STRUCTURES IN VICINITY OF SUNSPOTS AS SEEN ON DECONVOLVED SXT IMAGES

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Abstract. We have studied the coronal X-ray structures above the large sunspot groups related to NOAA 7220 and 7222 seen near the disc centre on 11 and 12 July 1992. The main source of information consists of X-ray images obtained by SXT on Yohkoh. In order to increase the spatial resolution on the X-ray images we have used the ANDRIL deconvolution algorithm developed in Wroclaw. The deconvolved images have been overlaid with the high resolution magnetograms and white light pictures taken at corresponding times.

Key words: Sun – X-rays – SXT deconvolution – Ground base data comparison

It is important to understand the relationship between the morphology of the structures seen in the corona and the underlying chromosphere and photosphere. In order to study this relationship we have used available observations of the photosphere in white light, magnetograms and the soft X-ray images of the corona. Large spots and numerous pores are seen on the high resolution white light images obtained in the Debrecen Heliophysical Observatory for the investigated AR. These well evolved active regions gave 18 subflares (C class in GOES) during the period analysed. Marshall Space Flight Center(MSFC) provides magnetograms which reveal complicated structure of the photospheric magnetic fields as well as white light images from the same set of measurements.

For the results of the present study a high spatial resolution of the images used and their accurate alignment are of great importance. The resolution on the Debrecen photospheric images is up to 1 arc sec. The pixel size of the Marshall magnetograms is 3.2 x 3.2 arc sec. Similar is the resolution on the SXT soft X-ray images (2.5×2.5 arc sec; see Tsuneta et al, 1991). With the known shape of the point spread function of the SXT instrument, it is possible to "increase" the resolution of the images by means of numerical deconvolution. We have used ANDRIL code developed in Wroclaw for this purpose. (Sylwester, J., Sylwester, B. and Siarkowski, 1996). This code makes use of the maximum likelihood approach discussed by Richardson (1972) and Lucy (1995). Maximum likelihood approach has been previously successfully used for removing instrumental effects from the images obtained by the Hubble Space Telescope. When applied to the SXT data, the ANDRIL routine allows to increase the resolution of the soft X-ray images up to ~ 1 arc sec.

The SXT observations are unique in the respect that they provide both soft X-ray and white light images obtained using the same mirror and detector. This enable for a precise overlay of the photospheric and coronal images.

The procedure we applied in order to overlay the images obtained from Debrecen, Marshall and SXT is the following:

- We aligned the deconvolved soft X-ray and white light SXT images using the data from the spacecraft pointing file. The accuracy of the alignment is better than 1 arc sec.
- We cross-compared the SXT and Marshall white light images in order to find the optimum match. Exact overlap of strong, well separated sunspots make us sure that the overlay is accurate to ~ 1 arc sec.
- Based on the results of this comparison we draw the position of the "neutral line" from the data on the vertical component of the magnetic field (Marshall data).
- The same procedure has been used to overlay the Debrecen and SXT white light images. In this comparison we have found that slight rotation (few degrees) between the images was necessary to overlap the images perfectly.

The example of the comparison performed for the rise phase of C5.3 flare observed by SXT on 11 July 1992 at 15:21 UT is shown in Fig. 1a. The following conclusions can be drawn based on the inspection of deconvolved soft X-ray images, magnetograms and high resolution Debrecen white light observations for this and several other analysed situations:

