Multi-instrument Observations of a δ-spot Hosting a C4.1 Flare

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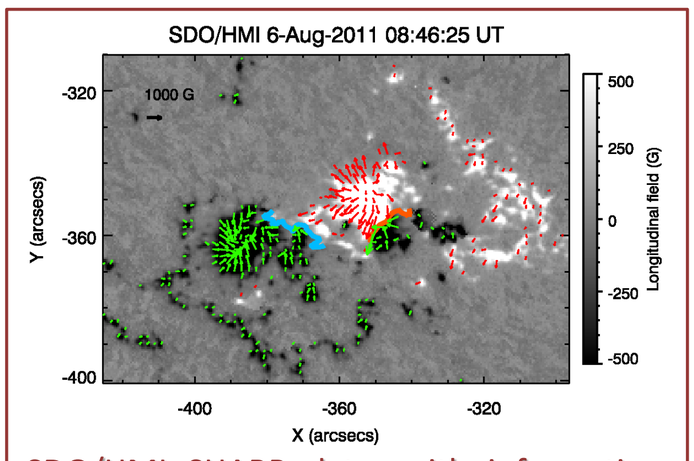
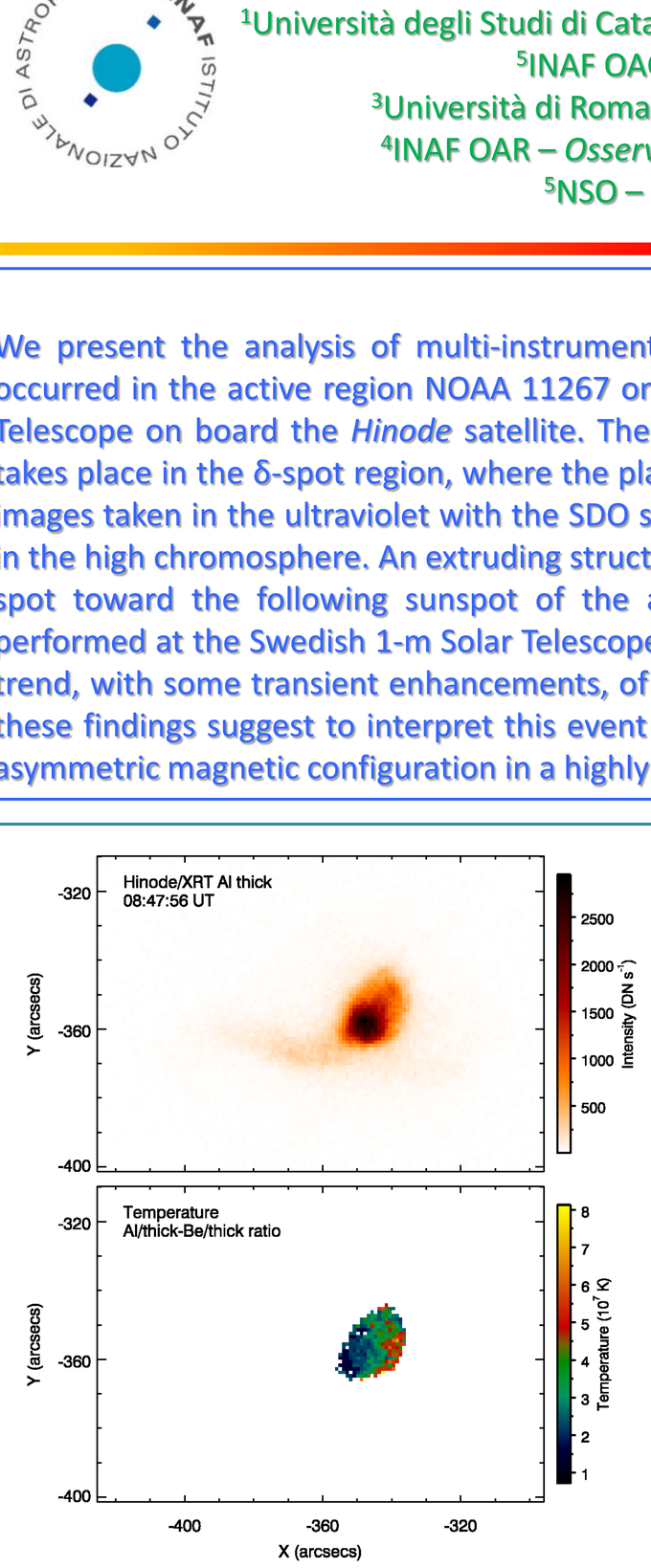
Abstract

We present the analysis of multi-instrument space- and ground-based observations relevant to a C4.1 flare occurred in the active region NOAA 11267 on 2011 August 6. At the peak, the flare was observed by the X-Ray Telescope on board the *Hinode* satellite. These unique observations reveal that the bulk of the X-ray emission takes place in the δ-spot region, where the plasma heats up to $2 \cdot 10^7$ K. During the gradual phase, we observe in images taken in the ultraviolet with the SDO satellite the development of a Y-shaped structure in the corona and in the high chromosphere. An extruding structure also forms, being directed from the emitting region above the δ spot toward the following sunspot of the active region. High-resolution (0".15) ground-based observations performed at the Swedish 1-m Solar Telescope in the core of the Ca II H chromospheric line indicate a decreasing trend, with some transient enhancements, of the intensity in the flare ribbons during the late gradual phase. All these findings suggest to interpret this event as a manifestation of magnetic reconnection, likely induced by an asymmetric magnetic configuration in a highly sheared region.

