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Large Deviation Statistics of Vorticity Stretching in Isotropic Turbulence[1] PERRY JOHNSON, CHARLES MENEVEAU, Johns Hopkins University — A key feature of 3D fluid turbulence is the stretching/re-alignment of vorticity by the action of the strain-rate. It is shown using the cumulant-generating function that cumulative vorticity stretching along a Lagrangian path in isotropic turbulence behaves statistically like a sum of i.i.d. variables. The Cramer function for vorticity stretching is computed from the JHTDB isotropic DNS (Re_\lambda = 430) and compared to those of the finite-time Lyapunov exponents (FTLE) for material deformation. As expected the mean cumulative vorticity stretching is slightly less than that of the most-stretched material line (largest FTLE), due to the vorticity's preferential alignment with the second-largest eigenvalue of strain-rate and the material line's preferential alignment with the largest eigenvalue. However, the vorticity stretching tends to be significantly larger than the second-largest FTLE, and the Cramer functions reveal that the statistics of vorticity stretching fluctuations are more similar to those of largest FTLE. A model Fokker-Planck equation is constructed by approximating the viscous destruction of vorticity with a deterministic non-linear relaxation law matching conditional statistics, while the fluctuations in vorticity stretching are modelled by stochastic noise matching the statistics encoded in the Cramer function. The model predicts a stretched-exponential tail for the vorticity magnitude PDF, with good agreement for the exponent but significant error (30-40%) in the pre-factor.

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