論文内容の要旨

論文題目 ： **Observational studies of SGR giant flares and New techniques of astrophysical gamma-ray observation**
（軟ガンマ線リピーター巨大フレアの観測的研究と新しい天体ガンマ線観測手法の開発）

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It is thought that Soft Gamma-ray Repeaters (SGRs) are neutron stars with ultra-strong magnetic fields of $10^{14} - 10^{15}$ G ('magnetars'), which are $100 - 1000$ times stronger than ordinary pulsars. SGRs occasionally emit giant flares whose total energy amounts to $\sim 10^{46}$ erg. Since SGRs are located in our Galaxy, observed gamma-ray fluxes exceed those of X-class large solar flares by several orders of magnitude. Therefore, it was impossible to obtain the peak profiles as well as the energy spectra by using X-ray/gamma-ray detectors on satellites because of saturation problems. New alternative methods were needed to observe these bright phenomena.

We developed a new method of celestial gamma-ray observation by utilizing a plasma particle instrument (LEP) on GEOTAIL satellite. Solar flare gamma-rays were unexpectedly detected with the particle detector. Using these gamma-rays, we determined sensitive energy range and effective area of the plasma particle detector for high-energy photons. We compared the time profiles of LEP with hard X-ray light curves observed with Hard X-ray Telescope (HXT) on YOHKOH satellite. We found that the LEP time profiles significantly correlated with $53 - 93$ keV light curves, indicating that LEP detected penetrating photons above ~ 50 keV. The effective area was also determined by estimating the photon fluxes from YOHKOH/HXT observations. SGR 1806$-$20 emitted a giant flare on 2004 December 27. We obtained the peak profile of this event for the first time and determined the energetics using the sensitive energy range and effective area.

GEOTAIL also detected gamma-rays from SGR 1900+14 giant flare on 1998 August 27. In this case, photons irradiated the satellite from obliquely above. The incoming direction is different from solar direction, and hence we could not directly apply the above calibration result. To investigate the absorption and/or scattering of incident photons inside the satellite, we performed Monte Carlo simulations using GEANT4. We also measured detection efficiency of the particle detector for gamma-rays. By combining

these results, we determined the sensitive energy range and effective area. Consequently, we revealed the peak profile as well as the energetics of this flare for the first time.

Based on the light curves observed with GEOTAIL, we presented a possible energy release scenario of SGR giant flares. We found two different timescales in the rise profiles, and interpreted them using magnetar model. Initial steep rise would reflect magnetospheric instabilities, while subsequent intermediate rise implies large scale fracturing of magnetar's crust, which would be triggered by the former instabilities. As a result, magnetic energy stored in the internal wound-up field lines are released.

To constrain the energy spectrum of SGR 1900+14 giant flare in 1998, we utilized the Earth's ionosphere. The ionosphere has been monitored by Very Low Frequency (VLF) radio waves. Gamma-rays from the giant flare unusually ionized the lower ionosphere, and the ionospheric disturbance was detected as a large amplitude change of the VLF signal. By model calculations and comparisons with the VLF data, we have found that the spectrum during the most intense period was one temperature (kT=240 keV) optically thin thermal bremsstrahlung. Standard trapped fireball model which explains spectra of short repeated bursts is difficult to account for this one temperature spectrum. We discuss possible emission scenarios of the initial spikes of SGR giant flares.