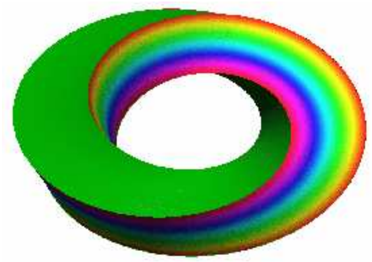
Universität Bielefeld
Fakultät für Mathematik



# Workshop on Random Dynamical Systems

## 30 November – 1 December 2007

Department of Mathematics

University of Bielefeld

Room H10

The workshop is part of the conference program of the DFG-funded CRC 701 "Spectral Structures and Topological Methods in Mathematics" at the University of Bielefeld.

**Organizer:** Barbara Gentz (gentz@math.uni-bielefeld.de)

http://www.math.uni-bielefeld.de/~gentz/2007/Workshop_RDS07/RDS07.html

## Programme

### Friday, 30 November 2007

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|---|---|
| 8:15 – 8:45 | *Registration* |
| 8:45 – 9:00 | *Welcome* |
| 9:00 – 9:50 | **Arkady Pikovsky** (University of Potsdam)<br>Synchronization and desynchronization of oscillators by common noise |
| 9:50 – 10:40 | **Nils Berglund** (MAPMO–CNRS, Orléans)<br>Metastable lifetimes and optimal transition paths in noisy spatially extended systems |
| 10:40 – 11:10 | *Coffee break* |
| 11:10 – 12:00 | **Peter Kloeden** (Johann Wolfgang Goethe-Universität Frankfurt)<br>Random attractors and the preservation of synchronization under noise and discretization |
| 12:00 – 12:50 | **Samuel Herrmann** (Université Henri Poincaré Nancy I)<br>Large deviations and a Kramers' type law for self-stabilizing diffusions |
| 12:50 – 14:20 | *Lunch break* |
| 14:20 – 15:10 | **Raphaël Lefevere** (Université Denis Diderot, Paris 7)<br>Normal heat conduction in weakly anharmonic chain of oscillators |
| 15:10 – 16:00 | **Peter Reimann** (University of Bielefeld)<br>Velocity Dependence of Atomic Friction: beyond the thermally activated hopping regime |
| 16:00 – 16:30 | *Coffee break* |
| 16:30 – 17:20 | **Gabriel Lord** (Heriot-Watt University, Edinburg)<br>Freezing Waves in Neurons |
| 17:20 – 18:10 | **Benjamin Lindner** (MPI for the Physics of Complex Systems, Dresden)<br>Correlations in sequences of first-passage times |
| *cancelled* | **Agnessa Kovaleva** (Space Research Institute, Russian Academy of Sciences, Moscow)<br>Approximation of residence time and exit location for Lagrangian systems with small additive noise |
| 19:30 – | *Joint dinner in the city* |

**Saturday, 1 December 2007**

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| 9:00 – 9:50 | **Bastien Fernandez** (CPT–CNRS, Marseille)<br>Discrete time dynamics of genetic regulatory networks |
| 9:50 – 10:40 | **Lee DeVille** (University of Illinois at Urbana–Champaign)<br>Regularity and synchrony for motor proteins |
| 10:40 – 11:10 | *Coffee break* |
| 11:10 – 12:00 | **Thilo Gross** (MPI for the Physics of Complex Systems, Dresden)<br>Generalized Structural Kinetic Modeling: From Chinese Dynasties to Photosynthesis |
| 12:00 – 13:30 | *Lunch and coffee break* |
| 13:30 – 14:20 | **Anton Bovier** (WIAS Berlin & TU Berlin)<br>Metastability in the random field Curie–Weiss model |
| 14:20 – 15:10 | **Dirk Blömker** (University of Augsburg)<br>Stabilization with additive noise |
| 15:10 – 16:00 | **Tomás Caraballo** (University of Sevilla)<br>Random dynamical systems generated by models with delay or memory |
| 16:00 – 16:10 | *Closing of the workshop* |

## Abstracts

**Nils Berglund** (MAPMO–CNRS, Orléans)

*Metastable lifetimes and optimal transition paths in noisy spatially extended systems*

We will discuss the dependance of metastable lifetimes in a system of interacting diffusions on coupling strength and noise intensity. We also describe the approximate shape of transition paths between metastable states. While this system behaves like a stochastic particle system for weak coupling, it tends to an SPDE as coupling intensity and particle number go to infinity in the right way. The transition between both extremal regimes involves a sequence of symmetry-breaking bifurcations.

