Weak ergodicity breaking and ageing in subdiffusive continuous time random walks analyzed with the distribution of generalized diffusivities

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We introduce a new analysis tool for anomalous diffusion, the distribution of generalized diffusivities, which describes the fluctuations during the diffusion process around the generalized diffusion coefficient that can be obtained from the asymptotic time behavior of the conventionally investigated mean squared displacement.
In this contribution we apply this tool to the continuous time random walk (CTRW) model with an algebraically decaying waiting time distribution which does not have a finite first moment.
This subdiffusive process is known to show interesting phenomena such as weak ergodicity breaking and ageing.
As a consequence, ensemble- and time-averaged quantities do not coincide, time averages become random variables,
and statistical quantities depend on the elapsed time (ageing time) between the start of the process and the start of the measurement.
We are going to show how the distribution of generalized diffusivities obtained from an ensemble of trajectories differs from the distribution
which is obtained as time average from only one single-particle trajectory and how the ageing time influences these distributions.
These investigations contribute to a deeper understanding of the phenomena of weak ergodicity breaking and ageing.

Short-Term Stochastic Behavior of Wind power and Solar irradiance, characterization and modeling

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The first part of this study will focus on characterization of the statistical properties of wind power and solar irradiance, while the second part discusses their appropriate modeling. The characterization will be carried out by analyzing the output power of wind turbines and solar irradiance spectrum, as well as the statistical properties of their increments, such as indicators for deviation from Guassianity over short time scale.
Our analysis indicates that these renewable sources also have strong intermittent behavior. We then compute the multi-fractal exponents of their fluctuations. In the second part, a model for wind power dynamics is developed using a nonlinear Langevin equation. To describe the solar irradiance fluctuations we show that the minimal model will be a diffusion-jump process.

Multi-point description of continuous time random walks

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Some of Prof. Friedrich's contributions to the theory of continuous time random walks are reviewed.

Invariants of the velocity gradient tensor in turbulent flows

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The velocity gradient tensor $A_=partial_j u_i$ characterizes the fine scale structure of a turbulent flow. We study A along Lagrangian trajectories in statistically homogeneous, isotropic and stationary turbulence. Due to the isotropy, the probability distribution of A is a function of its invariants. Therefore, we concentrate on a statistical description of these invariants. We estimate the drift-field of the invariants and examine the fluctuations of the forces around the mean drift-field. It turns out that these fluctuations have a large magnitude and are long-correlated. This implies that the fluctuations contain important information and the drift-field alone is not sufficient to understand the dynamics of these invariants.

Destabilization of the uniform solution in Swift-Hohenberg equation induced by time delayed feedback

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We are interested in the stability of the uniform solution in real Swift-Hohenberg equation subjected to time delayed feedback.
We demonstrate that time delayed feedback can lead to complex spatio-temporal patterns e.g., superlattice-like structures and oscillation between two opposite states.
Direct numerical simulations are also caried out, showing good agreement with analytical predictions based on linear stability analysis.

Area and perimeter covered by anomalous diffusion processes

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We investigate geometric properties of two-dimensional continuous time random walks that are used extensively to model stochastic processes exhibiting anomalous diffusion in a variety of different fields. Using the concept of subordination, we determine exact analytical expressions for the average perimeter and area of the convex hulls for this class of non-Markovian processes. As the convex hull is a simple measure to estimate the home range of animals, our results give analytical estimates for the home range of foraging animals that perform sub-diffusive search strategies such as some Mediterranean seabirds and animals that ambush their prey. We also apply our results to Levy flights where possible.

PDF Equations in Rayleigh-Bénard Convection

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Turbulent Rayleigh-Bénard convection as an ubiquitous phenomenon remains in the central interest of scientists and engineers alike. Though major advances from experimental, numerical and theoretical side have been achieved in recent years, there is no full theory of turbulent convection; especially a comprehensive connection between coherent flow patterns, small-scale fluctuations and the statistics has not been established so far.
To tackle this problem, we apply statistical methods to turbulent Rayleigh-Bénard convection, which lead to insights into the dynamics of the system. We investigate from first principles the temperature statistics in the context of PDF equations, which gives rise to the average transport behavior and flow structures in phase space.

Spiking neural networks: Pattern formation and plasticity

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We will present recent studies on spiking neural networks populated by pulse-coupled oscillators. The

underlying single neuron model has been introduced by H. Haken as the lighthouse model [1]. It is a model that falls between spiking neuron models and firing rate descriptions [1,4] and thus may combine the “best of both worlds”. In the limit of very slow synaptic interactions, it can be reduced to the classic Wilson-Cowan and Amari type firing rate models [2,3,4]; for fast synaptic dynamics, it shows some of the complex properties of real spiking neural networks. Here, we present two aspects of our work. On the one hand, we show some findings on pattern formation in these kind of spiking networks. We concentrate on the formation of spatially localized states of persistent high neuronal activity -- often referred to as "bumps" -- which have been associated with working memory, i.e., the ability of temporary storage of information over the time-scale of a few seconds. On the other hand, we discuss the influence of spike timing dependent plasticity (STDP) [5], which is considered to be linked to learning and evolution effects.

[1] H. Haken, Brain Dynamics, Springer, New York, Berlin (2002).
[2] H.R. Wilson, J.D. Cowan, Biophys. J., 12 , 1 (1972).
[3] S. Amari, IEEE Trans. Systems Man Cybernet., 2, 643 (1972).
[4] C.C. Chow and S. Coombes, SIAM J.Appl. Dyn. Syst., 5 (4), 552 (2006).
[5] G. Bi, M. Poo, Annu. Rev. Neurosci., 24, 139 (2001).

