DY 26: Fluid dynamics II

Time: Thursday 14:00–17:00 Location: MA 001

Invited Talk DY 26.1 Thu 14:00 MA 001

Statistical physics of atmospheric clouds — •Raymond A. Shaw — Leibniz-Institute for Tropospheric Research, Leipzig, DE — Department of Physics, Michigan Technological University, Houghton, USA

Atmospheric clouds, a crucial piece of the climate change problem, are iconic as visualizations of turbulence. The ubiquity of random turbulence in clouds, over a large range of spatial and temporal scales, suggests that statistical physics is a useful approach for obtaining simplified representations of such complex systems. Some of the many aspects of turbulence interacting with cloud particles and radiation fields will be reviewed: from inhomogeneous mixing, to inertial clustering, to stochastic coalescence. The fundamental role of the Lagrangian viewpoint in the cloud-particle coalescence problem will be discussed in the context of a toy model of stochastic rain formation. This provides a context for discussing the emerging recognition of the dominant role of fluctuations in cloud processes.

Support from the Alexander von Humboldt Foundation and the US National Science Foundation is gratefully acknowledged. The work described here has benefited greatly from my interaction with the International Collaboration for Turbulence Research (www.ictr.eu).

DY 26.2 Thu 14:30 MA 001

Wind velocity measurements under turbulent conditions using a sphere anemometer — •Hendrik Heisselmann, Michael Hölling, Bianca Schulte, and Joachim Peinke — Institute of Physics - University of Oldenburg

A well known problem of cup anemometry is the so-called overspeeding due to its momentum of inertia. As in nature turbulent flow conditions are predominant, cup anemometry leads to a wrong estimation of wind speeds. While cup anemometers do not provide the necessary time resolution to measure high frequency wind fluctuations, hot-wire anemometers are easily damaged under rough weather conditions. Therefore a robust, fast responding sphere anemometer was developed. The anemometer uses the thrust generated by the drag force on a sphere mounted on a flexible rod to detect wind velocities in two dimensions. The deflection of the rod is proportional to the drag force and can be measured either by means of a light pointer or by use of strain gauges. The two different measurement techniques were compared. The dynamic behaviour of the thrust anemometer was studied under laboratory conditions using a wind gust generator. The characteristics of different sphere-types and different rod materials were evaluated in order to optimize the setup. Results of open air measurements with hot-wire anemometer, sonic anemometer and sphere anemometer were compared by statistical methods.

DY 26.3 Thu 14:45 MA 001

Instationarity of the increment distribution of boundary layer wind speed — •Thomas Laubrich and Holger Kantz — Max-Planck-Institut fuer Physik Komplexer Systeme; Noethnitzer Str. 38, 01187 Dresden

The PDF of boundary layer wind speed increments can be understood as a superposition of Gaussian distributions whose variances are log-normally distributed (Castaing distribution). Motivated by instationarity of atmospheric winds we investigate the time dependence of the parameters of the Castaing distribution by analysing experimental data gathered in the boundary layer. We can recover the Castaing distribution on subsets smaller than a large time scale (hours) and show that the distribution parameters change with time. Studying this "dynamics" helps us to improve the prediction of wind speed increments, which plays an important role for wind gust prediction.

DY 26.4 Thu 15:00 MA 001

A new method for measuring lift forces acting on an airfoil under dynamic conditions — •Gerrit Wolken-Möhlmann and Joachim Peinke — Institute of Physics, University of Oldenburg, Germany

Wind turbines operate in a turbulent atmospheric boundary layer and are exposed to strong wind fluctuations in time and space. This can induce the dynamic stall, a phenomenon that causes extra loads.

Dynamic stall occurs under fast changes in the angle of attack (AoA) and was determined in detail in helicopter research. But in contrast to helicopter aerodynamics, the changes in the AoA of wind turbine airfoils are in general non-sinusoidal, and thus it seems to be difficult to use these measurements and models. Our goal is to acquire lift data under conditions more comparable to real wind turbines, including non-periodic changes in the AoA.