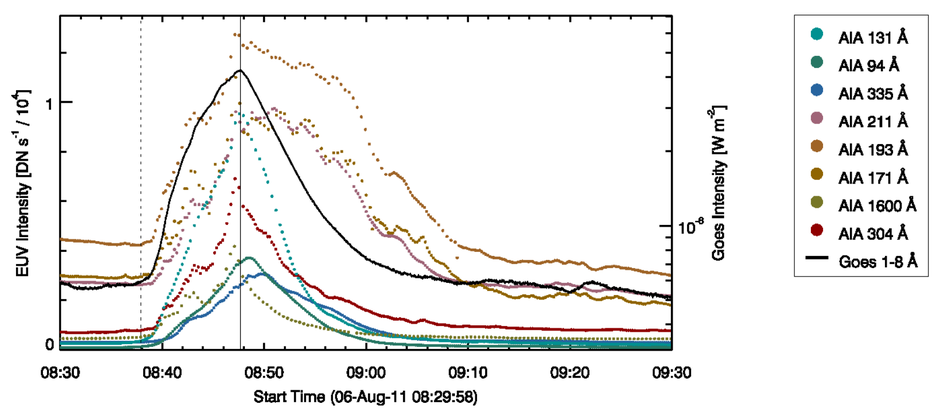


SDO/HMI SHARP data, with information about the full vector magnetic field, indicate the presence of a strong magnetic shear of ≈ 80° along the δ-spot polarity inversion line at the flare peak.

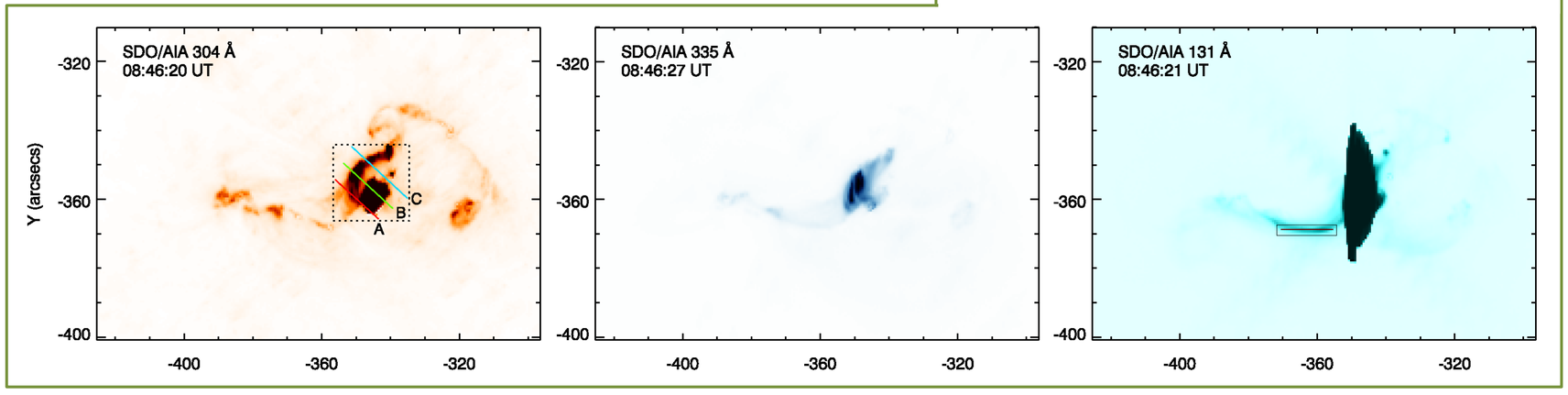


We benefit from high resolution (1".03 pixel scale) *Hinode*/XRT not saturated data through the Al/thick and Be/thick filters during the flare peak. At that time, the bulk of X-ray emission is located in the δ-spot area, with a temperature of ≈ $1.9 \cdot 10^7$ K.

