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Invariants of the reduced velocity gradient tensor in turbulent flows JOSE CARDESA, Universidad Politecnica de Madrid, DHIREN MISTRY, LIAN GAN, JAMES DAWSON, University of Cambridge — In this paper we examine the invariants p and q of the reduced 2×2 velocity gradient tensor formed from a 2D slice of an incompressible 3D flow. Based on 2D PIV measurements and 3D DNS, we show that the joint probability density function of p and q exhibits a common characteristic shape shared across various turbulent flows. This is confirmed by data from a turbulent jet, a turbulent channel flow, isotropic turbulence in a periodic cube and mixing tank shear turbulence. The asymmetry in the shape of the resulting scatter plot is studied and proved to follow from the predominance of vortex stretching in all these flows. The only assumptions required for the proof are local homogeneity and local isotropy applied to the velocity gradients. We compare this $p - q$ scatter plot for which only 2D data is required with the widely known $Q-R$ scatter plot based on 3D information. Finally, we explore the properties of the strain rates deduced from the 2D velocity gradient tensor only. We find in which cases these can be used to unambiguously discriminate between sheet-forming or tube-forming configurations of the full 3D strain rates.

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