

# **Spectroscopic Observations of Magnetic Reconnection and Chromospheric Evaporation in an X-shaped Solar Flare**

**Ying Li (李瑛)**

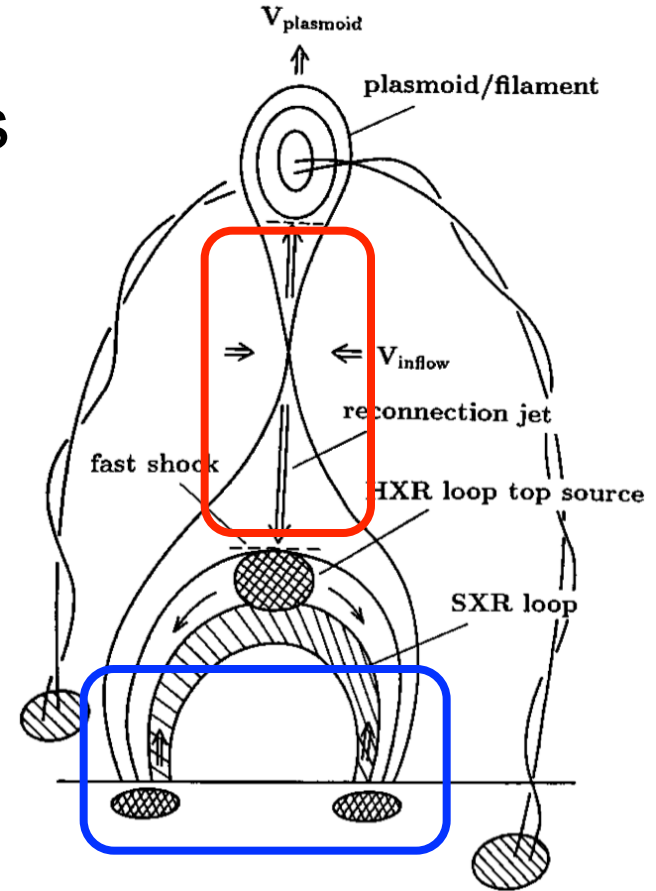
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PURPLE MOUNTAIN OBSERVATORY

NANJING, CHINA

# Introduction

- Solar flares are energetic events in the solar atmosphere.
- Energy release mechanism: **magnetic reconnection**
- Dynamic response: **chromospheric evaporation**
- Both can be diagnosed through **spectroscopic observations**.

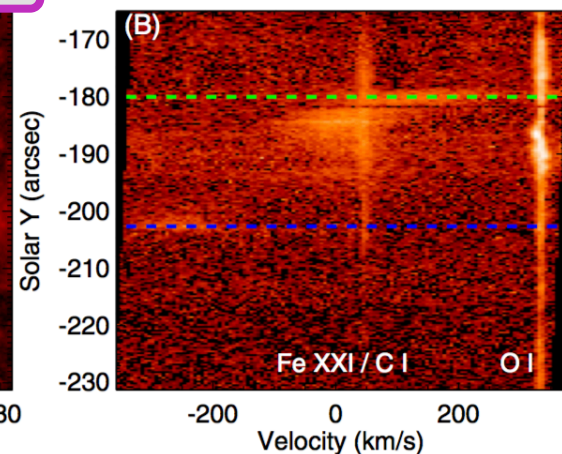
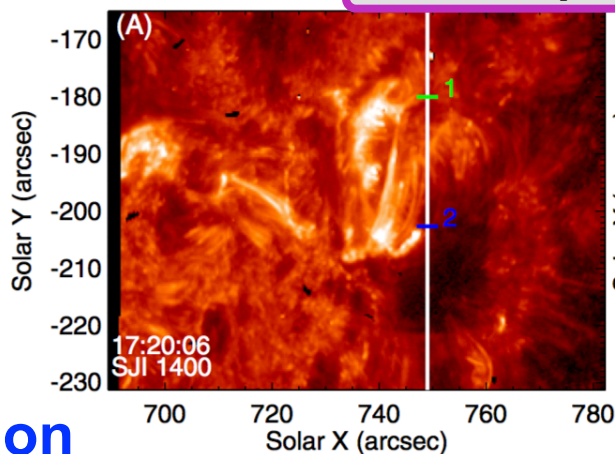


(Shibata et al. 1995, 2011)

