Generation mechanism of Z-mode waves in the equator of the plasmasphere – A possibility of direct generation of Z-mode waves

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Z-mode plasma waves as well as UHR waves are frequently observed in the geomagnetic equatorial region (MLAT is less than 10 degrees) of the plasmasphere by using plasma wave and sounder experiments (PWS) on board the Akebono (EXOS-D) satellite. Origin of the Z-mode plasma waves has been recognized as a consequence of mode conversion mechanism. However, on the basis of the simultaneous observation of low energy electrons and plasma waves by the CRRES satellite, Burke et al. [1995] reported that electrons with energy from keV to a few 10 keV range whose pitch angle distribution is enhanced in perpendicular to the magnetic field were detected, were associated with intense Z-mode waves in the plasmasphere; this fact suggests that these electrons may be responsible for the excitation of Z-mode waves.

In the present study, we have examined a possibility that such electrons may generate the Z-mode waves through cyclotron type wave - particle interaction.

When considering the resonance condition of Z-mode waves with low energy electrons from keV to a few 10 keV energy range under the condition of high value of the plasma parameter (fp/fc is greater than 5) in the plasmasphere, it has been shown that the only high order resonance is possible between these Z-mode waves and the electrons: for example, when we set fp/fc=6.60 and f/fc=6.55, a few 10 keV electrons are able to satisfy the cyclotron resonance condition of the 7th order.

Numerical calculations of the linear growth rate of the Z-mode waves have been carried out applying a ring-type electron distribution function enhanced in the perpendicular direction to the magnetic field. In a case where fp/fc=6.60, f/fc=6.55 and the average speed of the ring distribution is set to be as v=0.35c(~30 keV), Z-mode waves with wave normal angles larger than 80 degrees have significant positive temporal growth rates, though the cyclotron resonance of 7th order. The maximum growth rate has been found to be 10^(-3)fc when Z-mode waves propagate in the direction of 88 degrees to the magnetic field when we apply the ring distribution with mean energy of 30 keV and width of 4keV.

When Z-mode waves with the temporal growth rate of about 10^(-3)fc propagate through the magnetic equatorial region of the plasmasphere(r=2 Re, MLAT is less than 10 degrees), these waves are able to be amplified more than 60dB that is sufficient to explain the observation result of Akebono satellite.

When we consider the electrons whose fluxes were concentrated in the perpendicular direction to the magnetic field, the source region of Z-mode waves may be localized around the magnetic equator. Burke et al. [1995] has suggested that the origin of such electrons is probably transported to the inner magnetosphere during a magnetic storm and existing in the plasmasphere with a sufficient lifetime. Although the transportation mechanism and loss process of these electrons are not clear, we can infer that the Z-mode waves are also possible to be generated even in quiet conditions, with remained electrons in the plasmasphere.