

論文の内容の要旨

Study of the very-high-energy gamma ray emission from the gamma ray bursts (ガンマ線バーストからの高エネルギーガンマ線放射の研究)

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GRBs are the most energetic explosion in the universe. The typical luminosity of GRBs exceeds 10^{51} erg/s, which is comparable to the total energy of the light emitted by all the galaxies in the entire universe for a short time. In spite of such an extreme energy, fundamental knowledge such as progenitors, acceleration mechanism of relativistic jets and origin of gamma-ray emission is still unknown.

There have been many experiments in the space and on the ground to expand the understandings since the discovery of GRBs 50 years ago, however, there are still many aspects remained unknown. There are two types of emissions categorized by the periods, prompt emission and afterglow emission. The afterglow emission is successfully described by synchrotron emission by the standard forward shock model between relativistic jets caused by the explosions and the external medium. However, Fermi LAT, a gamma-ray satellite launched in 2008, detected GeV gamma rays from bright GRBs, some of which show a hint of an extra spectral component above GeV. This possible new feature can shed new light on the mysterious emission mechanism of gamma rays of the afterglow emission. However, due to the limited statistics of GeV gamma rays by satellites, there have been no strong claims of the new component so far.

There is a new technique which aims to detect sub-TeV gamma rays from the ground, which can be used to detect GRBs with a large effective area. So far there are no cases where gamma rays from GRBs are detected on the ground due to limited duty cycle and absorbed flux of sources at cosmological distances by extragalactic background light. In this study, I analyzed data of one of the brightest GRBs, GRB 190114C, taken by Major Atmospheric Gamma-ray Imaging Cherenkov (MAGIC) telescopes, one of the ground-based gamma-ray telescopes, to detect sub-TeV gamma rays and discuss possible emission mechanisms. I found a significant excess with larger than 50 sigma above 300 GeV around the GRB

position, which shows the discovery of significant TeV gamma rays from GRBs for the first time. From the analysis, I also found unquestionable existence of a new spectral component by confirming that the emission is well above the maximum energy emitted by the synchrotron radiation. This indicates that the standard model should be modified according to the TeV emission.

Since MAGIC detected a GRB for the first time in 15 years, the detection rate is expected to be very low. There is a future project of ground-based telescopes with better sensitivity than MAGIC. As the next-generation ground-based gamma-ray telescopes, Cherenkov Telescope Array (CTA) has been designed and it is now under construction. This increases the sensitivity of TeV gamma rays 10 times higher than any other currently-observing telescopes. I have been developing the so-called active mirror control (AMC) system of Large-Sized Telescopes (LSTs), the largest type of telescopes in the CTA array. The LSTs have low energy threshold 20 GeV, where gamma rays do not suffer significantly from the extragalactic light. The AMC system is critical for observations of distant sources with LSTs. I confirmed that mirrors were adjusted with an accuracy of around 5 arcseconds using the so-called Test Structure, which is a 1/8-size structure of one whole LST in the Max Planck Institute for Physics. Currently commissioning of the LST prototype has been performed in La Palma, and I have been installing devices and checking the performance of the AMC system.

Finally, I performed a simulation study of LSTs with the software *ctools* using the spectrum of GRB 190114C, to know how significantly gamma rays from GRBs can be detected. For the first 100 seconds MAGIC observed, I found that LSTs can detect 100 times and 20 times more events than MAGIC at zenith angle 20° and at zenith angle 60° respectively. By scaling the spectrum with redshift, I also found that LSTs can detect gamma rays even at redshifts higher than 2 at zenith angle 20° .