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Observational Study of the Flare Trigger Process

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Solar Flares are explosive phenomena driven by magnetic energy stored in the solar corona. Because interplanetary disturbances associated with solar flares sometimes impact terrestrial environments and infrastructure, understanding the flare-triggering mechanism is important not only from a solar physics perspective but also for space weather forecasting. There are numerous observational studies and numerical simulations which attempted to reveal the onset mechanism of solar flares. However, because different observations support different models, the underlying mechanism of flare onset remains elusive, and the predictability of flare occurrence is limited.

To elucidate flare-trigger mechanism, Bamba et al. 2013 investigated four major flare events that occurred in active regions NOAA 10930 and NOAA 11158. We used data obtained by the Solar Optical Telescope (SOT) onboard the Hinode satellite. We analyzed the spatio-temporal correlation between the detailed magnetic field structure and the emission image of the Ca II H line at the central part of flaring regions for several hours prior to the onset of flares. We observed that characteristic magnetic disturbances developed at the centers of flaring regions in the pre-flare phase. These magnetic disturbances can be classified into two groups depending on the structure of their magnetic polarity inversion lines; to the so-called ”Opposite-Polarity (OP)” and ”Reversed-Shear (RS)” magnetic field recently proposed by Kusano et al. 2012. The result strongly suggests that some major flares are triggered by rather small magnetic disturbances. We also show that the critical size of the flare-trigger field varies among flare events and briefly discuss how the flare-trigger process depends on the evolution of active regions.

Because of the limitation of SOT field of view, however, only four events in the Hinode data sets have been utilizable in our previous study. Therefore, increasing the number of events is required for evaluating the flare trigger model. Bamba et al. 2014 investigated the applicability of data obtained by the Solar Dynamics Observatory (SDO) to increase the data sample for a statistical analysis of the flare trigger process. SDO regularly observes the full disk of the sun and all flares although its spatial resolution is lower than that of Hinode. We investigated the M6.6 flare which occurred on 13 February 2011 and compared the analyzed data of SDO with the results of Bamba et al. 2013 using Hinode/SOT data. Filter and vector magnetograms obtained by the Helioseismic and Magnetic Imager (HMI) and filtergrams from the Atmospheric Imaging Assembly (AIA) 1600$\AA$ were employed. From the comparison of small-scale magnetic configurations and chromospheric emission prior to the flare onset, we confirmed that the trigger region is detectable with the SDO data. We also measured the magnetic shear angles of the active region and the azimuth and strength of the flare-trigger field. The results were consistent with Bamba et al. 2014. We concluded that statistical studies of the flare trigger process are feasible with SDO as well as Hinode data.