Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

Physics-informed Machine Learning of the Lagrangian Dynamics of Velocity Gradient Tensor YIFENG TIAN, DANIEL LIVESCU, Los Alamos National Laboratory, MICHAEL CHERTKOV, University of Arizona — Reduced Lagrangian models describing dynamics of the Velocity Gradient Tensor (VGT), probing Kolmogorov scale and also coarse-grained at the scales within the inertial range of turbulence, are developed under the Physics-Informed Machine Learning (PIML) framework. The coherent part of pressure Hessian contribution is reconstructed with the Tensor-based Neural Network (TBNN) using the integrity bases and invariants of the VGT, which provides an improved representation of magnitude and orientation of the pressure Hessian eigenvectors. The incoherent part associated with small scale fluctuations is modeled using standard ML techniques. Both constructs are trained on Lagrangian data from a high-Reynolds number Direct Numerical Simulation (DNS). Physical constraints, such as Galilean invariance, rotational invariance, and zero-pressure work condition, are embedded into the models. Statistics of the flow, as indicated by the joint PDF of second and third invariants of the VGT, show good agreement with the ground-truth DNS. A number of important features describing structure of the turbulence are reproduced correctly by the model. We have also identified features, e.g. related to inertial range dynamics, which require more in-depth modeling. This helps us to identify important directions for future research, in particular towards including inertial range geometry into TBNN.

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Date submitted: 11 Aug 2020 Electronic form version 1.4