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Instabilities and Turbulence in Two-Dimensional Magnetohydrodynamics

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The solar tachocline is a dynamically important thin region in the Sun, located between the convective and radiative zones and characterised by strong shear in both the radial and latitudinal directions. Furthermore, it is believed to play a key role in the solar dynamo process through the shearing of a poloidal field into a stronger toroidal component. Motivated by the dynamics of the tachocline we have conducted a detailed numerical exploration of the dynamics of sheared MHD turbulence.

Specifically, we have implemented a parallelized numerical model using the "shenfun" Python library to solve the nonlinear two-dimensional Magnetohydrodynamic (MHD) equations to study the dynamics of unstable jets and turbulence in astrophysical plasmas. In particular, we study details of how the jet becomes unstable and the resulting cascade of energy in the case of MHD turbulence. In addition to studying the evolution of the physical quantities, we also investigate the evolution of the spectral slopes and spectral fluxes. As has been found in previous studies of MHD turbulence, a very weak large-scale magnetic field can play a key dynamical role through its amplification on small scales. For extremely weak fields, the behaviour is essentially hydrodynamic. However, once the field is dynamic, the nature of the resulting MHD solution is very different. We are able to classify the various flows and quantify the nature of the solutions in the two regimes.