For this purpose a closed test section for our wind tunnel was built. An airfoil with a chord length of $0.2m$ will be rotated by a stepping motor with angular velocities of up to $300°/s$. With a maximum wind velocity of $50m/s$, Reynolds numbers of $Re = 700\,000$ can be realized. The lift force is determined by the counter forces acting on the wind tunnel walls. These are measured by two lines of 40 pressure sensors with sampling rates up to $2kHz$.

The results show distinct dynamic stall characteristics. Further experiments with different parameters and foils will give a better insight in dynamic stall and a verification and improvement of existing models.

DY 26.5 Thu 15:15 MA 001

Can aerosols be trapped in open flows? — •Rafael Vilela[1] and Adilson Motter[2] — [1]Max Planck Institute for the Physics of Complex Systems - Dresden — [2]Northwestern University, Evanston, IL 60208, USA

The fate of aerosols in open flows is relevant in a variety of physical contexts. Previous results are consistent with the assumption that such finite-size particles always escape in open chaotic advection. Here we show that a different behavior is possible. We analyze the dynamics of aerosols both in the absence and presence of gravitational effects, and both when the dynamics of the fluid particles is hyperbolic and nonhyperbolic. Permanent trapping of aerosols much heavier than the advecting fluid is shown to occur in all these cases. This phenomenon is determined by the occurrence of multiple vortices in the flow and is predicted to happen for realistic particle-fluid density ratios.

DY 26.6 Thu 15:30 MA 001

Numerical solutions of a recent theory for two-phase flow in porous media — •Florian Doster[1] and Rudolf Hilfer[1,2] — [1]Institute for Computational Physics, University of Stuttgart, 70569 Stuttgart, Germany — [2]Institute for Physics, University of Mainz, 55099 Mainz, Germany

The commonly used constitutive theory for multiphase flow in porous media on macroscopic scales – the extended Darcy theory – has several deficiencies regarding hysteresis and residual saturations. Experimental evidence shows that the fundamental parameter functions of the theory, i.e. capillary pressure and relative permeabilities are process dependent and hence are not parameter functions. A new constitutive theory addressed some of these challenges [1]. A subsequent work presented promising calculations in and near the hydrostatic equilibrium in [2]. We present a fully implicit finite volume algorithm to solve the set of coupled nonlinear PDE's in one dimension. Results of simulated reference problems, i.e. the Buckley-Leverett-Problem, the McWorther-Problem, etc. used for studying the parameter space of the theory and testing the algorithm are shown.

[1] R. Hilfer, Phys. Rev. E 58, 2090 (1998)
[2] R. Hilfer, Physica A 371, 209 (2006)

DY 26.7 Thu 15:45 MA 001

Prediction of transport parameters from resolution dependent analysis of porous media — •Thomas Zauner[1], Bibudhananda Biswal[1], Frank Raischel[1], Jens Harting[1], and Rudolf Hilfer[1,2] — [1]ICP, Universität Stuttgart, Pfaffenwaldring 27, 70569 Stuttgart, Germany — [2]Institut für Physik, Universität Mainz, 55099 Mainz, Germany

A recently proposed pore scale modeling technique [1] is used to obtain a laboratory scale (2.5 cm) continuum model of quartzitic sandstone. Synthetic μ-CT discretizations of the model are obtained at different resolutions and systematic resolution dependent microstructure analysis was carried out using Local Porosity Analysis [2]. Permeability measurements of digitized subsamples at different resolutions are obtained by large scale Lattice-Boltzmann simulations and extrapolated values for the macroscopic model are predicted.

