Relationship between solar type III radio bursts and electron energy spectra in solar impulsive electron events

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Solar Energetic Particles (SEPs) are protons, electrons, and heavy ions of 10 keV to several tens GeV generated with flares and coronal mass emissions (CMEs), which are explosive phenomena near the solar surface. SEPs are classified into two types; i.e., impulsive and gradual types, based on the elemental abundances and the time profile of ion flux variations. Impulsive SEPs, also known as electron-based events. In particular, electron events, in which the electron flux increases for a short period, have been understood to be the result of electrons accelerated by flares propagating through interplanetary medium and observed near the Earth. It has been reported that spectral shapes of electrons observed in electron events are frequently show broken power laws at the break energy of several tens of keV. Reid & Kontar [2013] proposed an explanation for the generation of the break: low energy electrons lose their kinetic energy during their propagations due to wave-particle interaction, which converts their kinetic energy into Langmuir wave energy. They also reported that type III radio bursts, which are suddenly appearing emissions caused by flares, are almost always observed in electron events in the several tens meter to kilometer wave bands. Type III radio bursts are thought to be generated by non-thermal electrons accelerated by magnetic reconnections, which propagate along open magnetic field lines. That is, an injection of energetic electrons into interplanetary medium leads to excite Langmuir waves, and the waves are converted into radio waves as type III bursts where the radio wave frequency is as same as the local plasma frequency. Type III bursts are therefore interpreted as being excited by energetic electrons causing electron events, and their characteristics have information on properties of energetic electrons. However, precise relationship between energetic electrons and Type III bursts in solar impulsive electron events has not been clarified.
In order to reveal the relationship by a statistical approach, we have made analyses for characteristics of energetic electrons and Type III radio bursts using solar electron spectral data of the 3DP instrument and type III bursts of the WAVES instrument onboard the WIND spacecraft. Among the significant single-event electron events observed by the WIND satellite from 1994 to 2005, we identified 37 events that simultaneously showed both a bend in the electron energy spectrum and type III burst spectrum with simple spectral form. As the results, we confirmed that the power law indices of electrons below the spectral break energy show a positive correlation with radio wave intensities/energies and the electron beam velocity calculated from the frequency drift features of type III bursts. On the other hand, no correlation was found between the kinetic energy of the electrons, which is assumed to be converted to wave energy and lost during the propagation, and the radio wave energy. These results suggest that 1) the electrons on the lower side of the break energy are responsible for the excitation of the type III bursts, and the spectral shape of energetic electrons is an important factor to control intensity and energy of Type III radio waves, and 2) the spectrum shapes of electrons with the break energy cannot be explained only by the energy loss process in the wave-particle interaction generating Type III bursts.

Keywords: sun, solar energetic particle, electron event, type III burst

