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Impact of interplanetary shock on ions in the inner magnetosphere

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Interplanetary (IP) shock is known to redistribute the charged particles trapped in the inner magnetosphere. As for ions with kinetic energy of the order of keV, observations have shown that the enhancement of the ion flux depends on the pitch angle and energy, and that the flux does not always peak at the equatorial pitch angle of 90 degrees after passage of the IP shock. We have performed test particle simulation under the electric and magnetic fields provided by the magnetohydrodynamics (MHD) simulation. The solar wind speed is 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, the fast mode wave propagates tailward in the magnetosphere. The amplitude of the electric field exceeds 20 mV/m. We started tracing oxygen ions at (7, 0, 0) Re in the GSM coordinates just before the arrival of the fast mode wave, and reconstructed a phase space density of ions. A summary of the simulation results is as follows. 1) In general, ions with initial pitch angles near 90 degrees are efficiently accelerated, but the degree of the acceleration depends on initial gyrophase, pitch angle, and energy, so that neither the bounce-averaged approximation nor the guiding-center approximation is valid. 2) Ions with small pitch angles are efficiently accelerated when the parallel velocity of the ion is closed to the parallel component of the propagation velocity of the fast mode wave. 3) The phase space density initially given by an isotropic Maxwellian distribution is redistributed to the one that is dominated by the perpendicular component. For initial distribution with temperature of 5 keV, the temperature anisotropy (Tperp/Tpara-1) is increased to 0.33 at an elapsed time of 1 minute from the arrival of the fast mode wave, which may favor the excitation of electromagnetic waves. We will discuss the overall impact of the IP shock on the major ion species in the inner magnetosphere such as protons and oxygen ions, as well as contribution of the electric field that is propagated by way of the field-aligned current and the polar ionosphere.

Keywords: Inner magnetosphere, interplanetary shock, keV ions