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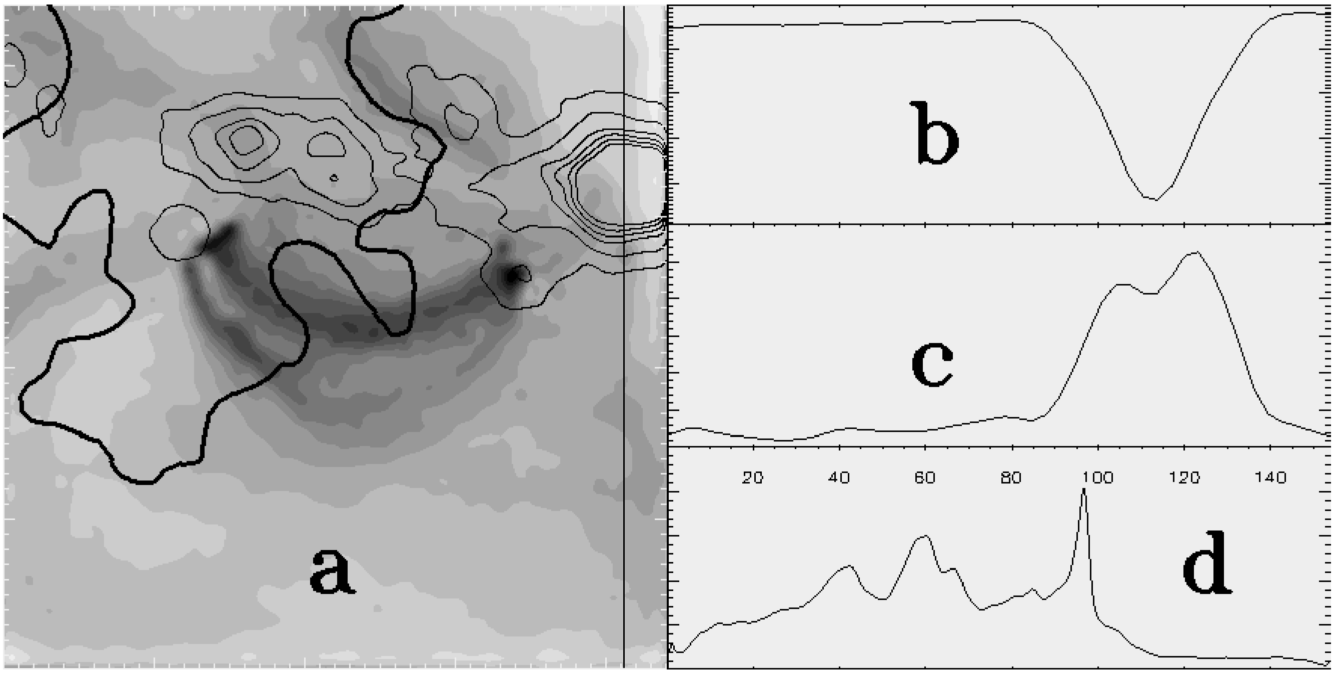

Figure 1. **(a)** The overlay of deconvolved SXT Al01 image (gray scale – dark indicates higher X-ray intensity) with the white light (SXT sensor) contour image. The SXT image envisages the plasma being at the temperature above ~ 2 MK. The iso-contours indicate the umbrae locations. Deconvolved X-ray image represents the mean of 10 exposures taken over the period 15:20:57 UT – 15:22:20 UT on 11 July 1992 when the flare (prominent double loop in **a**) was in progress. Heavy line marks the "neutral line" shape as derived from the Marshall vertical magnetic field component.
(b), (c) & (d) Profiles of the white light intensity, normal component of the magnetic field and the soft X-ray intensity (Al01) along the cut shown as upright line in **(a)**. The observed range of variations is respectively: 50% for the white light, (+100 Gs, +2600 Gs) for the magnetic field and (0.0005–0.02) of the maximum X-ray image intensity.

1. It is confirmed that regions in the corona directly above the strong sunspots are deficient in soft X-ray emission.
2. The footpoints of coronal loops usually do not correspond with the location of pores. Penumbra is the favourite place for their anchoring.
3. It often happens that the footpoints of bright X-ray loops coincide with (start from?) the small-size, tiny low lying loops.
4. It is sometimes seen that an individual X-ray structure may constitute the root of several loops. This may indicate for presence of numerous reconnecting places within this root structure.
5. In the particular case (11 July 1992, see at the top of Fig. 1a) the enhanced X-ray emission evidently matches the "neutral line" shape.

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