Form 8

Research Result Report
ICRR Inter-University Research Program 2022

Research Subject: Bayesian analysis on the origin of ultra-high energy cosmic ray events collected by the telescope array experiment

Principal Investigator:
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Participating Researchers:
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Summary of Research Result:

This research project aims to determine the fraction of Ultra-High Energy Cosmic Rays (UHECRs) originating from nearby sources by analyzing data obtained with the Telescope Array (TA). Building upon the initial work by Dr. Francesca Capel (arXiv:1811.06464), Keito Watanabe, currently master student at the University of Bonn (Germany), under my supervision, has extended the Bayesian Hierarchical Model to incorporate more realistic factors such as magnetic fields and heavier arrival compositions. Keito stayed twice for extended periods at ICRR during the summer 2020 and 2021.

Initially, we adopted a simplified energy loss model and focused on estimating the effects of deflections on the observed data. The findings suggested a higher fraction of events could be attributed to known source candidates. Notably, we discovered that the Northern Hemisphere, where TA is located, offers advantages for observing these sources. Our progress on this research was presented at the UHECR2022 conference (https://inspirehep.net/literature/2658739).

Despite the challenges posed by COVID-19 restrictions in 2022, which prevented the entry of foreigners into Japan, the project members were unable to visit Japan or secure sufficient travel funding. Unfortunately, this hindered the organization of a planned workshop among project members and interested participants. However, I was able to enter Japan until September 2022 and resumed my visits after the

restrictions were lifted. As a result, all granted ICRR Interuniversity Research Grant funds were utilized to support my visits to ICRR.

During these visits, Prof. Sagawa and I developed a new set of modeling assumptions concerning the propagation of UHECR nuclei. These assumptions simplify the mathematical model required for successful Bayesian fits with nuclei. One notable enhancement involves transitioning from energy to rigidity, primarily due to the impact of photonuclear disintegration on the Cosmic Microwave Background (CMB) via the Giant Dipole Resonance, in which nucleons don't experience a loss of boost, resulting in approximately constant energy per nucleon and rigidity. The primary loss process involves mass number loss, which we infer and tabulate using CRPropa simulations. Furthermore, as a new member of the TA experiment, I have contributed my expertise on hadronic interactions and UHECR propagation through discussions with the group members at ICRR.

Currently, all project participants are actively engaged in obtaining results using this new framework in a timely manner for the International Cosmic Ray Conference (ICRC) and preparing a comprehensive publication on this topic within the year.

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