Energy Exchange between Energetic Electrons via Interaction with Magnetospherically Reflected Whistlers

David R. Shklyar
Space Research Institute, Russian Academy of Sciences, Moscow, Russia

Extended Abstract

I. Kimura [1], using ray tracing analysis, has shown that a wave packet of whistler mode waves may suffer a reflection if ion contribution is included in dispersion relation. Such a reflection takes place in the region where the wave frequency is less, but close to the local lower-hybrid-resonance (LHR) frequency, so, it is also referred to as LHR reflection. This finding had, in fact, predicted magnetospherically reflected whistlers, which then were found in spectrograms of wave data from OG0 1 and 3 [2].

We present a consistent derivation of the equations of motion for relativistic electrons in the field of magnetospherically reflected whistler. These equations take into account the inhomogeneity of the magnetospheric plasma and the geomagnetic field. The magnetospherically reflected whistler is described by ten wave packets, with their parameters - amplitudes, frequencies, and the wave normal vectors - varying in space and time. These parameters are pre-calculated using the equations of geometrical optics, with the account of the variation of the ray-tube cross-section. These calculations are based on previously developed method of numerical modeling of spectrograms related to lightning-induced emissions [3]. The main new point of the present work consists in the investigation of resonant wave-particle interaction from the viewpoint of energy exchange between various groups of energetic particles. We show that this process is not only an inherent part of resonant wave-particle interaction, but in terms of energy, it is stronger than the energy exchange between waves and particles. In collisionless plasma that we consider, a direct interaction between particles is impossible, and the interaction is mediated by a wave, while each group of particles interacts with this wave independently.

The conclusions of this study as applied to radiation belt physics consist in the following. While wave-particle interactions in the radiation belts may indeed lead to local electron heating, the energy source for radiation belt electrons is not waves themselves, but the processes that maintain plasma instability and lead to wave generation. These waves in turn are able to mediate the process of energy transfer from one group of particles to another. In this process, the amount of energy that one group of particle gets may be much larger than the wave energy gain in an unstable space-time domain of wave growth, or than the wave energy loss in a stable space-time domain of wave damping. Thus, a local heating of the radiation belt electrons due to wave-particle interaction does not assume the heating of all resonant electrons. On the contrary, only part of resonant particles is heated, and, in the most important case of unstable plasma, this heating takes place at the expense of the energy of another group of resonant particles.

References

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