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# The helicity, induced electric field and Poynting flux of AR 11158 and their relationship with the X-class flare

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**Abstract.** With the photospheric vector magnetic fields provided by SDO/HMI team, the helicity accumulation, induced electric field and Poynting flux is calculated for AR 11158 by using the local correlation tracking technique (LCT). It is found that the helicity accumulation reaches $6000\times10^{40}Mx^2$, the average densities of the induced electric field about 0.15-0.35$Vcm^{-1}$, and that of the Poynting flux about 50-240$Wm^{-2}$, within 50 hours. One main flare of X2.2 occurs in the increasing phase of the helicity accumulation, which also corresponds to the decreasing phase of the induced electric field and the gradual change phase of the Poynting flux. Before the flare, all these quantities increase rapidly for about 20 hours firstly, then increase gradually or even decrease for 8-9 hours.

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Powerful flares relate closely to the evolution of the complex magnetic configuration on the solar surface which can be analyzed by some non-potential parameters. The photospheric flux of magnetic helicity has been computed by many researchers on the study of flares and other activities (Démoulin and Berger 2003; Liu and Zhang 2006; Park *et al*. 2010). The electric field $\mathbf{E}=(\mathbf{u}\times\mathbf{B})$, being proposed by Liu and Zhang (2008), can be as a dynamic and quantitative depiction of the changes in complexity of the active region, where $\mathbf{u}$ is the velocity of the foot-point motion of the magnetic field lines and $\mathbf{B}$ is the magnetic field. With Gauss units, the Poynting Flux can expressed as $\mathbf{P}=(\mathbf{E}\times\mathbf{B})$. It exhibits the energy transportation between the photosphere and the corona directly (Liu and Zhang 2008). The complexity across the photosphere and the energy budget can be determined by evaluating these parameters and their relationships with the flare.

The local correlation technique (LCT, Chae *et al*., 2001, 2004) is used to derive the horizontal velocity field in the photosphere from time-series of SDO/HMI vector magnetic-field data. Then the electric field and the poynting flux can be obtained. The cadence of the data is 720 seconds. The time period is through 00:00 UT 14 February to 23:48 UT 15 February 2011. The window size used in LCT is 4 pixels. The field of view of each magnetogram that we analyze is $200'' \times 150''$, covering the whole of AR NOAA 11158. Figure 1 shows temporal profiles of the helicity, induced electric field and Poynting flux of AR 11158 derived by LCT. The dashed lines indicate the GOES X-ray intensity peaks of the X2.2 flare on about 01:56 UT 15 February 2011.

It is found that the X2.2 flare occurs in the increasing phase of the helicity accumulation, decreasing phase of the averages of the mean densities of the $\mathbf{E}$, and flatness phase of those of the $\mathbf{P}$. All the three parameters have evolved from rapid increasing phase for about 20 hours to slower increasing one (for helicity accumulation) or flatness one (for $\mathbf{P}$) or even decreasing one (for $\mathbf{E}$) for 8-9 hours before the flare.

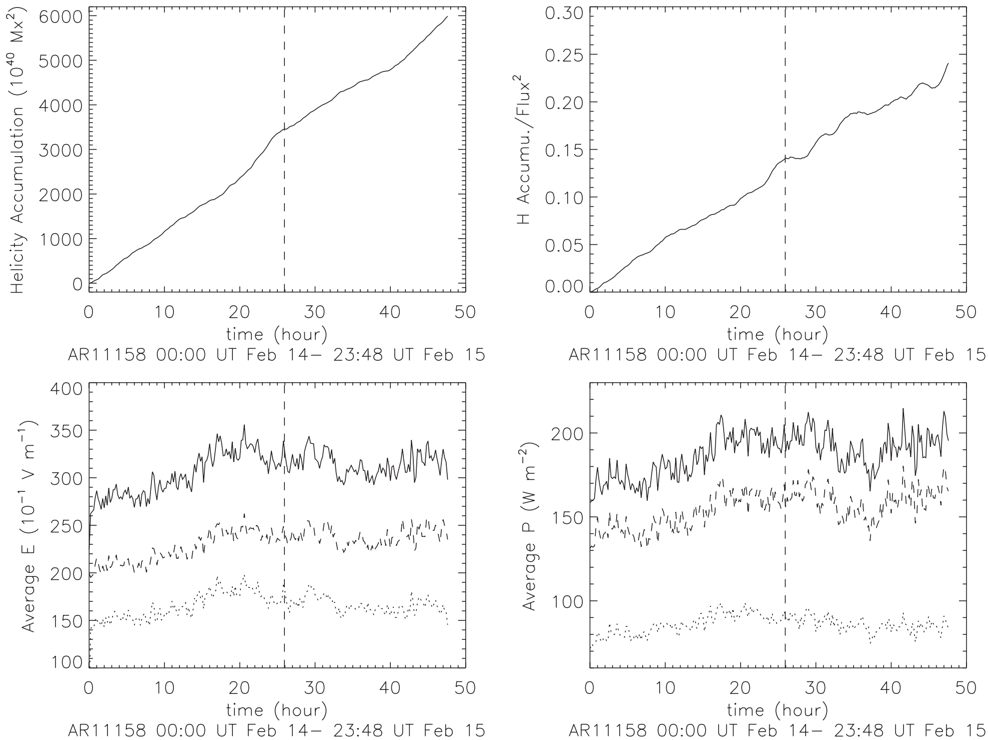


**Figure 1.** Left-upper: Temporal profile of the helicity accumulated. Right-upper: The ratio of the coronal helicity accumulation to the square of the magnetic flux. Left-downer: The averages of the mean densities of E (solid line), Et (dotted and dashed line), and En (dotted line). Right-downer: The averages of the mean densities of Poynting flux (solid line), Pt (dotted and dashed line), and Pn (dotted line). The dashed lines indicate the GOES X-ray intensity peaks.

The 20 hours of rapid increasing of all these parameters indicates that the active region undergoing a large amount of energy transportation and accumulation before the major flare firstly. The following 8-9 hours of slower increasing or even decreasing of them imply that there existing an time lag of free energy accumulation after the three parameters reaching at the erupting threshold subsequently.

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