Solar Activity and its Magnetic Origin
Proceedings IAU Symposium No. 233, 2006
V. Bothmer & A. A. Hady, eds.

doi:10.1017/S1743921306001621

Primary Analysis on the Temporal Behaviors of Electric Current in the Solar Flare Events

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Abstract. Using one-minute cadence vector magnetograms of BBSO, we analyze the temporal behavior of the derived vertical electric currents associated with two solar flares on July 26, 2002. One is an M1.0 flare occurred in AR10044, while the other is an M8.7 flare in the adjacent AR 10039. We find that the temporal behaviors of electric currents are very different. For the M1.0 flare, the current density drops rapidly near the flaring neutral line; while for the M8.7 flare, the current density rapidly increases.

Keywords. solar flare, electric current, temporal behavior

1. Calculating and Results

There are many people investigate the relations between the solar flare and the electric current (Alfven and Carlqvist, 1967; Lin and Gaizauskas, 1987; Li *et al.*, 1997, etc). And the techniques of deriving the electric current from vector magnetigrams are developed by many people (Severny, 1964; Canfield *et al.* 1993; Leka *et al.* 1996, etc). However, these researches are mainly concentrating on the spatial correlation, the detailed temporal relationship has never been investigated at all. In this work, we use the one-minute cadence vector magnetograms of BBSO to investigate the magnetic flux, electric current, and H_α brightness in 2 selected square regions (show in Figure 1) where the flares take place. The longitudinal current density are derived by the following formula: $j_z = \frac{1}{\mu_0}(\nabla \times B)_z = \frac{1}{\mu_0}(\frac{\partial B_y}{\partial x} - \frac{\partial B_x}{\partial y})$.

One of the major works is to resolve the 180 degree ambiguity for the transverse magnetic field. Here we adopt a three-step method developed by Moon *et al.* (2003) to resolve the ambiguity. The results of the temporal behaviors of magnetic field, electric current, and Ha brightness are showed in Figure 2 and 3. The sensitivity of BBSO vector magnetogram for transverse magnetic field is 20 Gauss, the spatial resolution is $2.4''$, and the corresponding uncertainty of current density is about $1.0 \times 10^{-3} Am^{-2}$.

2. Conclusions and Discussions

(1) The temporal behaviors of the electric current during different flares are quite different. For example, for the M1.0 flare, the vertical electric current density decreases

Table 1. The list of the events occurred on July 26, 2002

Flare	*Duration (UT)*	*Peak*	*Active Region*
$M1.0$	$18:57--19:09$	$19:03$	$NOAA10044$
$M8.7$	$20:49--21:29$	$21:11$	$NOAA10039$

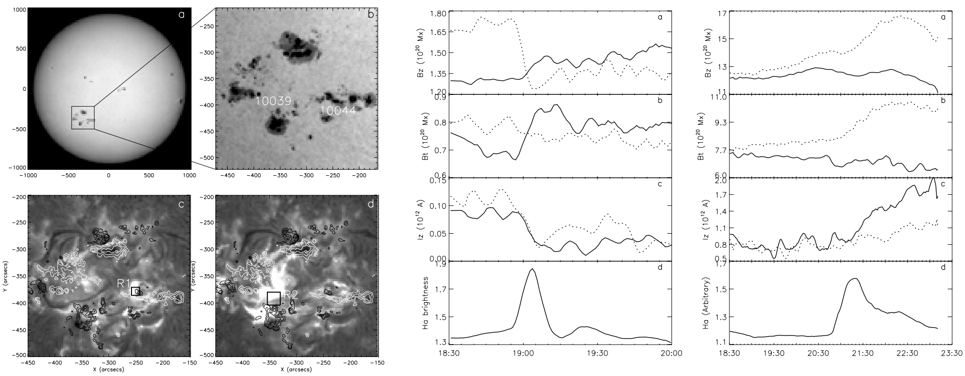

Figure 1. Left panel shows the positions of the flaring regions (R1 and R2). The mid (during M1.0 flare) and right (during M8.7 flare) panel show the temporal profiles of longitudinal magnetic flux (a, dashed line presents the positive flux, and solid line the negative flux), transverse magnetic flux (b), electric current density (c), and H_α brightness (d).

rapidly during the flaring, and the drop is over 50% (from $0.1 \times 10^{12} A$ to $0.05 \times 10^{12} A$); while for the M8.7 flare, the vertical electric current density increases rapidly during the flaring, the increasing rate is about $2.5 \times 10^{11} A$ per hour.

(2) During M1.0 flare, there was a rapid emergence of a small satellite sunspots (Ji, 2005), while during the M8.7 flare, there are a rapid emergence of magnetic flux (Wang *et al.* 2002, Wang et al. 2004), the positive longitudinal magnetic flux has an increase of about 10% (from $13.3 \times 10^{20} Mx$ to $14.6 \times 10^{20} Mx$) during the period of 21:00-22:00.

(3) The possible reason for the different behaviors of electric current density may be due to the different reconnection heights during the different flares. The M8.7 flare has a large flaring magnetic loop (Wang *et al.* 2004), but the filament is not erupted, its reconnection site (also dissipation site) is high in the corona, we cant observe the dissipation of the magnetic energy release near the photosphere. The spatial scale of the M1.0 flare is much smaller, its reconnection site maybe near the Suns photosphere, from where the magnetic field is sensitive to our observation, therefore the rapid drop may correspond to a rapid energy dissipation.

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https://doi.org/10.1017/S1743921306001621 Published online by Cambridge University Press