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Nonlinear Wave-Particle Interactions are Suppressed by Realistic Properties of Chorus Waves (bold, 14 pt)

Zeyu An[1, 2, 3], Yifan Wu[1, 2, 3], and Xin Tao[1, 2, 3]
[1]CAS Key Laboratory of Geospace Environment, Department of Geophysics and Planetary Sciences, University of Science and Technology of China, Hefei, China,
[2]CAS Center for Excellence in Comparative Planetology, Hefei, China,
[3]Mengcheng National Geophysical Observatory, University of Science and Technology of China, Hefei, China
e-mail (speaker): azy0325@mail.ustc.edu.cn

How to describe resonant interactions between chorus waves and energetic electrons remains an open question. Previous simulational works often assume chorus wave packets to be single waves, resulting in significant nonlinear effects when the waves are intense enough. However, observational works have revealed that chorus waves have complex properties, such as amplitude modulation and phase decoherence. These properties violate the assumptions of the single wave model, and could be able to reduce the efficiency of nonlinear interactions to a moderate level. This means that nonlinear models have overestimated the diffusion rates of electrons, and we must take such realistic properties of chorus waves into account.

A number of works have already analysed the effects of the realistic properties on nonlinear interactions qualitatively[1] [2], but there still lack an accurate study of what actually happens to the electrons in the real world. In this work, we generated a chorus wave packet through PIC simulation, and for the first time used it as an input of test-particle simulations. A chorus wave packet generated through PIC simulation is considered to be physically valid and have all the realistic properties, therefore, our simulations can well represent the case in the real world.

Figure 1 shows the equatorial pitch angle distribution functions at the end of the test-particle simulations. Wave Packet 1 denotes the chorus wave packet generated through PIC simulation, while Wave Packets 2 and 3 denote two additional chorus wave packets constructed artificially, in which only the temporal amplitude modulation of Wave Packet 1 is retained (Wave Packet 2) and the single wave model is used (Wave Packet 3). We can see that electrons undergo quite diffusive processes when interacting with a chorus wave packet generated with PIC simulation. Further quantitative analyses demonstrate that nonlinear interactions are suppressed to such a minor level---although not being destructed thoroughly---that we can roughly describe the interaction process with quasilinear theories.

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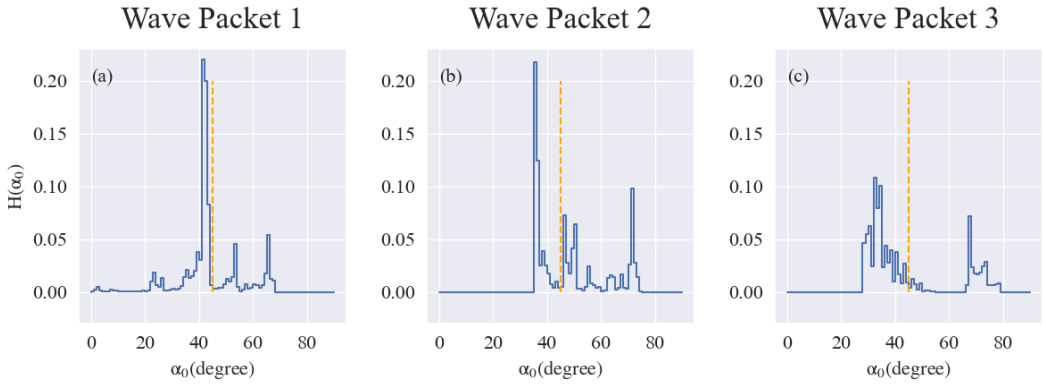

Figure 1. The equatorial pitch angle distribution functions of the electrons at the end of the test-particle simulations. The orange vertical dashed lines denote $\alpha_0 = 45^\circ$, which is the initial value of the equatorial pitch angles. Each electron encounter gyroresonance for one time during its interaction process with the chorus wave packet.