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Flame-like Ellerman Bombs and their Connection to UV Bursts

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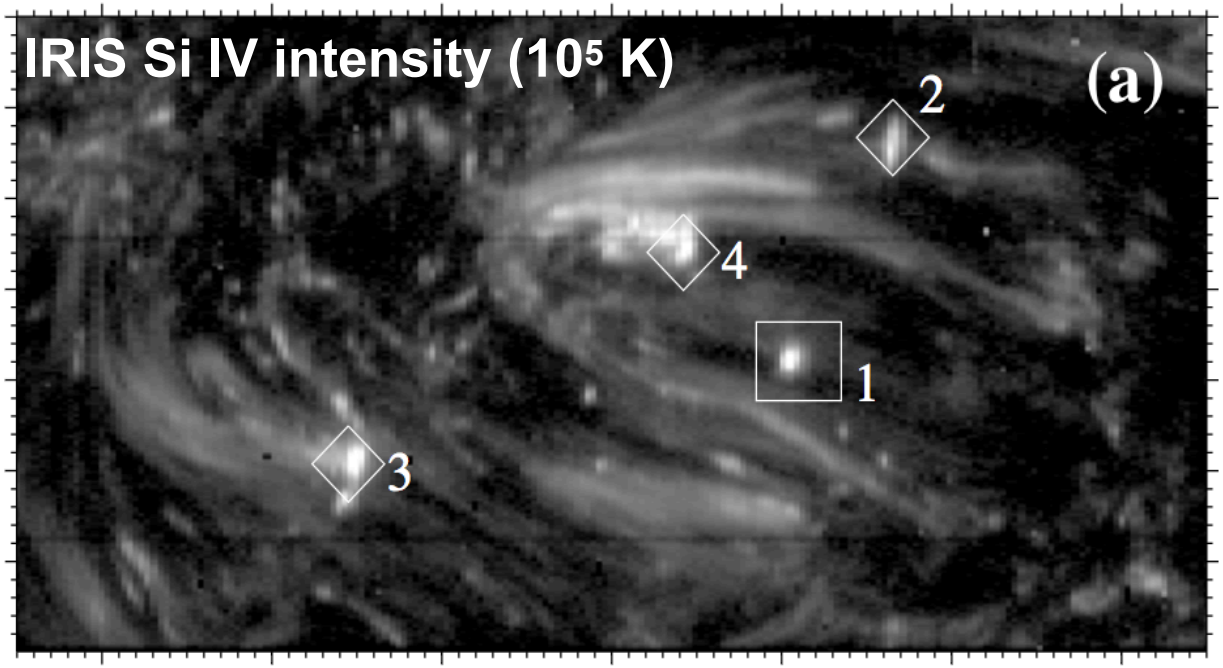
3. Big Bear Solar Observatory, New Jersey Institute of Technology
4. Center for Solar-Terrestrial Research, New Jersey Institute of Technology

UV bursts (IRIS bombs)



Peter, Tian, Curdt, Schmit, Innes, et al. 2014, Science

- Small-scale compact transient brightenings in TR (~10^5 K) images

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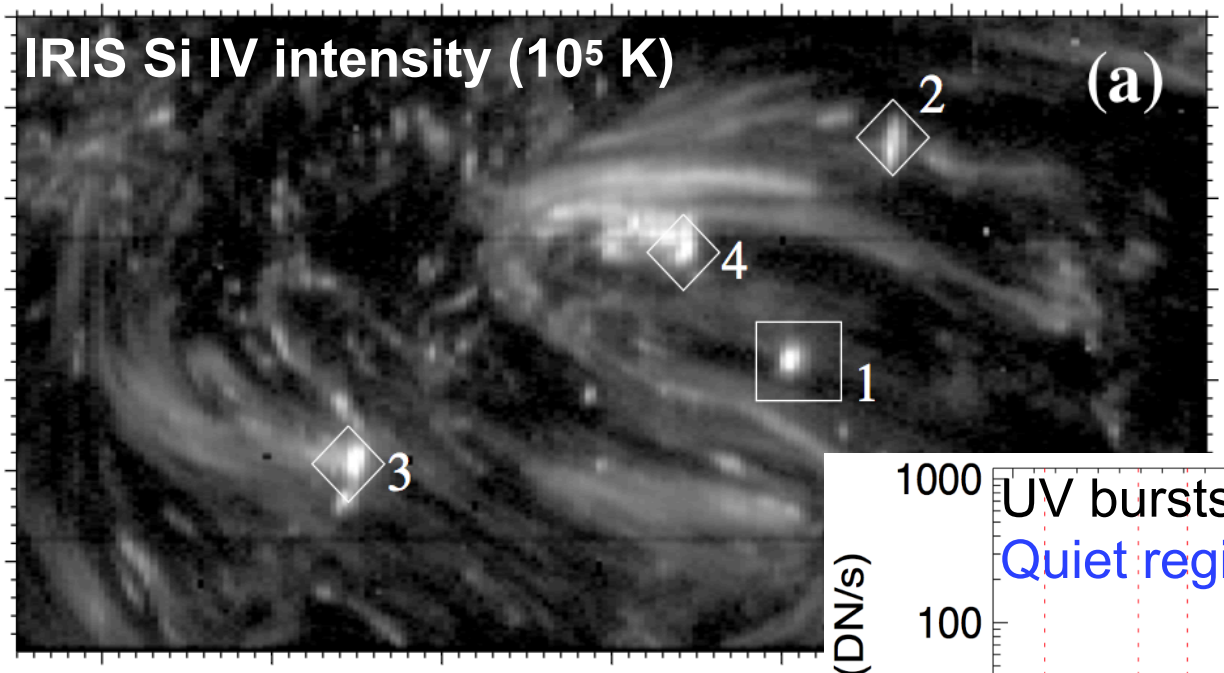

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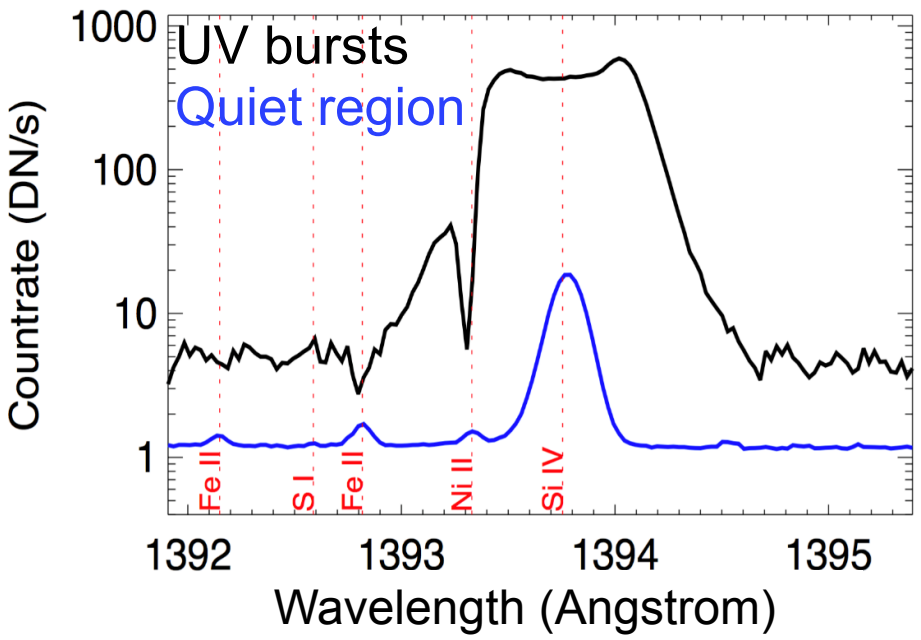
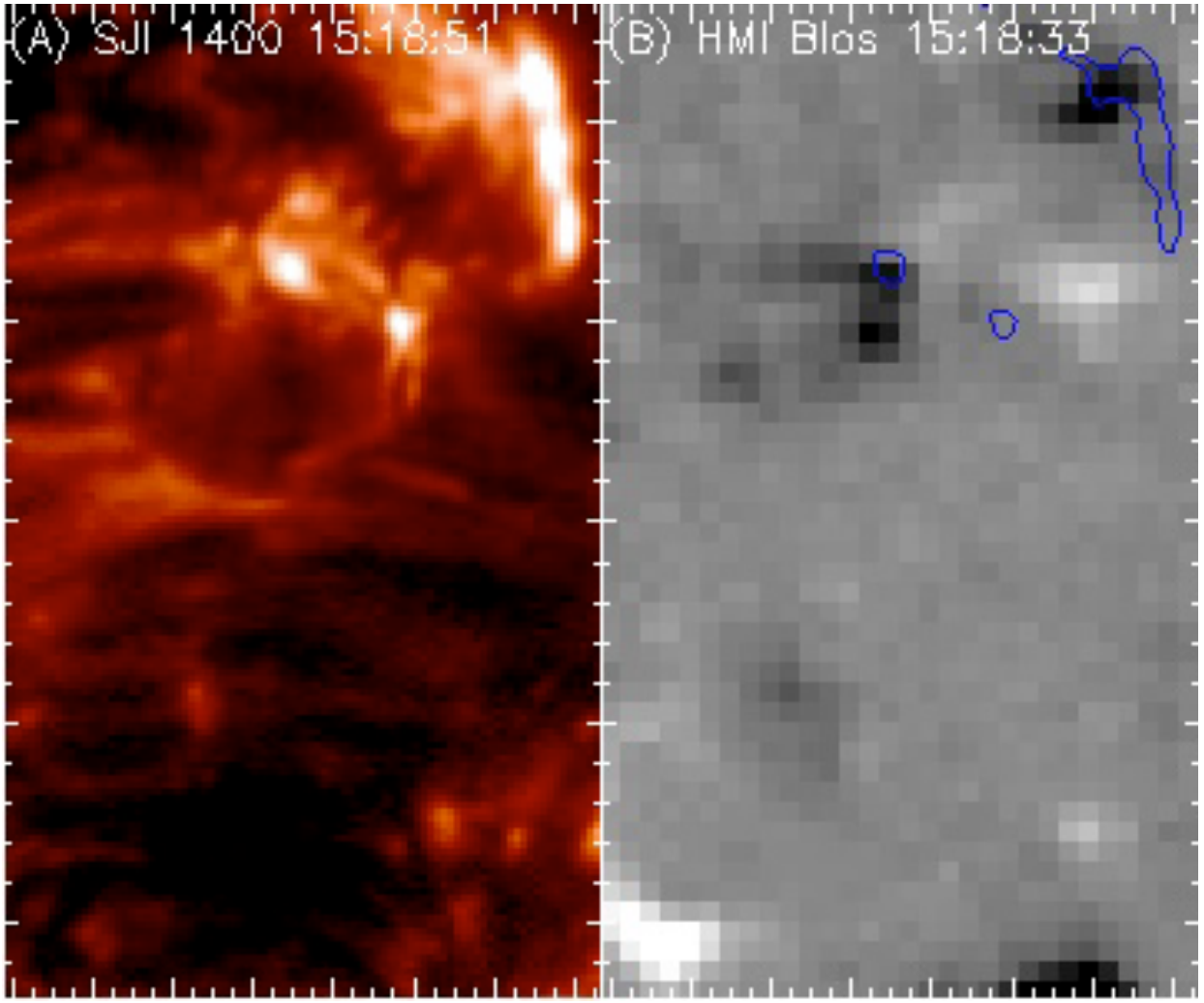