[1] B. Biswal et al., Phys. Rev. E **75**, 61303 (2007)
[2] R. Hilfer, Adv. Chem. Phys. **XCII**, 299 (1996)

DY 26.8 Thu 16:00 MA 001

Boundary induced Spirals in counter-rotating Taylor-Couette flow — •Kerstin Hochstrate, Matti Heise, Jan Abshagen, and Gerd Pfister — Institute of Experimental and Applied Physics, Kiel, Germany

One of the classical hydrodynamic systems for the study of bifurcation events is the flow of a viscous fluid confined in the gap between two concentric rotating cylinders, i.e. Taylor-Couette flow. The focus of our study is the onset of spiral vortex flow as primary instability from basic laminar flow between counter-rotating cylinders with stationary and rotating end plates. Spirals are traveling waves in axial and rotating waves in azimuthal direction having an azimuthal wave number of $m = \pm 1$ in the parameter space studied here. In contrast to many theoretical investigations considering infinite axial length almost all experimental realization of Taylor-Couette flow use stationary rigid end plates confining the flow in axial direction. These end plates are relevant for the dynamical characteristics and the bifurcation behavior of 'global' spiral vortex flow and even may induce 'localized' spirals near these ends. We used independently rotating end plates in order to study the stability and the underlying physical mechanism for the onset of 'global' and 'localized' spirals.

DY 26.9 Thu 16:15 MA 001

Drying of substrates covered by thin liquid films — •Rodica Borcia and Michael Bestehorn — Lehrstuhl Statistische Physik/ Nichtlineare Dynamik, Brandenburgische Technische Universität Cottbus, Erich-Weinert-Strasse 1, 03046, Cottbus, Germany

Composite systems of two or more phases like two immiscible fluids or an open fluid with its own vapor can be described using an additional variable – named phase field. This field contains information about the local state of the composition and permits to distinguish between different phases. With the help of the phase field variable all system parameters can be expressed as functions varying continuously from one medium to another. Therefore, the problem is treated like an entire one phase problem and the interface conditions will be substituted by some extra-terms in the Navier-Stokes equation.

Simple, flexible and elegant, the phase field model becomes now an useful tool for describing wetting and drying phenomena, processes with large applications for treatments involving paints, insecticides, detergents, composite materials, and porous media. We investigate using a phase field model the stability of liquid films on a flat solid support with variable wettability, transition via nucleation from film to drop, drops motion on an inclined substrate under gravity effects and viscous flow over chemically patterned surfaces.

DY 26.10 Thu 16:30 MA 001

Temporal instability and breakup characteristics of liquid sheets — •Bernhard Heislbetz, Klaus Madlener, and Helmut Ciezki — DLR Lampoldshausen, Institut für Raumfahrtantriebe, D-74239 Hardthausen

We investigate the temporal instability and the breakup charakteristics of sheets formed by two impinging jets under atmospheric conditions. Thereby we extend the theory for inviscid and viscous liquid sheets to highly viscous Newtonian and Non-Newtonian fluids and show the influence of several hydrodynamic parameters on the breakup process of the fluid sheets.

The results of the theoretical considerations are compared to data obtained by experiments conducted on fluid sheets formed by an doubled like-on-like impinging jet injector.

DY 26.11 Thu 16:45 MA 001

Binary mixture thin film in vertical and horizontal temperature gradients — •Ion Dan Borcia and Michael Bestehorn — Lehrstuhl für Theoretische Physik II, Brandenburgische Technische Universität Cottbus, Germany

Models for thin film binary mixture were developed using lubrication approximation with the surface tension depending on both temperature and concentration. A 2D simplified equation for the concentration (mass conservation equation) was added. The big advantage of these models is that the dimension of the problem is reduced by 1 and therefore the computing time considerably decreases. But this kind of models can not take into account horizontal temperature gradients on the solid substrate. In this case a complete model which includes the 3D energy and concentration equations will be used.

In the first step we didn't include the evaporation in the model. In the case of the drying processes in polymers this corresponds to the situation when the film pattern formation is complete before the fast evaporation takes place.