DY 58: Poster - Fluids

Fluid Dynamics and Turbulence Complex Fluids and Soft Matter

Time: Thursday 16:00–18:00 Location: Poster A

DY 58.1 Thu 16:00 Poster A

Optimal Mixing in Thin Liquid Films — •Michael Winkler and Markus Abel — Statistical Physics and Chaos Theory, Department of Physics and Astronomy, University of Potsdam, Potsdam, Germany

Films are nanoscopic elements of foams, emulsions and suspensions, and form a paradigm for nanochannel transport that eventually tests the limits of hydrodynamic descriptions. The complex interplay of thermal convection, interface and gravitational forces yields optimal turbulent mixing and transport.

Our experimental setup allows to capture thin film interference patterns under controlled surface and atmospheric conditions. The convection is realized by placing a cooled copper rod in the center of the film. The temperature gradient between the rod and the liquid film at ambient temperature results in a density gradient, so that the varying buoyancy induces turbulent motion.

Here we present the statistical analysis of a stable two eddy convection pattern by calculating the entropy and Lyapunov exponents and compare to the maximally possible mixing efficiency. Additionally, conditional probabilities for the center jet deflection are analyzed to look for deterministic components.

DY 58.2 Thu 16:00 Poster A

Markov processes linking stochastic thermodynamics and turbulent cascades — •Daniel Nickelsen — Institut für Physik, Carl-von-Ossietzky Universität Oldenburg, Germany

An elementary example of a Markov process (MP) is Brownian motion. The work done and the entropy produced for single trajectories of the Brownian particles are random quantities. Statistical properties of such fluctuating quantities are central in the field of stochastic thermodynamics. Prominent results of stochastic thermodynamics are so-called fluctuation theorems (FTs). FTs express the balance between production and consumption of entropy.

Turbulent cascades of eddies are assumed to be the predominant mechanism of turbulence generation fixing the statistical properties of developed turbulent flows. An intriguing phenomenon of developed turbulence, known as small-scale intermittency, are violent small-scale fluctuations in flow velocity that exceed any Gaussian prediction.

In analogy to Brownian motion, we show how the assumption of the Markov property leads to a MP for the turbulent cascade that is equivalent to the seminal K62 model. In addition to the K62 model, we demonstrate how many other models of turbulence can be written as a MP, including scaling laws, multiplicative cascades, multifractal models and field-theoretic approaches. Based on the various MPs, we discuss the production of entropy and the corresponding FTs. In particular, an experimental analysis indicates that entropy consumption is linked to small-scale intermittency, and a connection between entropy consumption and inverse cascades is suggestive.

DY 58.3 Thu 16:00 Poster A

Bernoulli bond percolation on random recursive trees — •Rüdiger Kürsten — Institut für Theoretische Physik, Universität Leipzig, Brüderstr. 16 D-04103 Leipzig

Random recursive trees are obtained from a root node by repeatedly attaching nodes randomly to one of the existing nodes. We use a stochastic coupling to obtain some exact results for Bernoulli bond percolation on random recursive trees of fixed size. We obtain among other things the expectation value of the root cluster size, of the number of nodes in the n-th gerneration clusters and the number of clusters of size one. Some combined limits of system size and percolation probability are considered and compared to previous work.

DY 58.4 Thu 16:00 Poster A

From low-dimensional chaos to complex behaviour in transitional pipe flow — •Paul Ritter — Lehrstuhl für Strömungsmechanik, Cauerstraße 4 91058 Erlangen

Turbulent pipe flow so far escapes an analytical explanation. The common approach of applying bifurcation theory to the linearized equations fails in this case because the transition occurs via finite amplitude perturbations and is characterized by localized turbulent spots surrounded by laminar flow (so-called “puffs”). A recent proposition to explain the origin of puffs postulates that, in analogy to low dimensional chaotic systems, turbulence is organized around invariant solutions of the governing equations, glimpses of which can be observed experimentally as coherent structures.

The work presented here tries to link some of the theory of low-dimensional chaotic systems to the infinite-dimensional spatio-temporal complexity of the Navier-Stokes equations. I present a mechanism, which elucidates how mildly chaotic transients acquire more complexity with respect to size, speed and kinematic properties and hence approach the properties of actually observed turbulence. This mechanism consists of the interaction and merging of chaotic saddles with distinct dynamical characteristics. The link between the saddles suggests that invariant solutions with a varying degree of internal wavelengths, possibly created in a snaking-like mechanism, might be responsible for the creation of the saddles. Finally, results from a search for these elementary building blocks of turbulence will be presented in several symmetry subspaces.