Tian, Xu, He et al. 2016, ApJ

- Chromospheric absorption lines superimposed on the greatly broadened and enhanced TR line profiles: heating of lower atmosphere to ~10^5 K

UV bursts produced by reconnection

Transition region (10^5 K) Magnetogram (B_{los})



- Most UV bursts appear to result from interactions between magnetic fields with different polarities.
- Flux cancellation with a rate of ~10^{15} Mx/s can be clearly identified for many bursts, suggesting the occurrence of reconnection (e.g., Wang & Shi, 1993; Priest et al. 1994)

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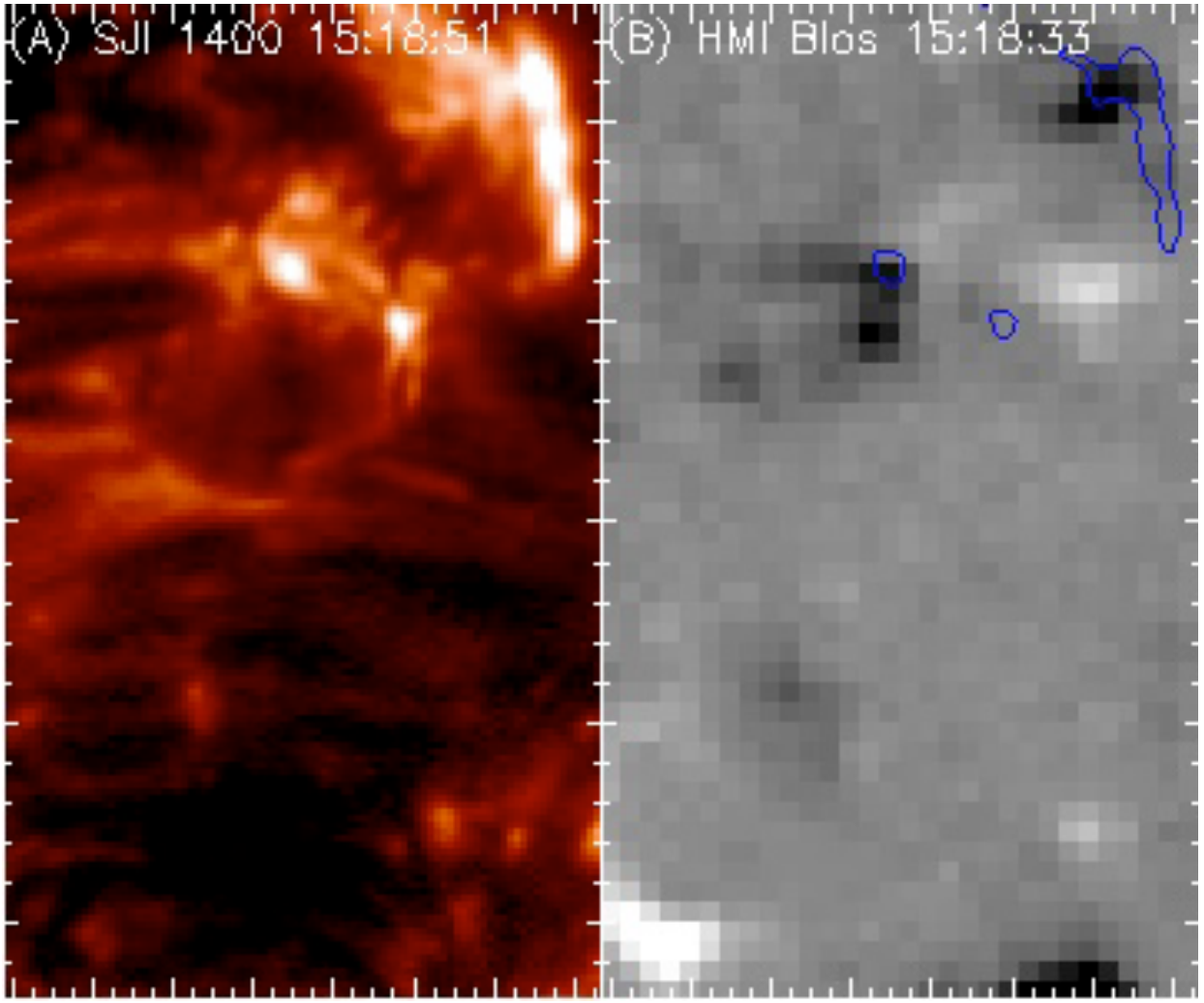

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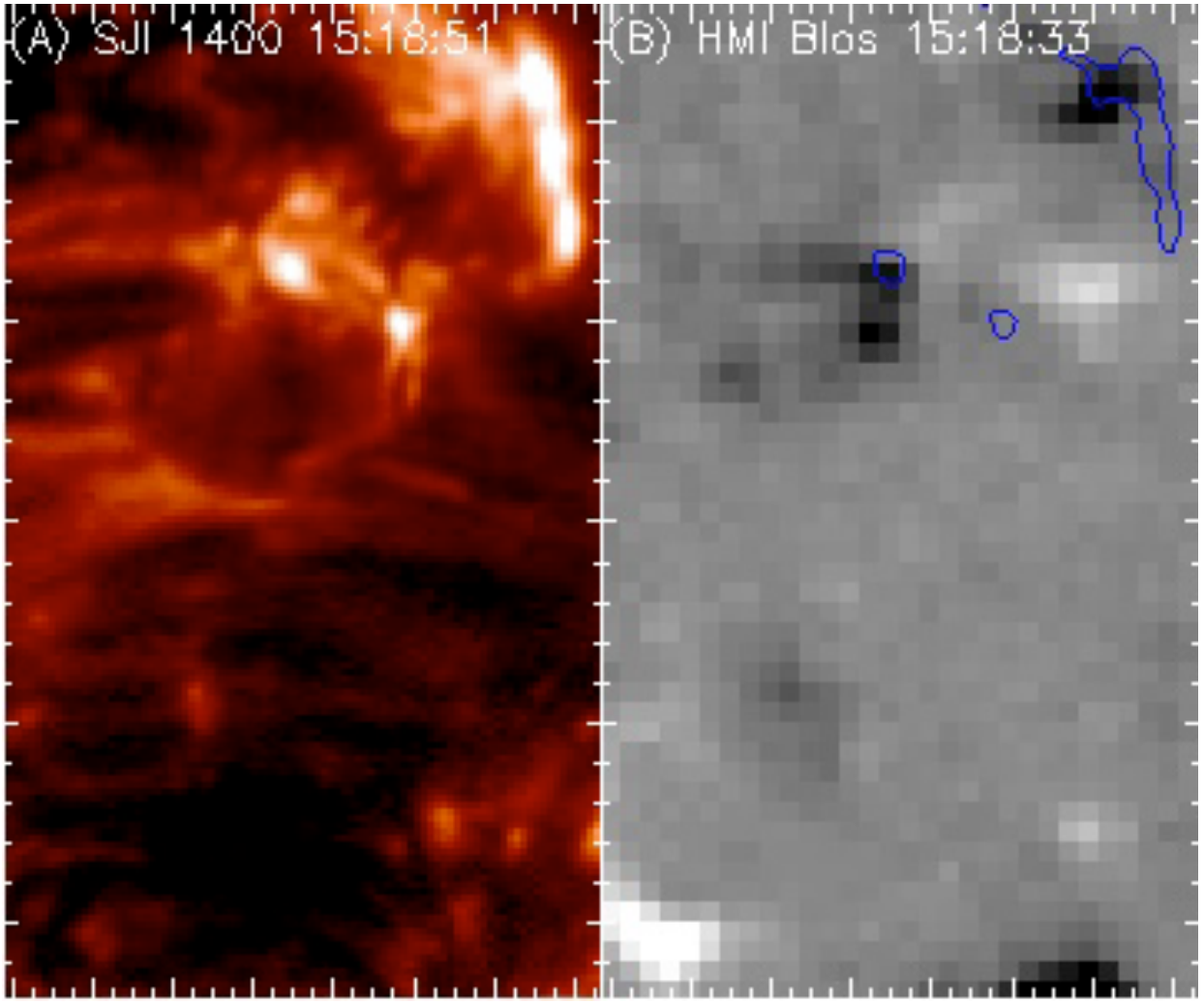

