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論　文　内　容　の　要　旨

Intensity of galactic cosmic rays (GCRs) shows dynamic temporal variations in various time scales; transient decreases lasting for several days, diurnal variation, 11-year or 22-year cycle variation, and so on. Only a worldwide detector network allows us to separately deduce variations of the isotropic intensity (or GCR density) and the anisotropy on an hourly basis. In this thesis, I present results of the space weather study based on the GCR observations with the Global Muon Detector Network (GMDN).

In former works analyzing a single detector data, diurnal (or ecliptic) and north-south (NS) anisotropies were derived on a daily basis from separate analysis methods and/or separate detectors. The GMDN, on the other hand, provides us with a three-dimensional (3D) anisotropy using a single analysis method on an hourly basis. I confirm that the anisotropy is more accurately derived by the GMDN than by the traditional analysis, while results obtained from two analyses are fairly consistent with each other as far as the yearly mean value is concerned.

Based on the convection-diffusion equation describing the large-scale transport of GCRs in the interplanetary space, the spatial gradient of GCR density is deduced from the observed anisotropy. High temporal resolution of the GMDN allows us to infer the spatial structure of the GCR depleted region formed behind the interplanetary shock (IP-shock) which causes a short-term density decrease (called Forbush Decreases; FDs) on its arrival at the earth. By analyzing FDs following the IP-shocks generated by the solar eruptions (such as coronal mass ejections; CMEs) from various heliographic locations on the sun, I derive the 3D average distribution of GCRs in the depleted region for the first time. It is confirmed that the magnetic sheath in the western flank of IP-shock excludes more GCRs than in the eastern flank, in accord with the east-west asymmetric magnetic configuration model of IP-shock expected from the spiral configuration of the interplanetary magnetic field (IMF) arising from the solar rotation. I also confirm the density gradient suggesting a density minimum in an expanding CME propagating radially outward from the eruption location on the sun. The FDs observed simultaneously by the neutron monitors (NMs) and the GMDN, which are sensitive to ～10 GV and ～60 GV GCRs, respectively, show a soft rigidity spectrum of the FD.

I also analyze the year-to-year variation of the 3D anisotropy using the GMDN for the first time. The first order anisotropy observed with the GMDN from 1992 to 2013 shows a variation in a correlation with the solar activities. Amplitude of the diurnal anisotropy shows 11-year cycle variation in a correlation with the solar activity, while the phase varies according to the 22-year periodic reversals of the solar dipole magnetic field polarity, referred as the $A > 0$ ($A < 0$) epoch when the dipole directs northward (southward). I find that the anisotropy component parallel to the IMF in the ecliptic plane shows a 22-year cycle variation which is responsible to the phase variation of the diurnal anisotropy. NS component of the gradient indicates a local density maximum close to the heliospheric current sheet (HCS) in $A < 0$ epoch while the gradient indicates a local minimum close to the HCS in $A > 0$ epoch. This 22-year variation of the gradient is in an agreement with the drift model prediction. The radial density gradient, on the other hand, does not show a clear 22-year variation predicted by the drift model, while it shows a significant 11-year variation. The parallel mean free path of the pitch angle scattering of GCRs deduced from the anisotropy and the radial gradient also show significant 11-year variations out of phase with each other, indicating equilibrium between the radial diffusion and the solar wind convection of GCRs. The parallel mean free path has an average magnitude of ~1 AU for ~60 GV GCRs which is comparable to the numerical simulation of the pitch angle scattering.

In addition to the GMDN data, I also analyze GCRs recorded by a single muon detector (MD) at Nagoya over 44 years from 1970 to 2013. The diurnal anisotropy is derived from the diurnal variation of the muon count rate, while the NS anisotropy is derived from a difference between count rates (called the "GG-component") recorded by the north-viewing channel and the south-viewing channel of Nagoya MD. The 3D anisotropy is deduced by combining the diurnal anisotropy and the NS anisotropy. From the long-term variation over 4 solar activity cycles, I find a small 22-year variation of the radial gradient, but it is masked by a larger 11-year variation and by a persistent long-term trend over the last several solar cycles. It is also found that the anisotropy parallel to the IMF, i.e. the parallel diffusion streaming of GCRs, has a flat rigidity spectrum, while the perpendicular anisotropy mainly arising from the drift streaming has a harder spectrum.