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DYNAMICS OF CORONAL FLUX TUBES IN FLARES

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Abstract. In this research we address the problem of dynamics of the soft X-ray coronal structures being excited during flares. The investigation of this problem has been possible thanks to development of dedicated *Yohkoh* SXT image deconvolution algorithm ANDRIL which allows to remove the instrumental blurring and increase spatial resolution on the images below ~ 1 arcsec.

Key words: Sun–X-rays–flares–SXT deconvolution–kernel dynamics

We have investigated spatial and temporal relationship between activation/motion of emission kernels as seen at footpoint and summit areas of flaring structures. We incorporated into the analysis the results of hard X-ray source imaging and the results of X-ray spectral fitting (line Doppler shifts).

In the analysis we have used the following *Yohkoh* observations: sequences of deconvolved SXT flare images, BCS spectra and HXT numerically reconstructed images (MEM approach). Deconvolution has been performed using ANDRIL algorithm (Sylwester and Sylwester, 1998a,b). Deconvolved images have been coaligned to within fraction of the arcsec using spacecraft pointing data and applying additional pointing corrections as described by Siarkowski et al. (1996). The BCS spectra of S, Ca and Fe ions have been fitted (single Doppler component) using the FIT_BSC routine (*Yohkoh* software). The HXT images have been numerically reconstructed using HXT_MULTIMG routine.

In this short publication we present just one example of the results obtained. We selected well observed flare on 27 September 1993 at 10:54 UT (C5.7, SF) which occurred in NOAA 7590 active region close to eastern solar limb (N11E80). However the conclusions of present contribution have been drawn taking into account results of analysis for all flares investigated by now.

In Fig. 1 the left panel presents time dependence of selected flare characteristics. Upper three plots are the lightcurves (normalized to unity at the maximum) for the full Sun detectors. The two enhancements are pronounced in both soft and hard X-ray emission. Strong redshifts of X-ray lines are associated with the first enhancement as observed in all BCS spectra. During respective decays of harder emission, blueshifts are pronounced. All shifts are determined relative to the position of lines as observed at the end of the flare. The amplitudes of velocity variations shown correspond to the change by 50, 70 and 350 km/s for SXV, CaXIX and FeXXV (entire spectra) respectively. Also the location of the brightest kernels displaces as determined from deconvolved SXT images. The displacement is determined as seen in projection and calculated referring to the initial position for respective filters. In the right panel correlation plots are displayed indicating that the displacements in Al01 and Al12 channels are related. Since the exposures in these filters are independent in terms of unreduced spacecraft pointing and exposure time, presence of significant correlations has to be related with the flare physics. Presence of the correlations for this and the other flares investigated provides evidence of fast evolutionary changes within flaring areas on spatial scales down to the resolution achieved on deconvolved images (~ 1 arcsec).

The following conclusions may be drawn from the analysis performed: **a)** The positions of local maximum brightness emission do change in all investigated flares for both footpoint and summit areas. **b)** The variations have "time organized" pattern and have different character for individual SXT filters. However the displacements as determined for individual filters usually correlate. **c)** Summit located kernels displace usually in the direction out of the solar surface. The displacements of footpoint and summit kernels appear also to be related. **d)** Correspondence is observed between the start time of HXT emission and beginning of transversal displacements. **e)** Average wavelengths of soft X-ray resonance lines do vary also for flares observed at the limb. The observed shifts indicate for presence of an overall hot plasma motions. The velocity of these motions increases with the formation temperature of the corresponding line.