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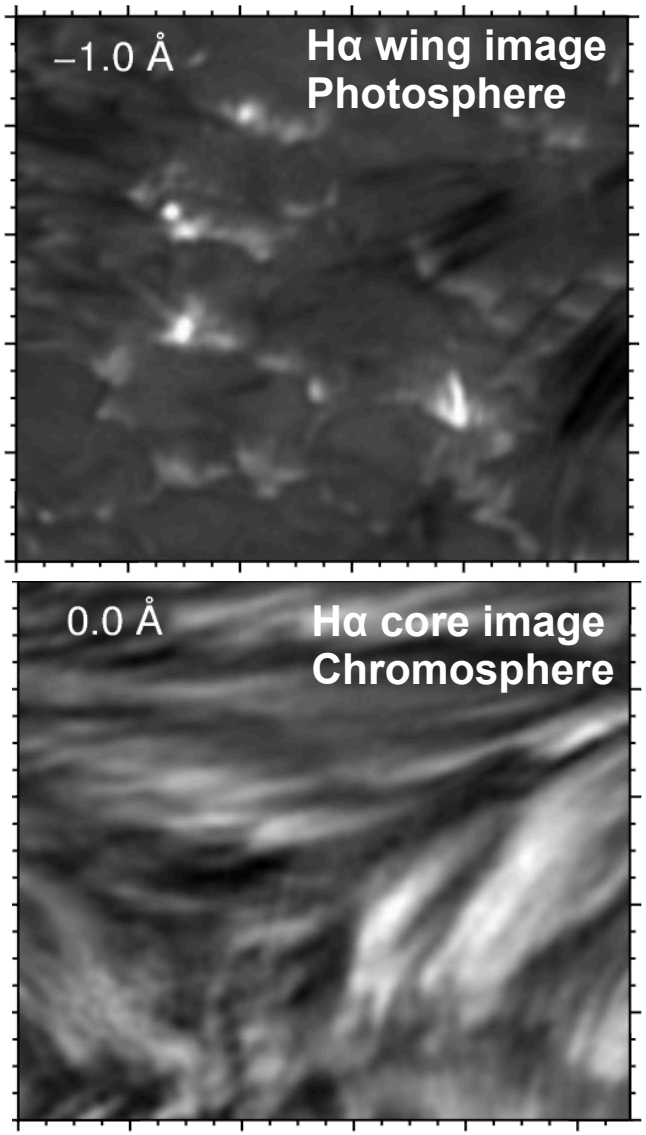
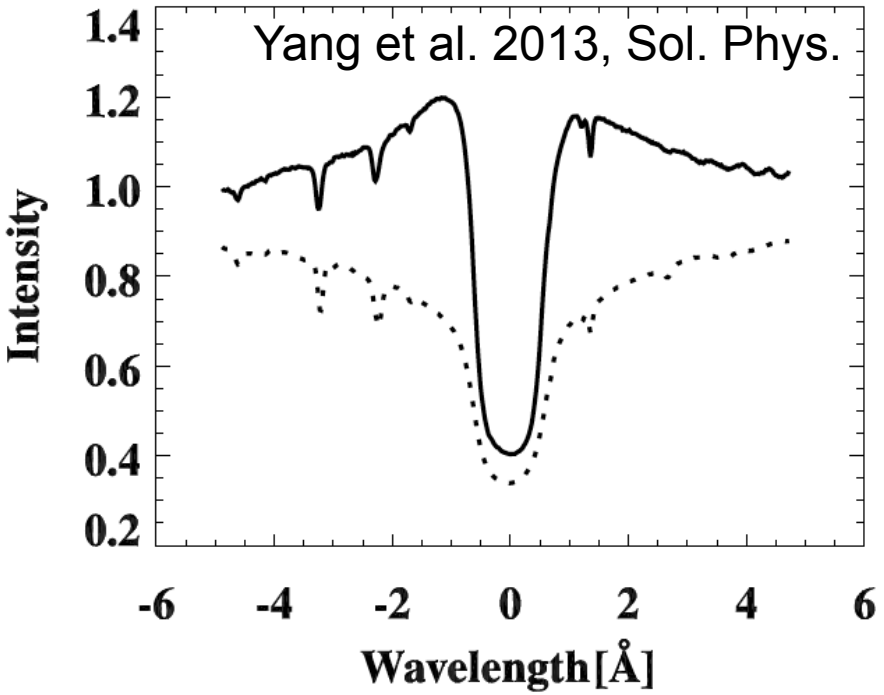
Ellerman bombs (EB)



Watanabe et al. 2011, ApJ



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- Signatures of heating by reconnection around temperature minimum region (TMR).
- $T<10^4$ K

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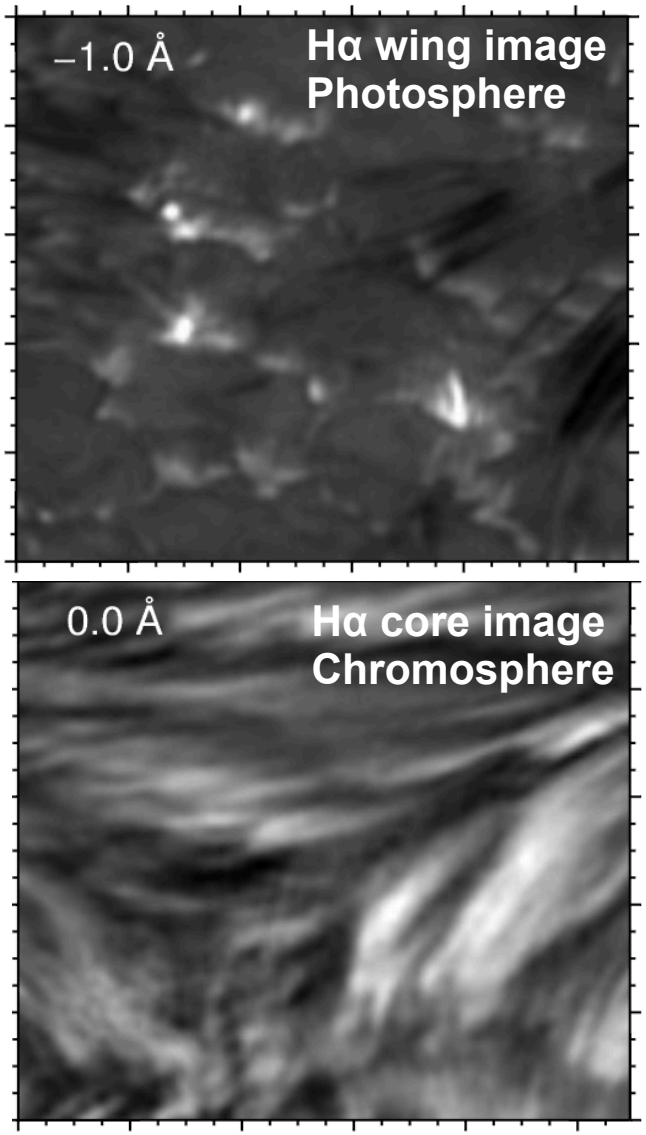

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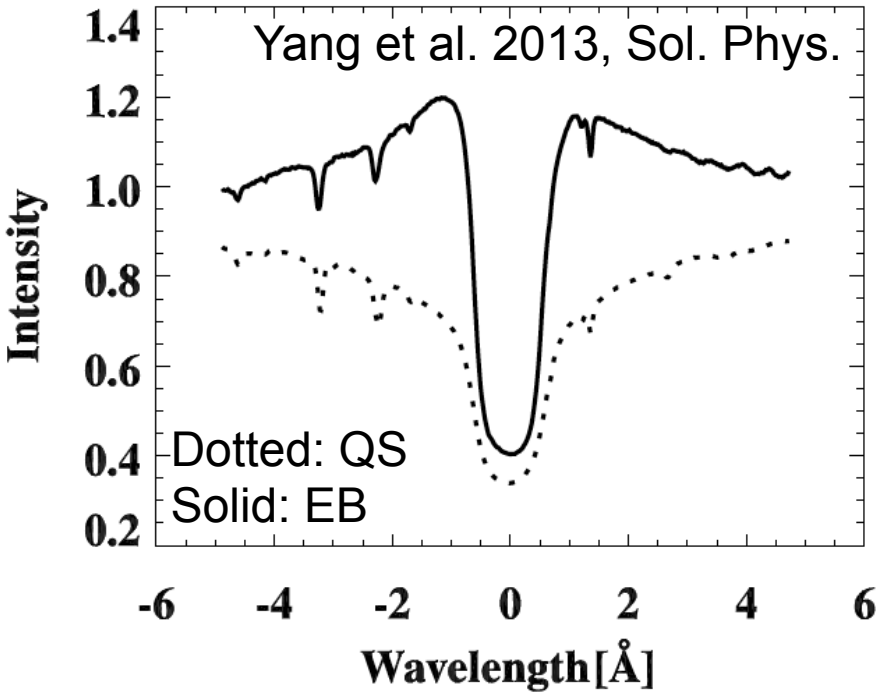

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Connection to Ellerman bombs

UV bursts (~10^5 K) Ellerman bombs (<10^4 K)

