

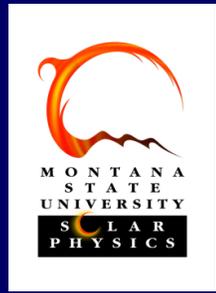
Multi-Spacecraft Observations of A Transition Region Reconnection Event

Charles Kankelborg, Hannah Alpert, and Sarah Jaeggli
Physics Department, Montana State University

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Abstract



While flares are among the most consequential manifestations of solar activity, there is much to learn by observing smaller reconnection events in the solar transition region (TR). In particular, the TR environment offers high emission measure and a short line-of-sight integration, allowing detailed and relatively uncluttered direct observations of the reconnection process. We report a well-resolved reconnection event in the solar transition region observed by IRIS on April 15, 2014. The event is resolved spatially and temporally in Si IV slit jaw images as a series of brightenings in a ribbon of pre-existing loops. In the spectra we see a complex, evolving velocity field indicated by blueshifts, redshifts, and nonthermal line broadenings. An associated footpoint region, resembling a flare ribbon, shows a strong redshift in Si IV. Imaging from AIA shows nearly simultaneous manifestation in all bands, suggesting localized heating. Magnetic field measurements from Hinode and HMI provide insight into the magnetic configuration of this event. After considering several alternatives, we interpret the data as a direct observation of reconnection in a TR current sheet. Implications are discussed for models of reconnection in the solar atmosphere.

Outline



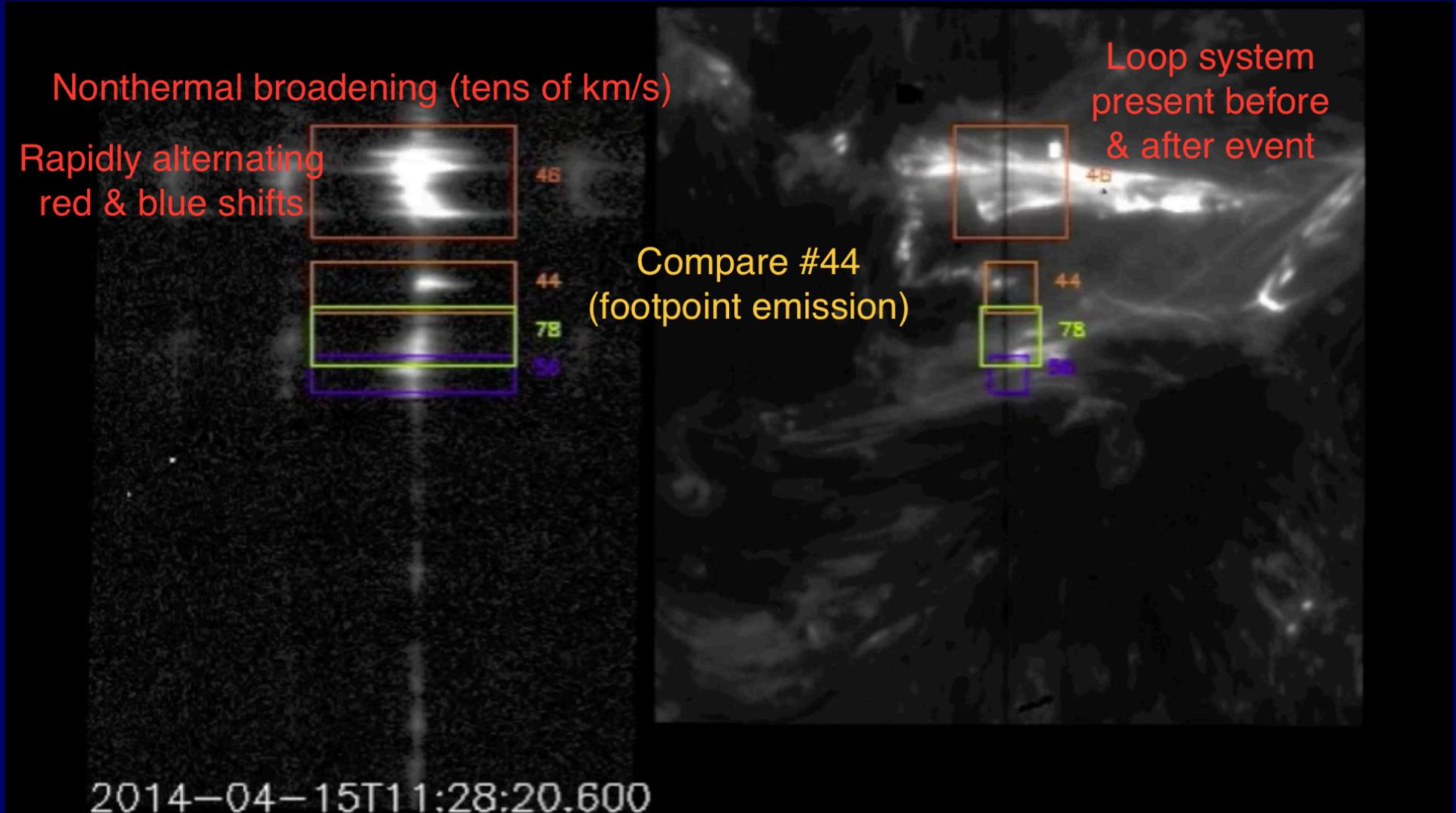
1. Motivation
2. Observations
3. Interpretation: Tearing Mode
4. Analysis (Beginnings)
5. Conclusions

