Onset Mechanism of the Largest Solar Flare in Solar Cycle 24

*Yumi Bamba[1,2], Satoshi Inoue[1], Shinsuke Imada[1], Kanya Kusano[1]

1. Institute for Space-Earth Environmental Research/Nagoya University, 2. Institute if Space and Astronautical Science/Japan Aerospace Exploration Agency

Solar active region (AR) NOAA 12673, which appeared on the solar surface in September 2017, showed us amazing grows of magnetic field and produced numbers of flares including four X-class flares. We focused on the X2.2 and X9.3 flares that occurred while rapid growth of the AR on September 6, because latter the X9.3 flare caused increase of disturbances in ionosphere and magnetosphere. We aimed to understand the onset mechanism(s) of the X-class flares. Hence we analyzed the data obtained by Hinode and Solar Dynamics Observatory (SDO), and compared the analysis results to nonlinear force-free field (NLFFF), which is extrapolated from observed vector magnetic field.

We revealed that the key feature to trigger the X-class flares is the negative polarity region that emerged in the east in the AR and rapidly intrude into the positive polarity region. Highly sheared fields were located along the intruding negative field, and those were elongated and were pressed along with the intruding motion. Then the sheared fields were reconnected, and that could be a trigger of X-class flares. Hinode and SDO observed proxies of the magnetic reconnection, such as fast (over 100 km/s) down flow and brightening in the solar corona, over the intruding negative field approximately 2 hours before the X2.2 flare onset. The NLFFF has several small flux ropes that lying along the magnetic polarity inversion line. We found that a part of those flux ropes erupt in our magnetohydrodynamics (MHD) simulation. Therefore, a possibility that the intruding motion of the negative field would drive the flux rope to unstable state. This would cause the X2.2 small eruption. Following the X2.2 eruption, we further found that a new flux rope, which is larger and highly twisted, is formed by the reconnection between another small flux ropes, that shows dramatic eruption. We suggest that this eruption causes the X9.3 flare. In fact, the continuous intruding motion of negative field is observed after the X2.2 flare, therefore it would play an important role in producing the X9.3 flare.

From these results, we propose the scenario that the sequential X2.2 and X9.3 flares were triggered by push-mode-like magnetic reconnection corresponding to the intruding motion of the negative polarity field. We also discuss possibility of another triggering scenario such as emerging flux that has specific features of so-called the reversed shear type.

Keywords: Solar Flare, Hinode, Solar Dynamics Observatory, Flare Trigger, Solar Magnetic Field, Sunspot

