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Gyrokinetic Simulations of Solar Wind Turbulence

JASON TENBARGE, University of Iowa

Recent high sampling rate solar wind turbulence observations of have been extended well into the frequency regime above the observed magnetic energy spectral break at $1Hz$, where a nearly power law spectrum with a spectral index around -2.8 is observed. The range of scales above the spectral break is typically referred to as the dissipation range and corresponds to the range of spatial scales between the Doppler- shifted ion and electron gyro-radii. One of the proposed theories to explain the dissipation range of magnetic turbulence is a cascade of low frequency kinetic Alfvén waves. We present the results of the first three-dimensional, non-linear gyrokinetic simulation of plasma turbulence resolving scales from the ion to the electron gyro-radius, where all dissipation is provided by resolved physical mechanisms. The simulation employs parameters comparable to solar wind plasma and yields a magnetic spectral index of -2.8, in excellent quantitative agreement with observations. Since the simulation fully resolves the physical dissipation, we are able to explore a variety of novel aspects of turbulence, including the first evidence of the proposed ion entropy cascade in a three-dimensional, electromagnetic turbulence simulation.