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Exploring the turbulent velocity gradients at different scales from the perspective of the strain-rate eigenframe JOSIN TOM, Duke University, NC, USA, MAURIZIO CARBONE, Politecnico di Torino, Torino, Italy; Duke University, NC, USA, ANDREW D. BRAGG, Duke University, NC, USA — The behavior of the filtered velocity gradient tensor (FVGT) in turbulence is analyzed by expressing its evolution equation in the strain-rate eigenframe. This provides an insightful way to understand the nature and interplay of various dynamical processes such as strain self-amplification, vortex stretching and tilting. Using Direct Numerical Simulation (DNS) data of isotropic turbulence, we consider the importance of local and non-local terms in the FVGT eigenframe equations across different scales. The eigenframe rotation-rate (that drives vorticity tilting) is shown to exhibit highly non-Gaussian fluctuations even at large scales due to kinematic effects, but dynamically, the anisotropic pressure Hessian plays a key role. The anisotropic pressure Hessian conditioned on the eigenvalues and vorticity exhibits highly non-linear behavior, with important modeling implications. We also derive a generalization of the Lumley triangle that allows us to show that the pressure Hessian has a preference for two-component axisymmetric configurations at small scales, with a transition to a more isotropic state at larger scales. Our results provide useful guidelines for improving Lagrangian FVGT models, since current models fail to capture a number of subtle features observed in our results.

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