# Introduction

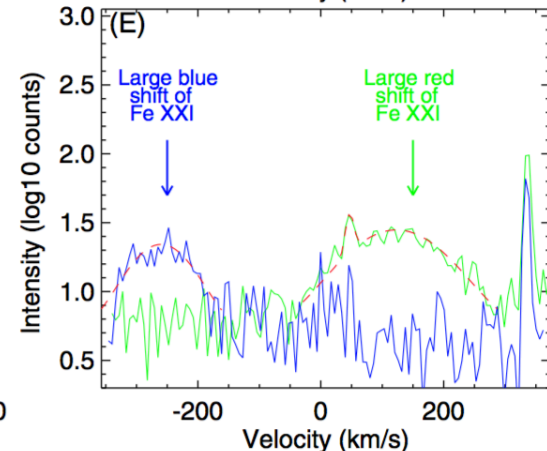
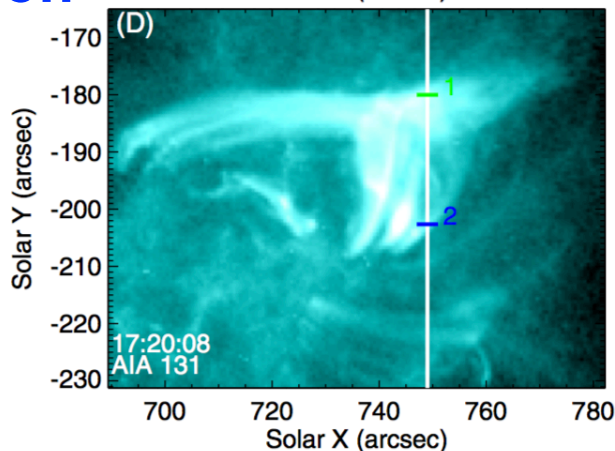
**Spectroscopic signatures of magnetic reconnection:**  
on the top of flare arcades, blue-wing enhancements in Fe XXI (Innes et al. 2003a,b), blueshifted & redshifted jets in Fe XIX (Wang et al. 2007), high redshifts in Fe XXIV (Hara et al. 2011, Simoes et al. 2015), fast flows in Si IV (Reeves et al. 2015), bidirectional flows in Ha (Hong et al. 2016).

