Study on the time evolution of the electron acceleration site in a solar flare by using Time-of-Flight analysis method

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It is well known that a large number of particles are accelerated during a solar flare. However, the particle acceleration process has not been clearly revealed yet. As for the acceleration site, there are few observational studies since it is difficult to identify directly it from imaging observations. The most outstanding study was done by Aschwanden et al. (1996) using the so-called Time-of-Flight (ToF) analysis technique. They concluded that the electron acceleration site is located slightly above the flare loop. Although the time evolution of the acceleration site during a flare is important for understanding the acceleration process, there are no studies on this topic.
In this situation, we try to obtain new information on the evolution of the acceleration site using high-time resolution X-ray data derived from the Gamma-ray Burst Monitor (GBM) on board the Fermi Gamma-ray Space Telescope. To investigate the time evolution of the acceleration site, ToF analysis was applied for each of the time-windows including an outstanding spike that appeared in the hard X-ray light curve for an M-class flare occurring on 25 June 2015. Then, a time series of time-lags between two different energy ranges were derived. Considering the mean-energy of electrons contributing to the X-rays in each energy band, we converted the time-lag to the ToF distance which corresponds to the distance between the acceleration site and the energy-loss site (chromosphere). It was found that the ToF distance became large in the later phase during the flare. This indicates that the acceleration site moved to a different magnetic loop system during the flare. To confirm this interpretation, we analyzed 1600A images observed with Atmospheric Imaging Assembly (AIA) onboard Solar Dynamics Observatory (SDO). Then, we found that a new brightening region appeared in the later phase.

キーワード：太陽フレア、粒子加速
Keywords: solar flare, particle acceleration

