Nonlinear Fluctuating Hydrodynamics as Model for Turbulent Superstructures

Turbulent superstructures can be loosely defined as events in a turbulent flow field that exhibit a certain kind of spatial and temporal coherence, where the observed correlation length and time scales possess a distinct separation from the (smaller) turbulence length and time scales. Such a scale separation interferes with classical modeling assumptions for energy transfers in turbulent flows and for that reason may imply a need for separate analyses and models. While a postdictive assessment of superstructures is important to gain phenomenological understanding, a predictive model is needed as well. Aside of considering descriptions as low-order dynamical systems, another approach is to devise and analyze mesoscale stochastic numerical models with non-standard dispersion-dissipation behavior that represent non-equilibrium fluctuations and may apply to turbulence and inverse-cascade events. The approach draws on several observations:

- Nonlinear Landau-Lifshitz-Navier-Stokes equations predict self-organization on the level of mesoscopic diffusion.
- Generalized Langevin Models reproduce Reynolds-stress models for turbulent fluctuations.
- Dissipative-particle dynamics exhibit non-trivial spectral dissipation (see figure).

The project investigates the following questions:

- How simple can and how complex must a stochastic model be such that the interaction of fluctuations with a mean gradient may result in the emergence of long-range momentum correlations ?
- What inherent mechanisms actually are relevant for the generation of large-scale correlations in the momentum field ?
- What is the significance of mean parameters on the emergence of long-range correlations ?