**an example** (Tian et al. 2014)



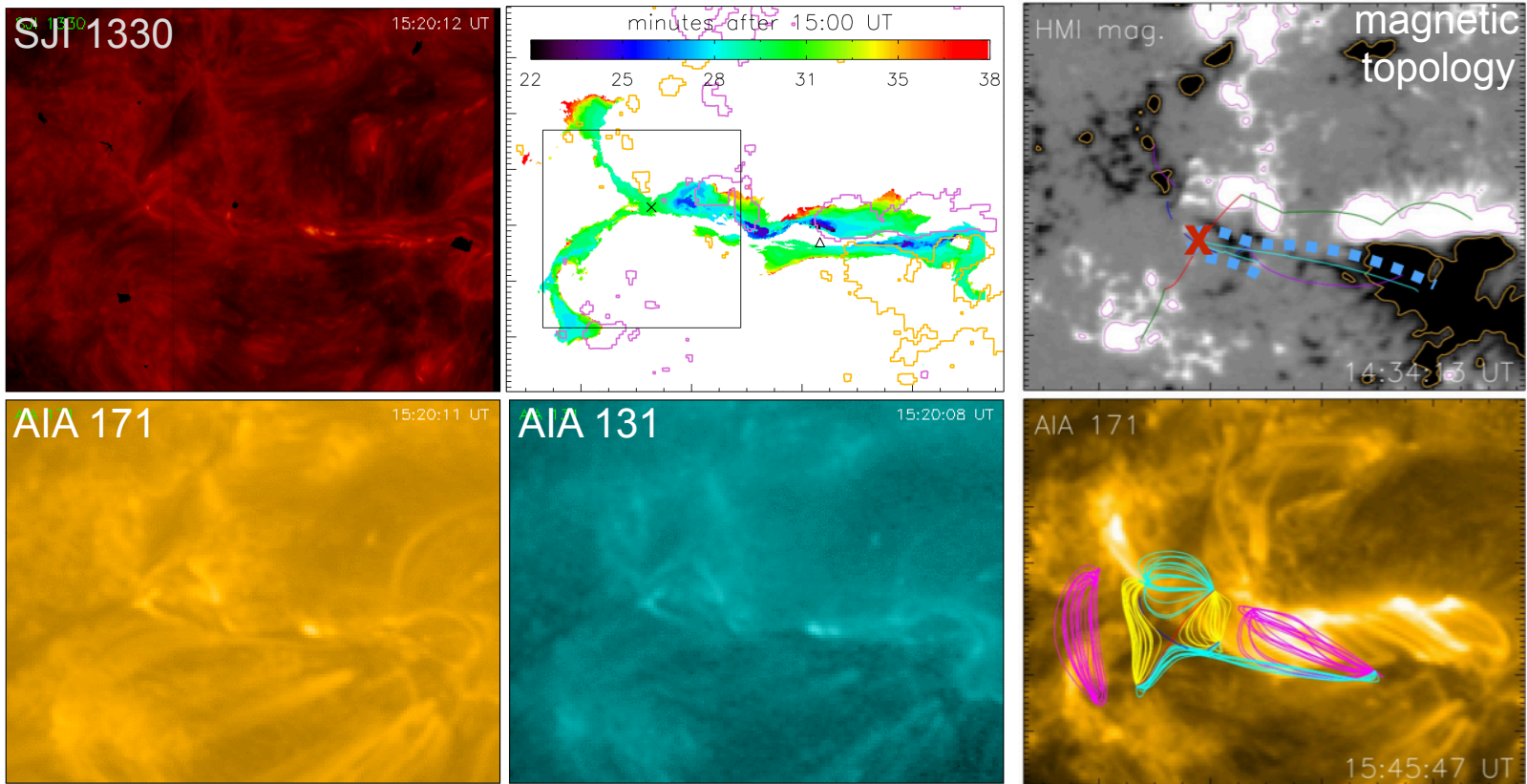
## Chromospheric evaporation

at flare ribbons, blueshifts in coronal lines & redshifts in Transition region (TR) and chromospheric lines (a large number of studies..)



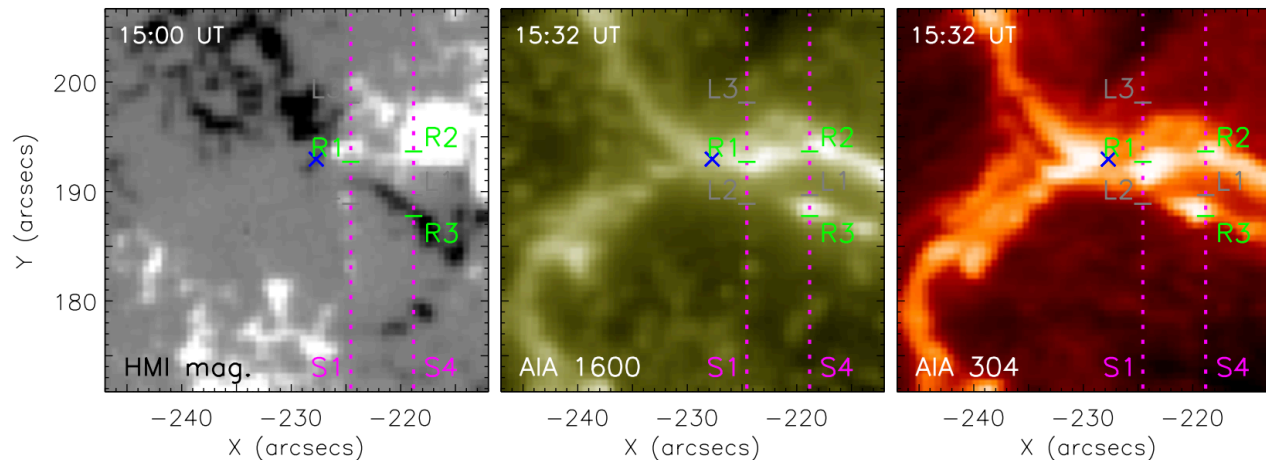
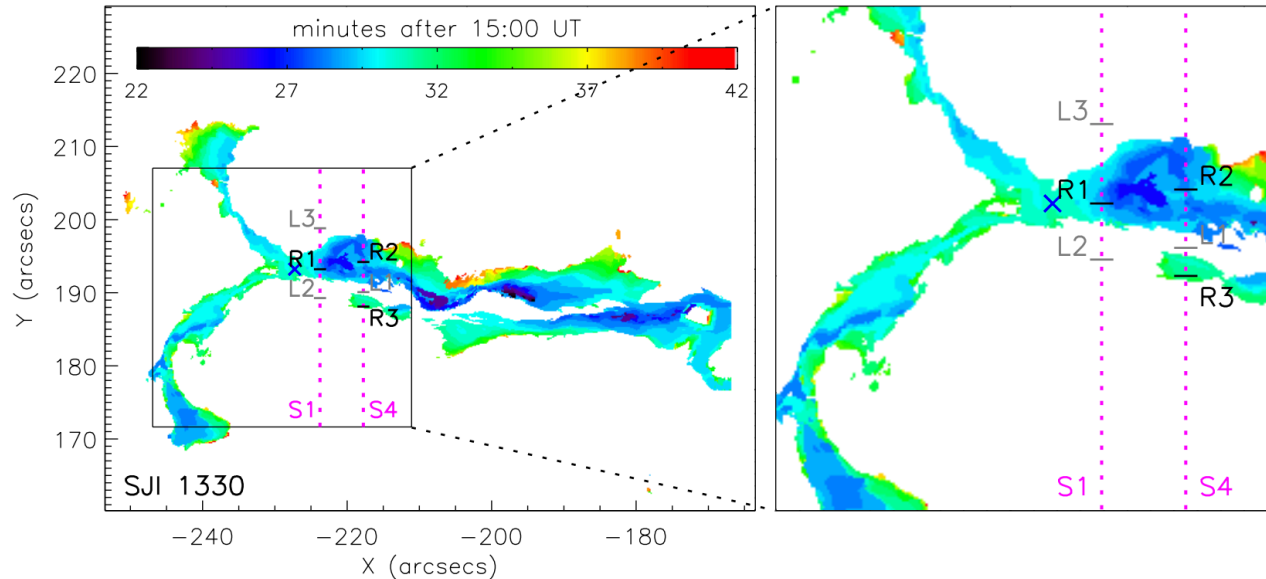
# Observations

- an atypical X-shaped flare (SOL2014-11-09T15:32 M2.3)
- Magnetic reconnection occurs at a separator, creating an X-shaped ribbon (Li et al. 2016).



