Structure formation and dynamical behavior of kinetic plasmas controlled by magnetic reconnection

Ritoku Horiuchi
Theory and Computer Simulation Center,
National Institute for Fusion Science, Toki, Gifu 509-5292, Japan

Self-organization of magnetized plasma is an interesting and fundamental problem in plasma physics. As one of typical problems of self-organization, we focus on structure formation and dynamical behavior of kinetic plasmas in an open system, where energy inflow and outflow exist through the boundary. There are four key factors to make the behavior of plasmas complex, i.e., 1) a hierarchy consisting of micro-scale physics through macro-scale physics, 2) non-linearity, 3) non-equilibrium, and 4) openness. In spite of such complex natures the self-organization phenomena are often observed in magnetized plasmas. To understand the physics it is important to investigate magnetic reconnection because it is a fundamental mechanism to control the structure formation process of magnetized plasmas in the complex open system.

First, we discuss the relationship between the dynamical behavior of kinetic plasmas and openness of the system. Two-dimensional EM particle simulation has revealed that there are two evolving regimes in the temporal behavior of collisionless reconnection, dependently on the openness of system, i.e., a steady regime and an intermittent regime [1,2]. The steady collisionless reconnection is realized when the spatial scale of energy input is small, in which the reconnection rate is balanced with the flux input rate at the upstream boundary and the global dynamic process of magnetic reconnection is dominantly controlled by ion dynamics [3]. As the input size increases, the current sheet becomes longer, which is favorable to the excitation of an electron tearing instability. The system evolves into an intermittent regime, in which magnetic islands are frequently generated in the current sheet.

In three-dimensional case the spatial structure of current sheet is dynamically modified by plasma instabilities excited through wave-particle interaction. The lower hybrid drift instability (LHDI) is observed to grow in the periphery of current layer in an early period, while a drift-kink instability (DKI) is triggered at the neutral sheet as a second instability after the current sheet is modified through nonlinear evolution of the LHDI and its width becomes less than ion Larmor radius[1,4]. It is also found that local island structures of plasmas that are generated by tearing instability in the central current sheet move to grow in the downstream, and suffer from the kink-like instability after the current accumulation inside the islands [5].

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