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References

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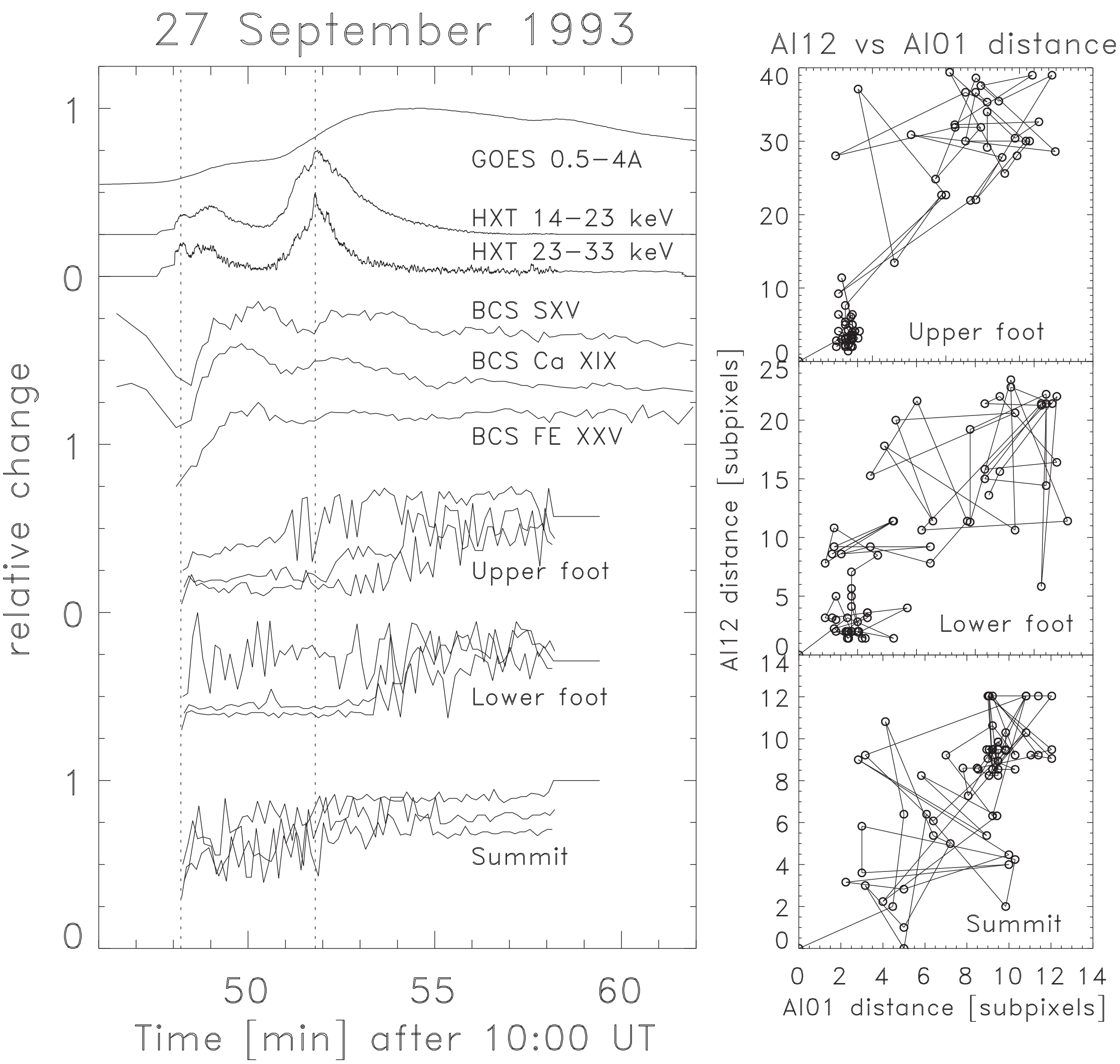

Figure 1. Left panel: Time variations of selected flare characteristics: *GOES* 0.5-4 Å flux, *Yohkoh* HXT fluxes in the lower energy bands, *Yohkoh* BCS Doppler shifts in the three indicated resonance lines, transversal displacement of maximum brightness for three selected areas: at the upper and lower footpoints, and at the summit. The displacements are plotted as determined based on analysis of deconvolved *Yohkoh* SXT images obtained for Be119, Al12 and Al01 filters (as going from the uppermost to lowermost curves for each area). All plots are normalized. **Right panel**: Correlation plots between displacements as seen in thin and thick aluminium filter sequences for the three regions selected. Note different range of variation.

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