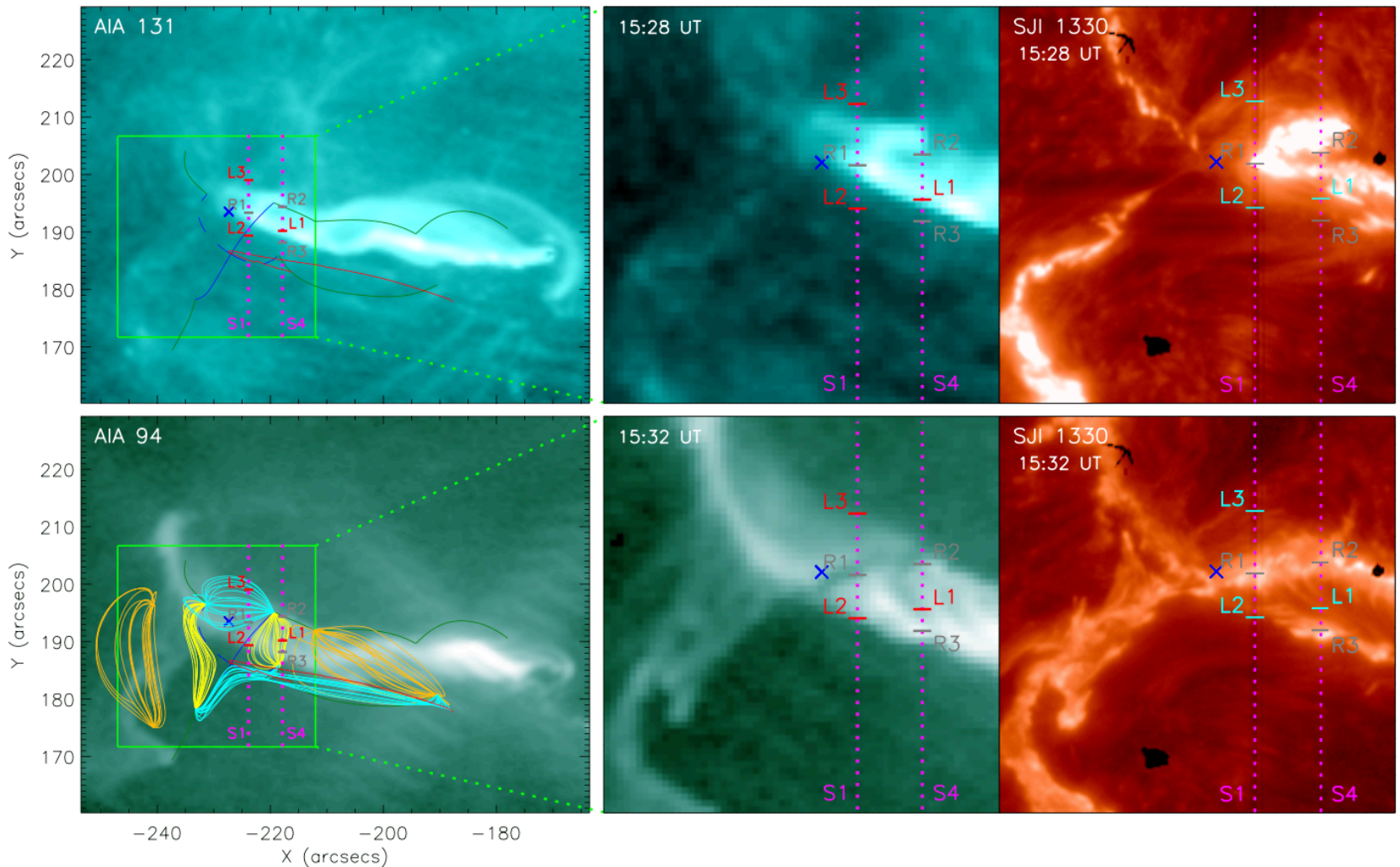
# Spatial context

- **three locations (R1-R3)** at the X-shaped flare ribbons
- **three locations (L1-L3)** outside the ribbons (near the separator)



