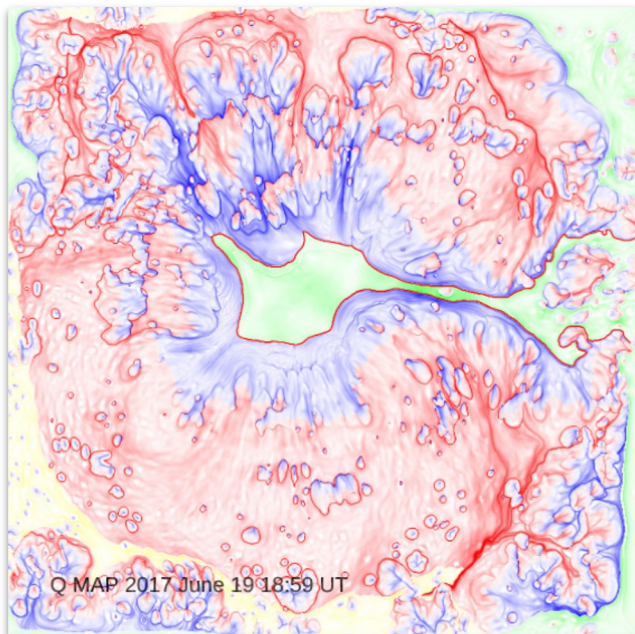
Spicules may be scaled-down versions of coronal jets that form via eruption of a microfilament flux rope built and triggered by canceling opposite-polarity magnetic fields.

*Sterling et al., 2020*



Analysis of a series of LOS magnetograms and potential field extrapolation showed that there are regions that consistently exhibit changes in loop connectivity, while other vast areas do not show such changes.

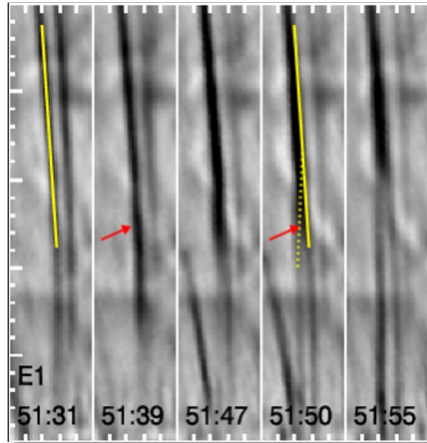
*Left: cumulative plot of all lines that i) closed (green), ii) "jumped" field lines (purple); iii) "opened" at a given pixel (red). Right: the same lines plus open field lines (blue) that did not show any status change described above.*



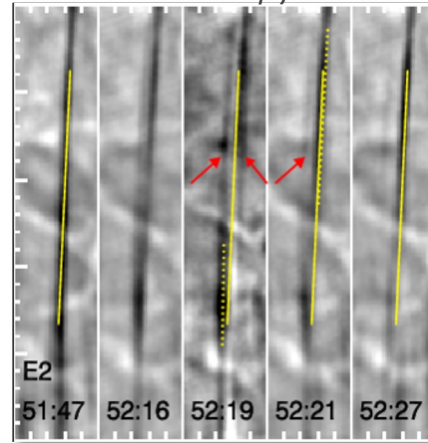
The photospheric footprint of the separatrix between open and closed loop systems well matches the roots of RBEs/RREs.

*Left: q-map calculated from the 18:59 UT extrapolated set. The blue and red shades indicate underlying polarity of LOS magnetic fields, while the yellow and green areas indicate patches with open field lines. The red contour highlights the boundary between open and closed field lines. Right: the average Ha-0.08 nm image with a red contour that is the same as in the left panel.*

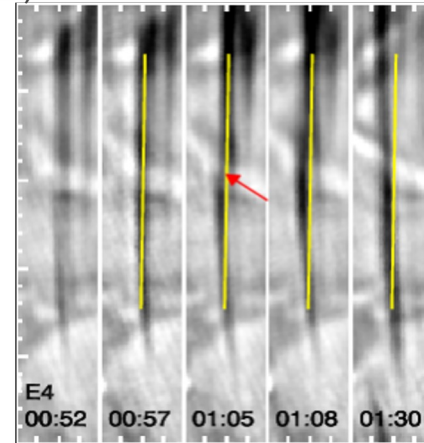
time stamp format: min:sec; tick marks at 0.2 Mm



