Energy Transfer between Different-Cyclotron-Resonance Electrons via Oblique Whistler-Mode Wave Packets in the Magnetosphere

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1 Extended Abstract

Energy transfer between various groups of particles and its role in particle dynamics in the magnetosphere have been recognized and investigated for a long time [1, 2, 3]. The mechanisms of energy transfer may be quite different, and the term "various groups of particles" may have different meaning. An example of energy transfer between two groups of electrons is provided by the well-known Landau damping. In a simplified picture of this phenomenon, electrons having velocities less than the wave phase velocity absorb the wave energy and a part of kinetic energy of particles having velocities greater than the wave phase velocity.

In recent years, the energy transfer between various particle populations has become the focus of many studies in connection with the problem of particle energization in the Earth's radiation belts. Obviously, in order for this process to be of importance for particle energization, the energy should be transferred from lower energy particles to higher energy particles, which is possible only in an unstable plasma. The mechanism of energy transfer from lower energy electrons to higher energy electrons in the radiation belts, which has been studied most extensively, consists in chorus generation by the lower energy ($\sim$ 30keV) electrons with subsequent quasi-linear phase space diffusion of the higher energy ($\sim$ 1MeV) electrons, which leads to energization of a part of these electrons (see [3] and references therein).

In this report, we follow up the idea expressed in [2] that *"waves represent a highly efficient conduit for the transfer of energy from the ring current to the plasmasphere"*, and study the resonant interaction between radiation belt electrons and lightning-induced whistler-mode wave packets from the viewpoint of energy transfer from lower energy electrons to higher energy electrons. A general approach that we use consists in the following. Resonant wave-particle interaction obeys energy conservation, namely, the wave energy, which includes electromagnetic energy and the oscillating energy of non-resonant particles, plus kinetic energy of resonant particles is conserved. This permits to relate the wave growth (or damping) rate γ with the rate of energy density variation of resonant particles. Then, using the expression for the growth rate of oblique whistler mode wave in an inhomogeneous plasma known from previous studies, we calculate the energy variation of resonant particles responsible for the wave growth. Taking into account that for oblique whistler-mode wave packets the first cyclotron and the Cerenkov resonances make the main contribution to wave-particle interactions, and that for the distribution function of energetic electrons typical of the inner magnetosphere the first-cyclotron-resonance particles loose their energy while the Cerenkov-resonance particles gain energy, we obtain the rate of energy transfer from the first group of particles to the second one. We elucidate the conditions under which this process corresponds to the wave-mediated energy transfer from lower to higher energy electrons, and discuss the difference between the energy transfer considered in the present report and that connected with chorus emission.

References

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[3] R. M. Thorne, "Radiation Belt Dynamics: The Importance of Wave-Particle Interactions," *Geophys. Res. Lett.*, **37**, 2010, L22107, doi:10.1029/2010GL044990.