Polarization signatures during the X1.6 flare observed in NOAA 12192

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Abstract

The X1.6 flare observed on 22 October 2014 (SOL2014-10-22T14:28) was among the strongest flares occurred in the magnetically complex, great active region NOAA 12192. It was a confined flare, without an accompanying CME, despite the large amount of released energy. In our work we attempt to deepen our understanding of the magnetic field configuration of the AR 12192. We analyzed the polarization signatures during the flare using spectro-polarimetric data acquired by the IBIS/DST instrument along the photospheric Fe I 617.3 nm and the chromospheric Ca II 854.2 nm lines in a time interval immediately following the peak of the X1.6 flare. The results obtained provided evidence of significant changes in the magnetic field configuration during the analyzed time interval.

The Target: AR NOAA 12192

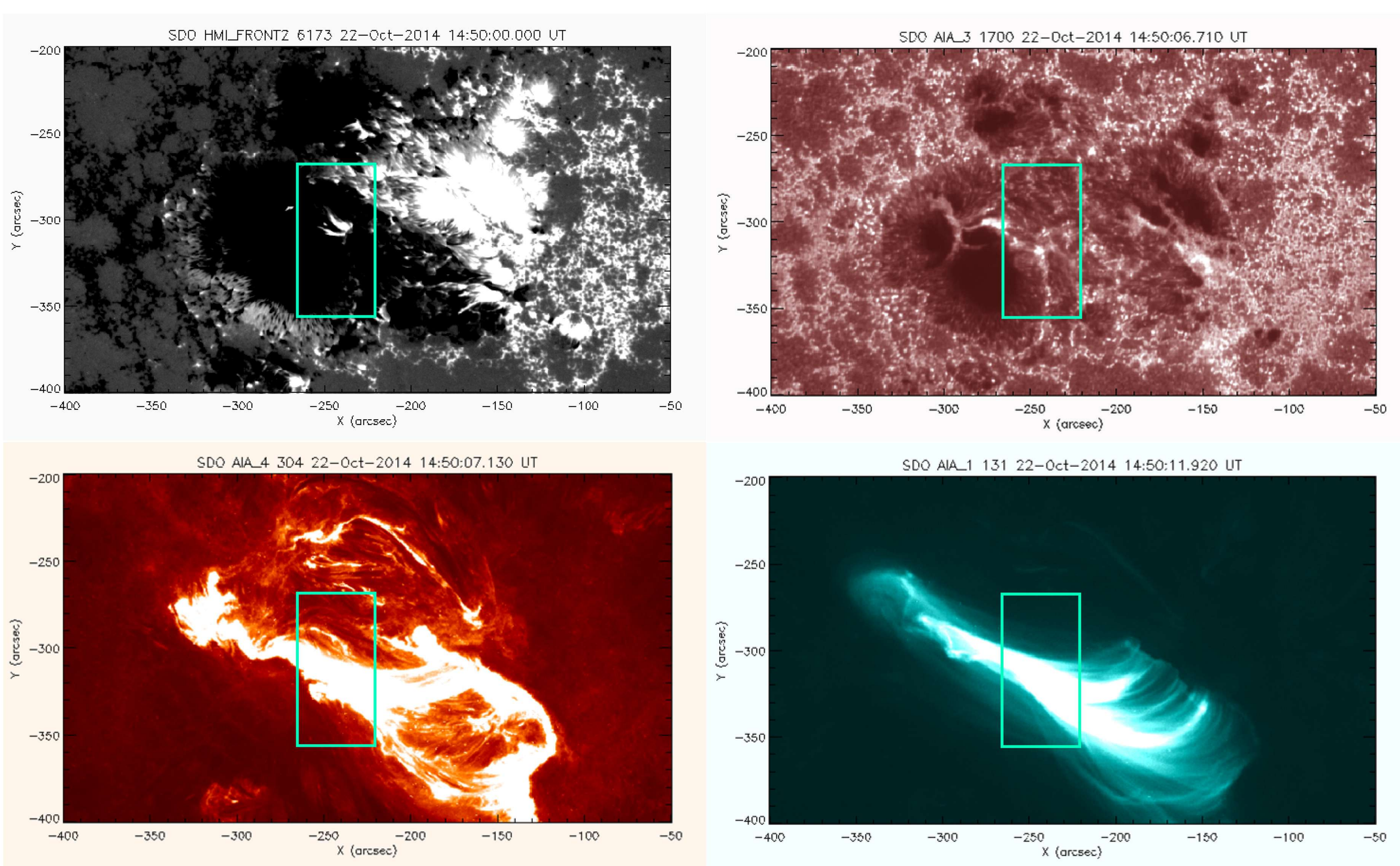

Fig. 1: The upper-left panel shows a HMI/SDO magnetogram of the AR, the upper-right panel shows the AR observed at 1700Å, the lower left panel shows the AR observed at 304Å and the lower right panel shows the AR observed at 131Å. The green box shows the FoV of the IBIS instrument.