Motivation



Reconnection is central to our interpretation of flares and heating yet, in a sense, elusive.

- Observations of coronal reconnection are mainly indirect, e.g. ribbons, outflows, postflare loops.
- The reconnection region in the corona has low emission measure and is often obscured line-of-sight confusion.
- Consider the **transition region**:
 - High event rate (explosive events)
 - High density in the reconnection region
 - Minimal LOS confusion
- **Can we resolve a reconnection region in the TR?**



Event #46: 11:17-11:33 UT (10% of obs duration)



IRIS Si IV



Si IV profile (left) and SJI (right). Square root scaled.

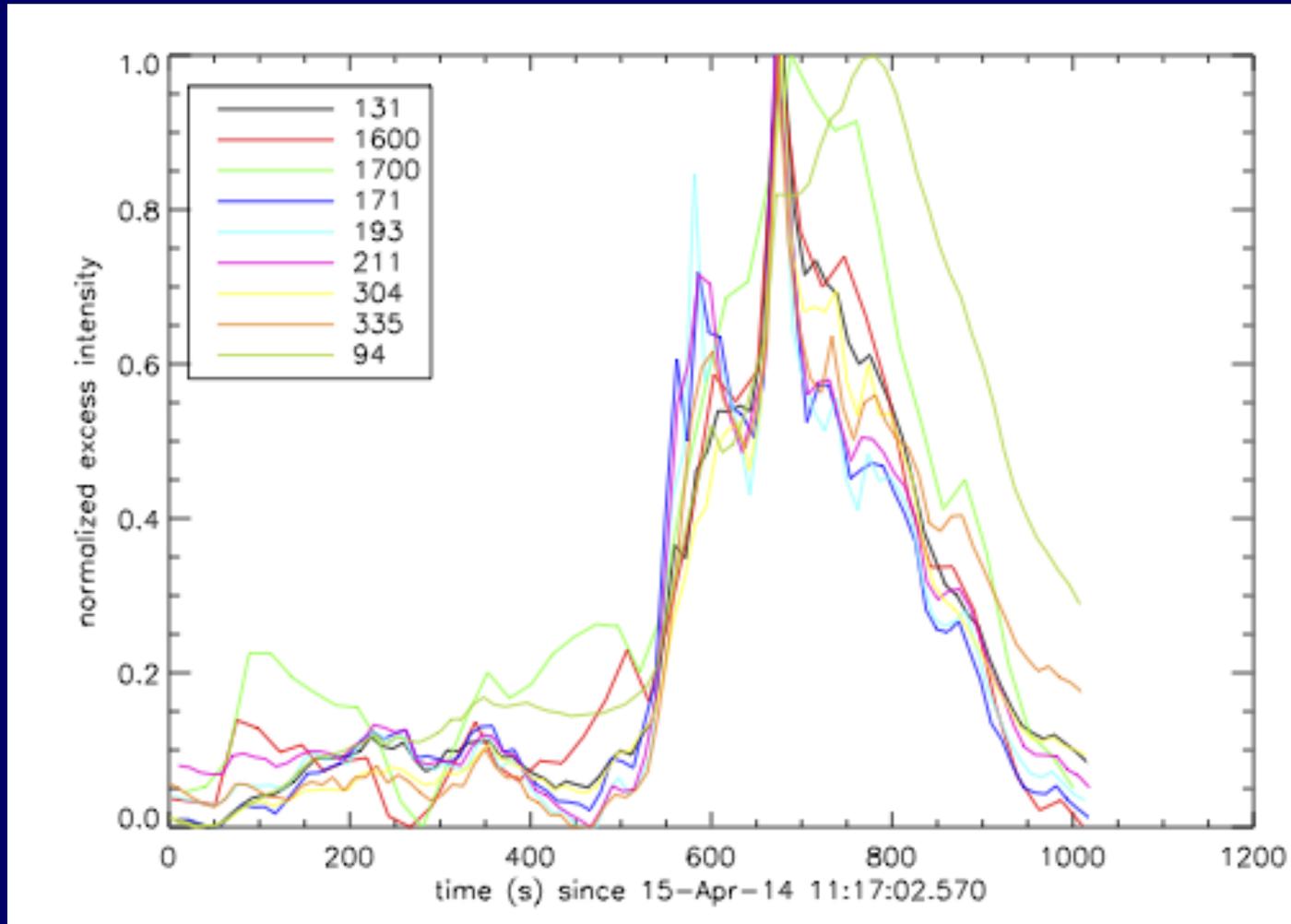
AIA Images



Hot loops in 94 Å & 131 Å connect to ribbon (#44) crossing
IRIS slit.

