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Physics Informed Learning of Lagrangian Turbulence: Velocity Gradient Tensor over Inertial-Range Geometry YIFENG TIAN, DANIEL LIVESCU, Los Alamos National Laboratory, MICHAEL CHERTKOV, University of Arizona — The phenomenological model of coarse-grained velocity gradient tensor (VGT) constructed by considering the Lagrangian dynamics of four points, or the tetrad, is extended under the Physics-Informed Machine Learning (PIML) framework. The pressure hessian contribution is re-constructed from the dynamics of Lagrangian tetrad, which provides an improved representation of its magnitude and orientation. The unclosed incoherent small scale fluctuations are modeled using ML techniques trained on Lagrangian data from a high-Reynolds number Direct Numerical Simulation (DNS). Certain constraints, such as Galilean invariance, rotational invariance, and zero-pressure work condition, are enforced to implement known physics into the ML model. Then, a comprehensive diagnostic test is performed. Statistics of the flow, as indicated by the joint PDF of second and third invariants of the VGT at different coarse-grained scales, show good agreement with the ground-truth DNS. Some important features regarding the structure of the turbulence are correctly reproduced by the model including skewed distribution of the velocity gradient, vorticity-strain rate alignment and vortex stretching mechanism. The pressure hessian and small-scale contributions to Lagrangian dynamics are also well-captured.

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