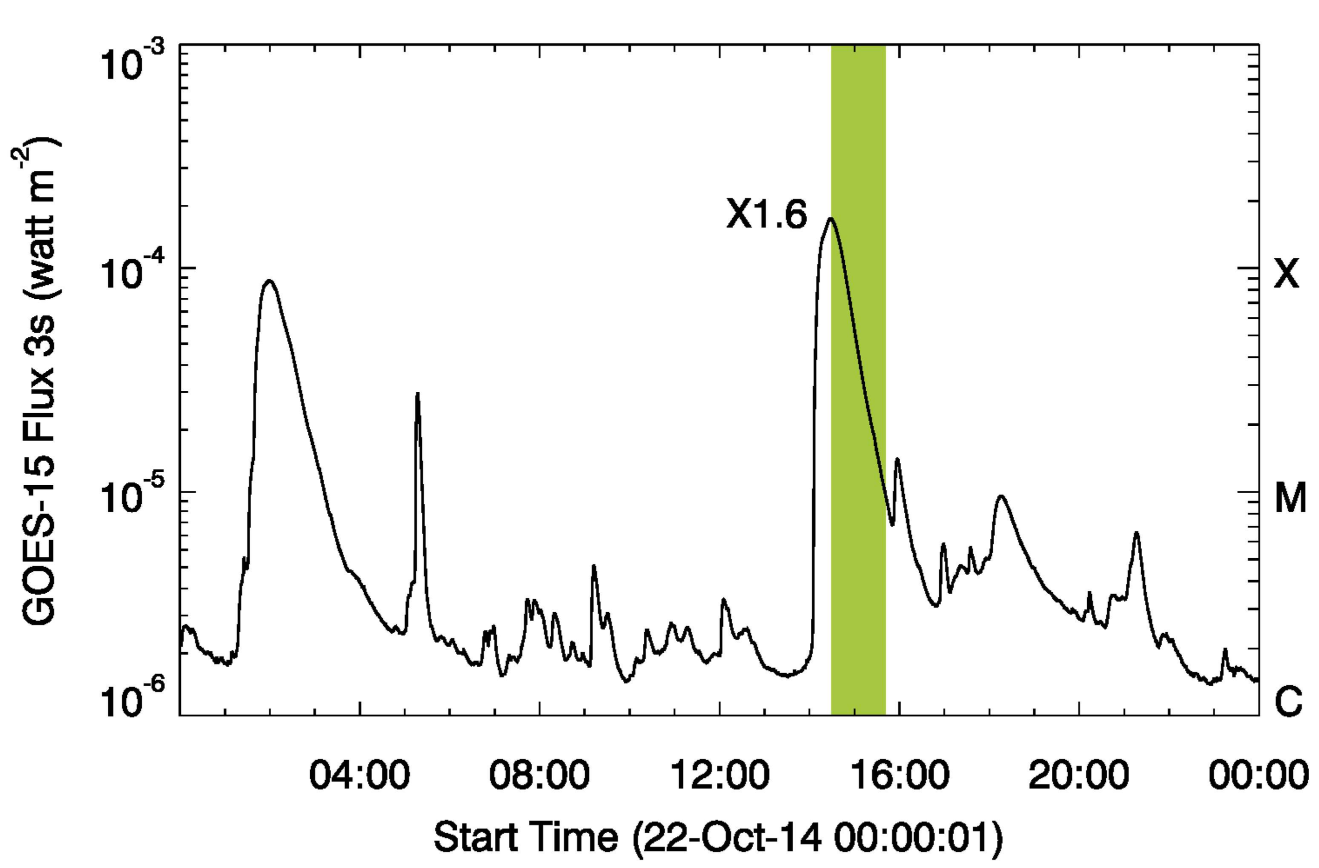

Fig. 2: GOES flux on October 22. The green part indicates the time interval of IBIS data acquisition.