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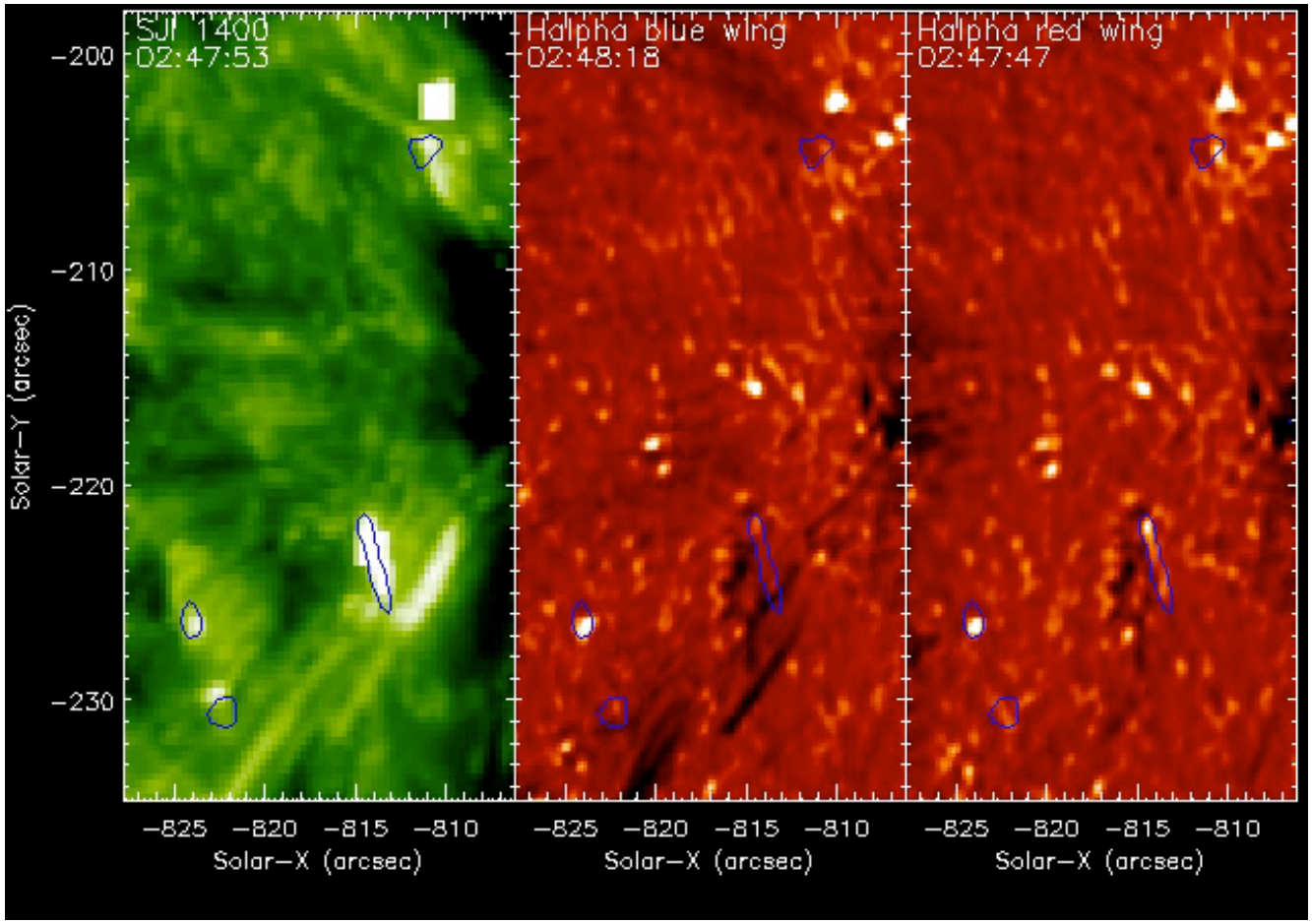

NVST

Tian, Xu, He et al. 2016, ApJ

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Also see Vissers et al. 2015, Kim et al. 2015

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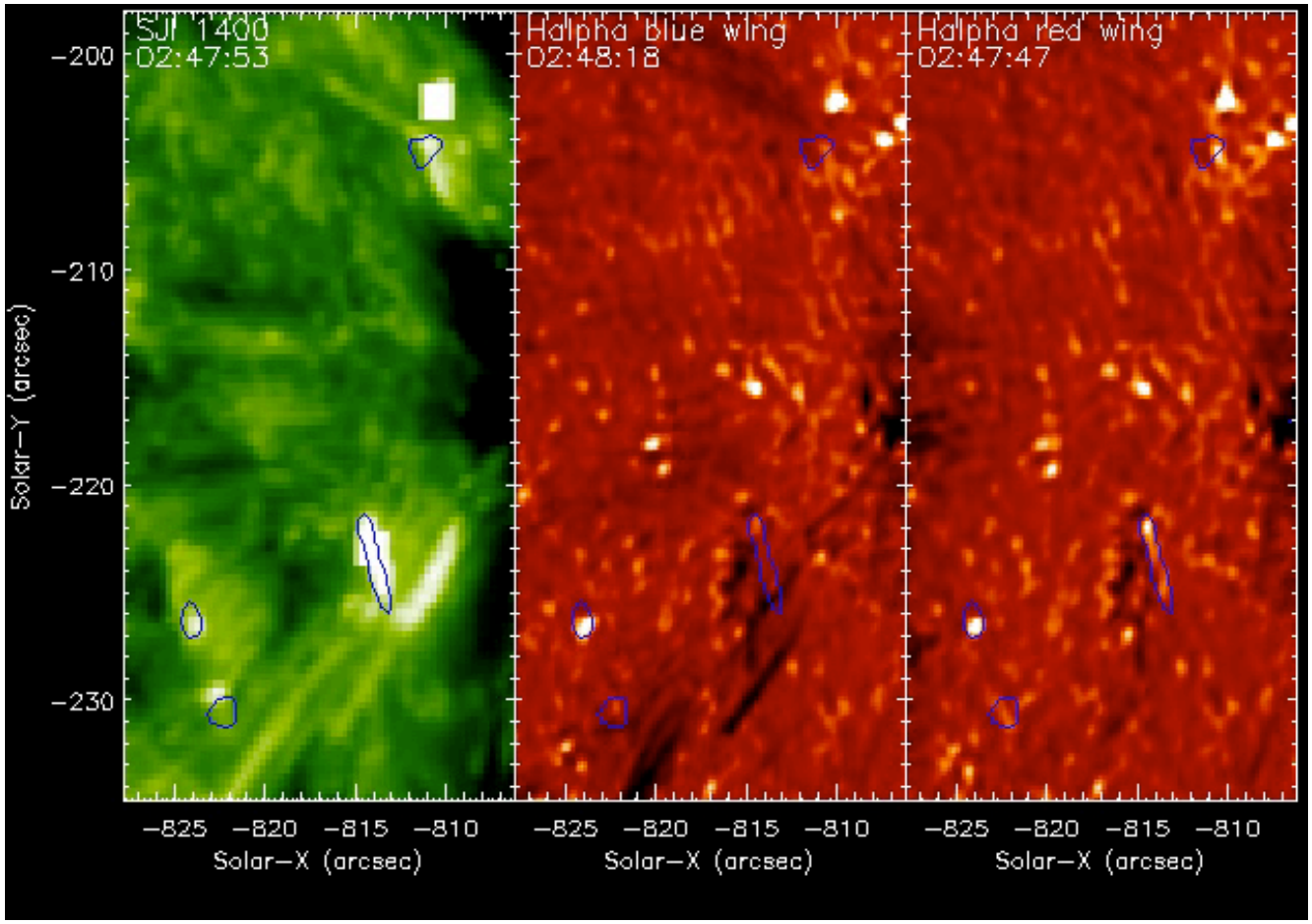

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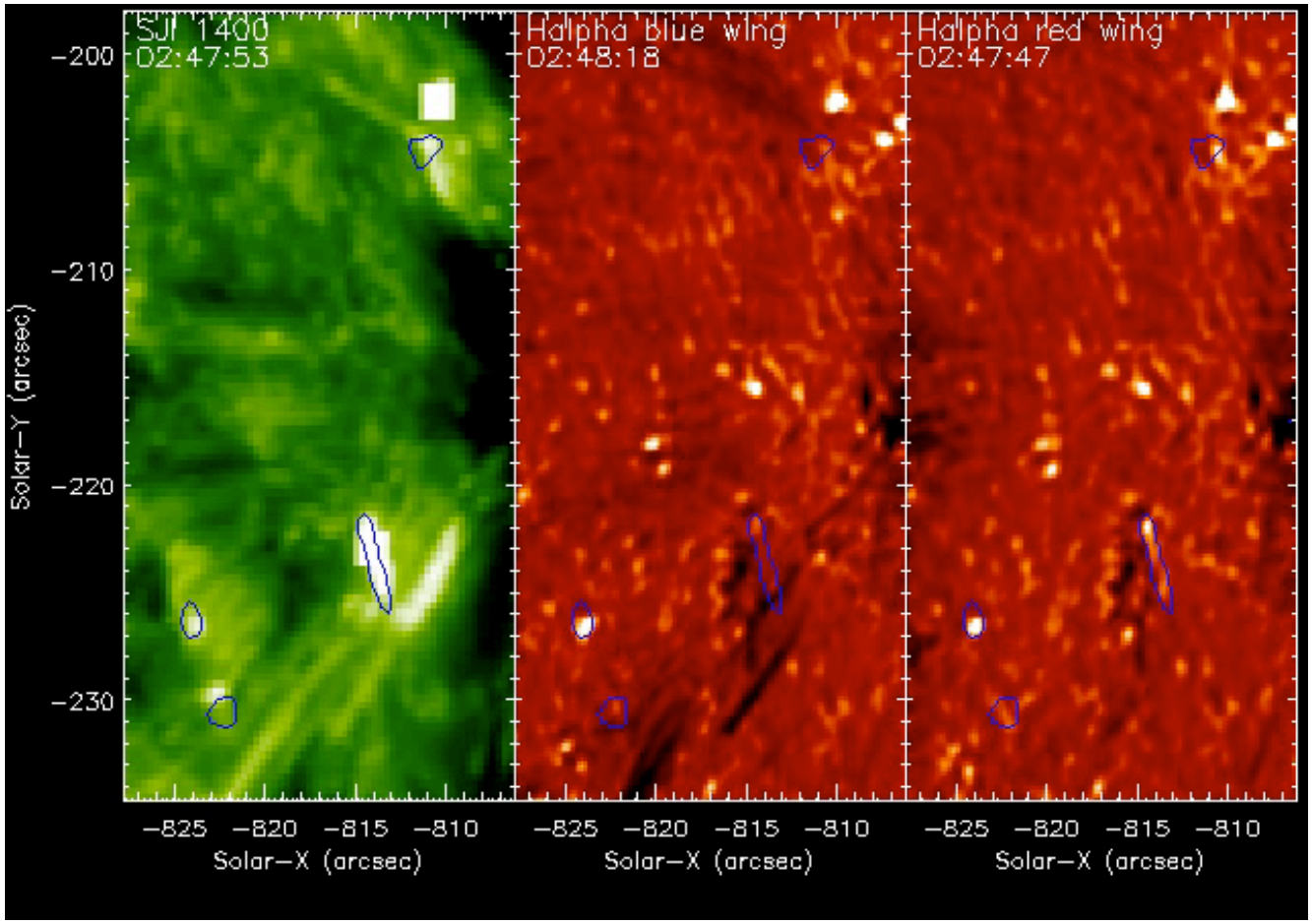