1600 Å channel resembles IRIS Si IV.

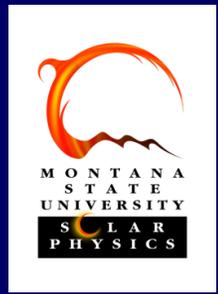
AIA Light Curves



All channels brighten simultaneously.
Multithermal, perhaps far from ionization equilibrium.



HMI LOS Magnetic Field



Emission external to reconnection region:

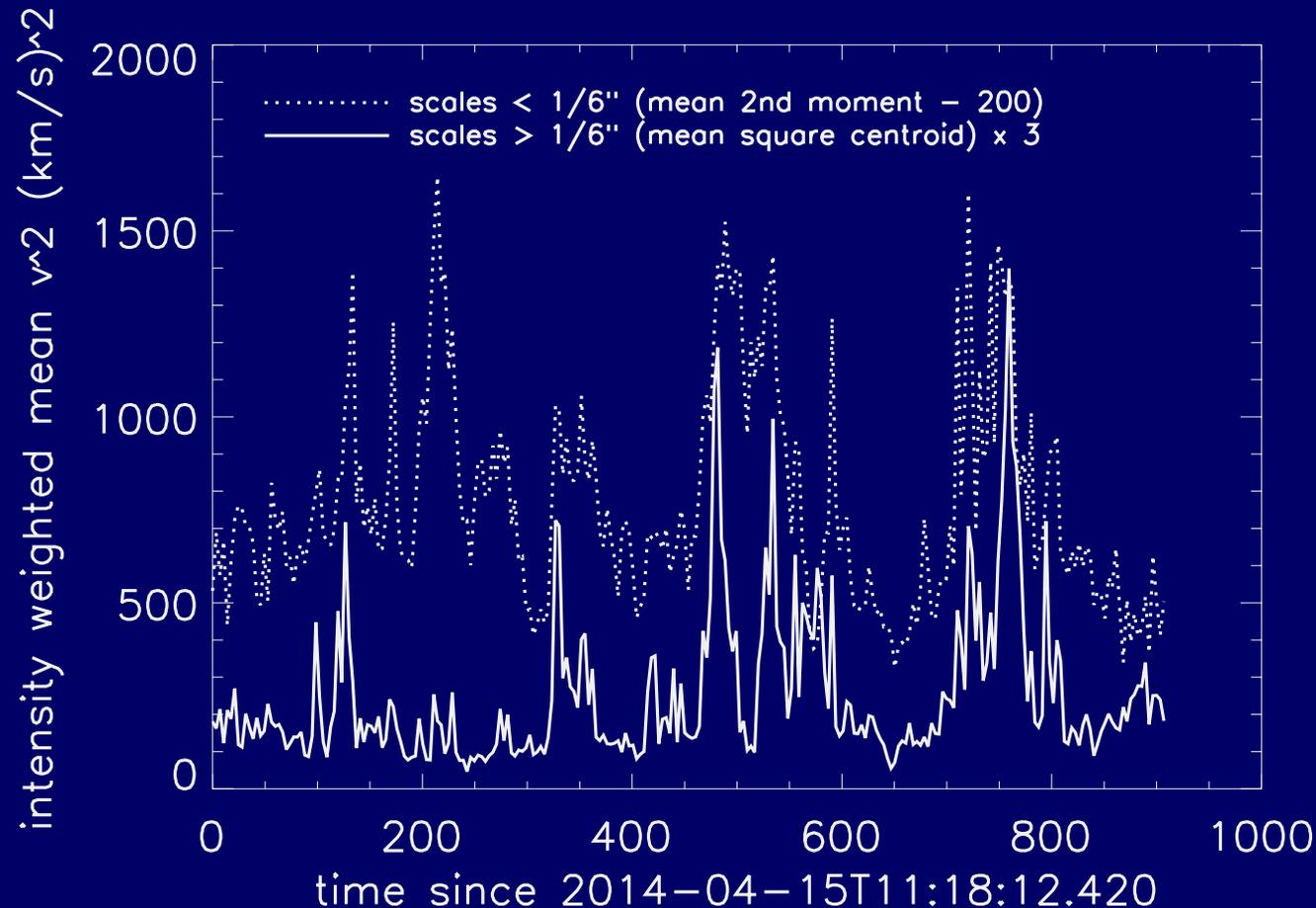
X Postflare loops	Emission in all channels precedes footpoint brightening.
X Reconnection outflow	Bidirectional flows do not trace back to a single remote reconnection site.
X Footpoint emissions	Loop morphology; red & blue juxtaposed and alternating. Contrast event #44 (ribbon with redshifted spectrum; crenulated morphology).