Weak Field Approximation

When the Zeeman separation induced by the magnetic field in a spectral line $\Delta\lambda_B$, is smaller than $\Delta\lambda_D$, the Doppler width due to the thermal motion, at any optical depth we can get a relationship between V and $\frac{dI}{d\lambda}$, from which it is possible to obtain the value of the magnetic field along the LOS direction $B_{LOS} = B\cos\theta$:

$$V = -\bar{g}\Delta\lambda_B \cos\theta \frac{dI}{d\lambda} \quad (1)$$

The Zeeman splitting is

$$\Delta\lambda_B = \frac{e}{4\pi m_e c} B\lambda_0^2 = 4.6686 \cdot 10^{-13} B\lambda_0^2 \quad (2)$$

We put for CaII 8542 Å, $\bar{g} = 1.1$ (Kleint, 2017) and for FeI 6173Å, $\bar{g} = 2.5$ (Landi Degl' Innocenti, 1982).

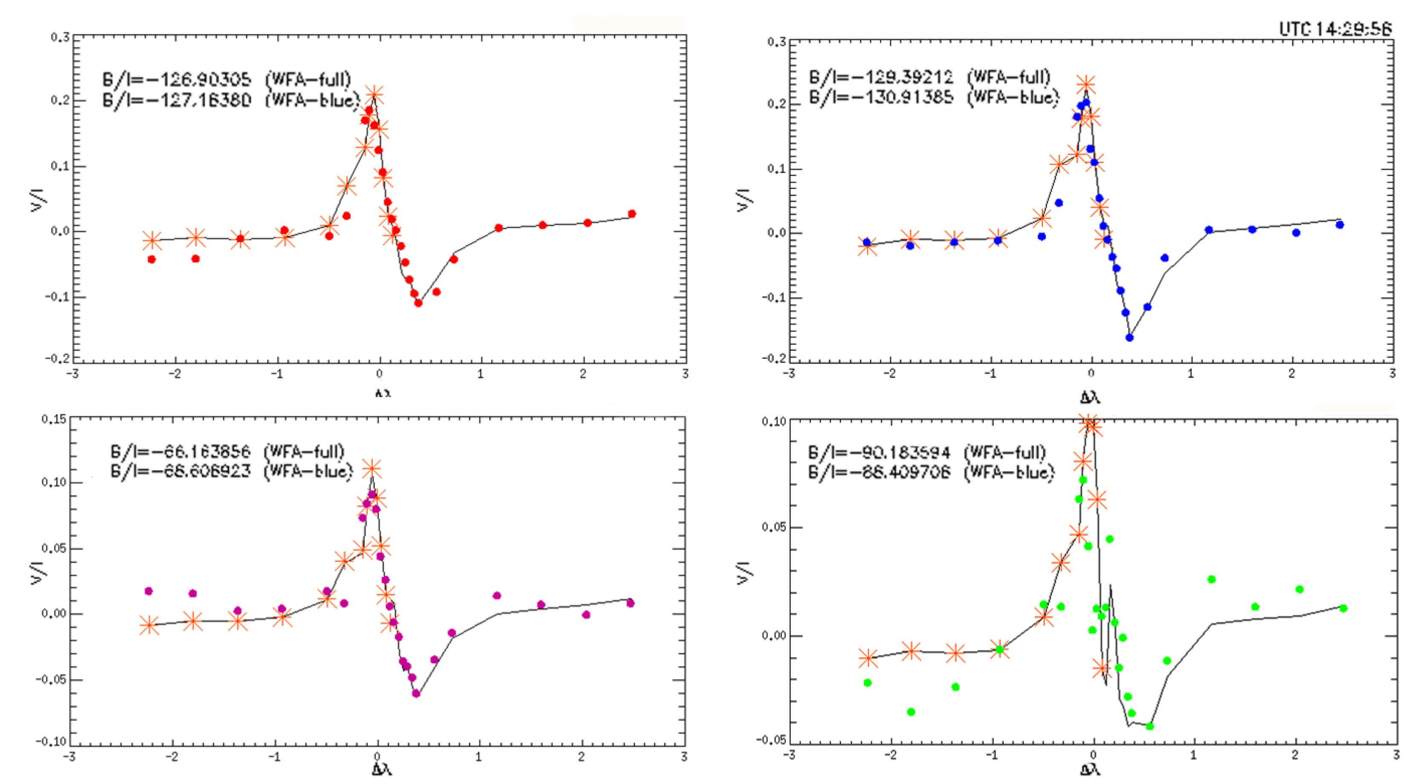

Fig. 3: The panels show $\frac{V}{I}$ for the Ca II line at the observed wavelengths (coloured circles) in four different pixels. The full-WFA fits are represented by the solid lines, while the orange asterisks represent the blue-wing fits. $\Delta\lambda = \lambda - \lambda_0$, where λ_0 is the central wavelength 8542 Å.

