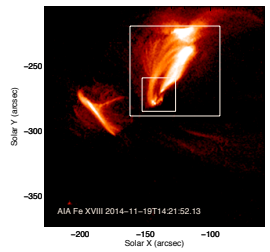
Building a Multi-threaded Flare Model with RHESSI, Hinode, & IRIS

J.W. Reep (NRC Postdoc at Naval Research Laboratory), H.P. Warren (Naval Research Laboratory), N.A. Crump (Naval Research Laboratory), & P.J.A. Simões (University of Glasgow)

Introduction

- Energy release in flares occurs across many magnetic threads
- Determining the energy distribution across threads is difficult
- We propose a new method based on TR line intensities
- We use this model to explain TR line red-shifts that last for > 30 min

Loop arcade in the event



Long Duration Red-shifts

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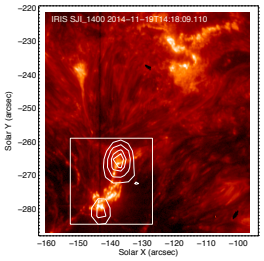
- GOES B4
- Non-thermal HXR emission at FP, measurements of electron beam parameters
- IRIS brightenings at FP
- EIS/XRT temperature, density, EM measurements

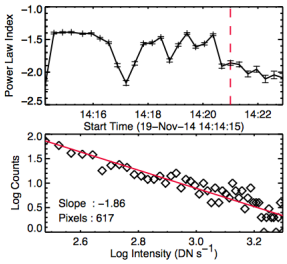
Foot-point energy release



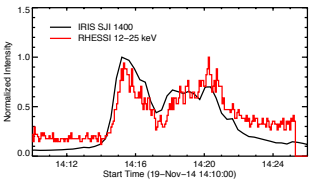
IRIS intensities at the FP described by a power-law with slope around -1.6

As expected, HXR and TR intensities are well correlated:

IRIS intensity distribution



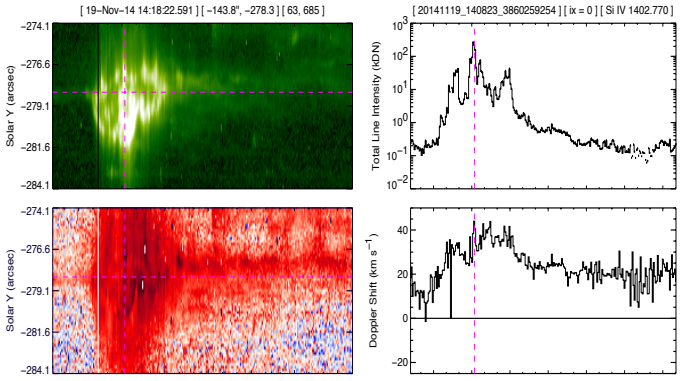
TR and HXR light-curves



TR lines in this event, and many others, red-shifted for > 30 min in a single IRIS pixel. The speed is approximately constant. Fisher 1989 showed condensation flows last ~ 1 min, regardless of heating.

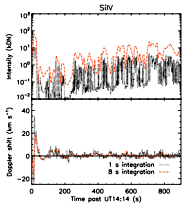
➢ What's going on?

Si IV intensity and Doppler shift



Multi-threaded Loop Model

Single Loop with 7 heating events



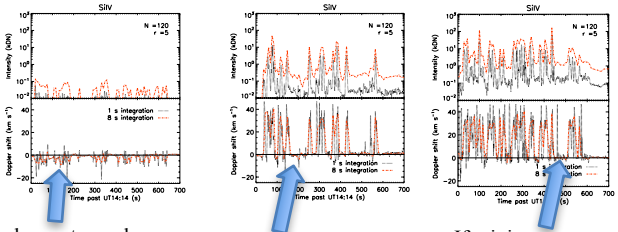
- Heating a single loop cannot reproduce long duration red-shifts!
- After the first burst, the inertia is too high to drive strong condensation flows

Lots of unknowns in a multi-threaded model: energy partition, cross-sectional areas, heating duration, number of threads, minimum/maximum energy burst

Can't determine **any** of these observationally with current instrumentation!

➢ The red-shifts are a strong constraint, however

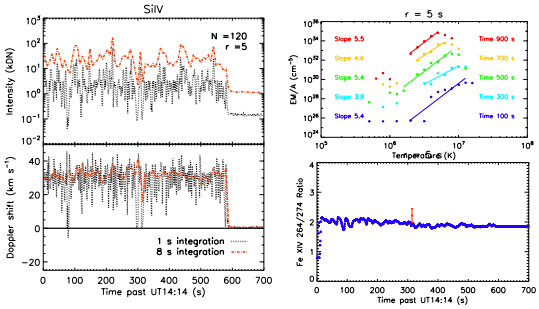
- Randomly select energy burst from observationally measured power-law
- Number of threads N times mean waiting time r must be at least as long as HXR burst to produce constant red-shift: $N \times r > 600$ s



Weak events produce blue-shifts!

Weak events weight the emission, producing gaps in the red-shifts

If minimum energy beneath explosive evaporation threshold, gaps in the red-shifts



- With $N > 60$ threads *in a single IRIS pixel*, persistent red-shifts can be reproduced
- Temperatures, EM distribution, and density measurements all comparable to values observed with Hinode and SDO

Modeling constrains parameters that can't be found observationally!

Acknowledgements

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References

Observations:
Warren et al. 2016, arXiv:1606.09045
Modeling:
Reep et al. 2016, arXiv:1607.06684

Fisher 1989, ApJ, 346, 1019