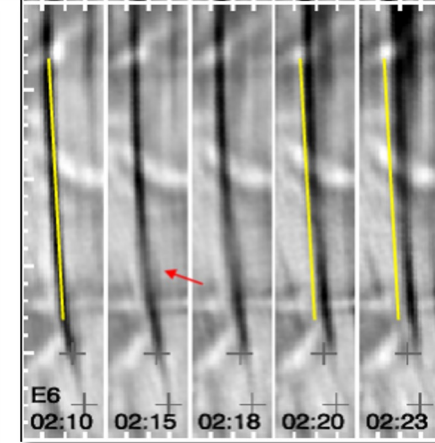
Inverted “Y/V” pattern



Peeling off new strands  
(25km/s)



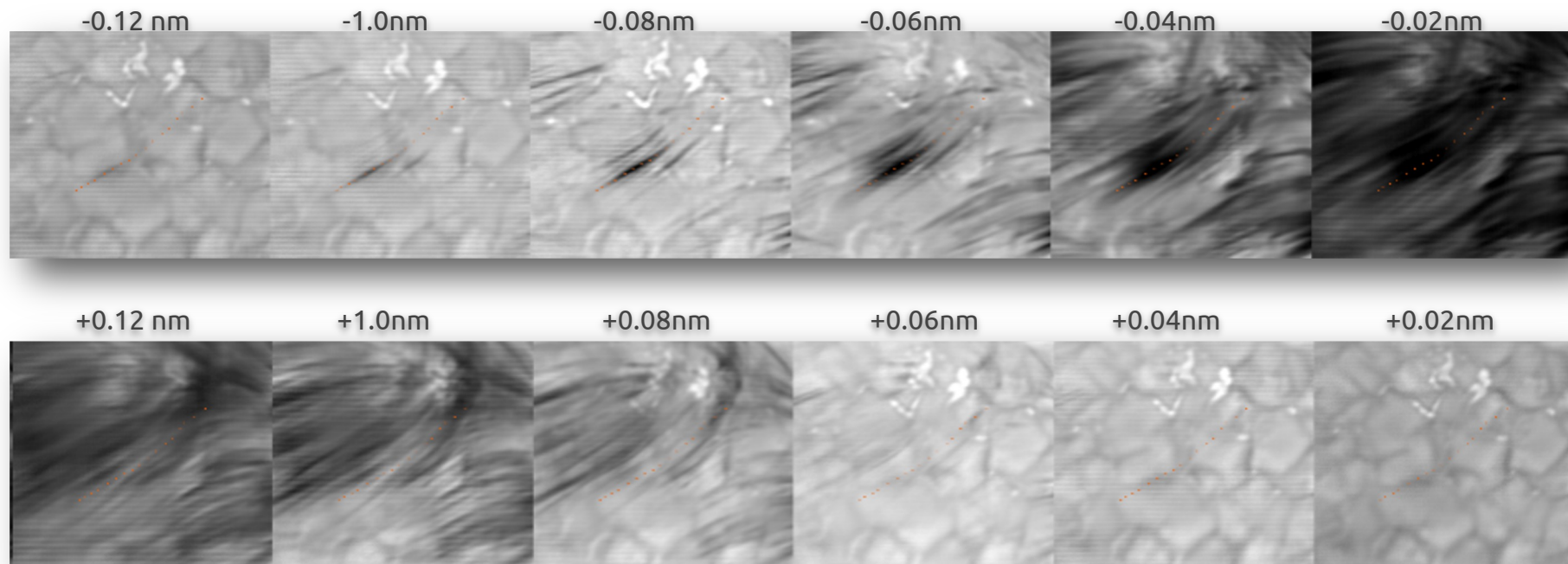
Broken RBEs pattern



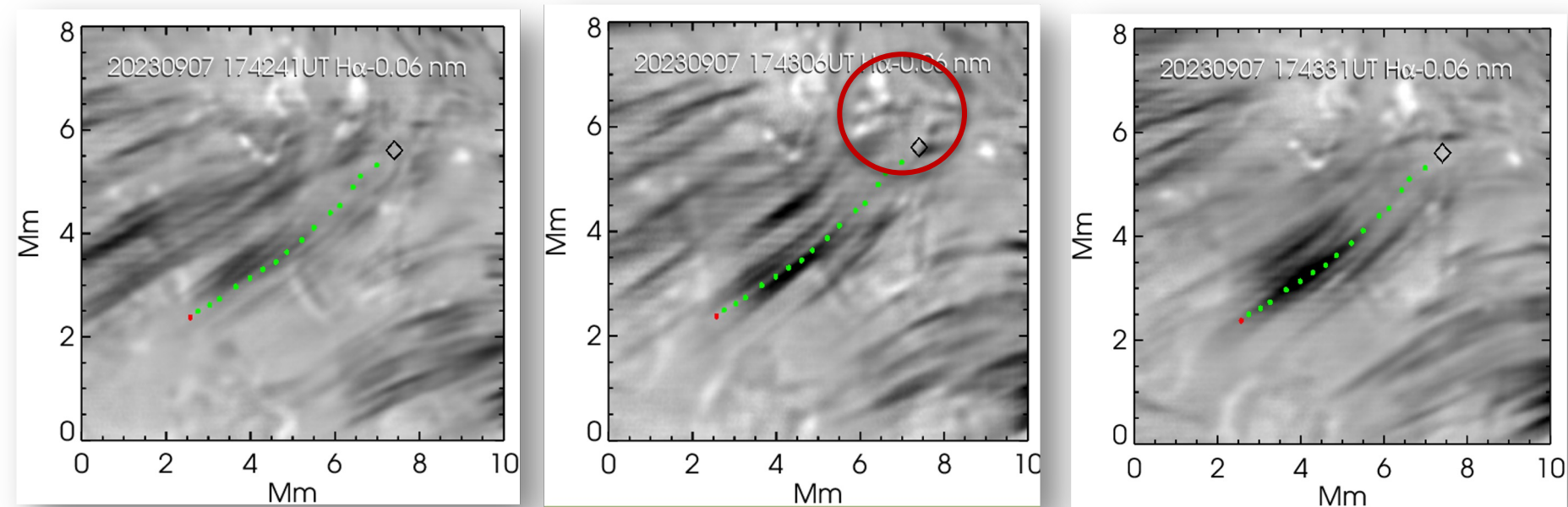
Ballooning (RBE displacement  
at 30-50 km/s rate)

- Various patterns of RBE evolution were observed, which are not consistent with evolution of jets
- RBEs evolve (split, extend downward, become diffuse) on a time scale of several seconds. Manifestation of “Parker’s” reconnection occurring along the length of the loop? *Yurchyshyn et al., 2020*