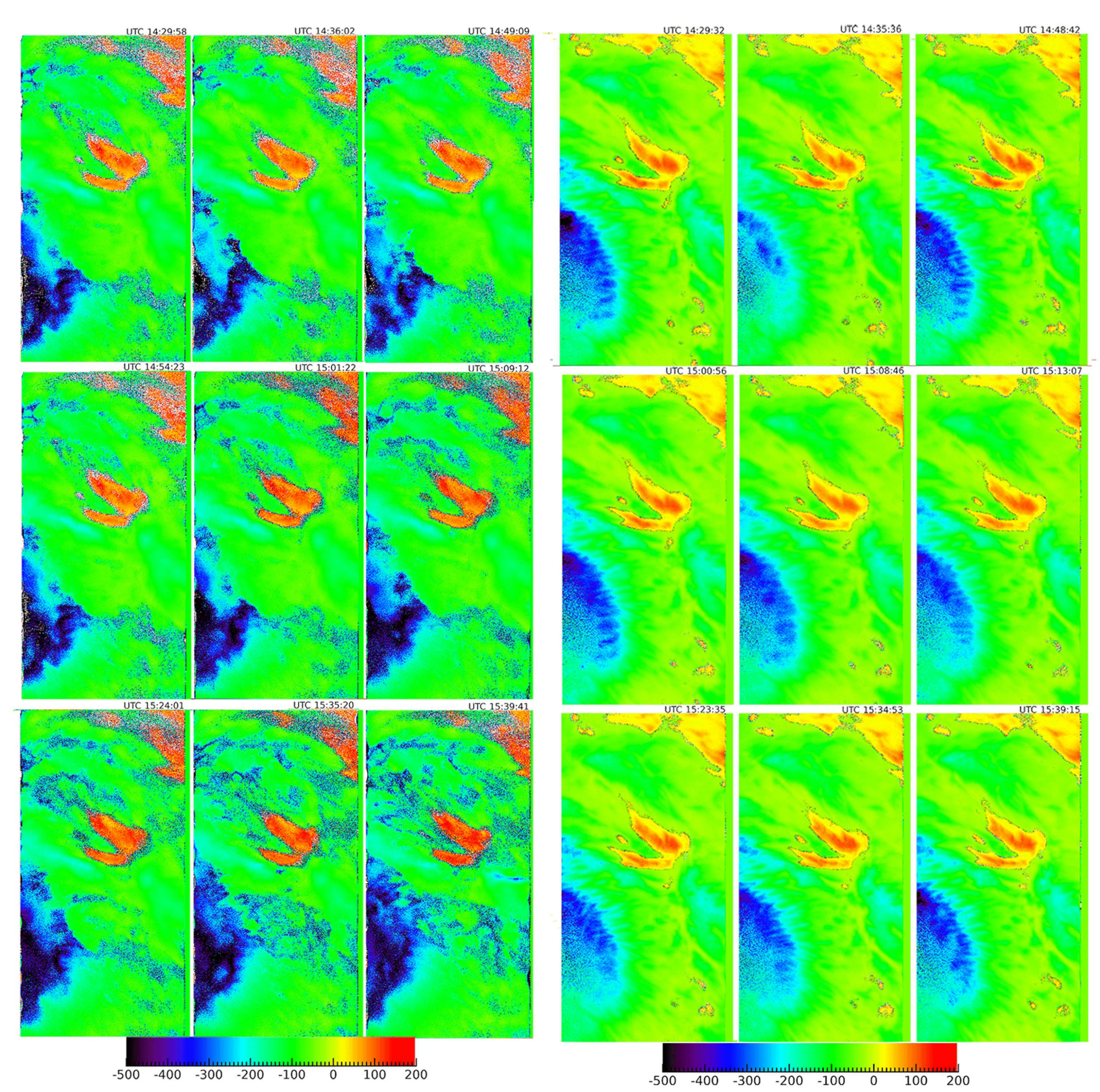

Fig. 4: Temporal evolution of B_{LOS} obtained with the WFA for the CaII line (left) and Fe I (right).

Determination of the magnetic field changes

The temporal variation of the magnetic field occurring during a flare can be characterized at the first order by a step function (Sudol and Harvey, 2005).

$$B(t) = a + bt + c\left\{1 + \frac{2}{\pi}\arctan[n(t - t_0)]\right\} \quad (3)$$

- c is the half amplitude of the step, $2c$ is the amplitude of the step and it represents the measure of the change in the magnetic field, dB.
- $\frac{\pi}{n}$ is the time interval at which the stepwise change occurs, dt.

