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Energy cascade and proton-electron heating in turbulent plasmas

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Despite decades of study of high-temperature weakly-collisional plasmas, a complete understanding of how energy is transferred between particles and fields remains elusive. Two major questions in this regard are how fluid-scale energy transfer rates associated with turbulence connect with kinetic-scale dissipation, and what controls the fraction of dissipation on different charged species. Using kinetic simulations and in-situ spacecraft data, a possible connection between the fluid-scale energy flux and the energy dissipation rate, as measured by pressure-strain interaction is found. Further, both simulation and observational data support a phenomenology of proton heating by turbulent electric field at intermittent current sheets [1, 2].

References

[1] Matthaeus, W. H., Parashar, T. N., Wan, M., & Wu, P. 2016, The Astrophysical Journal Letters, 827, L7, doi: 10.3847/2041-8205/827/1/l7
[2] Chandran, B. D. G., Li, B., Rogers, B. N., Quataert, E., & Germaschewski, K. 2010a, The Astrophysical Journal, 720, 503, doi: 10.1088/0004-637x/720/1/503

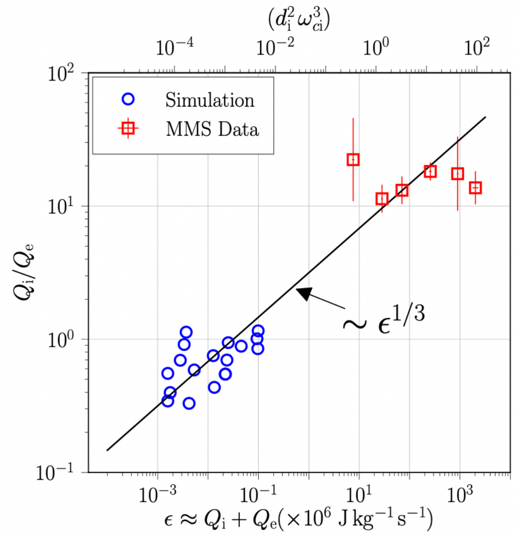

Figure 1: Ratio of proton to electron heating rate with total (proton + electron) heating rate. PIC simulation results, including the ones reported in [1] are shown using blue circles. For MMS results, only intervals with positive ion and electron heating rate were considered. Both results indicate that the relative heating of protons increases with the total heating rate (the solid line, with a slope of 1/3, is given for reference.) The horizontal axis has been normalized using the typical values for magnetosheath: d_i = 10 km, ω_{ci} = 0.6 Hz.