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**Spontaneous mirror-symmetry breaking induces inverse energy cascade in 3D active fluids** JONASZ SLOMKA, JORN DUNKEL, Massachusetts Institute of Technology — Classical turbulence theory assumes that energy transport in a 3D turbulent flow proceeds through a Richardson cascade whereby larger vortices successively decay into smaller ones. By contrast, an additional inverse cascade characterized by vortex-mergers exists in 2D fluids and gases, with profound implications for meteorological flows and fluid mixing. The possibility of a helicity-driven inverse cascade in 3D fluids had been rejected in the 1970s based on equilibrium-thermodynamic arguments. Recently, however, it was proposed that certain symmetry breaking processes could potentially trigger a 3D inverse cascade, but no physical system exhibiting this phenomenon has been identified to date. Here, we present direct analytical and numerical evidence for the existence of a robust inverse energy cascade in 3D active fluids, such as bacterial suspensions, which can develop flows that spontaneously break mirror-symmetry. We show analytically that self-organized scale selection, a generic feature of many biological and engineered nonequilibrium fluids, can generate parity-violating Beltrami flows. Using large-scale numerical simulations, we further demonstrate how active scale selection controls mirror-symmetry breaking and the emergence of a 3D inverse cascade.

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