EVAPORATION FLOWS IN A BRIGHT KERNEL OF A X1.6 FLARE OBSERVED ON 2014 OCTOBER 22 BY IRIS, HINODE, AND RHESSI

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Solar flare – Models & observations

1. Introduction

- Magnetic reconnection occurs
- Energetic particles are accelerated at the reconnection site
  - Particles precipitates along the magnetic loop (radio emission) and hit the chromosphere footpoints (Hard X-ray emission, Hα emission and flare ribbon)
  - Heated chromospheric plasma evaporates into the corona (soft X-ray emission, post flare loop arcade)

Evaporation flows
- From the spectroscopic observation, evaporation flows are observed by Doppler velocity measurements

Krucker et al. (2008)
Spectroscopic observations of evaporation flows in flares

- Previous studies for the evaporation flows from spectroscopic observation

1. Introduction

Brosius (2013) – Hinode/EIS

Milligan et al. (2009) - Hinode/EIS

Tian et al. (2014) – IRIS
X1.6 flare on 2014 October 22 (AR12192)
Bright kernels in the flare

Background (blue):
IRIS SJI 1330

Foreground (red):
Hinode EIS Fe XII 195Å

White box: IRIS raster for spectral window
Bright kernels in the flare

2. Observation

Background (blue): IRIS SJI 1330

Foreground (red): Hinode EIS Fe XII 195Å

White box: IRIS raster for spectral window

- Position 1: Before flare (13:34 UT / X:-254, Y:-307)
Bright kernels in the flare

- Position 1: Before flare
  (13:34 UT / X:-254, Y:-307)

- Position 2: flare starts
  (14:06 UT / X:-248, Y:-320)

Background (blue):
  IRIS SJI 1330

Foreground (red):
  Hinode EIS Fe XII 195Å

White box: IRIS raster for spectral window
Bright kernels in the flare

2. Observation

Background (blue):
IRIS SJI 1330

Foreground (red):
Hinode EIS Fe XII 195Å

White box: IRIS raster for spectral window

- Position 1: Before flare
  (13:34 UT / X:-254, Y:-307)

- Position 2: First peak of flare
  (14:06 UT / X:-248, Y:-320)

- Position 3: Second peak of flare
  (14:20 UT / X:-254, Y:-318)
3. Results (1)

Doppler velocity variation with formation temperatures – combination of IRIS and EIS

Explosive evaporation

- IRIS (single Gaussian)
- IRIS (double Gaussian)
- EIS (single Gaussian)
- EIS (double Gaussian)
Temporal variation of the plasma properties – Intensity, Doppler velocity, and line width

- IRIS (O I, Si IV, Fe XXI) – Position 1 – EIS Intensity

3. Results (1)
Temporal variation of the plasma properties – Intensity, Doppler velocity, and line width

- IRIS (O I, Si IV, Fe XXI) – Position 2 – EIS Intensity
Temporal variation of the plasma properties – Intensity, Doppler velocity, and line width

- IRIS (O I, Si IV, Fe XXI) – Position 3 – EIS Intensity

3. Results (1)

<table>
<thead>
<tr>
<th>Fe XXIV</th>
<th>Fe XXIII</th>
<th>Fe XVI</th>
<th>Fe XV</th>
<th>Fe XIV</th>
<th>Fe XII</th>
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Start Time (22-Oct-14 13:03:51)
Temporal variation of the HXR and SXR emission from the RHESSI

Red contour: SXR, Blue contour: HXR

HXR peak – cooler line intensity
SXR peak – hotter line intensity
Spectroscopic view of the evaporated flows in the bright kernels in the flare

- Temporal evolution of the Doppler velocities at the bright kernel with different spectral lines
  - Before the flare – Blue shift at the bright kernel at the most spectral lines
  - During the impulsive phase (1st peak)
    - Explosive evaporation flows (EIS + IRIS)
      - cooler emission: red shift (~100km/s)
      - hotter emission: blue shift (~ 300-400 km/s)
    - Intensity enhancement at the lower temperature (O I & Si IV)
      - impact of non-thermal particle
      - O I emission doesn’t have significant Doppler velocity variation
      - Si IV shows red shifted emission
    - Strong blue shift without intensity enhancement at the hotter emission (Fe XXI)
  - Decay phase (2nd peak)
    - Intensity enhancement of the hotter emissions - evaporation flows and thermal emission
    - Several peak of the Doppler velocity and intensity - multiple reconnection?
    - Continuous blue shift (hotter lines) and red shift (cooler lines)
Intensity variation of the bright kernel and a relation with HXR and SXR from RHESSI

- Intensity variation with time and different spectral lines
  - Cooler emission shows sharp intensity peak before the enhancement of the hotter emission
    - White light flare
    - O I intensity enhancement
  - Intensity enhancement of the spectral lines a little delay with increasing temperature

- Temporal variation of the RHESSI HXR and SXR
  - The peak of HXR emission (30-100 keV) is observed at the start of the flare
    - White light flare occurring time – Chromospheric line intensity enhancement -> non-thermal particle
  - There are two peak of SXR emission (12-25 keV) are observed (1st: HXR peak, 2nd: ~18 min later)
    - Around the timing of 2nd peak, we observed intensity enhancement of the hotter emission (coronal lines) -> thermal emission
We observed X1.6 flare on 2014 October 22 using IRIS+HINODE +RHESSI.

High temporal resolution and wide temperature coverage
- IRIS (8 sparse slit scan) : 15 s for an each slit, 2 min for a scan raster
- Temperature coverage form combined IRIS and EIS observation : log T ~ 4.5 – 7.2

From the Doppler velocity measurements, we observed the explosive evaporation at the flare bright kernel.

We investigated the temporal evolution of the intensity, Doppler velocity using the combined observation of the IRIS and EIS
- Impulsive phase: strong blue shift at the hotter lines (weak intensity enhancement) and red shift at cooler lines (intensity enhancement).

HXR related with white light flare and chromospheric line intensity enhancement and SXR related with hotter spectral line intensity enhancement.

We plan to measure the density variation with time and different region to understand the evaporation process with the intensity variation.
THANK YOU