DY 58.5 Thu 16:00 Poster A

Sedimentation stacking diagram of colloidal mixtures under gravity — •Daniel de las Heras and Matthias Schmidt — Theoretische Physik II, Physikalisches Institut, Universität Bayreuth, D-95440 Bayreuth, Germany

The observation of stacks of distinct layers in a colloidal or liquid mixture in sedimentation–diffusion–equilibrium is a striking consequence of bulk phase separation. Drawing quantitative conclusions about the phase diagram is, however, very delicate. Here we present a general theory to obtain a unique stacking diagram of all possible stacks under gravity. Simple bulk phase diagrams generically lead to complex stacking diagrams. We also extend the Gibbs phase rule to determine the maximum number of sedimented layers under gravity.

References:

[1] D. de las Heras, and M. Schmidt, Soft Matter, 9, 8636, (2013)

[2] D. de las Heras, and M. Schmidt, Accepted in J. Phys: Condens. Matter, (2014)

DY 58.6 Thu 16:00 Poster A

Photonic Bands of Colloidal Quasicrystals — •Ricardo Atahualpa Solorzano Kraemer and Schmiedeberg Michael — Institut für Theoretische Physik II - Soft Matter, Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany

Quasicrystals are structures with long-range positional order but no translational symmetry. These structures lie between periodic and disordered structures but still show sharp diffraction patterns that confirm the long-range order. They possess several interesting properties that differ from those of periodic crystals or glasses. This may lead to an important role for new photonic applications.

Determining photonic bands of quasiperiodic systems represents a challenge. In this work we study the paths of photons in quasiperiodic Lorentz gas models in order to calculate the photonic bands. The models can be extended to achieve more realistic results. For example, in order to consider the effects of refraction, we employ Fresnel's equations. In order to include diffraction, we use Mie scattering. We calculate the band structures for three different geometries: periodic square lattices, the quasiperiodic Penrose tilling, as well as for a quasicrystal with 8-fold rotational symmetry.

DY 58.7 Thu 16:00 Poster A

Photonic Bands of Colloidal Quasicrystals — •Ricardo Atahualpa Solorzano Kraemer and Michael Schmiedeberg — Institut für Theoretische Physik II - Soft Matter, Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany

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DY 58.8 Thu 16:00 Poster A

Excitation of defects in colloidal quasicrystals close to the melting transition — •Miriam Martinsons and Michael Schmiedeberg — Institut für Theoretische Physik 2: Weiche Materie, Heinrich-Heine Universität Düsseldorf, 40204 Düsseldorf, Germany

Quasicrystals are structures with long range order but no translational symmetry. They can have any rotational symmetry including those that are not allowed in periodic crystals. In quasicrystals there are phononic modes as well as additional hydrodynamic modes called phasons. Such phasons correspond to correlated rearrangements of the particles and arise as a consequence of the additional degrees of freedom that do not exist in periodic crystals.

We study how local and global excitations or defects develop in quasicrystals close to the melting transition. Local excitations termed phasonic flips only occur in quasiperiodic systems. Other defects, e.g. dislocations and disclinations, cause the melting of the quasicrystal as predicted by the KTHNY theory. We analyze the positional and bond-orientational correlation functions during the melting process. Our studies reveal the similarities and differences of the melting mechanism of quasicrystals as compared to the melting of periodic crystals.

DY 58.9 Thu 16:00 Poster A

Effects of temperature on spinodal decomposition in liquid-vapor systems — •Martin Pütz and Peter Nielaba — University of Konstanz, Germany

We use the "Smoothed Particle Hydrodynamics" (SPH) simulation method to investigate the dynamics and thermal evolution of spinodal decomposition of instantaneously temperature-quenched liquid-vapor systems. The numerical approach follows a modern formulation of SPH with a van der Waals equation of state, thermal conduction and a simple scaling thermostat that allows thermal fluctuations at a constant predicted mean temperature. The results are in excellent agreement with theoretical predictions for all time regimes from the initial growth of "homophase fluctuations" up to the inertial hydrodynamics regime. We find that the initial stage spinodal decomposition is strongly affected by the temperature field. The domain growth in the late stage of demixing is found to be rather unaffected by thermal fluctuations. However, the crossover between these stages is found to occur earlier in time for higher initial temperatures. We explain this dependency with the phase interfaces that become diffuse and hence overlap when the predicted temperature becomes closer to the critical point.