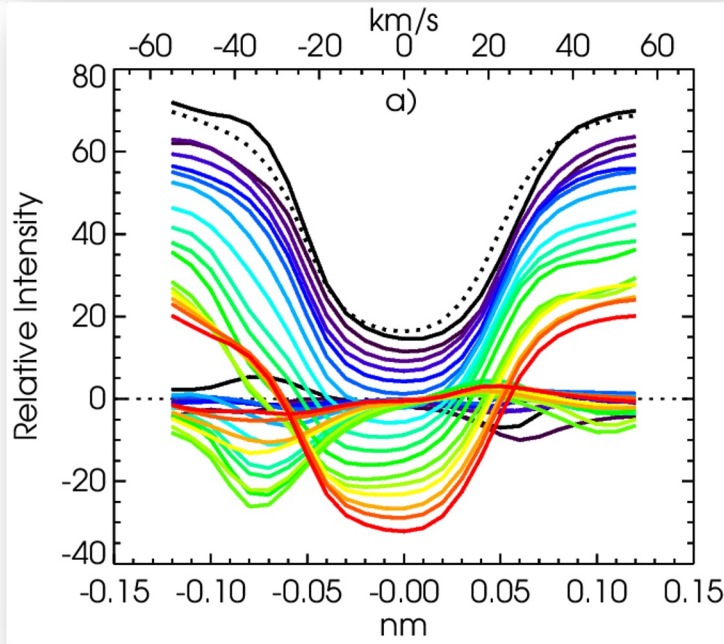
# An RBE Event as Seen in $H\alpha$



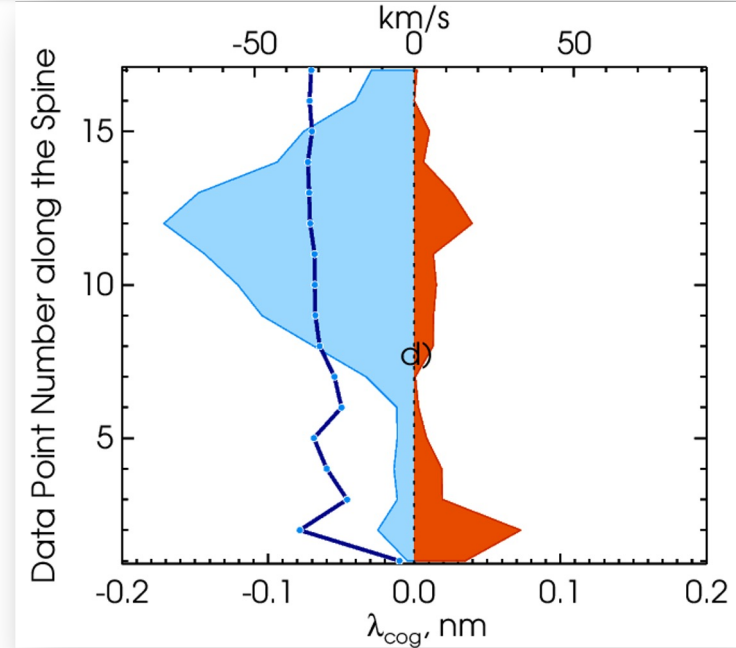




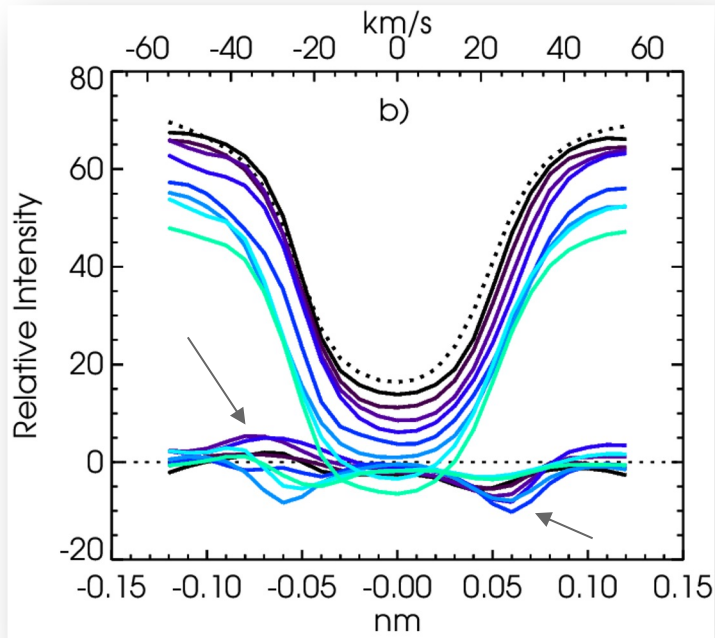
*The RBE does not appear to be extending to the photosphere; It showed some upward extension ( $\sim 30$  km/s) and no downward extension (only very faint traces can be detected in blue-shifted images). The black diamond indicates the inferred starting point and the red dot indicates the endpoint*



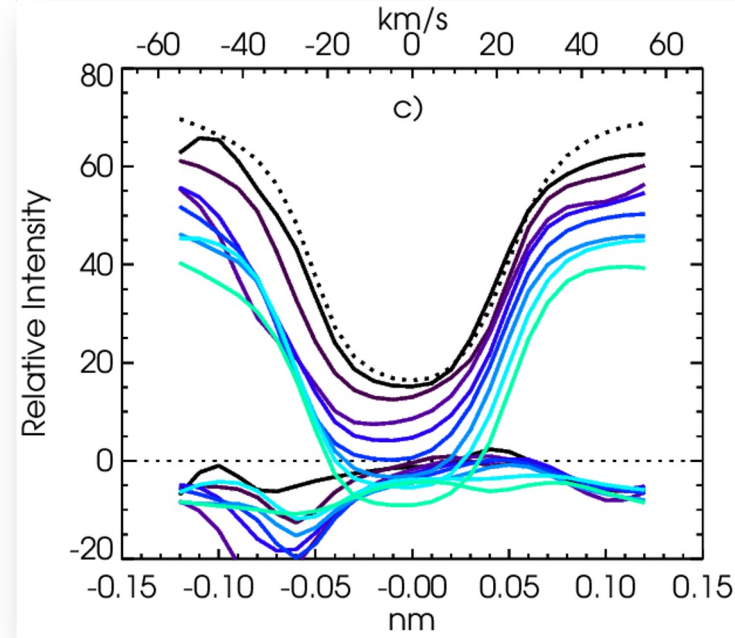
Black - RBE start point, red - endpoint; dotted line - average profile; horizontal curves - contrast profile = observed - average



