An approach to turbulence from first principles

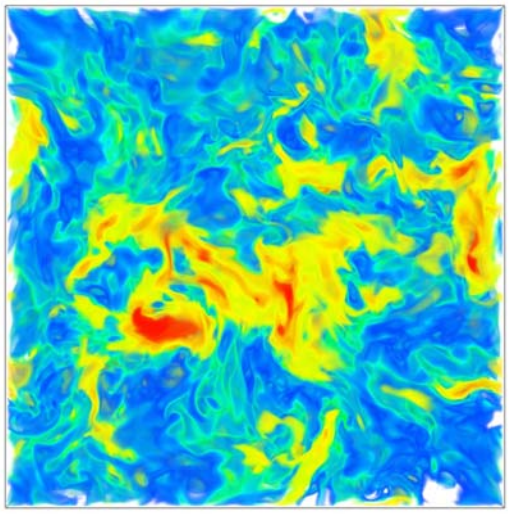
Anton Daitche

Institute for Theoretical Physics, Münster University, Germany
E-mail: anton.d@uni-muenster.de

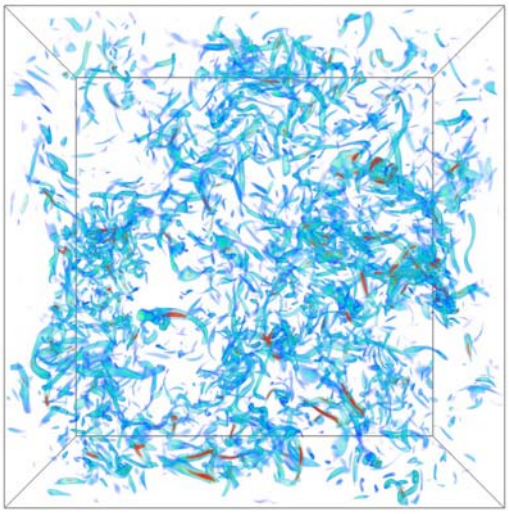
Most theories of turbulence are phenomenological in their nature, i. e., they encompass a model based on observations instead of being deduced from first principles. Despite numerous attempts to obtain a statistical description of the phenomenon turbulence from first principles, exact results in this field are rather sparse. This is often accounted to the very high inherent complexity and the wide range of time and length scales appearing in a turbulent flow.

This talk will present an approach based on a combination of theoretical and numerical analysis. Starting from the Navier-Stokes equation, exact relations for the statistical quantities of interest are derived and supplemented with data obtained from numerical simulations. In particular, the one-point probability density function (PDF) of the velocity and the vorticity in a statistically homogeneous and isotropic turbulent flow will be considered. The evolution of the PDFs are described by equations which are directly derived from the Navier-Stokes equation. These equations, however, contain unclosed terms which can be obtained from numerical simulations (or experiments). Through this approach one can analyze the shape of the PDFs in detail and relate it to other physical quantities like the condional dissipation or pressure.

In particular, the talk will discuss deviations of the velocity PDF from the normal distribution and give a comparison of the velocity and vorticity PDFs and the related quantities.



Velocity in a turbulent flow



Vorticity in a turbulent flow

[1] M. Wilczek, A. Daitche, R. Friedrich. On the velocity distribution in homogeneous isotropic turbulence: correlations and deviations from Gaussianity. J. Fluid Mech. 676, 191 (2011)