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GEMSIS-Magnetosphere: Kinetic numerical modeling of the ring-current dynamics in the Earth's inner-magnetosphere

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The geomagnetic storm is the strongest disturbance of the geospace environment, causing violent auroral activities, development of global electric circuits, abrupt loss and subsequent enhancements of radiation belt particles, etc. It is generally believed that the storm-time geospace environment is strongly affected by the dynamics of the ring-current ions (protons and oxygens) with energies of 1-100 keV. Many ring-current models have so far used the dipole magnetic field, however, the geomagnetic field can be substantially modified by the ring current themselves, which in turn affects their drift paths. This coupling between particles and fields is actually known to be important for the time development of geomagnetic storms. The problem for the self-consistent modeling of the ring current is that the usual magnetohydrodynamic (MHD) description may not be valid for plasmas in the inner-magnetosphere due to their large temperature anisotorpies and non-negligible magnetic drifts. Hence, kinetic effects should properly be taken into account.

To advance our understanding of the ring current evolution and its roles during geomagnetic storms, we need a new numerical algorithm to solve the kinetic dynamics of the ring-current particles which is coupled with the field in a self-consistent manner. We adopt a five-dimensional drift-kinetic equation including the polarization drift, as it is the driver of MHD waves. Evaluating the polarization drift using Ampere's law, we obtain a closed set of equations, which describes the self-consistent coupling between particles and fields.

In this report, we demonstrate the self-consistent coupling is actually included into the model. We also discuss several numerical simulation results. These includes the time evolution of MHD waves excited by fluctuations in the solar wind, the response of particle injection from the plasma sheet.