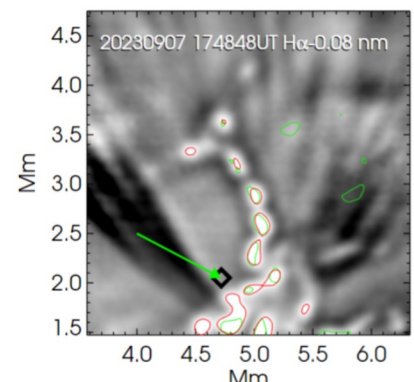
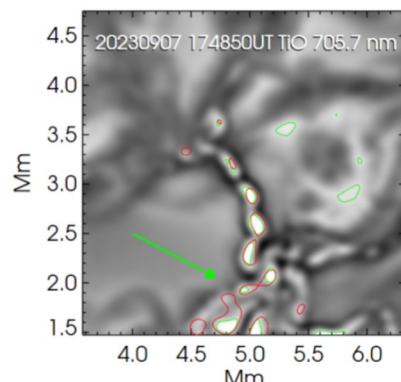
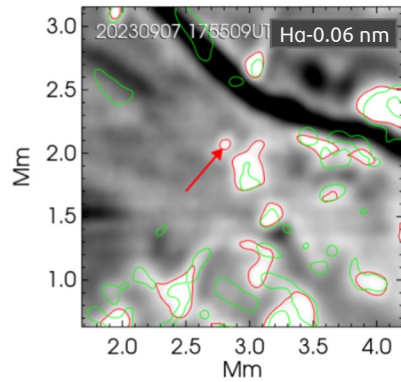
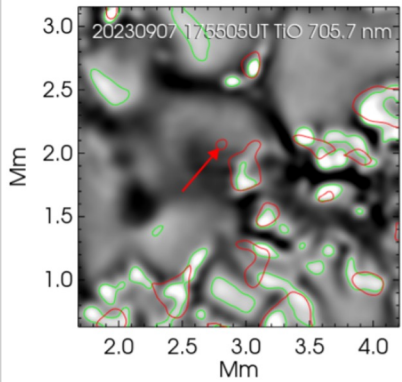
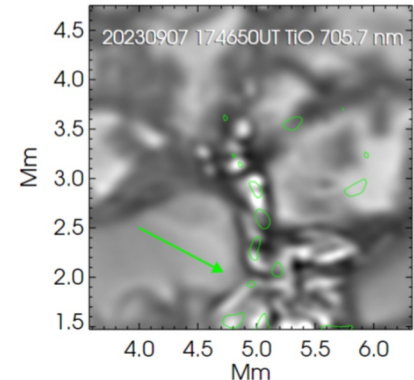
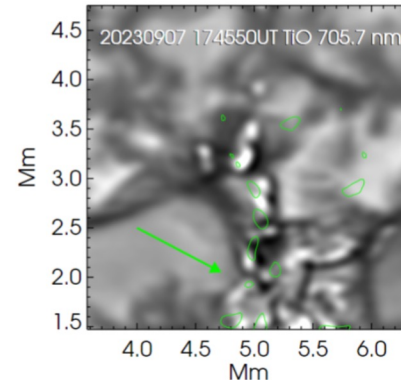
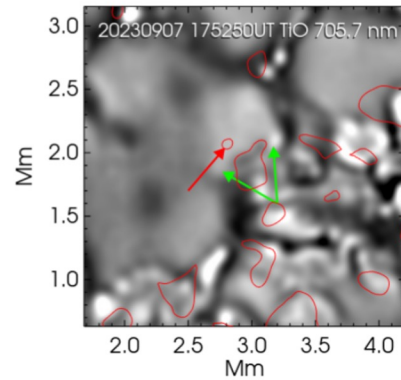
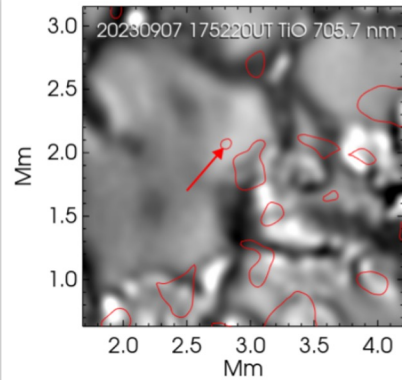
Vertical blue line - COG Speed; Blue/Red shaded area represent the depth of the contrast profile on the blue/red side of the spectral line



