Reconnection and Resistivity in Collisionless High-Beta Plasmas

Himawan Wicaksono Winarto[1,2] and Matthew W. Kunz[1,2]
[1] Department of Astrophysical Sciences, Princeton University
[2] Princeton Plasma Physics Laboratory

e-mail (speaker): hwinarto@princeton.edu

The majority of the visible universe consists of weakly collisional, high beta, magnetized plasma. Such plasmas tend to be far enough out of local thermodynamic equilibrium to excite various Larmor-scale kinetic instabilities, such as the firehose and the mirror. These instabilities rapidly produce micro-scale structures in the magnetic field that trap and scatter particles, regulating the particles' transport of momentum and heat. These micro-instabilities can also affect the onset of reconnection by distorting the profile of a forming current sheet and nonlinearly seeding tearing modes on Larmor scales [1]. In our most recent work, we have used kinetic particle-in-cell simulations to investigate the direct effect of these micro-instabilities on the plasma electrical resistivity by solving the high-beta version of the Spitzer-Härm problem: applying a constant external electric field to the unstable plasma and measuring the steady-state current, with their ratio implying an effective resistivity. Based on our results, we conjecture that the effective resistivity of a weakly collisional, high-beta plasma depends on the strength of the magnetic field and on the characteristic timescale of the macroscopic dynamics. Our scaling can be implemented explicitly in fluid simulations to incorporate the missing kinetic physics. The fundamental scaling difference will modify various plasma phenomena, e.g., the magnetic reversal scales in stages of fluctuation dynamo and the scale of the resistive reconnection layer.

References
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