DY 24: Turbulence and wind energy

Time: Thursday 9:30–13:00 Location: H47

Topical Talk DY 24.1 Thu 9:30 H47

Wind energy conversion - how statistical physics can improve our future energy supply — •Stephan Barth[1,2], Matthias Wächter[1,2], Tanja Mücke[1,2], and Joachim Peinke[1,2] — [1]ForWind - Center for Wind Energy Research, Oldenburg, Germany — [2]University of Oldenburg, Institute of Physics, Oldenburg, Germany

Renewable energy sources will play an important role in Europe's future energy supply and for the next decades wind energy will be the major contributor of all renewables. Although being a mature and proven technique with more than 120 GW installed capacity worldwide, future installation plans require further improvements - especially looking at offshore wind energy. Engineers from numerous disciplines have committed themselves to this task. However, an energy supply with a high penetration of wind energy will require modern concepts of statistical physics, too: Wind turbines can be seen as dynamic systems, continuously excited by turbulent fluctuations and therefore showing a quite complex behavior. The commonly used engineering models can not grasp this complex behavior properly. To some extend this leads to a tremendous underestimation of extreme events, e.g. gusts, mechanical loads, et cetera. Modern methods of time series analysis and nonlinear methods provide a more profound description of the wind energy conversion process. We present applications from wind fields to production of electricity itself.

15 min. break

DY 24.2 Thu 10:15 H47

Lift measurements in turbulent flow — •Jörge Schneemann, Pascal Knebel, and Joachim Peinke — ForWind, University of Oldenburg, Institute of Physics, Germany

We present lift measurements in a wind tunnel on a FX 79-W-151A airfoil using simultaneously two different methods in laminar and turbulent flow. The first method measures the pressure distributions on the wind tunnel walls to calculate the lift coefficient. This method was shown to work in laminar flow before. The second method measures the lift forces directly on the mounting of the airfoil with a strain gauge based system. Simultaneous measurement gives the opportunity to compare the results of both methods. Hereby, the wall pressure method was proven to obtain good time averaged results in turbulent flow.
Lift was measured in several turbulent inflows with different turbulence intensities Ti generated by grids. Lift forces in the stall range of the foil increased with Ti. One of the grids had a fractal geometry (fractal grid). The turbulence generated by this grid differs from turbulence generated by 'classic grids' in the distribution of the velocity increments. This leads to a different behaviour of the airfoil: Lift fluctuations measured in the stall range of the foil were much higher in the wake of the fractal grid than those in the wake of a classical grid with higher Ti. This suggests a nonlinear behaviour of the airfoil for which research is ongoing.

DY 24.3 Thu 10:30 H47

Turbulenzerzeugung mit aktiven Gittern — •Pascal Knebel und Joachim Peinke — ForWind, Carl von Ossietzky Universität Oldenburg

Wir stellen ein neu entwickeltes aktives Gitter für unseren Windkanal vor bei dem mit digitalen Schrittmotoren 16 Gitterstäbe mit Klappen unabhängig angesteuert werden können. Im Vergleich zu einem passiven Gitter konnten mit unterschiedlichen Anregungsprotokollen in Turbulenzmessungen hinter dem Gitter die Skalenbereiche für Leistungsspektren und Strukturfunktionen erheblich hin zu großen Skalen vergrößert werden. Die großskalige Dynamik wird dabei im wesentlichen durch die Dynamik der Gitteransteuerung erzielt. Die genaueren Untersuchungen ergeben je nach Wahl der Anregungsprotokolle unterschiedliche Übergangsverhalten zwischen der durch das Gitter aufgeprägten großskaligen Dynamik und der sich selbst einstellenden kleinskaligen turbulenten Dynamik. Diese Erscheinung wird im Zusammenhang mit Phasenübergängen diskutiert.

DY 24.4 Thu 10:45 H47

Eulerian and Lagrangian statistics in compressible fluid turbulence — •Christian Schwarz and Rainer Grauer — Institut für Theor. Physik I, Ruhr-Universität Bochum

In order to get insight in statistical properties of turbulent compressible flows numerical simulations using a conservative shock capturing CWENO scheme were performed. In particular, the connection between the PDFs of the Eulerian and Lagrangian velocity increments will be discussed and compared to recent theories developed for incompressible flows. Due to the compressibility of the flow the influence of the density fluctuations can clearly be seen in the velocity increments as well as in the corresponding structure functions. A way to take into account the effect of compressibility on the statistics will be presented.

In order to get long time statistics especially necessary in compressible flows a new framework *cudaHYPE* is under development. This framework solves the compressible Euler equations on a cluster of graphics cards. First results will be presented.

