

Structures and Turbulence in Electron Magnetohydrodynamics

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Abstract

Two aspects of the electron plasma are investigated analytically and numerically in the frame work of the model of electron magnetohydrodynamics (EMHD). EMHD Provides a fluid description for the electron plasma at small length and short time scales. All dynamics, in particular the current, are carried by the electrons while the ions provide a neutralizing background.

The first aspect is the generation of electron vortical structures by strong localized heating analytically and numerically. Magnetic structures are generated by the thermal electro-motive force that arises due to non-alignment of pressure and density gradients. Their topology is determined by the heating power and the equilibrium density gradient. These structures are shown to be capable of confining and transporting heat across the plasma. The long term behaviour of the structures agrees qualitatively with the behaviour of stationary equilibrium solutions. As these structures survive for rather long times, a filamentary profile of the temperature develops.

The second aspect is the small-scale turbulence at high frequencies. We will focus on decaying turbulence. The strategy was to start with perturbations with specific mode numbers and to simulate the ensuing turbulence while it decays into a (usually self-similar) state that is insensitive to the details of the initial perturbations and therefore has a number of universal characteristics. Analysis of the simulation results has shown that properties of the turbulence are different for scales that are larger or smaller than the inertial skin depth, the intrinsic scale in the electron fluid.