Impact of interplanetary shock on ring current ions

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An interplanetary (IP) shock is known to have a large impact on magnetospheric ions. We have performed test particle simulation under the electric and magnetic fields provided by the global magnetohydrodynamics (MHD) simulation developed by Tanaka et al. (2010). In this particular simulation, the solar wind speed was increased from 372 to 500 km/s in order to reproduce the IP shock. The number density in the solar wind was set to a constant to be 5 cm-3, and the Z component of the interplanetary magnetic field (IMF) was turned from +5 to -5 nT. Just after the arrival of the IP shock, a fast mode wave propagated tailward in the magnetosphere. Dawnward electric field comes in first, followed by duskward electric field. The amplitude of the electric field exceeded 20 mV/m. We reconstructed the evolution of phase space density of H+, He+, O+ ions by tracing trajectories of the ions backward on the basis of Liouville’ s theorem. The trajectory and the phase space density are found to be drastically modified by the fast mode wave in different ways. (1) The ion flux increases at entire energy range. This effect has been traditionally considered. (2) Multiple energy-time dispersion appears in energy-time spectra of the ions with energy less than ~100 keV due to adiabatic acceleration at high latitudes. This is associated with bounce motion (bounce phase bunching), and consistent with the Cluster satellite observation reported by Zong et al. (2012). (3) The ion flux depends on gyro phase due to gyro phase bunching. The gyro phase bunching is prominent for ions with initial speed being comparable to, or less than the ambient ExB drift speed. These results imply that the guiding center approximation is invalid for the ring current ions when large-amplitude fast mode wave is propagating associated with the IP shock. We also calculated temperature anisotropy. The temperature anisotropy increases near the leading edge of the wave where the dawnward electric fields is strong. The increase in the temperature anisotropy may favor the excitation of electromagnetic ion cyclotron (EMIC) waves, and may lead to rapid precipitation of ions and electrons. We evaluated growth of EMIC waves by using KUPDAP (Kyoto University Plasmas Dispersion Analysis Program). We will discuss the effect of IP shock on growing EMIC waves.

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