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Long-time properties of MHD turbulence and the role of symmetries

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(Submitted on 9 Apr 2012)

We investigate long-time properties of three-dimensional MHD turbulence in the absence of forcing and examine in particular the role played by the quadratic invariants of the system and by the symmetries of the initial configurations. We observe that, when sufficient accuracy is used, initial conditions with a high degree of symmetries, as in the absence of helicity, do not travel through parameter space over time whereas by perturbing these solutions either explicitly or implicitly using for example single precision for long times, the flows depart from their original behavior and can become either strongly helical, or have a strong alignment between the velocity and the magnetic field. When the symmetries are broken, the flows evolve towards different end states, as predicted by statistical arguments for non-dissipative systems with the addition of an energy minimization principle, as already analyzed in \cite{stribling_90} for random initial conditions using a moderate number of Fourier modes. Furthermore, the alignment properties of these flows, between velocity, vorticity, magnetic potential, induction and current, correspond to the dominance of two main regimes, one helically dominated and one in quasi-equipartition of kinetic and magnetic energy. We also contrast the scaling of the ratio of magnetic energy to kinetic energy as a function of wavenumber to the ratio of eddy turn-over time to Alfv\'en time as a function of wavenumber. We find that the former ratio is constant with an approximate equipartition for scales smaller than the largest scale of the flow whereas the ratio of time scales increases with increasing wavenumber.

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