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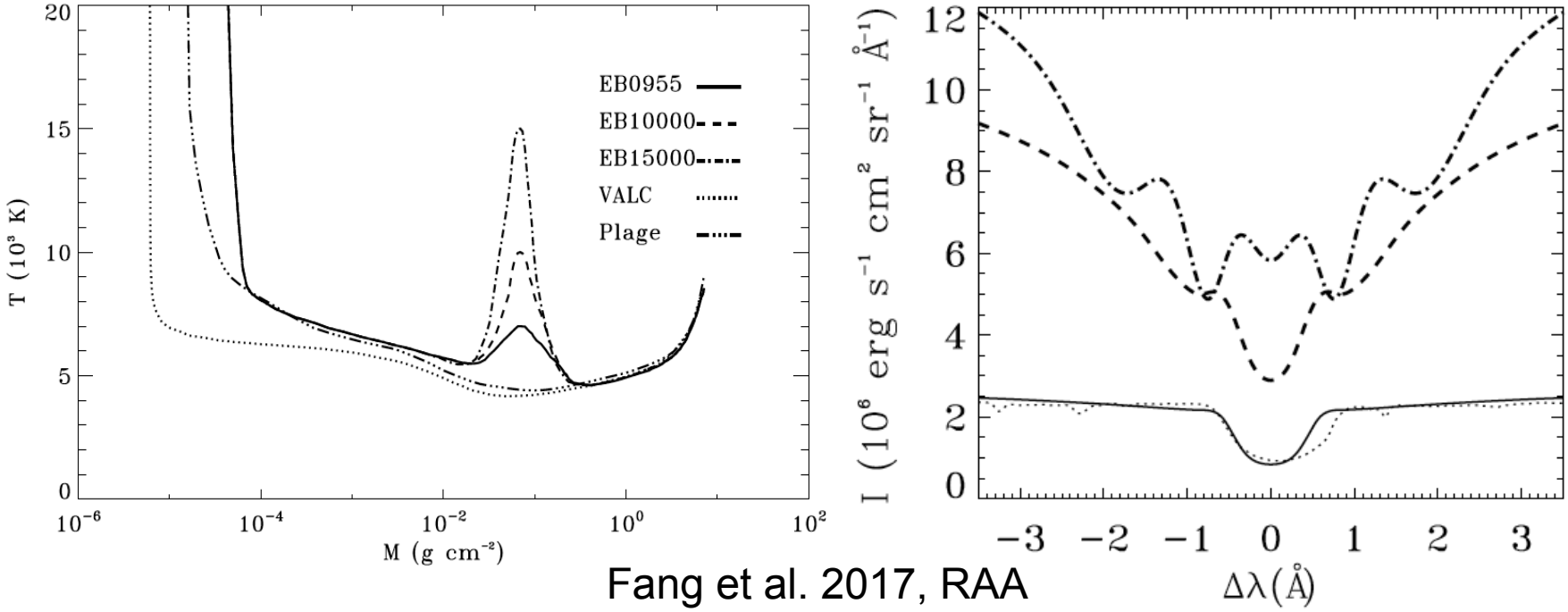
Can the temperature minimum region (TMR) be heated to 10^5 K?

- 1D RHD simulations: If the EB maximum temperature reaches more than 10 000 K around the TMR, then the resulting Hα and Ca II 8542 Å line profiles and the continuum emission would be much stronger than those of EB observations (e.g. Fang et al. 2017, Hong et al. 2017)



Fang et al. 2017, RAA

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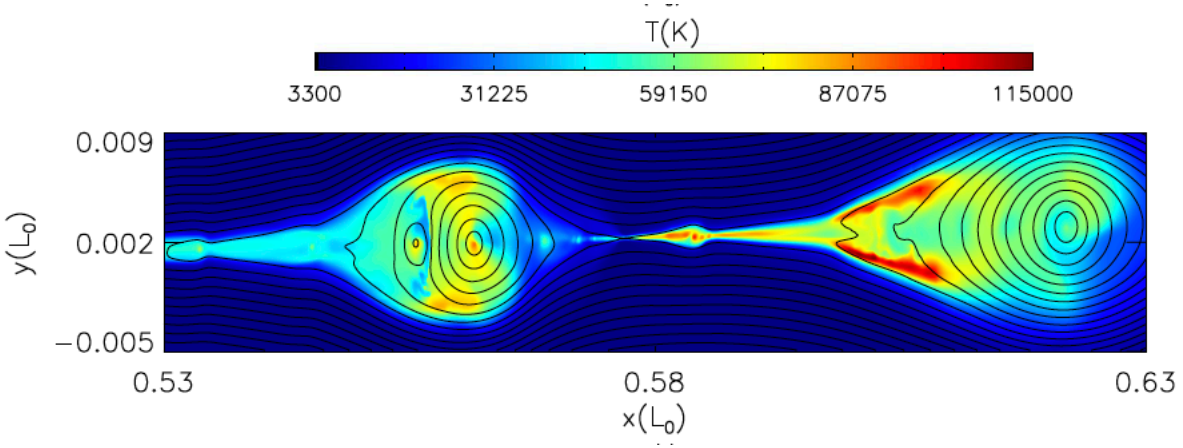
- 2.5D MHD simulations: If B>1000 G and β<0.0145, the initially weakly ionized plasmas can become fully ionized within the reconnection region and the current sheet can be strongly heated to above 25 000 K (Ni et al. 2016, 2018).



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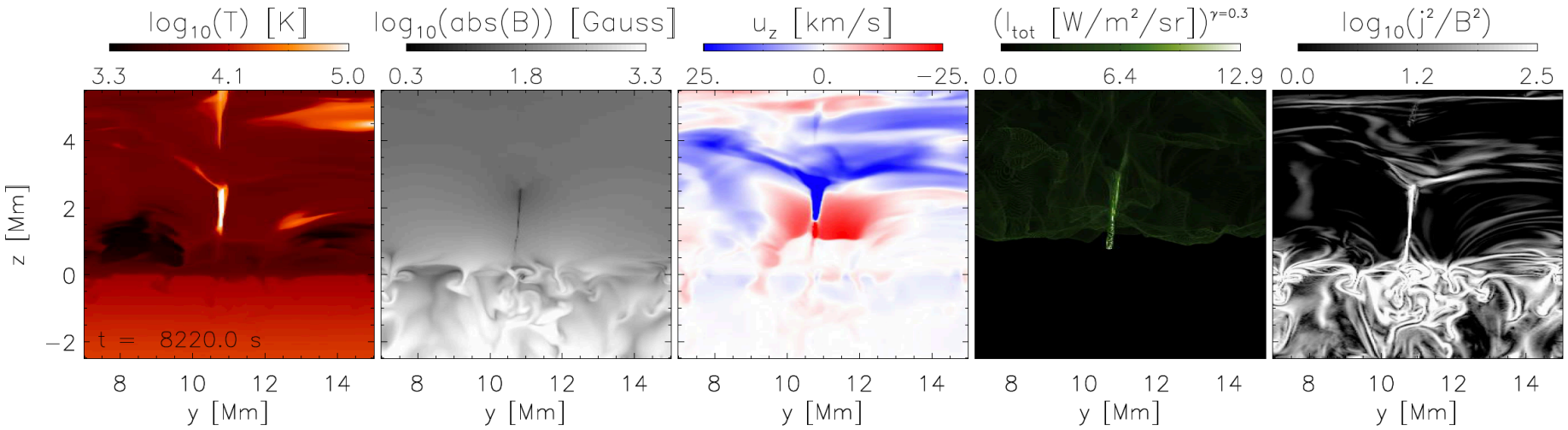
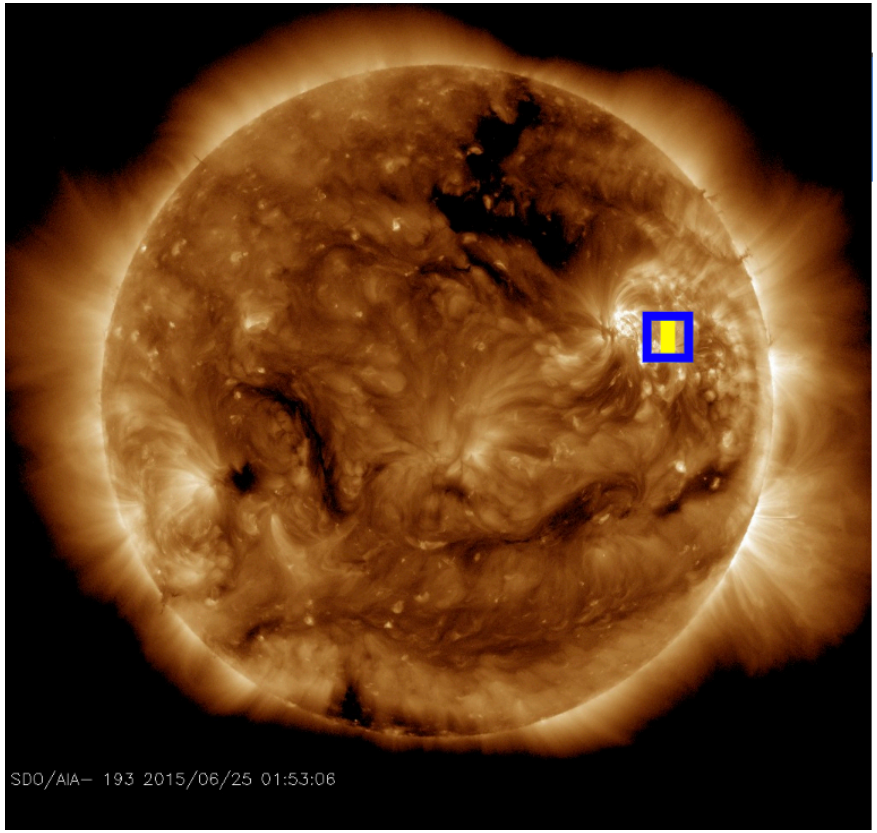
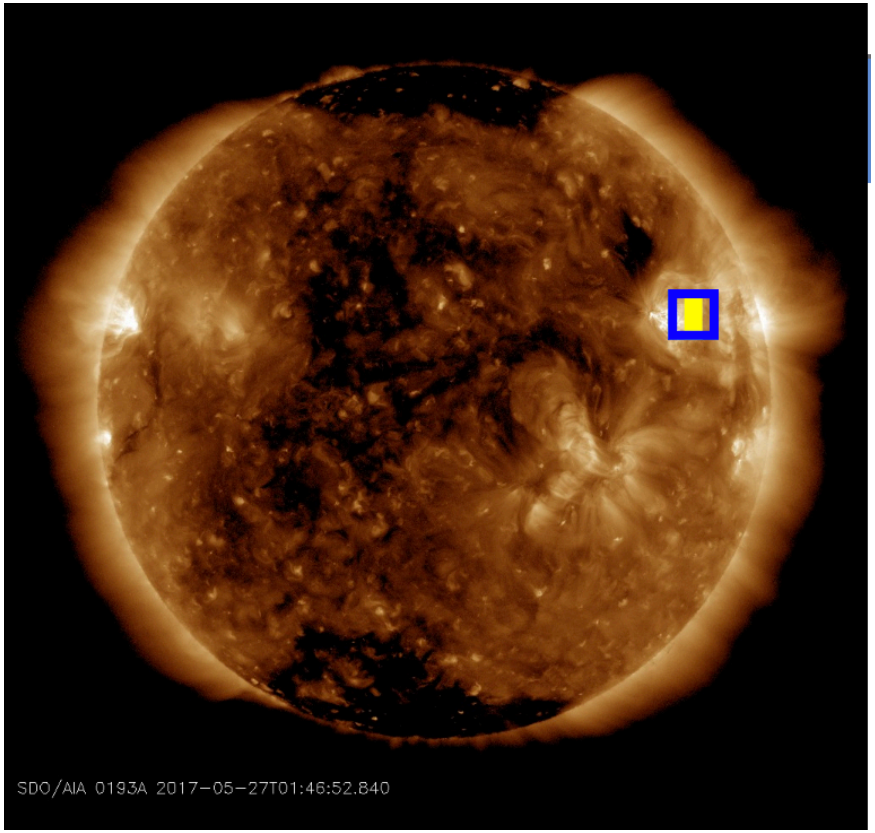