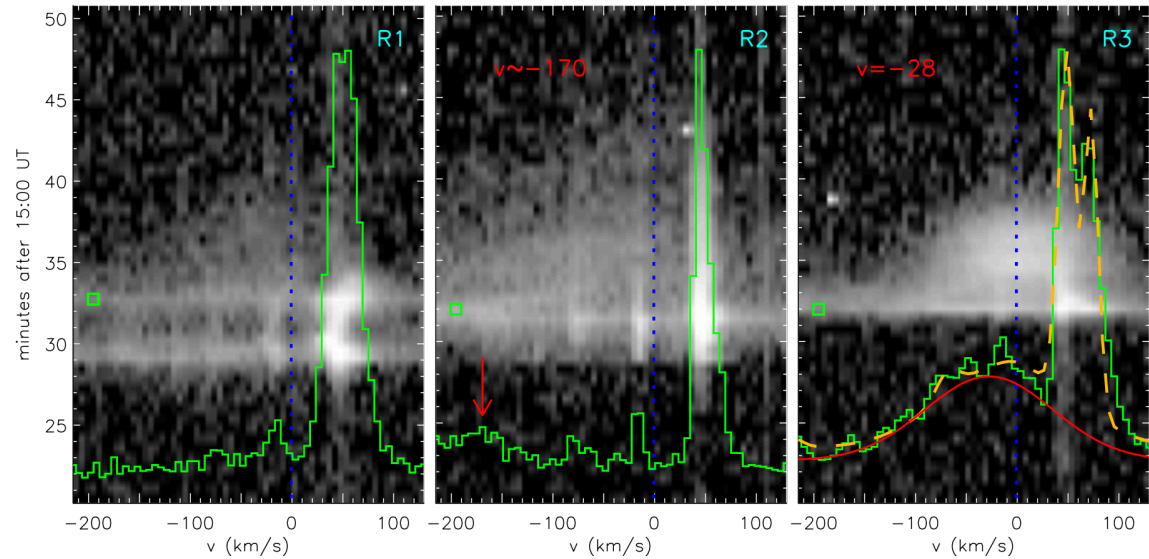
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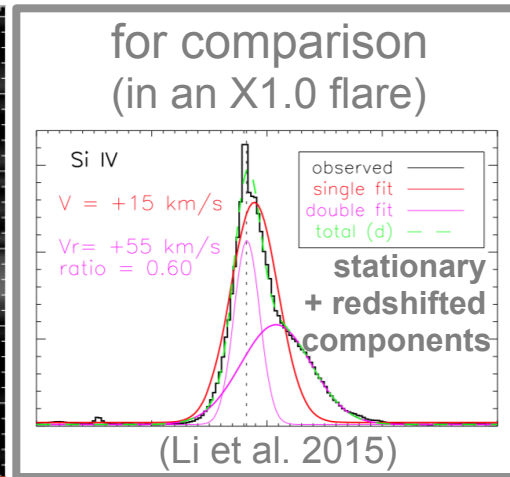
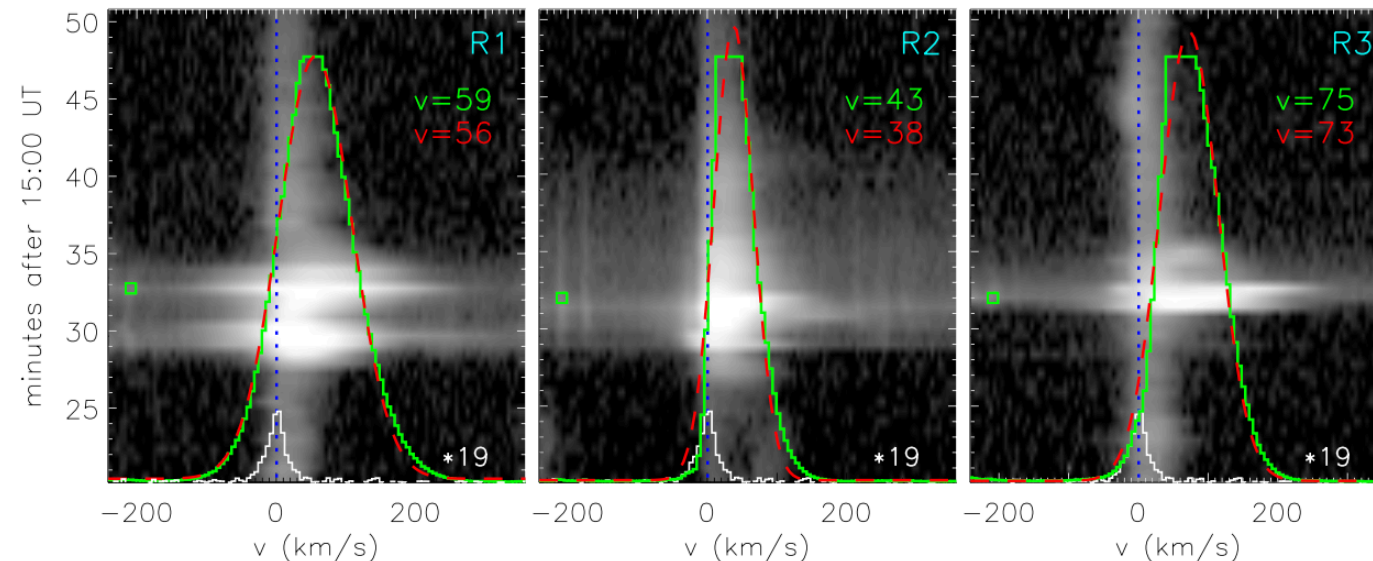