Kinetic energy transport in Rayleigh-Bénard convection

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Convective systems are often characterized by scaling laws for the heat transport. Several studies have indicated that these scaling laws are inextricably linked to the viscous dissipation rate and therefore to the kinetic energy balance.
In the present study, direct numerical simulations of turbulent Rayleigh-B'enard convection are analyzed with respect to the horizontally averaged kinetic energy balance. Based on this budget equation, distinct regions where energy is produced, dissipated and transported by several flux processes are identified. These regions depend strongly on the Prandtl number, which gives new insights into the flow dynamics in the different Prandtl number regimes.

Self-Organized Synchronization and Voltage Stability in Networks of Synchronous Machines

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Residual saturation dynamics and hysteresis in two-phase flow

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Authors
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Abstract
Complex porous microstructures filled with two or more immiscible fluids present longstanding problems for an effective macroscopic description of the underlying strongly interacting fluid subsystems. Traditionaly, the effective macroscopic equations are systems of coupled nonlinear partial differential equations involving relative permeabilities and capillary pressures. The concepts of relative permeability and capillary pressure are crucial for the accepted traditional theory of two phase flow in porous media. A certain straightforward generalization of the traditional theory does not require these concepts as input [1],[2],[3] Instead it is based on the concept of hydraulic percolation of fluid phases. The presentation will

describe this novel approach. It allows to predict residual saturations and local spatiotemporal changes between imbibition and drainage during two phase immiscible displacement [1],[2],[3],[4],[5],[6]. Recently an analytically tractable hyperbolic limit of the generalized theory was investigated [7]. In this limit a fractional flow formulation exists, that resembles the traditional theory. The Riemann problem for this system of nonlinear partial differential equations is solved analytically in one dimension by the method of characteristics. Initial and boundary value problems exhibit shocks and rarefaction waves similar to the traditional Buckley Leverett theory. However, contrary to the traditional theory, the generalized theory permits simultaneous drainage and imbibition processes. Displacement processes involving flow reversal are equally allowed. Shock fronts and rarefaction waves in both directions in the percolating and the nonpercolating fluids are found, which can be compared directly to experiment.

References

[1] R. Hilfer, Capillary Pressure, Hysteresis and Residual Saturation in Porous Media Physica A, vol. 359, pp. 119, (2006)
[2] R. Hilfer, Macroscopic Capillarity and Hysteresis for Flow in Porous Media, Physical Review E, vol. 73, pp. 016307, (2006).
[3] R. Hilfer, Macroscopic capillarity without a constitutive capillary pressure function, Physica A, vol. 371, pp. 209, (2006)
[4] R. Hilfer, Modeling and Simulation of Macrocapillarity, in: P. Garrido et al. (eds.) Modeling and Simulation of Materials vol. CP1091, pp. 141, American Institute of Physcis, New York, 2009.
[5] R. Hilfer and F. Doster, Percolation as a basic concept for macroscopic capillarity, Transport in Porous Media, vol. 82, pp. 507, (2010)
[6] F. Doster and P. Zegeling and R. Hilfer, Numerical solutions of a generalized theory for macroscopic capillarity, Physical Review E, vol. 82, pp. 036307, (2010)
[7] F. Doster and R. Hilfer, Generalized Buckley-Leverett theory for two-phase flow in porous media, New Journal of Physics, vol. 13, pp. 123030, (2011)

Dynamics of Bound States in a real-valued Swift-Hohenberg Equation induced by Delayed Feedback

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We are interested in the stability-properties of stationary bound state solutions of the real-valued Swift-Hohenberg Equation, subjected to time-delayed feedback. We show that the change in delay-time and delay-strength leads to various dynamical solutions including the formation of travelling waves, labyrinth-like patterns, as well as moving and rotating bound states.

We provide a linear stability analysis of the delayed system and obtain an analytical expression for the delay-induced instability-threshold. Numerical calculations are also carried out, showing good agreement with the analytical predictions.

A Theoretical Description of Pattern Formation in Dip-Coating Processes

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Dip-coating is a method widely used to prepare patterns with thickness control on substrates. Using a solution of an organic semiconductor, the growth of dendritic structures of monolayer and multilayer thickness can be achieved [1]. The thickness as well as the morphology of the deposited layer can be controlled by adjusting the transfer velocity.
Here we are interested in a theoretical description of the formation of dendritic structures. Our approach yields a system of coupled PDEs for the temporal evolution of solution layer thickness and solute concentration. We provide a gradient formulation of the conservative part of such equations as derived in [2], allowing a self-consistent inclusion of further contributions to the free energy of the system in

question.

[1] Li, Liqiang, et al. "Structure Formation by Dynamic Self-Assembly." Small 8.4 (2012): 488-503.
[2] Thiele, U. "Note on thin film equations for solutions and suspensions." The European Physical Journal Special Topics 197.1 (2011): 213-220.

Pattern formation in Cahn-Hilliard models for Langmuir-Blodgett transfer

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Langmuir-Blodgett transfer is an established method for covering substrates with monomolecular layers of lipids. During the transfer, partial condensation of the monolayer can lead to the formation of patterns in different phases of the transferred monolayer. Experimental parameters like the transfer velocity influence the properties of the pattern, like the orientation and wavelength of stripes.
In this work, we investigate the pattern formation process in the framework of spinodal decomposition by means of Cahn-Hilliard models. Besides the transfer onto homogeneous substrates, the influence of prestructured substrates is studied. In particular, the occurrence of synchronization phenomena is described. They can be used to control the pattern formation process as well as to enable the production of new and more complex patterns.