Coronal mass ejections and cosmic ray observations at Syowa Station

June 15 2021

Credit: CC0 Public Domain

Solar activities, such as CME(Coronal Mass Ejection), cause geomagnetic storms that disturb the Earth's magnetosphere. Geomagnetic storms can affect GPS positioning, radio communication, and power transmission system. Solar explosions also emit radiation, which can cause satellite failures, radiation exposure to aircraft crew, and space activity. Therefore, it is important to understand space

weather phenomena and their impact on the Earth.

Space weather research by continuous observation of cosmic rays on the ground is mainly conducted using observation data from neutron monitors and multi-directional muon detectors. Since the phenomenon of space weather is on a short-term, days-long scale, it is effective to investigate changes in the flow of cosmic rays for several hours, which requires a total-sky monitor of cosmic rays.

The global muon detector network (GMDN) has been observing space weather phenomena since 2006, and the Spaceship Earth project constitutes a similar observation network and the role of the all-sky monitor for neutrons. Until now, observations by neutron monitors and muon detectors have been performed independently.

In February 2018, Professor Chihiro Kato of Shinshu University took the lead in acquiring simultaneous observations of the neutron monitor and muon detector at Syowa Station in the Antarctic in order to acquire bridging data. In the polar regions, unlike low latitude regions on the earth, it is possible to observe cosmic rays coming from the same direction with a neutron monitor and a muon detector due to the weaker deflection by geomagnetism. This is the reason why Syowa Station was selected as the observation point.

Syowa muon detector and neutron monitor observed small fluctuation in CR count like a Forbush decrease on 2018.8. The research group including researchers from Shinshu University and the National Polar Research Institute found curious cosmic-ray density variation on this event by analyzing GMDN data.

On the CME event, a huge amount of coronal material released with a bundle of the solar magnetic field, called Magnetic Flux Rope (MFR), into the interplanetary space. MFR moves through interplanetary space

while expanding. CR density is low inside of it because it is originally coronal material. When the earth enters the MFR, CR counts on the ground decreases. This is called Forbush Decrease.

Normally, when MFR arrives on Earth, CR density observed at the ground level decreases rapidly, and then turns to increase recovering to the original level while the earth is in the MFR. On this event, however, the CR exceeded the original level before the earth exited the MFR.

This event attracts interest from researchers because 1) The solar activity is currently near the minimum and the scale of the event itself is small, 2) It causes a disproportionately large geomagnetic storm, and 3) There is high-speed solar wind catching up the MFR expected to interact with it.

By analysis of the GMDN and solar plasma data, the team concluded that the high-speed solar wind causes the unusual enhancement of the CR density by compressing the rear part of the MFR locally.

Cosmic ray observation data is closely related to space weather research and to atmospheric phenomena such as sudden stratospheric temperature rise, and is expected to be used in a wide range of fields in the future.

More information: Chihiro Kato et al, New cosmic ray observations at Syowa Station in the Antarctic for space weather study, *Journal of Space Weather and Space Climate* (2021). DOI: 10.1051/swsc/2021005

Provided by Shinshu University