# Spectral features at flare ribbons: R1-R3

**Fe XXI**  
blueshifted

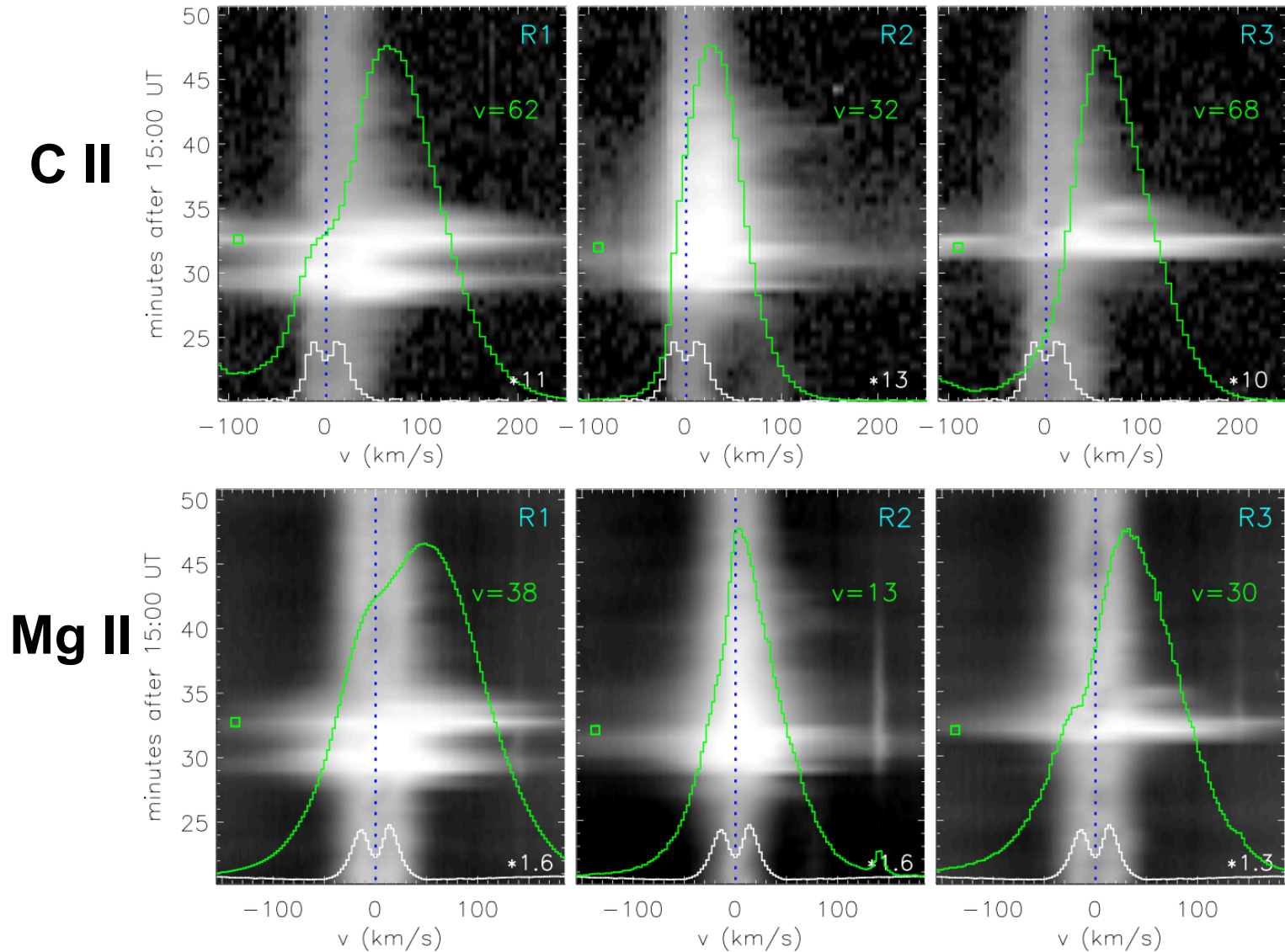


in particular, **entirely redshifted Si IV profiles** (single Gaussian fitting)