- 3D RMHD simulations: EBs and UV bursts are successfully produced. EBs and UV bursts are occasionally formed at opposite ends of a long current sheet that resides in an extended bubble of cool gas. (Hansteen et al. 2019).

Limb observations





Date: 2015-06-25
IRIS: SJI 1400, 1330, 2796, 2832 Å
GST: Hα core, ±1, ±0.6 Å

Date: 2017-05-27
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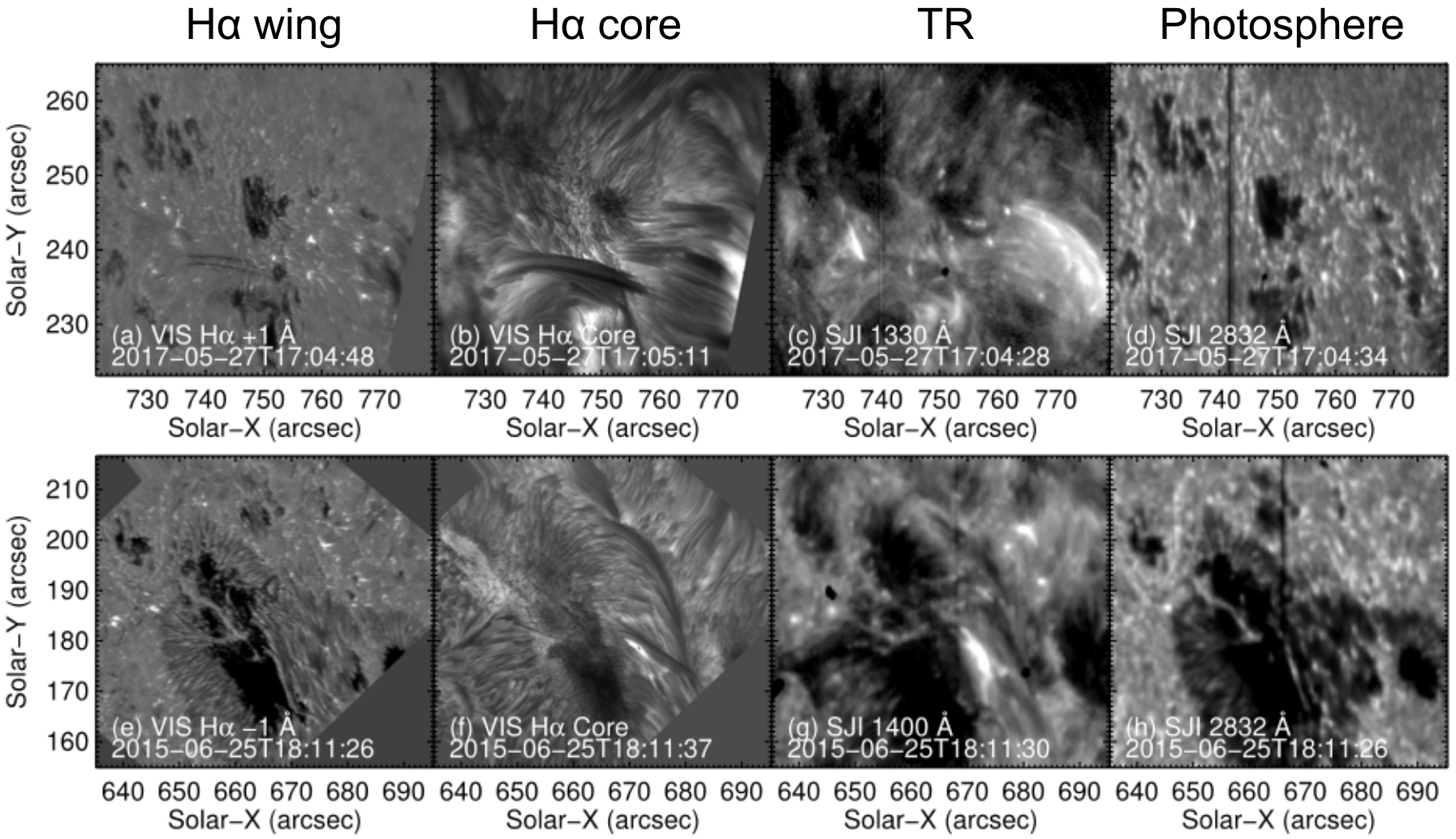

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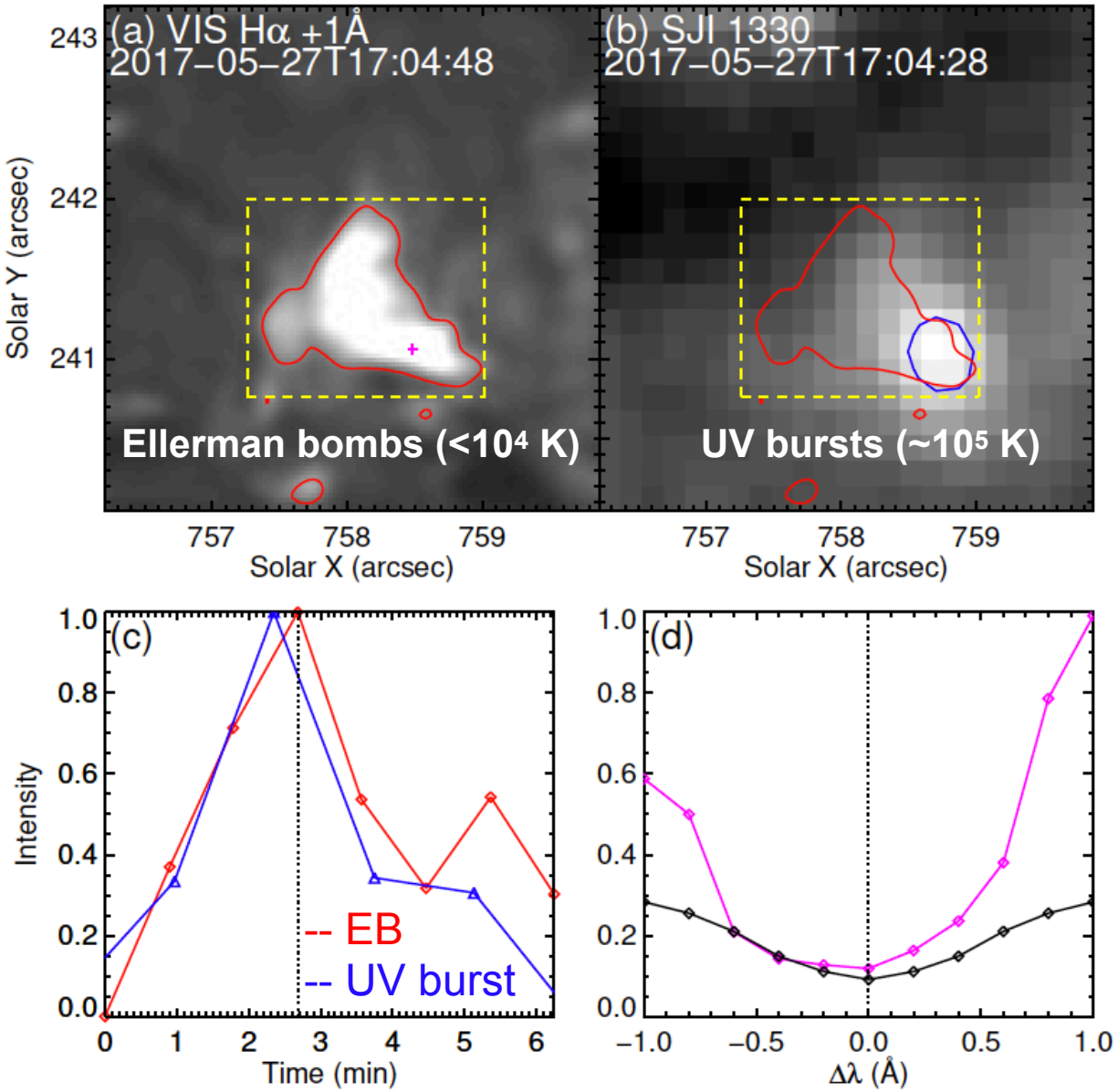

