# Future Theoretical Challenges in Magnetic Reconnection: Plasma Heating and Acceleration

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The basic theory of the fast magnetic reconnection was established by Petschek in the middle sixties, following earlier ideas proposed by Giovanni, Dungey, Sweet and Parker. Magnetic reconnection is now widely believed to be a key process in cosmic plasmas such as the aurora-substorms, the solar and stellar flares, the pulsar wind and nebula, and the AGN jet and so on, and the generation of energetic particles in reconnection is regarded as a common important problem in the plasma universe. It is extensively discussed that the multi-scale couplings of the macroscopic reconnection dynamics and the microscopic kinetic plasma processes play an important role on plasma heating and acceleration, but the understandings on energization processes are still limited. Recently, thanks to the modern geo-space satellite observations as well as the kinetic plasma simulations, a new approach of the physics of the multi-scale couplings has been emerged. Coherent, small-scale, intense electric fields embedded in the turbulent electromagnetic fields have been discovered in and around the reconnection region. The scale of the coherent wave is as small as ion/electron inertia lengths, but the amplitude of the wave is about 10 to 100 times that of a motional electric field induced in the MHD scale. Then it is suggested that the micro-scale processes appear to control the global dynamics. This new kind of multi-scale coupling process is beginning to shed light on a long standing problem of plasma heating and acceleration. In fact, the physics of the multi-scale couplings is one of the key problems of the future MMS/SMART geo-space mission that focuses on the potentially rich multi-scale structuring plasma phenomena that result from the coupling of the MHD scale to the scale of electron kinetics. In this talk, we will review some theoretical and computational challenges of the multi-scale reconnection phenomena and its particle acceleration, and will discuss what we have understood so far and the future open issues.