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The End of the Turbulent Cascade?: Exploring possible signatures of MHD turbulent dissipation beyond spectra in a magnetically-dynamic laboratory plasma[1]

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A typical signature of dissipation in conventional fluid turbulence is the steepening power spectrum of velocity fluctuations, signaling the transition from the inertial range to the dissipation range where scales become small enough for fluid viscosity effects to be dominant and convert flow energy into thermal energy. In MHD fluids, resistivity can play an analogous role to viscosity for magnetic field fluctuations, where collisional scales determine the onset of dissipation. However, turbulent plasmas can exhibit other mechanisms for converting magnetic energy into thermal energy such as through the generation of current sheets and magnetic reconnection or through coupling to kinetic scale fluctuations such as Kinetic Alfven waves or Whistler waves. In collisionless plasmas such as the solar wind, only these alternative dissipation mechanisms are likely active. Recent experiments with MHD turbulence generated in the wind-tunnel configuration of the Swarthmore Spheromak Experiment (SSX) provide an environment in which various potential non-resistive signatures of magnetic turbulent energy dissipation can be studied. SSX plasma is magnetically dynamic with no background field. Previous work has demonstrated that a steepening in the magnetic fluctuation spectrum is observed which can be roughly interpreted as a transition from inertial range to a dissipation range magnetic turbulence. The frequency range at which this steepening occurs can be correlated to the ion inertial scale of the plasma, a length which is characteristic of the size of current sheets in MHD plasmas. Detailed intermittency and structure function analysis presented here coupled with appeals to fractal scaling models support the hypothesis that the observed turbulence is being affected by a global dissipation mechanism such as the generation of current sheets. Information theory based analysis techniques using permutation entropy and statistical complexity are also applied to seek dissipation signatures.

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