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Spatially intermittent kinetic range turbulence and plasma heating in fully self-consistent kinetic (PIC) simulations of reconnection

Ersilia Leonardis (1), Sandra Chapman (1,4), William Daughton (2), Vadim Roytershteyn (3), and Homayoun Karimabadi (3)

(1) University of Warwick, Centre for Fusion, Space and Astrophysics, Physics Dept., Coventry CV4 7AL, United Kingdom (s.c.chapman@warwick.ac.uk, +44 2476 692016), (2) Los Alamos Lab., Los Alamos, NM, United States, (3) SciberQuest, Inc., Del Mar, CA, United States, (4) University of Tromso, Dept. of Mathematics and Statistics, Norway

Recent fully self-consistent kinetic (PIC) simulations of reconnection in three dimensions [Daughton et al, Nat. Phys, 2011] are strongly suggestive that collisionless magnetic reconnection leads to self-generation of turbulence. We investigate whether this 'turbulent reconnection', in particular when evolved on kinetic scales, does indeed proceed in a manner that shares features of its phenomenology with classical intermittent fluid turbulence. If so, this would be the first indication of a universal physics central to turbulent reconnection and would provide quantitative insights into the role that turbulence plays in plasma heating. We present the results of formal quantitative tests for reconnection driven turbulence in these fully self-consistent kinetic (PIC) simulations. In the finite sized domain of a reconnection region, one anticipates a generalized scaling, that is, Extended Self Similarity (ESS). We find the characteristic signatures of intermittent turbulence, specifically ESS and non-Gaussian pdfs of fluctuations and confirm that these show multifractal scaling, which is anisotropic. Importantly, we can distinguish this scaling from that of the correlated noise generated by the PIC simulation. We find that the scalar field J.E is also multifractal so that plasma heating is spatially intermittent, following the topology of the magnetic field fluctuations. Similarities and differences between simulations in two and three dimensions will also be discussed. This quantitative characterization of fully kinetic simulations of turbulent reconnection in terms of turbulence phenomenology also suggests tests that could be applied to in-situ satellite observations of regions where reconnection is occurring.