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Two and three-dimensional binary-fluid turbulence

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We study two- and three-dimensional (2D and 3D) binary-fluid turbulence by carrying out an extensive direct numerical simulation (DNS) of the forced, statistically steady turbulence in the coupled Cahn-Hilliard and Navier-Stokes equations. In the absence of any coupling, we choose parameters that lead (a) to spinodal decomposition and domain growth, which is characterized by the spatiotemporal evolution of the Cahn-Hilliard order parameter ϕ, and (b) the formation of an energy-cascade regime. We show that the Cahn-Hilliard-Navier-Stokes coupling leads to an arrest of phase separation at a length scale L_c, which we evaluate from $S(k)$, the spectrum of the fluctuations of ϕ. We demonstrate that (a) $L_c \sim L_H$, the Hinze scale that follows from balancing inertial and interfacial-tension forces, and (b) L_c is independent, within error bars, of the diffusivity D. We elucidate how this coupling modifies the energy transfer in spectral space.