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Velocity gradients and fluid element deformation in turbulence: a new stabilizing mechanism due to the pressure Hessian MAURIZIO CARBONE, Max Planck Institute for Dynamics and Self-Organization, JOSIN TOM, ANDREW BRAGG, Duke University, MICHELE IOVIENO, Politecnico di Torino, MICHAEL WILCZEK, Max Planck Institute for Dynamics and Self-Organization —
We analyze the internal motion of a small and incompressible fluid element through the velocity gradient and deformation tensor at its center of mass. We identify a novel stabilizing effect due to the pressure Hessian, leading to a decomposition of the Hessian into a conservative and non-conservative part. Restricting the Hessian to its conservative part generates a new class of time-reversible and spin-preserving models for the velocity gradient, which also includes the inviscid tetrad and Recent Fluid Deformation closures. In contrast to those models, the presented conservative system allows controlling the smoothness of the solutions by means of its first integral of motion. Despite time-reversibility, the new model can accurately predict the vorticity alignment with the intermediate strain-rate eigenvector. The new stabilizing effect of pressure is detected and studied in steady and isotropic turbulent flows from direct numerical simulations. The presented stabilizing mechanism is directly related to the strain-rate rather than vorticity, which is instead key for the reduction of nonlinearity (Chertkov et al. 1999). Therefore, those two stabilizing mechanisms are complementary and together can lead to an enhanced understanding and modeling of non-localities in turbulence.

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