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Disappearance of a sunspot accompanying an M-Class flare

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Abstract. A white-light flare on 2001 March 10 was well observed in the Hα line and Ca II λ8542 line using the imaging spectrograph installed in the Solar Tower Telescope of Nanjing University. Three small sunspots appeared in the infrared continuum image, one of which showed that the infrared continuum is enhanced by 4%-6% compared to the preflare value and it almost disappeared in the continuum image for about 3 min. Near the sunspot, there appeared a hard X-ray (HXR) source, the flux of which showed a good time correlation with the profile of the continuum emission. We propose that electron precipitation followed by radiative backwarming may play the chief role in heating the sunspot.

1. Introduction

Whight-light flares (WLFs) are defined as flaring events that are visible in the optical continuum. During WLFs, the photosphere and the temperature minimum region (TMR) can be heated to some extent, as is shown in spectral observations and atmospheric modeling (e.g., Mauas, Machado, & Avrett 1990; Ding et al. 1994). As a consequence, the sunspot, if located close to WLF patches, may dwindle or even disappear in the photographic image.

In this paper we study a WLF that occurred on 2001 March 10. During this WLF, the atmosphere of a nearby sunspot was gradually heated. The observations and data analysis are described in Sect. 2, results are shown in Sect. 3, followed by conclusions in Sect. 4.

2. Observations and data analysis

This WLF, with Hα/soft X-ray importance 1B/M6.7, occurred at N27W42 ($\mu = 0.63$) on 2001 March 10. It started at 04:00 UT, peaked at 04:05 UT, and ended at 04:07 UT. The good time correlation between the continuum emission and the HXR flux implies that it is a type I WLF. Detailed description of the observations and data reduction can be found in Liu, Ding, & Fang (2001).

3. Results

Figure 1 displays the contours of the continuum enhancement near the Ca II λ8542 line at different times. The enhancement is defined as $R = (I_f - I_q)/I_c$, where I_f is the continuum intensity at the flare time, I_q the preflare continuum intensity, and I_c refers to the background continuum intensity (value in the quiet sun region). The continuum enhancement is mainly located at the north-eastern region, where a sunspot can initially be seen but later almost disappeared.

To understand the magnetic configuration of the sunspot region , we use the high time cadence (1 min) full-disk level 1.8 MDI data. All magnetograms have been applied a correction of solar rotation to match the flare peak time. Figure 2 shows a magnetogram at 03:00 UT, which was observed 1 hr before the onset of the flare. The sunspot to disappear, marked by a black box, is in fact composed of two regions that have opposite magnetic polarities and are very close to each other.

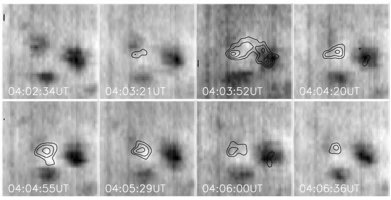

Figure 1. Contours of continuum enhancement at different times overlaid on the gray-scale images. The contour levels are (2.5, 3.5, 4.5, 5.5)%. The field of view is 50″× 50″. North is up and east is to the left.

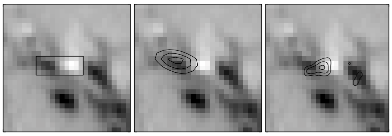

Figure 2. Magnetogram from MDI/SOHO at 03:00:00 UT. Middle panel: HXR contours in 23-33 keV channel from *Yohkoh* with levels of 50, 70, 90% of the peak intensity. Right panel: contours of continuum enhancement at 04:04:20 UT.

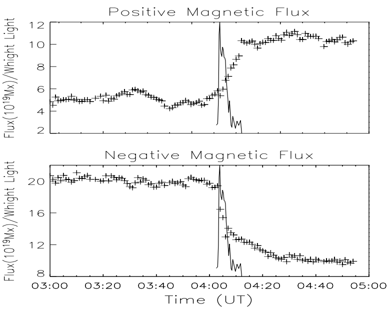

Figure 3. Top panel: Positive magnetic flux of the disappearing sunspot as a function of time. Bottom panel: Negative magnetic flux. Overplotted is the continuum time profile (solid line).

The middle panel of figure 2 shows the HXR contours overlaid on the magnetogram, and the right panel shows the contours of the continuum enhancement at 04:04:20 UT. There exists a slight deviation between the HXR source and the continuum region, but we still conjecture that they are spatially consistent, considering the uncertainties due to the limited spatial resolution of each instrument.

Figure 3 shows the time profile of magnetic flux of the sunspot region marked by a black box in figure 2, together with the mean continuum enhancement of the same region. It is clear that both positive and negative fluxes suffer a very rapid change (see figure 3). The positive magnetic flux rises a little before the flare onset and keeps rising for tens of min till the flare end. At the same time, the negative magnetic flux drops suddenly. As a consequence, the initial imbalance between the positive and negative magnetic polarities is reduced to almost zero after the flare.

Based on the above findings, there should be new fluxes that emerge in the sunspot region and trigger magnetic reconnection. Then high energy electrons precipitat along magnetic filed lines and deposit energy at the sunspot region, which cause HXR emission and continuum enhancement. By making non-LTE model calculations, Ding et al. (2003) found that the energy flux of the electron beam deduced from the HXR emission is large enough to account for the continuum enhancement. Hence electron beam bombardment, followed by radiative backwarming, is the main mechanism for the sunspot heating.

4. Conclusions

A sudden change of the magnetic fluxes indicates that the flare is most possibly triggered by emerging fluxes. The spatial and temporal correlations between the HXR source and the continuum enhancment indicate that electron beam bombardment, followed by radiative backwarming is the main mechanism for the sunspot heating.

Acknowledgements

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