*Time evolution at the start point (black -> green)*  
 Note: i) -0.07nm intensity increase at the start of the event; ii) downflows at +0.06nm

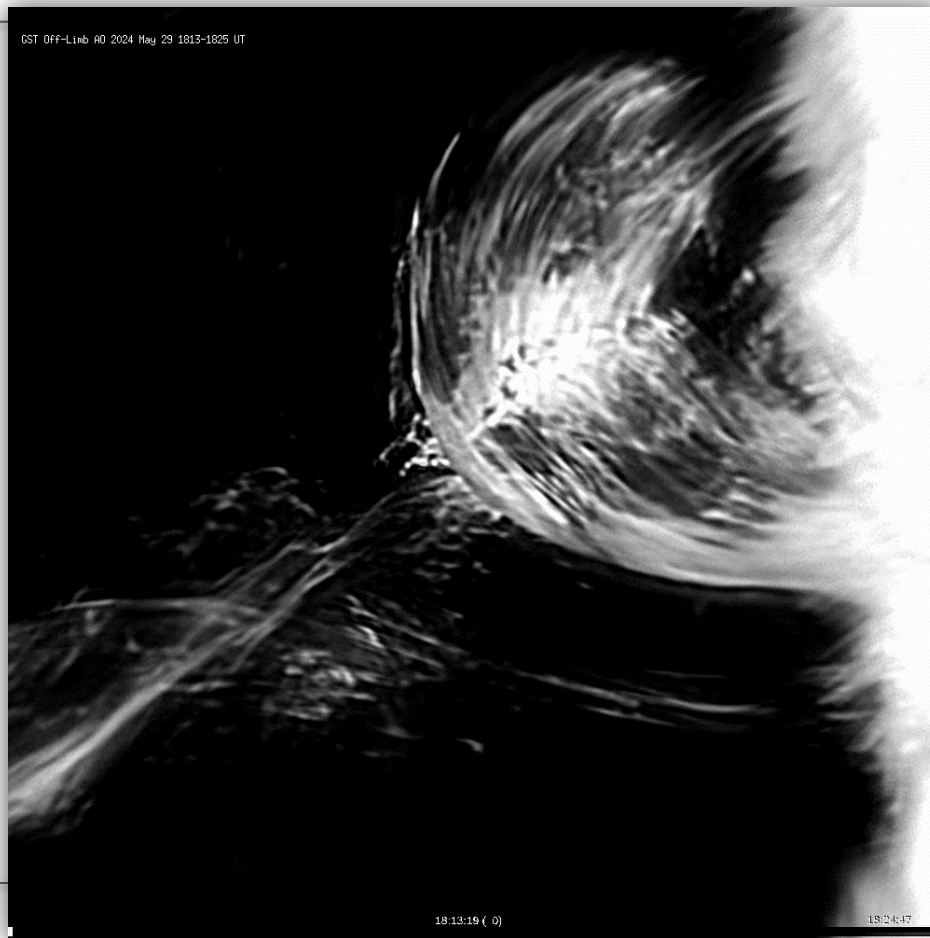


*Time evolution at middle point (black -> green)*  
 Note: variations of the depth of the contrast profile without significant changes in the doppler shift





# Digging with New Tools in Old Places





# 10+ Years of GST: Live (sort of) Collection of Results



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We have tested recent claims that the magnetic switchbacks (SBs) detected by the Parker Solar Probe (PSP) carry information on the scales of solar supergranulation and granulation using the high-resolution H-alpha images obtained with GST. As possible solar sources for SBs, we counted all the spicule-like features standing along the chromospheric networks near the coronal hole boundary visible in the H-alpha blue-wing but absent in the red-wing images and measure the geometric parameters of dense sections of individual flux tubes such as lengths, diameters, and inter-distances between them. We found that spicules standing along a chromospheric network near the coronal hole boundary present similar scales to the medium scale of SBs, but tending to be smaller than them. Considering the number of spicules within a network as high as 40-100, and the typical network diameter of  $0.6^{\circ}\text{C}-1.8^{\circ}\text{C}$ , we argue that the medium scale of SBs can, in fact, be understood as an equilibrium distance between flux tubes in solar wind resulting from random walk within each diverging magnetic field funnel.

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[10+ Years of GST: Collection of Results](#)

[GST Publications \(ADS List\)](#)

**"The Sun Watchers"**  
AstronomyOutreach network

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## 10+ Years of GST: Collection of Science Publications (1999-2022)

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