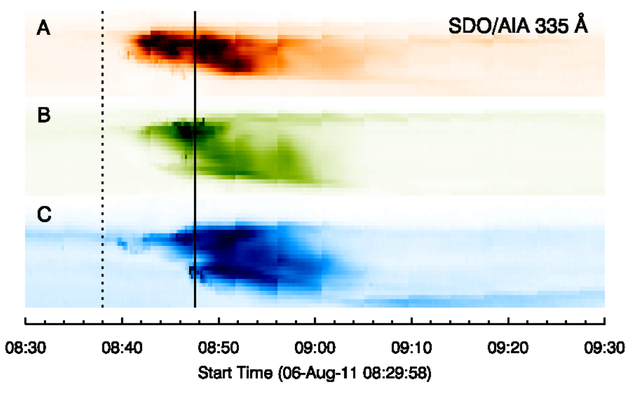
Lightcurves for all the SDO/AIA channels, computed within the box shown at 304 Å, point out the presence of some time delays between the peaks in the SDO/AIA channels and the SXR emission measured by the GOES satellite.

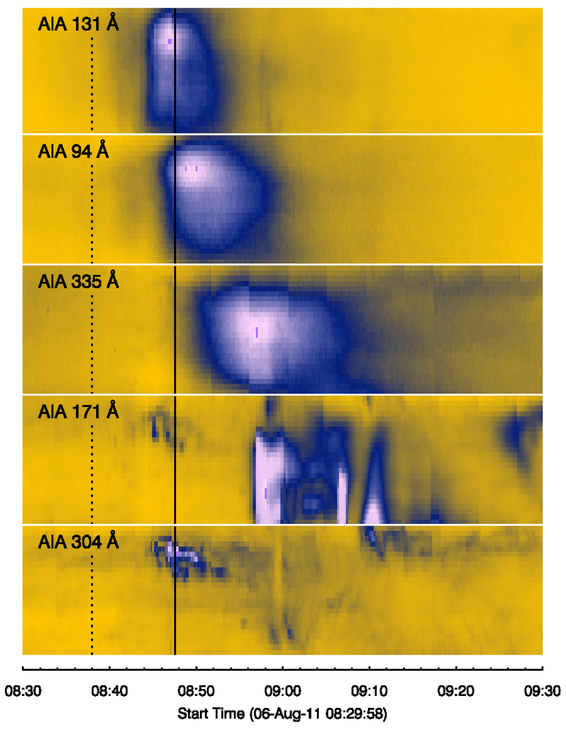


Three snapshots show the morphology of AR NOAA 11267 simultaneously observed by SDO/AIA at different wavelengths.
In the upper chromosphere we detect some emission in between the ribbons (304 Å), while in the corona we note that the ribbons are overarched by coronal loops which connect them (335 Å). Interestingly, an extruding structure being directed from the flaring region towards the East is extremely evident at 131 Å.



The spatial evolution of the flare ribbons in the δ-spot region, studied through intensity time slices along the segments A – B – C indicated in the image at 304 Å, shows an asymmetric behavior between the northern and the southern ribbon. The former activates before the latter, which conversely moves faster (see the image relevant to the 335 Å channel). We also find a time delay between different atmospheric layers in ribbons activation. The flare ribbons motion has a preferential direction: they separate progressing to the North – West.

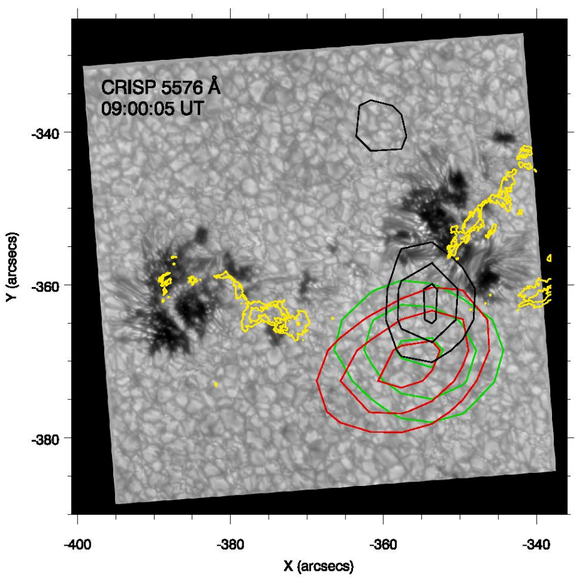




A time slice along the segment shown at 131 Å indicates that the extruding structure is progressively observed in the EUV channels referring to decreasing plasma temperatures, while moving to the East.

The Swedish 1-m Solar Telescope (SST) acquired images of AR NOAA 11267 in the Ca II H line core 13 minutes after the flare peak. Three regions with UV enhancements, that correspond to the flare ribbons in the δ-spot area and to the footpoint of the extruding structure, are observed in the chromosphere, as shown with yellow contours over the simultaneous SST/CRISP continuum map, taken at 5576 Å.

Co-temporal RHESSI measurements over the AR, which refer to an event peaking at 09:00 UT, are shown with contours of the X-ray emission in the: 3-6 keV (red), 6-12 keV (green), and 25-50 keV (black) channels. They point out that X-ray emission occupies the region between the main sunspots of the AR.



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