On the Space-Time Structure of Sheared Turbulence

We develop a model that predicts all two-point correlations in high Reynolds number turbulent flow, in both space and time. This is accomplished by combining the design philosophies behind two existing models, the Mann spectral velocity tensor, in which isotropic turbulence is distorted according to rapid distortion theory, and Kristensen’s longitudinal coherence model, in which eddies are simultaneously advected by larger eddies as well as decaying. The model is compared with data from both observations and large-eddy simulations and is found to predict spatial correlations comparable to the Mann spectral tensor and temporal coherence better than any known model. Within the developed framework, Lagrangian two-point correlations in space and time are also predicted, and the predictions are compared with measurements of isotropic turbulence. The required input to the models, which are formulated as spectral velocity tensors, can be estimated from measured spectra or be derived from the rate of dissipation of turbulent kinetic energy, the friction velocity and the mean shear of the flow. The developed models can, for example, be used in wind-turbine engineering, in applications such as lidar-assisted feed forward control and wind-turbine wake modelling.

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