# Spectral features at flare ribbons: R1-R3

Singly peaked, redshifted



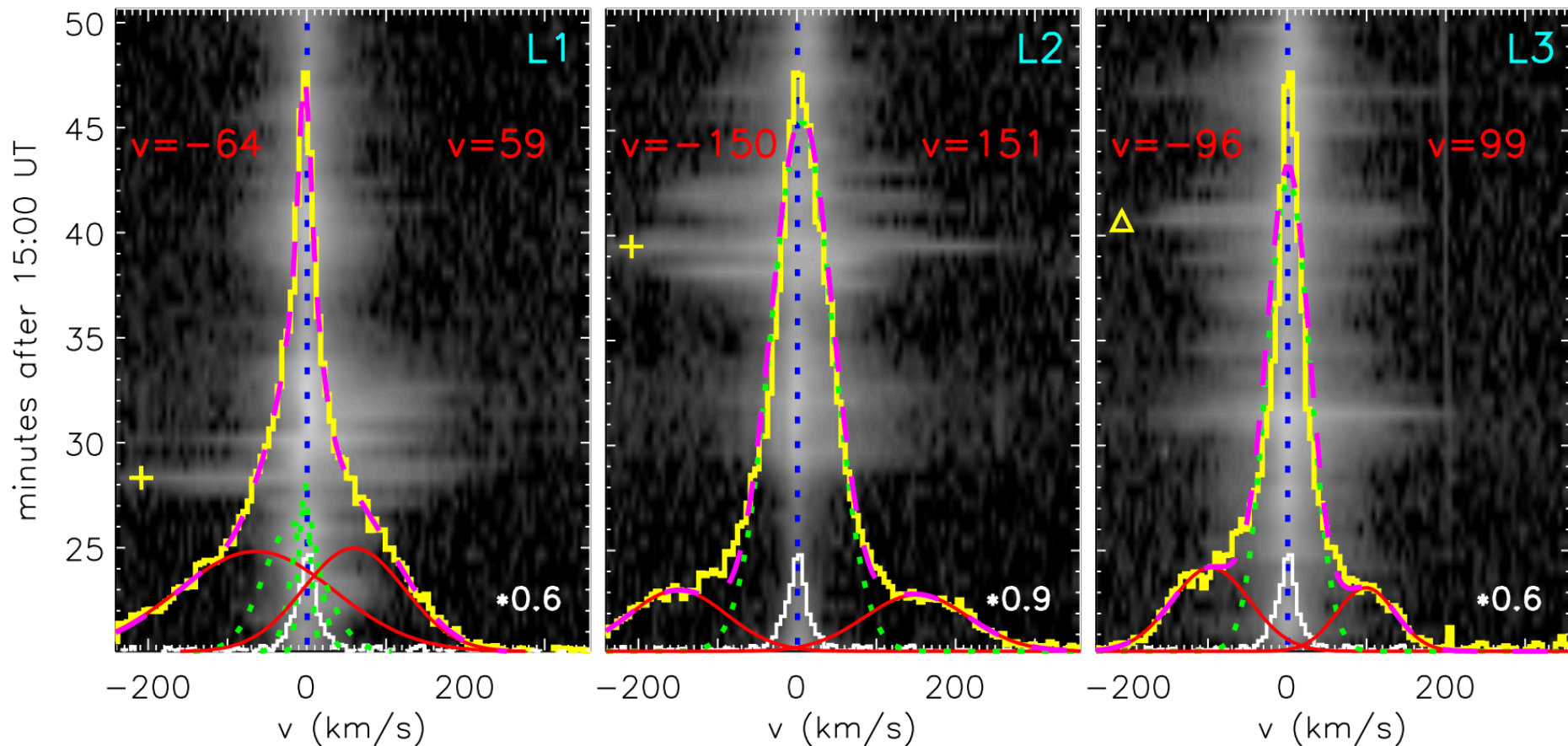


# Spectral features at flare ribbons - implications

- blueshifts in Fe XXI & redshifts in Si IV, C II, and Mg II
  - consistent with **chromospheric evaporation**  
(explosive evaporation)
- **wholly redshifted Si IV profiles** vs.  
stationary + redshifted Si IV components
  - IRIS may resolve/unresolve the condensation region
  - energy deposition in a narrow/wide (multiple) layer  
by thermal/non-thermal heating?

