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Direct measurement of turbulent resistivity

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We have directly measured the vector turbulent emf in a two-vortex flow of liquid sodium in the Madison Dynamo Experiment. Using a novel probe design, we simultaneously measure magnetic and flow fluctuations to determine their correlated effect on mean-field induction. Through our electromagnetic model for the flow-induced mean magnetic field, constrained by measurements throughout the flow, we construct the vector mean current density at the probe location. With this information we are able to construct the mean-field model for the α and β-effect terms of the turbulent emf and compare them with the direct measurement of the time averaged correlated fluctuations. The measured turbulent emf is anti-parallel with the mean current and is almost entirely described by an enhanced resistivity. The residual turbulent resistivity presents a difficulty for establishing the onset of the kinematic dynamo in a laboratory turbulent flow in that the effective magnetic Reynolds number is reduced making it more difficult to exceed the critical Rm. We have demonstrated that this enhanced resistivity can be mitigated by eliminating the largest-scale eddies. By tailoring the large-scale flow, we have achieved flows operating near threshold for dynamo self-excitation.