Observation of an ionospheric disturbance caused by an SGR giant flare: Constraints on an energy spectrum of the flare

Yasuyuki T. Tanaka[1]; Toshio Terasawa[2]; Masashi Hayakawa[3]; Mari Yoshida[4]; Takumi Horie[4]

[1] Earth and Planetary Sci., Univ of Tokyo; [2] Dept. Phys., Tokyo Tech.; [3] Univ. Electro-Comms.; [4] University of Electro-Communications

A soft gamma-ray repeater (SGR), which is a neutron star with ultrastrong magnetic field B~10^{15} Gauss, rarely emits a giant flare (GF). So far three SGR GFs are recorded. Its peak flux is about thousands times larger than the X-class solar flares. Because of this extraordinary intensity, almost all the gamma-ray detectors on satellites are saturated and the spectrum during the most intense period is not well-determined.

Gamma-rays emitted from SGR GFs unusually ionized the lower ionosphere. The ionization was observed as large amplitude and phase changes of very low frequency (VLF) radio waves which are propagating in the Earth-ionosphere waveguide. Our goal is to determine the spectrum of SGR GFs from the observed changes of VLF signals. To do this, the procedure is as follows. Firstly, we calculate altitude profiles of electron density corresponding to various spectral shapes of gamma-rays such as planck distribution and power-law distribution. Secondly, using each electron density profile as an input parameter of VLF propagation model, we simulate the amplitude and phase changes of VLF signals. Finally, we choose an appropriate gamma-ray spectrum which well reproduce the observed amplitude and phase changes.

We calculated the energy deposition and ionization by the gamma-rays incident on the upper atmosphere by means of Monte Carlo method. The simulated altitude profile of energy deposition agrees well with past calculations. Then time evolution of the electron density was calculated, assuming that the constituents of lower ionosphere is electrons, positive and negative ions and positive cluster ions. The simulation results also coincide with previously reported results. Now we are constructing a VLF propagation model.