Violation of the Guiding Center Approximation for Oxygen Ions in the Inner Magnetosphere during Magnetic Storms.

Kohki Shibahara[1]; Masahito Nose[2]

[1] SPEL,Kyoto Univ.; [2] DACGSM, Kyoto Univ.

A charged particle motion in the electromagnetic field consists of gyration, bounce motion, and drift motion. The Guiding Center Approximation (GCA) is valid when the spatial scale of the magnetic field is much smaller than the gyroradius.

Since gyration is high-frequency motion and the GCA can reduce the amount of calculation, it becomes popular in these days to simulate the ring current in the self-consistent field with the GCA (Lemon et al., 2004; Zaharia et al., 2006).

Considering the following two facts, however, we suspect an approach to treat motion of ring current oxygen ions with the GCA. One fact is that during magnetic storms a large amount of total energy of the ring current is carried by oxygen ions (Daglis at al., 1999) which are 16 times heavier than protons; that is, gyroradius of oxygen ions is 4 times larger than that of protons with the same kinetic energy. The other is that during magnetic storms magnetic field configuration becomes far deviated from dipole field, and curvature radius of field line becomes smaller significantly even at ring current region.

The kappa parameter is used to evaluate validity of the GCA (Buchner and Zelenyi, 1989). This is the ratio of the curvature radius of magnetic field line relative to the gyroradius. One can recognize easily that if the kappa parameter becomes close to 1, particle motion may violate the GCA.

In this study, we examine whether the GCA is valid for ring current ions, in particular for oxygen ions. We studied the kappa parameters at ring current region around midnight during magnetic storms and compared ion trajectories computed by the Lorentz equation and those by the GCA equation. We used the IGRF10 and TS04 (Tsyganenko et al., 2005) magnetic field model as well as the Volland-Stern (Volland 1973; Stern 1975) electric field model.

We obtained the following two results. First, the kappa parameter for energetic oxygen ions becomes as small as unity at ring current region during the storm main phase. Second, while motion of a proton can be treated with GCA, oxygen ion with the same energy violates GCA; as a result, oxygen ion trajectories are much different between the computation by the Lorentz equation and the one by the GCA equation.