

Magnetic reconnection in astronomical plasmas as a multi-scale problem

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In multi-scale problems, the interaction between elementary dynamics at the micro-scale and bulk dynamics at the macro-scale plays a crucial role for the system evolution. The multi-scale problems are now highly focused in the various fields of sciences and technologies, not only for plasma physics but also for solid-dynamics, hydrodynamics, chemistry, and biology. The conventional methodologies, which have been developed to describe the phenomena at particular scale, can not be applied directly to the multi-scale problems. In fact, it is pointed out that the magnetohydrodynamics (MHD), which has been developed to describe only slow and large-scale plasma processes, cannot well handle magnetic reconnection, that is the crucial process in solar flares and magnetospheric sub-storms, and that the interaction between the kinetic process in the local diffusion region and the MHD in the environmental region must control the fundamental dynamics in reconnection processes. Furthermore, in the astronomical system like the solar corona, since there is a huge scale gap between the system scale and the kinetic scale, many nonlinear dynamics should arise in the process when the small scale structure is created. Therefore, magnetic reconnection is the most typical multi-scale phenomena in plasmas.

In this talk, we argue multi-scale dynamics in magnetic reconnection based on the comparison between the studies of solar flares and experimental plasmas, and show the results of the high-resolution simulations of magnetic reconnection for very high magnetic Reynolds number. The recent studies of magnetic reconnection mainly by the non-MHD models are also reviewed, and finally we will explain the general framework of the multi-scale coupled simulations, which are now developed in the Earth Simulator Center as the new type of methodology for the multi-scale problems.