Emission external to reconnection region:

X Alfvén waves launched by reconnection near footpoints	SJI shows initiation near middle, not at either end.
X Response to overlying hot reconnection	We see a ribbon (#44) connected to hot loops, but this idea fails to explain juxtaposed red & blue shifts.

Emission in the vicinity of the reconnection region:

<p>X Single X-point</p>	<p>Morphology and evolution are too complex.</p>
<p>X Many independent events</p>	<p>Correlated motions in SJI suggest that the events are strongly coupled. Timescales consistent with coupled evolution.</p>
<p>? Tearing mode</p>	<p>Tentative interpretation.</p>



Most of the quantity $\langle Iv^2 \rangle / \langle I \rangle$ is in sub-pixel scales.
 However, fastest rise times (~ 3 s) at scales of $\sim 1''$.

Back of Envelope...

Fastest-growing mode $k_M \sim 1/l$, apparent growth rate $\omega_M = 0.3 \text{ s}^{-1}$. In linear tearing mode theory,¹

$$k_M l L_u^{1/4} = 1.4, \quad \omega_M l^2 = 0.6 \eta L_u^{1/2},$$

Where l is current sheet thickness, $L_u = l v_A \eta^{-1}$ is the Lundquist number, and η is resistivity.

Caveats:

- What we observe is likely **nonlinear** development.
- $\langle I v^2 \rangle / \langle I \rangle$ introduces time dependence through $I(y, t)$; is this appropriate for estimating rise-time ω_M ?

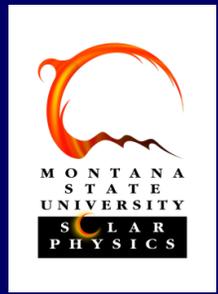
¹Furth *et al.* (1963); see Priest & Forbes (2000).

Conclusions

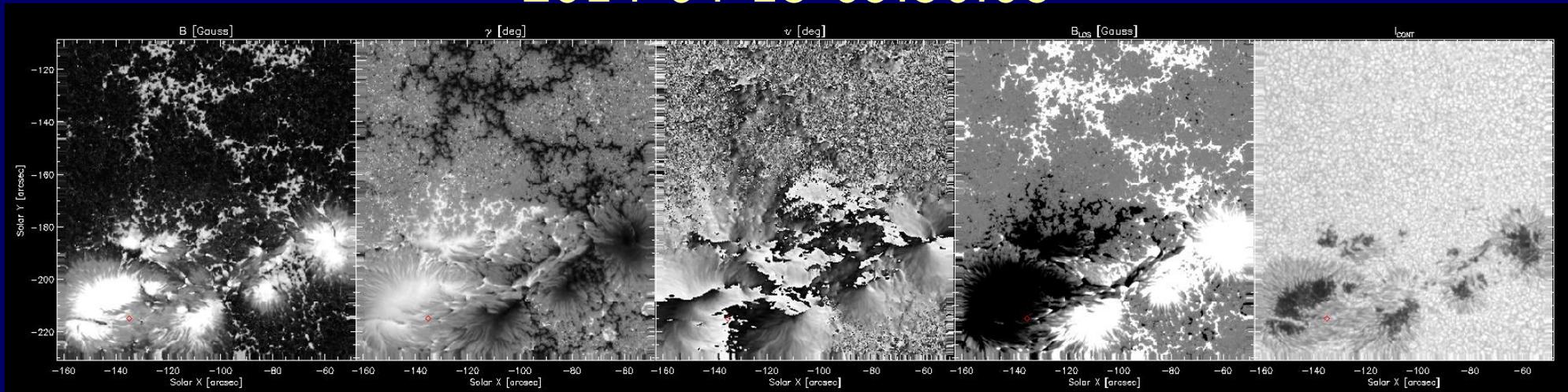
1. Reconnection can be observed directly in the TR. There are many similar events!
2. We interpret this event as tearing mode, resolved in space and time.
3. Most of the nonthermal $\langle Iv^2 \rangle / \langle I \rangle$ is at scales smaller than a pixel.
4. Rise times for $\langle Iv^2 \rangle / \langle I \rangle$ at large scales are **faster** than at small scales.
5. We aim to estimate things like L_u, l, η (TBD).
6. Quantitative interpretation may require consideration of nonlinear evolution.



Backup Slides



2014-04-15 09:56:08



Hinode SOT/SP

2014-04-15 12:27:57

