DY 10 Fluid Dynamics I

Zeit: Freitag 10:00–13:00 Raum: TU H3010

Hauptvortrag

DY 10.1 Fr 10:00 TU H3010

On the connections between chaos theory and statistical mechanics — •Henk van Beijeren — Institute for Theoretical Physics, Utrecht University

The past years have seen a surge of activity on the connections between chaos theory and statistical mechanics. In the Gaussian thermostat formalism, developed by Hoover, Evans et al, the irreversible entropy production in a stationary non-equilibrium system is related to the sum of all of its Lyapunov exponents. In the escape-rate formalism of Gaspard and and Nicolis, transport coefficients determining the rate of escape of systems from phase space through an open boundary are related tot the Kolmogorov-Sinai entropy and the sum of all positive Lyapunov exponents on a small subset of phase space. In Ruelle's thermodynamic formalism chaotic as well as transport properties can be obtained from a single dynamical partition function. This is even more ambitious, but for the majority of many-particle systems calculation of the dynamical partition function is a very hard task.

Here I will briefly introduce dynamical systems and discuss their characteristic properties. I will show how quantities like Lyapunov exponents, Kolmogorov-Sinai entropies and topological pressures may be calculated for a dilute Lorentz gas (disordered billiard), which is a system with fixed scatterers on random positions, with which a point particle makes elastic collisions. Comparisons of the results with computer simulation results show a very good agreement.

For a dilute hard sphere gas in equilibrium both the KS entropy (equal to the sum of all positive Lyapunov exponents) and the largest Lyapunov exponent can be calculated analytically to leading orders in the density. Again, comparisons to computer simulations show good agreement. The smallest positive Lyapunov exponents for these systems show very interesting collective behavior, which can also be explained through kinetic theory calculations.

Finally I wil discuss some outstanding open problems.

DY 10.2 Fr 10:30 TU H3010

Patterns in Reaction-Advection-Diffusion systems — •Markus Abel — Universitaet Potsdam

We develop a theory describing the transition to a spatially homogeneous regime in a mixing flow with a chaotic in time reaction. The transverse Lyapunov exponent governing the stability of the homogeneous state can be represented as a combination of Lyapunov exponents for spatial mixing and temporal chaos. This representation, being exact for time-independent flows and equal Péclet numbers of different components, is demonstrated to work accurately for time-dependent flows and different Péclet numbers.

DY 10.3 Fr 10:45 TU H3010

Predictability and properties of turbulent wind gusts — •Detlef Holstein and Holger Kantz — MPIPKS, Noethnitzer Str. 38, 01187 Dresden

Dynamics in complex systems often contains long range memory. An information theoretical treatment aims for quantifying stochastic modelling of the dynamics behind time series data. As an application of our analysis an improvement of prediction of extreme events, especially of turbulent wind gusts in the atmospheric boundary layer is intended. Coherent structures in the turbulent boundary layer are analyzed for their impact on wind gusts.

DY 10.4 Fr 11:00 TU H3010

Linear stability of viscoelastic shear flows — •Juergen Buehrle — AG Komplexe Systeme, Philipps-Universität Marburg

The linear perturbation of a plane shear flow is decomposed into vortices and streaks. Their amplitudes decay exponentially at large times. At the same time, non-normal amplification of streaks leads to a transient growth, such that the maximum value of the kinetic energy associated with the perturbation exceeds its initial value by several orders of magnitude. For Newtonian fluids the maximum amplification occurs, when the width of the vortices is of the order of the channel height. We find, that for viscoelastic fluids the optimal vortex width is significantly larger. This motivates a different approach to the understanding of the transition to turbulence in viscoelastic flow.

DY 10.5 Fr 11:15 TU H3010

Change of the surface morphology in the evolution of liquid two-layer films — •Andrey Pototsky[1], Michael Bestehorn[1], Domnic Merkt[1], and Uwe Thiele[2] — [1]Lehrstuhl fuer Theoretische Physik II, BTU Cottbus, Erich-Weinert Str. 1, 03046 Cottbus, Germany — [2]MPI fuer Physik komplexer Systeme, Noethnitzer Str. 38, 01187 Dresden, Germany

We consider a two-layer liquid film placed on a solid support made of two different immiscible liquids, driven by long-range apolar and short-range polar interactions, with free liquid-liquid and liquid-gas interfaces. Using the long wave approximation we derive the evolution equations for the local film thicknesses. For the initially unstable flat films, the primary unstable mode can be of two different types: a varicose or a zigzag mode. We show that during the time evolution, the mode type can change via switching between two stable stationary solutions and due to coarsening.

DY 10.6 Fr 11:30 TU H3010

FEM simulations on the production of hyperpolarized xenon — •Alexander Fink and Eike Brunner — Institut für Biophysik und physikalische Biochemie, Universität Regensburg, 93040 Regensburg

Hyperpolarized xenon can be used to increase the sensitivity of NMR experiments by up to 6 orders of magnitude. Applications include medical imaging, low-field NMR, surface NMR spectroscopy, biological magnetic resonance, fundamental physics etc.

Hyperpolarized xenon is produced in pump cells within which Rb vapor is optically pumped by the irradiation of circularly polarized laser light. The Rb electron spin polarization is then transferred to the Xe-129 nuclei.

