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Chorus emissions as nonlinear coherent structures and their role in acceleration of radiation-belt electrons

A. G. Demekhov and V. Yu. Trakhtengerts

Institute of Applied Physics RAS, Nizhny Novgorod, Russia (andrei@appl.sci-nnov.ru)

We present a nonlinear theory of generation of chorus emisions in the Earth's magnetosphere, based on the operation of the magnetospheric cyclotron maser in the regime of a backward wave oscillator (BWO). In this regime, chorus signals appear as dynamic coherent whistler-mode structures generated by sharp gradients on the distribution of radiation-belt electrons in the field-aligned velocity component. These sharp gradients are formed self-consistently at the initial stage of the cyclotron instability. The amplitude and dynamical parameters of coherent signals, following from theoretical consideration, are in good quantitative agreement with Cluster measurements of chorus emissions in the generation region.

The important secondary phenomenon accompanying the chorus generation is direct acceleration of radiation-belt electrons by chorus signals near the generation region. We consider the acceleration in the regime of trapping of resonant electrons by the potential well of a chorus wave. For such a regime, the time-varying frequency of chorus elements is essential and can lead to much higher acceleration efficiency than in the conventional acceleration regime due to stochastic energy diffusion. Estimates show that an increase in the energy of a resonant electron can reach several to tens of keV during a single interaction with a chorus signal.