ABSTRACTS (MASTER THESIS)

Formation of multiple energy dispersion of H^+, He^+, and O^+ ions in the inner magnetosphere in response to interplanetary shock

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The sun sometimes emits a magnetic cloud. There is a shock ahead of the magnetic cloud, called an interplanetary (IP) shock (IP). When the IP shock arrives at Earth's magnetosphere, the particle environment in the magnetosphere is known to be change drastically. Satellite observations have shown that soon after arrival of the IP shock, overall intensity of the ions rapidly increases and multiple energy dispersion appears in an energy-time spectrogram of the ions. In order to understand the response of the magnetospheric ions to IP shock, we have performed test particle simulation under the electric and magnetic fields provided by the global magnetohydrodynamic simulation. On the basis of the Liouville theorem, we reconstructed the differential flux of H^+, He^+, and O^+ ions situated at (7, 0, 0) Re in GSM coordinates by means of the semi-Lagrangian (phase space mapping) method. The H^+, He^+, and O^+ ions are known to be majority of ionic species in the magnetosphere.

Simulation results show that the ions respond to the IP shock in two different ways. First, overall intensity of the flux gradually increases at all pitch angles. As the compressional wave, which is one of the magnetohydrodynamics waves, propagates tailward, the magnetic field increases, which accelerates the ions due to the gyrobetatron. This change is well known. Second, multiple energy-time dispersion appears in the reconstructed spectrograms of the ion flux. The energy-time dispersion is caused by interaction between bouncing ions and compressional wave propagating tailward. When the tailward propagating compressional wave catches up the ion moving toward mirror point at off-equator, the ion gains the kinetic energy efficiently. The ions are primarily accelerated by the drift betatron under the strong electric field looking dawnward. The dispersion is clearly seen in the mirroring ions, but is absent in equatorially mirroring ions. The dispersion appears at higher energy for heavier ions. These features are consistent with the satellite observations. Because the acceleration depends on bounce phase, the bounce-averaged approximation is probably invalid for the ions during the interval of geomagnetic sudden commencement. The result is published in Journal of Geophysical Research Space Physics [1].

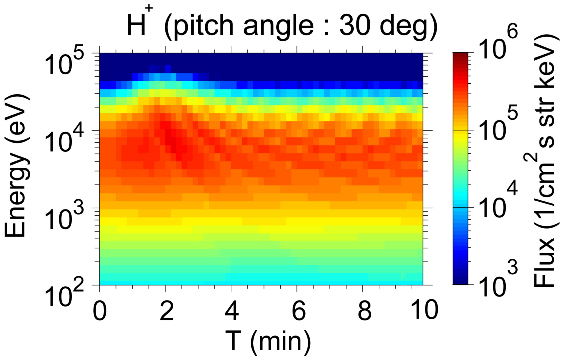

Figure 1. Energy vs. time spectrogram of simulated differential H^+ flux at (7, 0, 0) Re.

Acknowledgements

The computer simulation was performed on the KDK computer system at the Research Institute for Sustainable Humanosphere (RISH), Kyoto University.

References

[1] Tsuji, H., Y. Ebihara, and T. Tanaka (2017), Formation of multiple energy dispersion of H^+, He^+, and O^+ ions in the inner magnetosphere in response to interplanetary shock, J. Geophys. Res. Space Physics, 122, 4387–4397, doi:10.1002/2016JA023704.