While the underlying quantum mechanical processes are understood quite well, little is known about the hydrodynamic and thermodynamic processes taking place inside the pump cell.

By use of the finite element method (FEMLAB 3.0a) we numerically solve 8 coupled macroscopic differential equations, coupling the velocity field, temperature, spin pump rate, and spin polarizations.

We discuss the optimisation of experimental parameters of the pump cell, e.g. flow rate, laser power etc., in order to receive a maximum Xe-129 spin polarization.

DY 10.7 Fr 11:45 TU H3010

Influence of noise on anomalous transport in steady viscous flows — •Michael Zaks — Institut für Physik, Humboldt-Universität Berlin

In time-independent plane flows of viscous fluids past arrays of vortices or solid obstacles there can be neither turbulence nor Lagrangian chaos. Nevertheless, such fluid motions may exhibit unusual transport properties which originate in the slowdown of tracers in vicinities of stagnation points or near the solid borders with no-slip conditions. We discuss modifications which appear if tracers are viewed as passive Brownian particles in noisy environments. In flows through periodic lattices of solid obstacles the anomalous transport yields to normal diffusion. For flows past arrays of vortices the outcome is different. Here introduction of noise allows the tracers to penetrate across the separatrices into the vortices which thus turn into a kind of traps; this enhances the spreading, ensuring long epochs of nearly ballistic transport.

DY 10.8 Fr 12:00 TU H3010

Long-wave evolution of thin liquid binary mixture films — •Ion Dan Borcia and Michael Bestehorn — Lehrstuhl für Theoretische Physik, Brandenburgische Technische Universität Cottbus, Erich-Weinert-Straße 1, 03046 Cottbus, Germany

The oscillatory regime for surface-driven convection was studied in [1] in the case of a binary mixture of two miscible liquids using a method based on the 3D hydrodynamic basis equations. In the present work the binary mixture is considered to form a thin film, case in which one can use the lubrication approximation [2]. That permits us to reduce the dimension of the equations to one (1D) for the two dimensional case and to two (2D) for the three dimensional case. Using 1D and 2D fully nonlinear codes, one investigates the long-wavelength instability and the Soret effect influence on the film dynamics.

[1] M. Bestehorn and Pierre Colinet, "Bénard-Marangoni convection

of a binary mixture as an example of an oscilatorry bifurcation under strong symetry-breaking effects,"Physica D, **145**, 84-109 (2000).

[2] A. Oron, S. H. Davis and S. G. Bankoff, "Long-scale evolution of thin liquid films,"Rev. Modern Phys., **69**(3), 931-980 (1997).

DY 10.9 Fr 12:15 TU H3010

Luftströmung über Transversaldünen — •Volker Schatz und Hans J. Herrmann — Inistitut für Computerphysik der Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart

Sanddünen sind formschöne Ablagerungen granularer Materie, die auf allen Erdteilen zu finden sind. Sie sind besonders in Wüsten und in Küstengebieten verbreitet, und große Teile des Planeten Mars sind davon bedeckt. Dünen entstehen durch ein Wechselspiel zwischen dem Sandtransport durch Wind und die durch die Form der Düne beeinflusste Luftströmung. In Simulationen wurde festgestellt, dass die Form der sich bildenden Düne empfindlich davon abhängt, wie die Luftströmung über sie modelliert wird. In bisherigen Untersuchungen der Strömungsverhältnisse über Dünen wurde der Querschnitt der Düne in Windrichtung meist als ein Dreieck modelliert, was ein Untersuchen der Abhängigkeit von Länge und Höhe, aber nicht von der Form erlaubt. In der hier vorgetragenen Arbeit wurde die Fluiddynamik-Simulationssoftware FLUENT verwendet, um die Strömung üeber eine Düne in Abhängigkeit von der Dünenform zu untersuchen. Eine besondere Rolle spielt dabei die Position des "Slip Faces", an dem der an der windabgewandten Seite abgelagerte Sand herunterrutscht.

DY 10.10 Fr 12:30 TU H3010

Metastabilität geschichteter Fluide für großskalige Strukturen — •Domnic Merkt — Lehrstuhl für Theoretische Physik, BTU-Cottbus, Erich-Weinert-Str. 1, 03046 Cottbus

Ausgehend von der kürzlich abgeleiteten Evolutionsgleichung der Grenzfläche zweier geschichteter, nicht mischbarer Fluidschichten in Langwellennäherung wird unter der Einwirkung von Gravitation und Thermokapillarität (Marangoni-Effekt) die Möglichkeit einer Lyapunovformulierung vorgestellt. Diese ermöglicht 1.) eine Aussage über das Langzeitverhalten der Lösung für $t \to \infty$ und 2.) eine Untersuchung der Metastabilität. In diesem Vortrag wird die Metastabilität des Systems unter Verwendung des Energiefunktionals untersucht.

DY 10.11 Fr 12:45 TU H3010

Statistical properties of a particle model for twodimensional turbulence — •Oliver Kamps — Institut für Theoretische Physik WWU Münster, Wilhelm-Klemm-Str.9 48149 Münster

Starting from a point-vortex description of a forced twodimensional flow we investigate numericaly the statistical properties of the lagrangian and eulerian fluid dynamics. We focus on the probability distribution functions for the positions and the velocity increments of the vortex particles.