Adiabatic acceleration of O+ ions by magnetic fluctuations accompanied by dipolarization

Masahito Nose[1]; Masafumi Shoji[2]; Kunihiro Keika[3]; Yukinaga Miyashita[4]
[1] DACGSM, Kyoto Univ.; [2] ISAS, JAXA; [3] STEL; [4] STEL, Nagoya Univ.

Strong magnetic fluctuations/oscillations are often accompanied by magnetic field dipolarization. According to previous studies, their characteristic timescale is from a few seconds to 100 seconds, which is much shorter than a timescale of magnetic field dipolarization. Takahashi et al. [1987] first reported the period of the magnetic fluctuations observed by the AMPTE/CCE satellite at a radial distance (r) of 8.1 Re. They found that the fluctuations mostly appear in the magnitude of the field with the dominant frequency (f_F) of ~0.07 Hz. This study is followed by a number of satellite observations that reported f_F=0.01-0.3 Hz at r=7.4-8.8 Re [Ohtani et al., 1995, 1998; Lui et al., 2008], and f_F=0.2-0.33 Hz in the inner magnetosphere of L=3.6-5.9 [Nose; et al. 2010]. All of these previous studies revealed that the magnetic fluctuations are generally dominant in the compressional and radial components rather than the azimuthal component. Comparison of f_F with the local gyrofrequency of proton, $f_G(H^+)$ shows that the ratio is generally 0.03-0.25; that is, f_F is close to the local gyrofrequency of O^+ ions, $f_G(O^+)$.

One of possible excitation mechanisms for the magnetic fluctuations is the “drift-driven” electromagnetic cyclotron (EMIC) instability, which is different from the popular “temperature-anisotropy-driven” EMIC instability. Free energy to excite EMIC waves is supplied from the cross-field drift motion of ions instead of temperature anisotropy. This instability generates EMIC waves with larger amplitude in the component parallel to the ambient magnetic field and in the frequency range much lower than $f_F(H^+)$, which are consistent with the previous observations. Because of property of EMIC waves, we suggest that the fluctuating inductive electric field coexists during the dipolarization and it can accelerate ions, in particular, O^+ ions.

In this study the above idea is tested by numerical calculation. Using the linear dispersion relation of this instability, we simulate EMIC waves associated with the dipolarization and obtain waveforms that are similar to the observations. Particle tracing is also performed in this simulated wave fields for both H^+ and O^+ ions. We find that the O+ ions are accelerated to the energy range of $<$10 keV, while the H+ ions show no clear acceleration. We conclude that O^+ ions can be locally and nonadiabatically accelerated by the fluctuations associated with the dipolarization in the inner magnetosphere.