§29. Generation of Langmuir Turbulence by Intensive Relativistic Electron Beam Injection in an Open Plasma System

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Generation mechanism of the Langmuir turbulence by the intensive Relativistic Electron Beam (IREB) injection in an open and collisionless plasma system is investigated by using newly developed three-dimensional full-relativistic and electromagnetic particle simulation code (open- EXEMPLAR). In last decade, the complexity simulation group in theory and computer simulation center in NIFS found the idea of "self-organization": in MHD plasma, the parallel plasma current provides a free magnetic energy by which a current-driven kink instability (global instability) is excited to give rise to a global topological change in magnetic field configuration, whereby a nonlinear rapid energy dissipation takes place. On top of the above conditions, if a superfluous entropy (thermal energy) produced during the process is swiftly removed from the system to an surrounding world, a new stable ordered structure is established.

In this work, we attempt to investigate a self-organization process in a kinetic plasma. As a candidate for such a process, a generation of Langmuir turbulence by IREB is chosen. According to the experimental results [1], the Langmuir turbulence will be expectedly generated after IREB was passing through the bulk plasma region. Thus, we investigate the temporal evolution of plasmas after the IREB is already injected. The simulation region with the initial radial electric field is extracted in the realistic experimental configuration. Simulated particles for both bulk and IREB plasma are smoothly exchanged with the surrounding plasmas by using the net particle flux control method [2]. Also outgoing electromagnetic waves toward the surroundings is evanescent by using the Lindman ' s absorption boundary condition [3]. Namely, the whole system is thermodynamically equivalent to the grand-canonical system with flow.

First, from phenomenological viewpoint, we try to explain what determines its generation mechanism, size, location, lifetime, and so on. After the bulk plasma is heated by an IREB injection and the IREB is passing through the plasma, large amplitude Langmuir waves are excited and can quickly develop into wave packets. These wave packets are called caviton which behaves like an independent entity. Once they are created, the cycle between "collapses," "burnout," and "relaxation" is repeated. In the caviton, high frequency electrostatic wave that oscillates with plasma frequency is trapped.

Second, from self-organization viewpoint, we try to propose what determines selforganization, namely, what creates eliminated matters for ordered states (Langmuir turbulence is generated). By investigating the temporal evolution of both kinetic and electromagnetic entropy values, the scenario is discussed. In early phase, the electron entropy is gradually and selectively increased and the region of caviton spreads throughout the system. However, the intensity of Langmuir waves corresponds to the ion behaviors. The collapse of global structure for the Langmuir turbulence correlates to the negative entropy generation for ions. It is found that the previous scenario of MHD self-organization is basically established in the kinetic plasmas.

Reference

[1] R. Ando, et.al., IEEE Trans. Plasma Sci., 27, 1545(1999).

[2] H.Takamaru, et.al., J.Phys.Soc.Jpn, 66, 3826(1997)

[3] E.Lindman, J.Comp.Phys., 18, 66 (1975)