DY 24.5 Thu 11:00 H47

Bridging Lagrangian and Eulerian fluctuations in electron MHD turbulence — •Martin Rieke and Rainer Grauer — Institut für Theor. Physik I, Ruhr-Universität Bochum

Electron MHD is especially suited for addressing the relation between Lagrangian and Eulerian fluctuations since this system allows a direct energy cascade in two space dimensions. Using the CUDA framework for GPU computing, high resolution and long time statistics can be achieved to determine transition probabilities between Eulerian and Lagangrian fluctuation. The results are compared to known models for Navier-Stokes turbulence.

DY 24.6 Thu 11:15 H47

Measurement of Lagrangian Particle Trajectories by Digital in-line Holography — •Tim Homeyer, Christoph Hindriksen, Gerd Gülker, and Joachim Peinke — ForWind, University of Oldenburg, Institute of Physics, Germany

A digital holographic in-line setup was used to track particles in a small turbulence chamber. Different particle validation methods have been tested to filter out speckles and to enhance accuracy of the longitudinal particle coordinates. In first measurements particle trajectories were measured and visualized together with fitted spline curves. A pronounced decrease of the standard deviation of the particle coordinates with respect to their spline curves was achieved.

DY 24.7 Thu 11:30 H47

Anomalous Region in Fractal Flows — •Stefan Weitemeyer[1], Joachim Peinke[1], and Christos Vassilicos[2] — [1]ForWind, University of Oldenburg, Institute of Physics, Germany — [2]Imperial College, Department of Aeronautics, London, UK

Fractal grids produce high turbulence intensities and high Reynolds numbers.
Using different fractal grids in four different wind tunnels, we studied by hot wire measurements which grid parameters determine the properties of the flow behind the grid. We focused on a region close to the grid where the flow is intermittent and carried out statistical analyses. Flatness values much higher than three and skewness values below zero both reflect the presence of highly energetic bursts in this region. Furthermore we studied the two-point correlations and found the flow to be intermittent on all scales. In our current research we want to determine if the flow behind the fractal grid is a superposition of 'classical grid flows' or if the fractal structure of the grid creates a completely different kind of flow.

DY 24.8 Thu 11:45 H47

Dynamic alignment in supersonic compressible MHD turbulence — •Christoph Beetz, Jürgen Dreher, and Rainer Grauer — Institut für Theor. Physik I, Ruhr-Universität Bochum

It is fairly known that in compressible MHD turbulence the compressibility remains on a very low level although the supersonic, turbulent motion of the gas develops strong shocks which are a typical property of compressible flows. Following an idea of Boldyrev (2005) for incompressible turbulence, we investigate the possibility of a dynamical alignment of the velocity- and the magnetic field. Such a non-perfect scale-dependent alignment would on the one hand explain the quasi-incompressibility of the velocity, admitting on the other hand shock

formation in the density. To address this question, high resolution numerical simulations of compressible, supersonic MHD-turbulence with a strong background magnetic field were performed with our framework *racoon*.

DY 24.9 Thu 12:00 H47

Finite-size effects in the dynamics of neutrally buoyant particles in turbulent flow — •Holger Homann[1], Jérémie Bec[2], and Rainer Grauer[1] — [1]Institut für Theoretische Physik I, Ruhr-Universität Bochum, 44780 Bochum — [2]Laboratoire Cassiopée UMR6202 Observatoire de la Côte d'Azur BP4229, 06304 Nice Cedex 4, France

The dynamics of neutrally buoyant particles transported by a turbulent flow is investigated for spherical particles with radii of the order of the Kolmogorov dissipative scale or larger. The pseudo-penalisation spectral method that has been proposed by Pasquetti et al. (2008) is adapted to integrate numerically the simultaneous dynamics of the particle and of the fluid. Such a method gives a unique handle on the limit of validity of point-particle approximations, which are generally used in applicative situations. Analytical predictions based on such models are compared to result of very well resolved direct numerical simulations. Evidence is obtained that Faxén corrections give dominant finite-size corrections to velocity and acceleration fluctuations for particle diameters up to four times the Kolmogorov scale. The dynamics of particles with larger diameters is dominated by inertial-range physics, and is consistent with predictions obtained from dimensional analysis.

15 min. break

Invited Talk DY 24.10 Thu 12:30 H47

Puzzles in Eulerian and Lagrangian turbulence — •Rainer Grauer — Institut für Theor. Physik I, Ruhr-Universität Bochum

Basic and elementary questions which arise in the context of fully developed turbulent systems are still open and discussed controversially. Some of these questions are:

- What is the relation between Eulerian longitudinal and transversal structure functions?

- Is there a relation between Eulerian and Lagrangian fluctuations?

- Can we say something about the energy spectrum in slightly more complex systems as e.g. in magnetohydrodynamical turbulence?

In my talk, I will present different viewpoints and possible solution strategies.