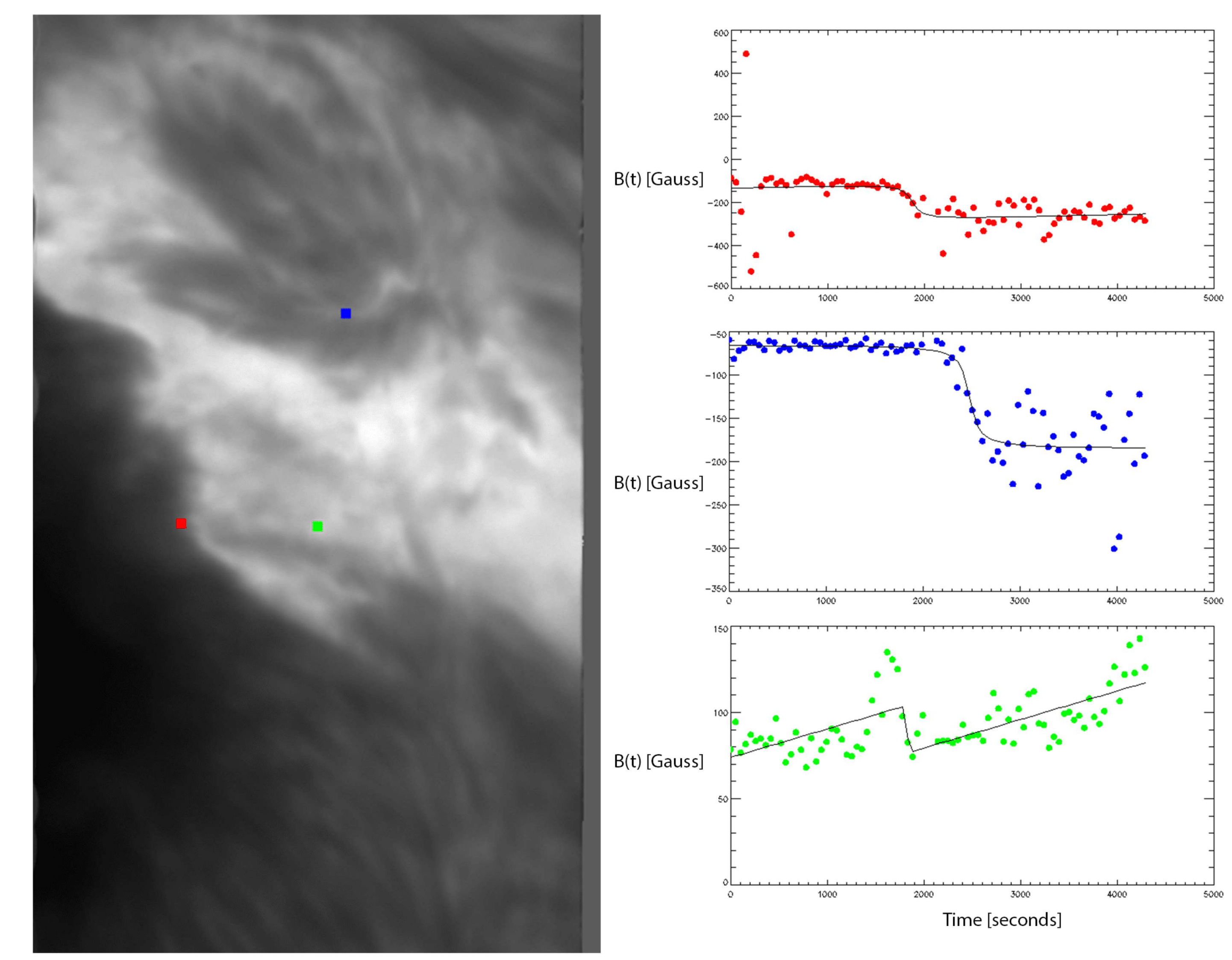

Fig. 5: In the left panel a chromospheric image acquired by IBIS is shown. The colored circles indicate the points in proximity of the flare ribbon, used to obtain the plots shown on the right. Right panel: fits relevant to the selected pixels.

Results

- A consistent change of the longitudinal magnetic field occurred in the ribbon in chromosphere.
- The location of the chromospheric changes are unrelated to the location of the changes in photosphere.
- We did not find an evident correlation between the magnetic field strength and the magnitude of the magnetic field changes.
- The distribution of the magnetic field change is more asymmetric in chromosphere than in photosphere.
- Fast and abrupt changes are more frequent than slow changes both in chromosphere and in photosphere.

Bibliography

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E. Landi Degl'Innocenti, Sol. Phys., 77, 285 (1982)
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