ビーム不安定性の時間発展:ビーム不安定からの低周波波動の発生

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Time evolution of beam instabilities: generation of low frequency waves from beam instabilities

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To explore and utilize the geospace environment efficiently, it is very important to understand interactions between spacecrafts and electromagnetic environment around themselves. Electron beam instabilities are also important in space plasma. According to our PIC simulations, ESW(Electrostatic Solitary Wave) is generated from electron beam instabilities. We know ESW is composing the upper frequency part of BEN(Broadband Electrostatic noise) which is frequently observed in space plasma. The generation mechanism of the lower frequency part of BEN, however, is still unexplained. To clarify whether such low frequency waves are generated by electron beam instabilities, we have to perform a series of long-term simulations of beam instabilities with different parameters, and observe time evolutions of these beam instabilities.

In order to investigate time evolutions of beam instabilities, we are performing three-dimensional computer experiments of beam instabilities, and demonstrate nonlinear evolutions of beam instabilities, in time as well as in space. Simulation study of beam instabilities are difficult because these instabilities are very sensitive to numerical thermal noises in full-particle simulations. We developed, therefore, three-dimensional particle simulation code which is specialized to parallel computing on large-scale super computers. In the present study, we perform three-dimensional particle simulations of the most fundamental beam instabilities excited by a spatially uniform beam at first. Next, we perform simulations of localized beam instabilities excited by a spatially localized beam particles, and investigate on the interaction between beam particles and space electromagnetic environment. Especially, we focus on the spatial characteristics on the perpendicular plane against the ambient magnetic field. These perpendicular dynamincs of plasma particles are essential for generation mechanisms of low frequency waves, such as Lower Hybrid waves, Whistler waves.

In analyzing time evolutions of three-dimensional spatial structure of potential, electric fields, magnetic fields, electron densities, etc., it is essential how to visualize these three-dimensional spatial structures. We are developing various visualization tools for three-dimensional spatial structures with using AVS. With our visualization tools, we can see spatial structures with stereoscopic vision, in addition can observe their time evolutions in animation. These visualization tools are useful to analyze time evolutions of three-dimensional spatial structures of various phsical parameters.