# Spectral features near the separator: L1-L3

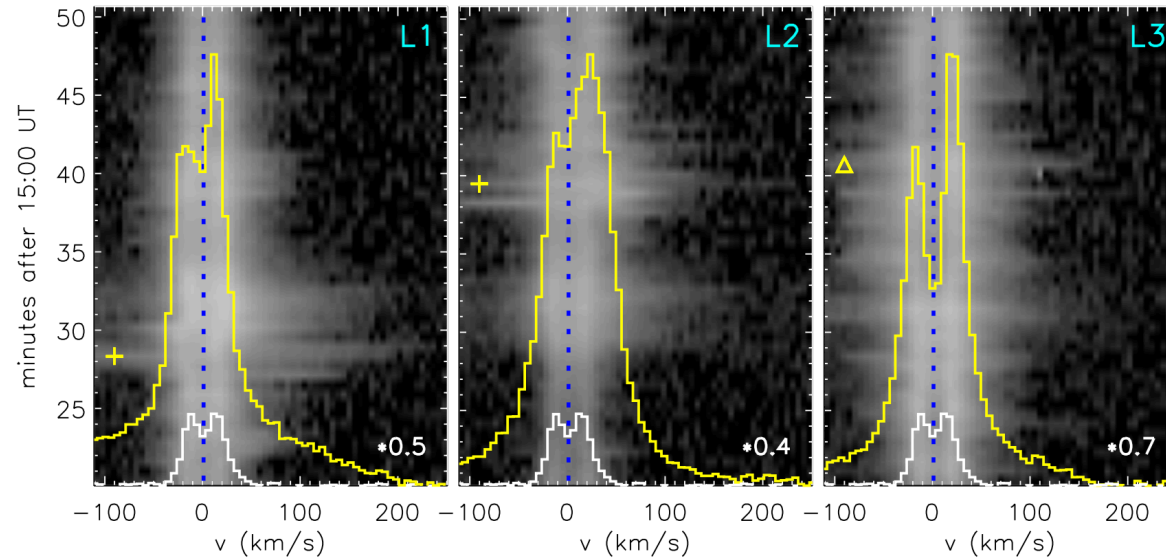
**Si IV** : broadened line wings extending to 200 km/s  
with an unshifted line core (multiple Gaussian fitting)



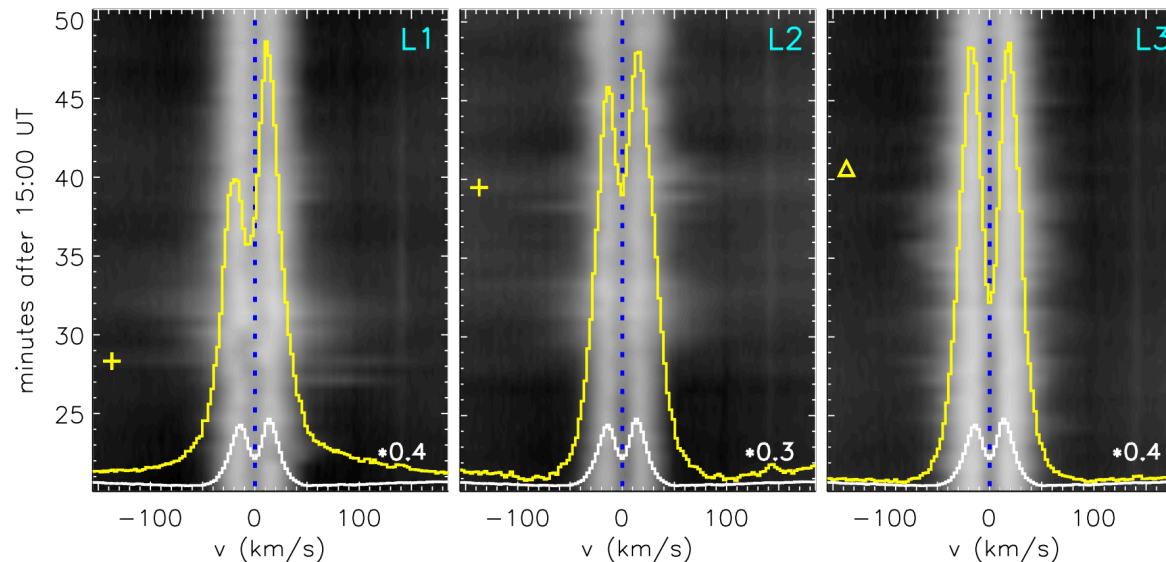
# Spectral features near the separator: L1-L3

broadened line wings (double peaked) & red asymmetry

**C II**



**Mg II**



# Spectral features near the separator - implications

- broadened line wings with bumps at  $\pm (60-150)$  km/s in **Si IV**: **existence of bidirectional reconnection outflows**;
- broadened line wings with a red asymmetry in **C II** & **Mg II**: **downward reconnection outflows**;
- The energy is released via **separator reconnection around the transition region**, which is rarely reported in previous flare studies.

# Summary

- **Distinct spectral features** are observed **at the flare ribbons** and **near the separator** in an X-shaped flare, as implications for **energy release** and **dynamics** in the flare atmosphere.
- Near the location of the separator, **the Si IV line** exhibits significantly broadened line wings extending to 200 km/s, suggesting the presence of bidirectional flows related to the **separator reconnection** in the transition region.
- At the flare ribbons, **the hot Fe XXI line** shows blueshifts and **the cool Si IV, C II, and Mg II lines** show evident redshifts up to 80 km/s, consistent with **chromospheric evaporation /condensation**. In particular, **the Si IV line** is entirely redshifted with no rest component.

More details can be found in **Li et al. 2017, ApJ, 848, 118**

*Thanks for your attention!*