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Nonlinear Triad Interactions in Magnetohydrodynamic Plasma Turbulence

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Abstract : Nonlinear triad interactions in incompressible three-dimensional magnetohydrodynamic (3D-MHD) turbulence are studied by analyzing data from high-resolution direct numerical simulations of decaying isotropic (5123 grid points) and forced anisotropic (10242 x256 grid points) turbulence. An accurate numerical approach toward analyzing nonlinear turbulent energy transfer function and triad interactions is presented. It involves the direct numerical examination of every wavenumber triad that is associated with the nonlinear terms in the differential equations of MHD in the inertial range of turbulence. The technique allows us to compute the spectral energy transfer and energy fluxes, as well as the spectral locality property of energy transfer function. To this end, the geometrical shape of each underlying wavenumber triad that contributes to the statistical transfer density function is examined to infer the locality of the energy transfer. Results show that the total energy transfer is local via nonlocal triad interactions in decaying macroscopically isotropic MHD turbulence. In anisotropic MHD, turbulence subject to a strong mean magnetic field the nonlinear transfer is generally weaker and exhibits a moderate increase of nonlocality in both perpendicular and parallel directions compared to the isotropic case. These results support the recent mathematical findings, which also claim the locality of nonlinear energy transfer in MHD turbulence.

Keywords : magnetohydrodynamic (MHD) turbulence, transfer density function, locality function, direct numerical simulation (DNS)
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