Chen, Tian, Peter et al. 2019, ApJL

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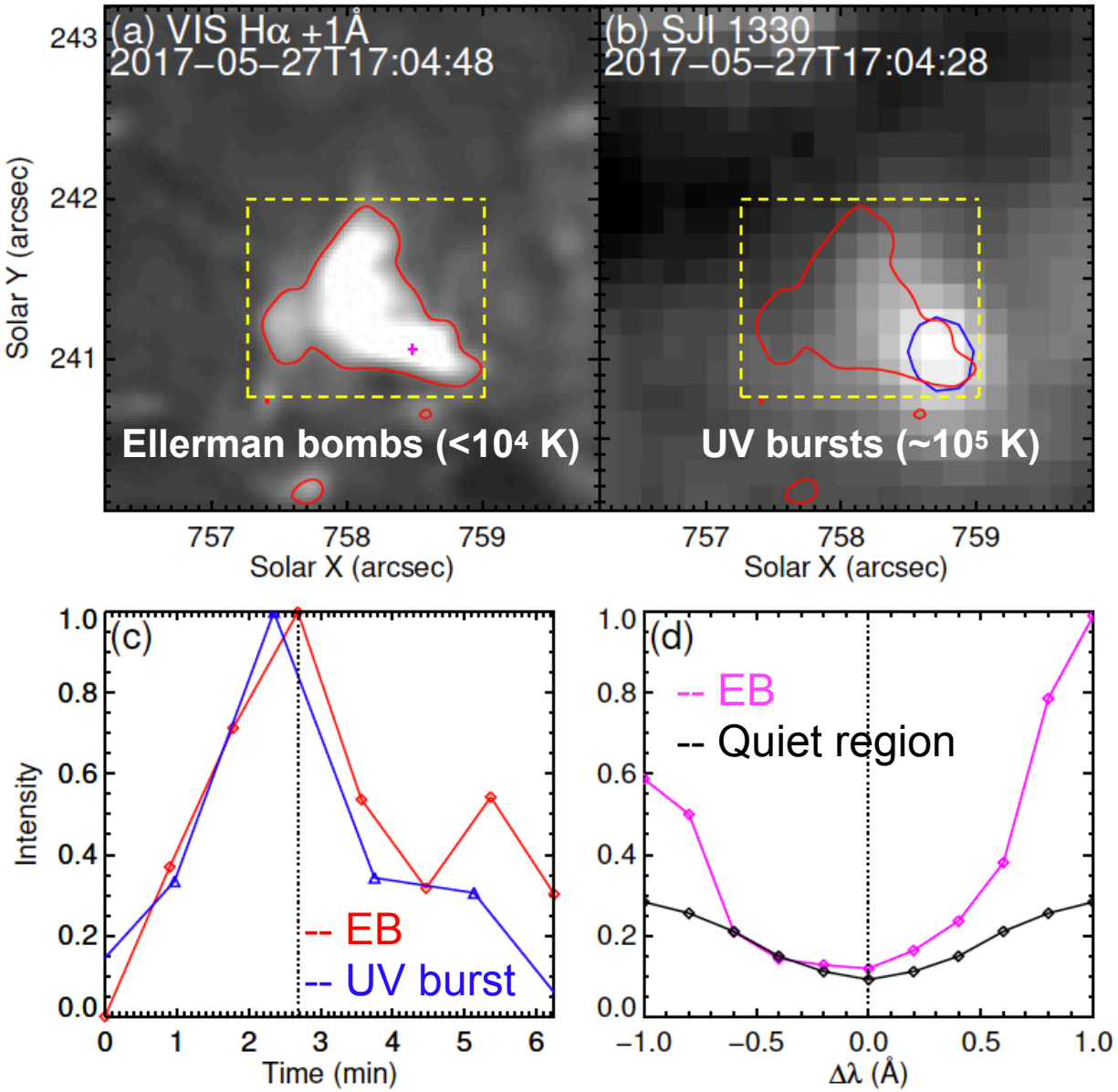

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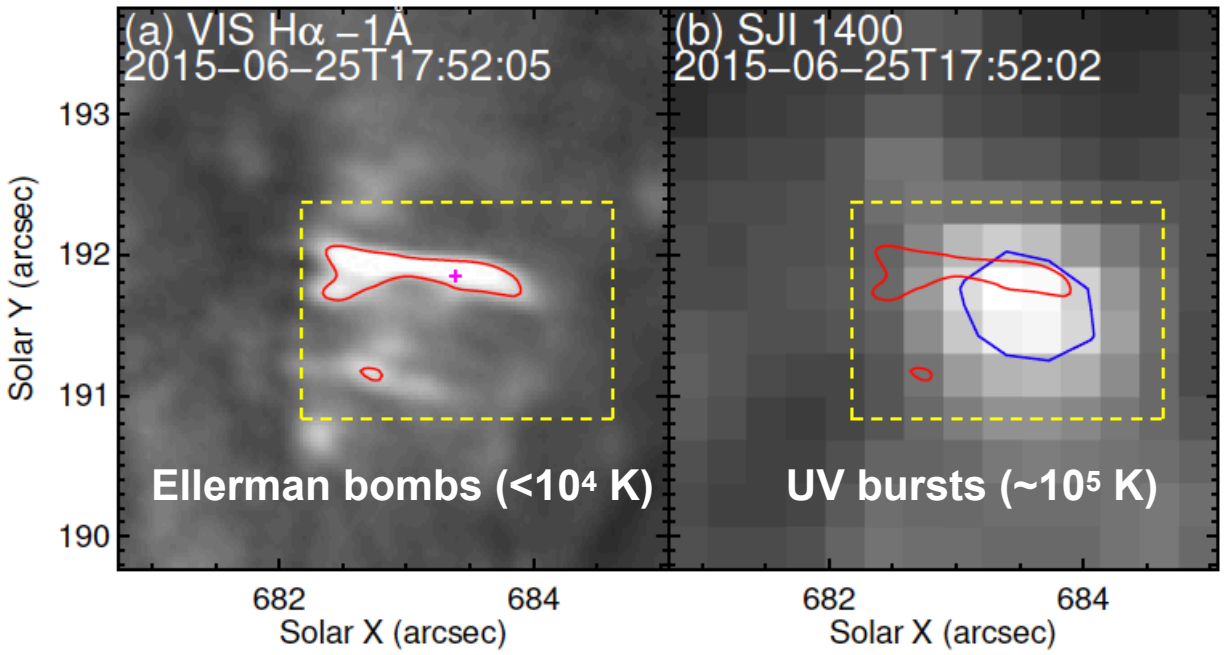

