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Plasma wave enhancement and its interaction with energetic electrons in the equatorial plasmasphere

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In order to investigate the distribution and the generation mechanism of upper hybrid resonance (UHR) and Z-mode waves frequently observed in the equatorial region of the plasmasphere, statistical studies have been performed by using plasma waves and sounder (PWS) system [Oya et al., 1990] on board the Akebono satellite, and the plasma wave instability have been calculated numerically. To obtain UHR and Z-mode wave intensity, we have developed the intensity data of 7-years UHR and Z-mode waves for statistical analyses based on the automatically determined electron cyclotron frequencies, Z-mode cut-off frequency, plasma frequency, and UHR frequency.

It has been clarified by statistical studies that both UHR and Z-mode waves intensify within 5 degrees of geomagnetic latitudes in an altitude range from 2000 to the apogee (10500 km) without obvious local time dependence. Furthermore, these waves extend in a geomagnetic latitude range of 10 degrees within 1 day after the onsets of geomagnetic disturbances.

The statistical analysis results that UHR and Z-mode waves have been observed in the same regions, suggest that these waves are caused by some common sources. However, since Z-mode waves as intense as UHR waves, it seems that Z-mode waves are not produced by the mode conversion process from electrostatic waves but generated by some direct processes. Under the storm-time strong electric field [Nishimura et al., this meeting], energetic electrons are injected into L=2 and confined in a narrow latitude range by conserving the first and second adiabatic invariants. Therefore, it is expected that equatorially mirroring energetic electrons exist in the equatorial plasmasphere during geomagnetic storms. These electrons become a free energy source of plasma waves in the equatorial region.

The plasma instability of Z-mode electromagnetic waves under such energetic electrons with large pitch angles has been calculated based on the linear theory including relativistic effects [Baldwin, 1969]. The energetic electrons are modeled by the ring-type velocity distribution, and the plasma parameter (fp/fc) is 2.9. Since Z-mode waves have the phase velocity larger than the speed of light in vacuum, these waves cannot be generated by the Landau-type interactions but by the cyclotron-type process.

It has been found that the linear growth rate of Z-mode waves reaches up to 10^{-3}fc with nearly perpendicular wave normal angles. These waves are amplified to 33.8 dB within the propagation of 0.05 earth radii, which is consistent with the Akebono observations of around 26 dB. By the cyclotron-type process under these energetic electrons, UHR and whistler waves are also generated with large and small wave normal angles, respectively. This is consistent with the Akebono observations. Intense UHR waves tend to be observed just below the UHR frequency. It is strongly suggested that these waves have large wave normal angles and are not generated by the Landau-type interactions but also by the cyclotron-type interactions. On the other hand, although whistler mode waves are observed associated with the equatorial enhancement of UHR and Z-mode waves, the amplitude is smaller than these waves. This fact suggests that the whistler mode waves have small wave normal angles and quickly escape from the equatorial region before significant amplifications.

Form the present study, it is suggested that energetic particles are injected into the equatorial plasmasphere with large pitch angles during geomagnetic disturbances, and generate intense plasma waves confined in these regions.