DY 58.10 Thu 16:00 Poster A

Lateral migration of soft microparticles in wavy microchannels — •Matthias Laumann[1], Badr Kaoui[1], Alexander Farutin[2], Andreas König[1], Diego Kienle[1], Chaouqi Misbah[2], and Walter Zimmermann[1] — [1]Theoretische Physik, Universität Bayreuth, Bayreuth — [2]Laboratoire Interdisciplinaire de Physique, CNRS-Univerisite Joseph Fourier / UMR 5588, BP 87, F-28402 Saint-Martin d'Heres Cedex, France

We study the cross-streamling migration (CSM) of deformable particles in the limit of vanishing Reynold number in 2D and 3D Poiseuille channel flow, which boundaries are spatially modulated. Using 1D dumbbells, 2D ring polymers, and 3D tetrahedrons (all of which may be symmetric or asymmetric), we demonstrate how the CSM can be modified when the waviness of the micro-channel is varied. Starting with the case of flat boundaries (zero modulation), these particles perform a CSM that is always directed towards the channel center[1]. In the case of wavy boundaries, this centric motion may be reversed once the modulation amplitude exceeds a lower threshold, in which case the particles migrate off-center and approach a stationary, non-curvelinear trajectory, located between the walls and the center of the channel. The distance between such a trajectory and channel center can be increased by turning up the modulation amplitude, but depends also on other parameters such as the particle elasticity, for example. The results shown are obtained via a perturbation calculation of the wavy Poiseuille flow in the limit of small modulation amplitudes, and compared with those from Stokesean particle dynamics for arbitrary modulation amplitudes, showing good agreement. Out study suggests that the flow generated between wavy boundaries may be exploited for the separation of particles with varying properties in microfluidic channels.

[1]B. Kaoui, G. H. Ristow, I. Cantat, C. Misbah, W. Zimmermann, Phys. Rev. E 77, 021903 (2008)

DY 58.11 Thu 16:00 Poster A

Cross-streamline migration of soft and asymmetric particles in oscillatory shear flow — •Matthias Laumann[1], Paul Bauknecht[2], Andre Förtsch[1], Stephan Gekle[2], Diego Kienle[1], and Walter Zimmermann[1] — [1]Theoretische Physik, Universität Bayreuth, 95440 Bayreuth, Germany — [2]Biofluid Simulation, Physikalisches Institut, Universität Bayreuth, 95440 Bayreuth, Germany

We investigate the dynamics and cross-streamline migration (CSM) of asymmetric, soft particles in oscillatory, linear shear flow. Using 1D dumbbells, 2D ring polymers, and 3D capsules as elementary representatives of such particles, we show that these may indeed migrate within the shear plane only if they have an intrinsic material asymmetry and if the shear gradient varies with time. The CSM exists over a wide range of parameters and, importantly, is a generic property, i.e., it does neither depend on the dimensionality of the particle nor on the details how the particle asymmetry is realized. The migration velocity can be tuned by various parameters, including the frequency and amplitude of the time-dependent, linear shear flow as well as the elastic properties of the particle. Besides the fundamental importance of this phenomenon, the ability to tune the migration process externally has promising applications in microrheology such as particle separation.

DY 58.12 Thu 16:00 Poster A

A Theoretical Investigation of Patterned Depositions from Thin Films of Evaporating Solutions — •Walter Tewes, Svetlana Gurevich, and Uwe Thiele — Institut für Theoretische Physik, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Straße 9 48149 Münster, Germany

We aim at a theoretical description of patterned deposition of solute from an evaporating thin film of solution on a substrate.

For this purpose we formulate a system of coupled partial differential equations for thin solution layers, describing phase separation within the solution as well as dewetting and evaporation of the solvent.

The deposition process is investigated in the case of a contact line of the solution film which recedes due to pulling of the substrate (dip-coating) and/or evaporation.

The deposition patterns obtained by direct numerical simulations comprise stripes and patterns of hexagonal type. Central control parameters defining the properties of the occurring patterns are the velocity of the receding contact line and the initial concentration of the solution.

DY 58.13 Thu 16:00 Poster A

The shapes of simple comb polymers — •Christian von Ferber[1], Marvin Bishop[2], Thomas Forzaglia[2], Cooper Reid[2], and Gregory Zajac[2] — [1]Coventry University, UK — [2]Manhattan College

This paper proposes an innovative approach towards the determination of shapes of branched polymers in the long chain limit. The method proposed develops an earlier suggestion by G. Wei which however in its evaluation is limited to specific regular structures. Here, we show that by numerically evaluating and extrapolating the corresponding sums and integrals this approach is very powerful and will e.g. allow to determine in the same spirit the shapes of irregular branched structures. The carefully performed simulations including two different simulation schemes fully support the results of the semi-analytic approach. We demonstrate the method and compare the results with two different carefully performed MC simulation methods which favorably support the analytical results.

DY 58.14 Thu 16:00 Poster A

Differential Dynamic Microscopy of fluid microstructures in eutectic systems — •Christopher Wittenberg — Universität Mainz, Mainz, Rheinland-Pfalz

The Differential Dynamic Microscopy (DDM) is a novel light microscopy technique to gain dynamic information of mesoscopic systems via real space imaging. DDM excels if the probed system is inhomogeneous in nature. In this case the advantage of microscopy comes into effect by sampling a specified location in the system. Using DDM the dynamics of various microstructures in a eutectic system has been analysed. We observed much smaller dynamic changes of such a structure over time compared to the variation between different microstructures.