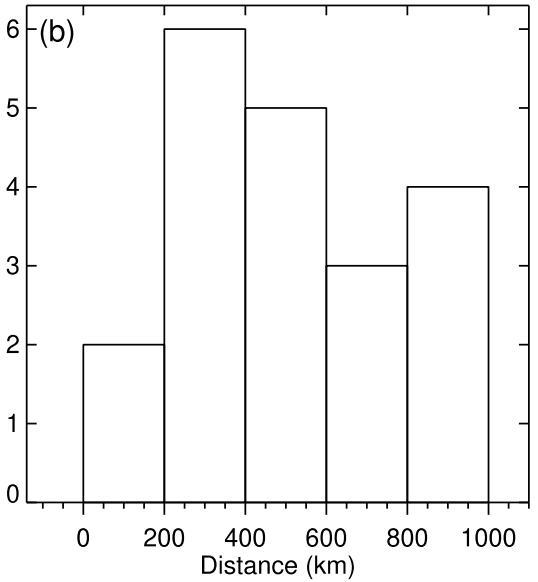

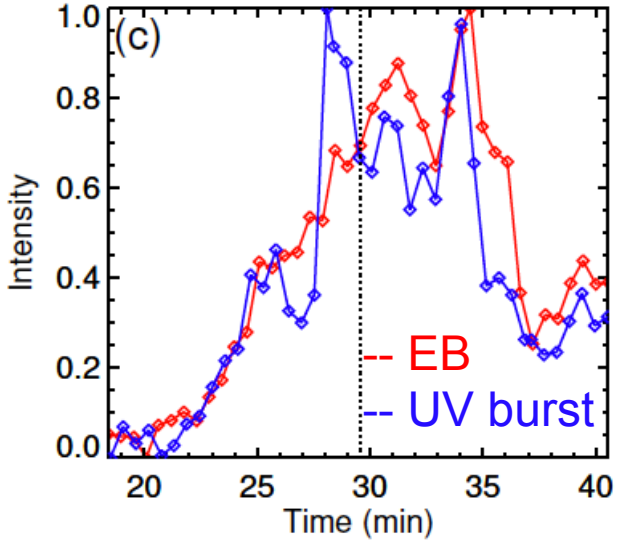

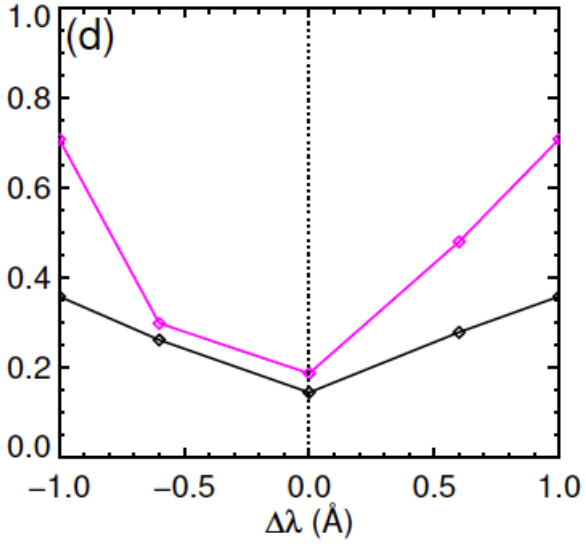

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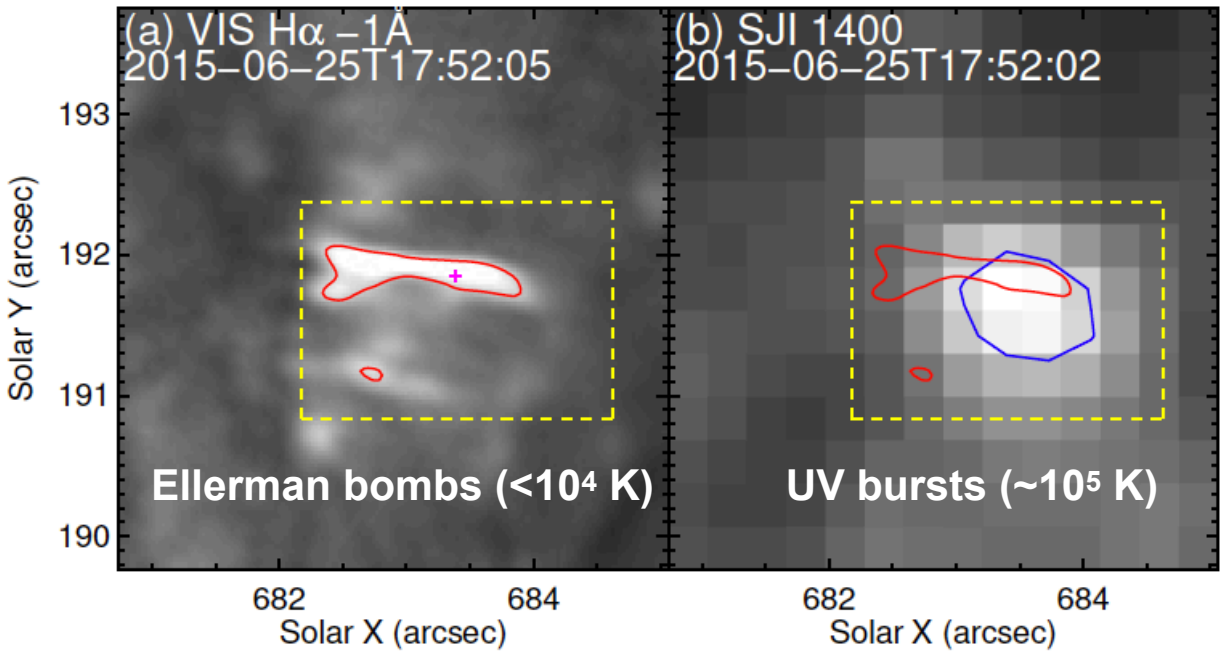
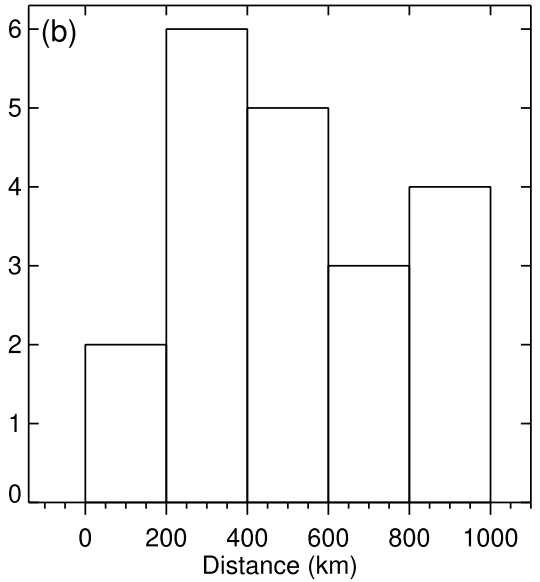
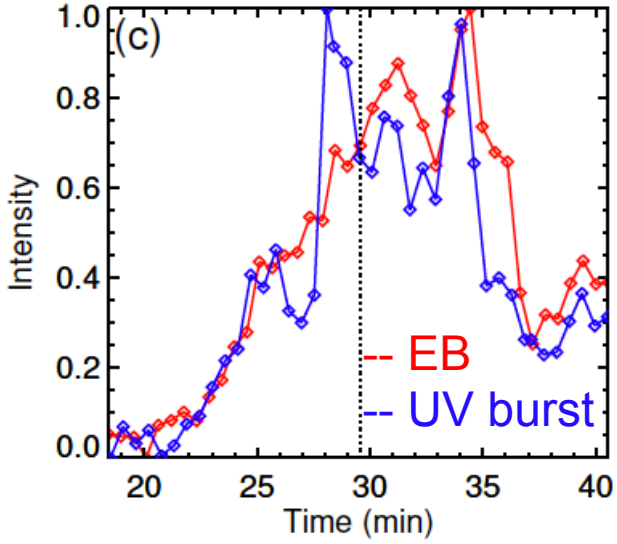
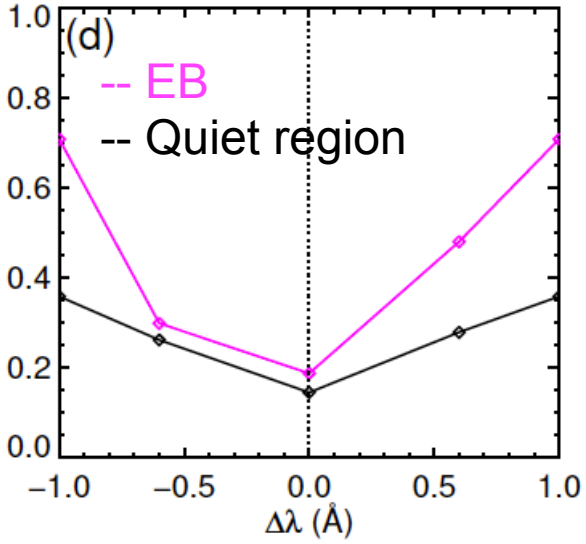


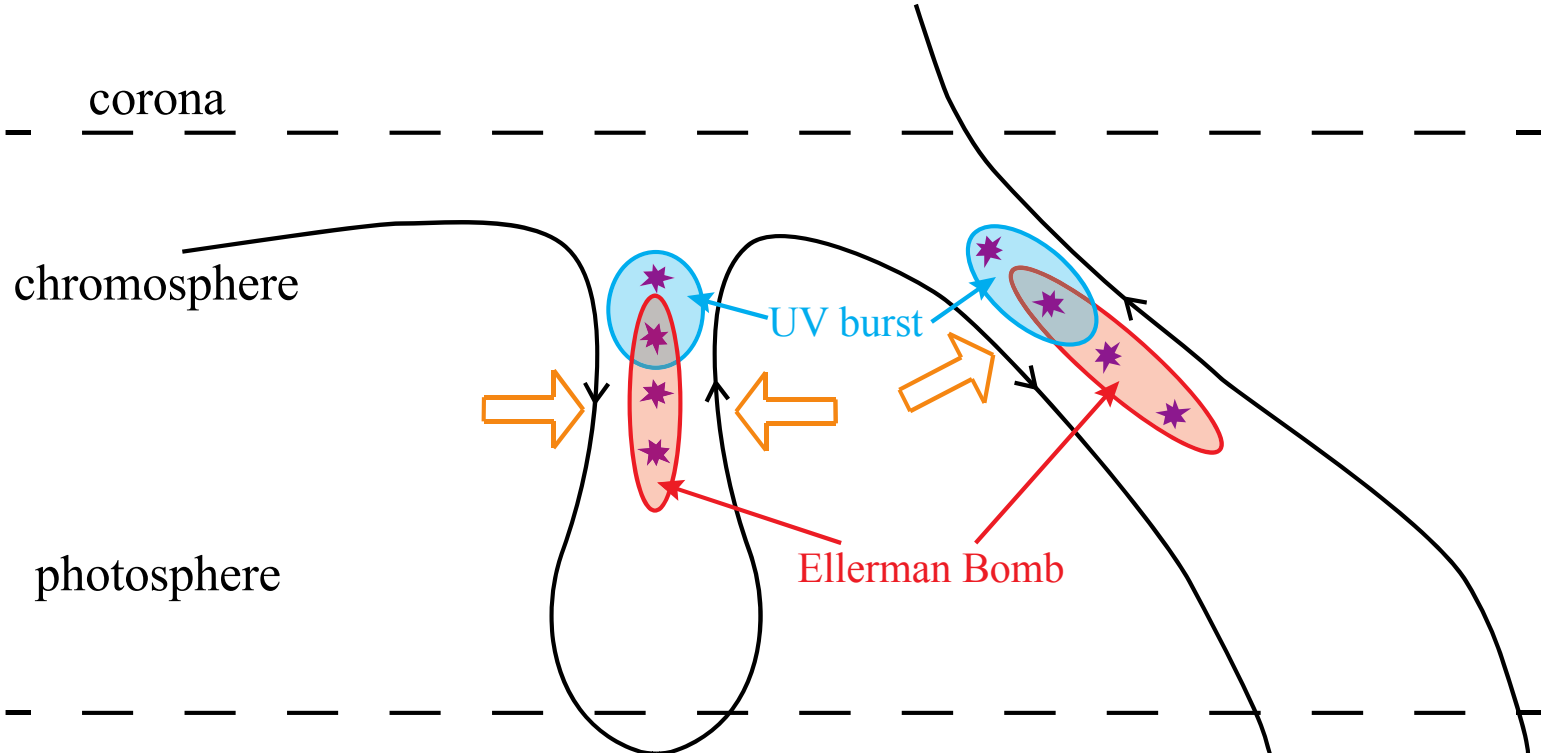






- UV bursts have a tendency to appear at the upper parts of flame-like EBs.
- Intensities of most EB-related UV bursts and their corresponding EBs reveal correlated variations.

A possible scenario



UV bursts and their associated EBs are likely formed at different heights during a common reconnection process.

Summary

- Magnetic field and spectroscopic observations have demonstrated that UV bursts result from reconnection in the lower chromosphere or photosphere.

- Recent 3D RMHD simulations suggest that EBs and UV bursts are occasionally formed at opposite ends of a long current sheet.

- Limb observations imply that UV bursts and EBs may be formed at different heights during the same reconnection processes.