A simulation study of the generation mechanism of RX-mode waves observed in the equatorial plasmasphere

Mohammad Javad Kalaee[1]; Yuto Katoh[1]; Takayuki Ono[1]
[1] Dept. Geophys., Grad. Sch. Sci., Tohoku Univ.

We study the generation process of RX-mode waves observed by the Akebono satellite in the equatorial inner magnetosphere. Sato (2002, Ph.D thesis in Tohoku University) presented a result of the Akebono observation of plasma waves in the equatorial region of the inner magnetosphere at 3:35-3:50 UT on February 4, 1992, showing the possibility of the local enhancement of RX-mode waves due to wave particle interactions. In the present study, by conducting the linear analysis and self-consistent electron hybrid simulations, we study a possible mechanism of the RX-mode wave generation.

First, we estimated the linear growth rate of various type of wave modes in the presence of energetic electrons having a ring-type velocity distribution with the typical kinetic energy of 40 keV, the spread of the velocity distribution of 17.5 keV, and the number density of 1 /cc. Since the Akebono observation presented above has been made during a geomagnetically disturbed period, we assume that the free energy of the plasma wave excitation could be supplied by the energetic electrons injected into the inner magnetosphere which are not only adiabatically energized but accelerated to the perpendicular direction to the background magnetic field due to the large-scale electric field in the inner magnetosphere. The ratio between the plasma frequency and the gyrofrequency of the background cold electrons is 4.9, and other parameters used in the calculation are assumed by referring the observation result. The result of the calculation shows that Z-mode waves having the wave normal angle of 83 degree can be enhanced with the positive growth rate of 0.04 Omega_e, where Omega_e is the electron gyrofrequency, while the maximum growth rate of RX-mode waves is estimated to be 6 x 10^-9 Omega_e for the perpendicular wave normal case.

Next, we performed a self-consistent numerical experiment by using a electron hybrid code. The simulation system is spatially one-dimensional assumed to be perpendicular to the external magnetic field. Since we find in the Akebono observation that a large spatial inhomogeneity of cold plasma distribution, we assume a spatial variation of the number density of cold electrons in the simulation system, corresponding to the spatial variation of the ratio between the local plasma frequency and gyrofrequency from 4.1 to 5.3. The range of the variation of the local plasma frequency is determined by referring the result of the Akebono satellite. The initial parameters used in the simulation are the same which we assumed in the calculation of the linear growth rate. In the simulation result, we observe an efficient enhancement of RX-mode waves as well as an excitation of Z-mode waves as predicted by the linear theory. We also find in the simulation result that the frequency separation between the enhanced RX-mode and Z-mode waves is exactly equal to one electron gyrofrequency. By referring the results of the linear growth rate and the nonlinear coupling condition, we propose a possibility of RX-mode wave generation by nonlinear wave-particle interactions. The simulation result suggests that the efficient energy transfer from Z-mode to RX-mode waves could take place in the equatorial inner magnetosphere through the combination among wave coupling processes and kinetic motion of energetic electrons.