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Magnetic and Velocity Field Variations in the Active Regions NOAA 10486 and NOAA 10488

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Abstract. We study the magnetic and velocity field evolution in the two magnetically complex active regions NOAA 10486 and NOAA 10488 observed during October–November 2003. We have used the available data to examine net flux and Doppler velocity time profiles to identify changes associated with evolutionary and transient phenomena. In particular, we report detection of rapid moving features observed in NOAA 10486 during the maximum phase of the X17.2/4B superflare of October 28, 2003. The velocity of this moving feature is estimated around 40 km/s, i.e., much greater than the usual Hα flare-ribbons' separation speed of 3–10 km/s, but similar to the velocity of seismic waves, i.e., $\sim$ 45 km/s reported earlier by Kosovichev & Zharkova (1998).

Key words. Sun: magnetogram—Sun: Dopplergram—Sun: flare.

1. Introduction

During the declining phase of solar cycle 23, two large active regions NOAA 10486 and NOAA 10488 appeared in the period October 17–November 4, 2003. The active region NOAA 10486 was most active, producing flares of unprecedented magnitudes and fast moving coronal mass ejections. Rapid and permanent changes of photospheric magnetic shear associated with large flares were observed in earlier studies (Ambastha *et al.* 1993; Wang *et al.* 1994; Wang 2006). We report here rapid change in the photospheric magnetic flux in association with the large, energetic X17.2/4B flare observed in NOAA 10486 on October 28, 2003.

2. Magnetic and velocity field changes in the active regions

We found a correlation of $\approx 40\%$ in the net magnetic flux time-series data obtained for the two ARs, NOAA 10486 and NOAA 10488. SOHO-EIT image also clearly shows an interconnection between the two ARs through a trans-equatorial loop. We selected eight areas-of-interest, as marked in Fig. 1(a), along the neutral lines, forming narrow channels of strong magnetic field gradients around the location of flare ribbons, and in quiet regions away from the flare. We evaluated net magnetic flux over these boxes,

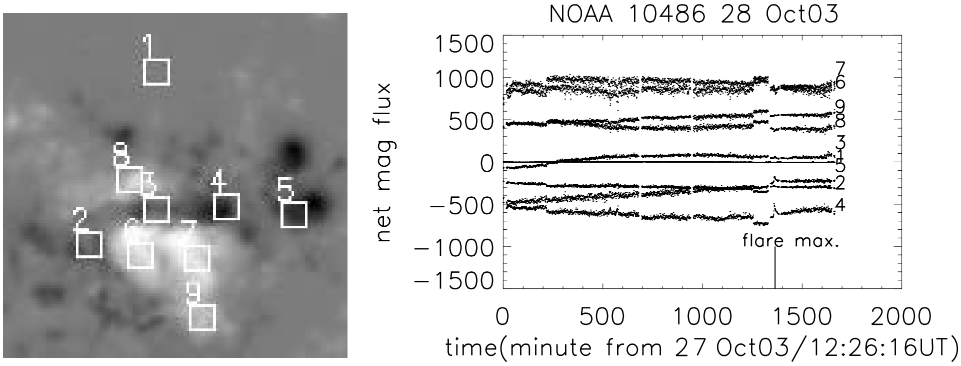

Figure 1. Temporal evolution of net magnetic flux in selected areas-of-interest (10 × 10 pixel size) in NOAA10486 during October 27–28, 2003.

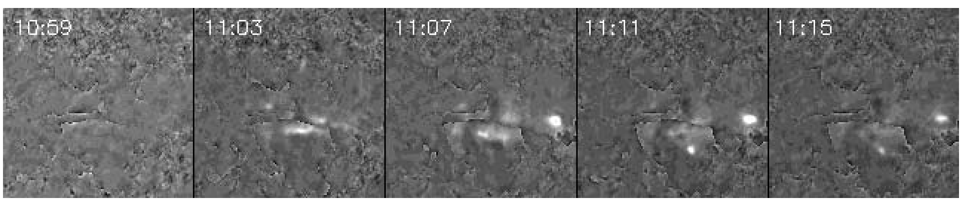

Figure 2. Evolution of magnetic flux and the moving feature observed during 10:59–11:15 UT seen in difference images ($I_t - I_{10:55}$).

10 × 10 pixel in size, during the day of flare, i.e., October 27–28, 2003 (Fig. 1b). Both gradual, evolutionary and abrupt, flare associated changes in magnetic flux are observed from the temporal profiles.

3. Moving "magnetic" features observed during the X17/4B superflare of October 28, 2003

From the GONG + magnetogram images obtained during the super-flare of October 28, 2003, a "magnetic" feature was observed moving rapidly from the flare site towards the leading sunspot in a short duration from 10:56 UT to 11:15 UT (Fig. 2). Both GONG and MDI data showed this feature. A portion of the feature was observed moving away from the neutral line, originating near the site of the flare onset, towards the leading sunspot and the other, perpendicularly to it. The scenario looks like a wave propagating away, like a blast wave, or Moreton waves, observed in chromosphere. Interestingly, no such feature was observed during the X10/3B flare on October 29, 2003, which also was a white light flare.

Using center-of-mass formula we found the velocity of the moving magnetic feature of the order of 40 km/s, which is much larger as compared to the usual separation speed of two-ribbon flares, but similar to the velocity ∼ 45 km/s of seismic waves reported earlier by Kosovichev and Zharkova (1998). If the moving feature is caused due to line profile changes, it is expected to show a relationship with the speed of flare ribbons' separation, which is usually much slower. Also, it does not appear to be instrumental artifact either, as both the GONG + and MDI images exhibit this feature. It is to be noted that GONG magnetic field measurements are not found very sensitive to line shape variation as shown by computer simulation of flare models (Edelman *et al.* 2004). The exact nature of the moving feature would require further detailed investigation.

4. Conclusions

- A correlation ($\approx$ 40%) between the net magnetic flux time profiles of NOAA 10486 and 10488 was found on October 28, 2003, suggesting an interconnection between these ARs, which is further corroborated by SOHO-EIT image showing their interconnection by a trans-equatorial loop.
- Both gradual evolutionary and abrupt flare associated changes in the magnetic flux are observed in several locations in NOAA 10486 during the X17/4B superflare of October 28, 2003.
- A rapidly moving feature was observed originating from the flare site. It appeared like a wave propagating as Moreton wave observed in chromosphere. Its estimated speed $\sim$ 40 km/s is much larger compared to the usual separation speed of 3–10 km/s of two-ribbon flares, but similar to that of the seismic waves $\sim$ 45 km/s reported earlier by Kosovichev & Zharkova (1998). Exact nature of this feature needs further investigation.

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