This is joint work with Bastien Fernandez (CPT–CNRS, Marseille) and Barbara Gentz (Universität Bielefeld).

**Anton Bovier** (Weierstrass Institute for Applied Analysis and Stochastics & Technical University Berlin)

*Metastability in the random field Curie–Weiss model*

We study the metastable behavior of one of the simplest disordered spin system, the random field Curie–Weiss model. We will show how the potential theoretic approach can be used to prove sharp estimates on capacities and metastable exit times also in the case when the distribution of the random field is continuous. Previous work was restricted to the case when the random field took only finitely many values, which allowed the reduction to a finite dimensional problem using lumping techniques. Here we produce the first genuine sharp estimates in a context where entropy is important.

This is joint work with Alessandra Bianchi (WIAS, Berlin) and Dmitry Ioffe (Technion, Haifa).

**Dirk Blömker** (University of Augsburg)

*Stabilization with additive noise*

We consider a stochastic partial differential equation of Burgers type. Near a change of stability the evolution is dominated by the modes (or eigenfunctions) changing stability, and the evolution is described by the so called amplitude equation. Degenerate additive noise not acting on these modes can lead to stabilization effects in the dominating dynamics.

Joint work with M. Hairer (Warwick) and G. Pavliotis (Imperial).

**Tomás Caraballo** (University of Sevilla)

*Random dynamical systems generated by models with delay or memory*

The aim of this talk is to show the usefulness of the theory of Random Dynamical Systems in order to analyse the long time behaviour of models which can contain or exhibit some hereditary characteristics. The appearance of delay terms in the equations of a certain model is now fully justified since it is sensible to assume that the future evolution of a phenomenon is somehow determined by what happened in the past, and not only on the present state of the system. We will consider models with finite and infinite delays, as well as those with random delays.

**Lee DeVille** (University of Illinois at Urbana–Champaign)

*Regularity and synchrony for motor proteins*

The majority of intracellular transport is performed by nanometer-scale proteins, known as "molecular motors", or "motor proteins". These motors convert chemical energy to mechanical work, but, unlike macroscopic motors, the energy is typically transferred by a single ATP molecule. Because of this, one expects the dynamics of the motor to be quite random; however, it has been observed that populations of such motors act regularly in certain situations. We present a family of models for the dynamics of motor proteins and show that there are generic organizing principles which lead to regular behavior in a motor's dynamics during interaction with its environment. This analysis is able to explain observations made in the literature of regularity for myosin V during vesicle transport and myosin II during muscle contraction. This work is joint with E. Vanden-Eijnden.

**Bastien Fernandez** (CPT–CNRS, Marseille)

*Discrete time dynamics of genetic regulatory networks*

I will describe a class of discrete time dynamical systems which model the dynamics of genetic regulatory networks. From the biological viewpoint, these models provide a simple way to take into account delays effects. From the mathematical viewpoint, they are also relevant as dynamical systems with rich and original dynamics.

**Thilo Gross** (Max-Planck Institute for the Physics of Complex Systems, Dresden)

*Generalized Structural Kinetic Modeling: From Chinese Dynasties to Photosynthesis*

In theoretical biology complex networks appear in many different forms ranging from metabolic networks to food webs and social networks. While the topology of the networks is often known or suspected, the systems are still characterized by a high degree of uncertainty. In this talk I propose a new approach to such system. By studying so-called generalized models, which only require very little information about the system, certian insights in the dynamics can be obtained. While conventional models can extract much more information, the main advantage of generalized models is that they require only little manual work and computer time. Therefore they can be used as a high-throughput screening method to sample a large conceptual space of potential models and identify promising model structures, important paramters and interesting points in parameter space for subsequent conventional modeling.

**Samuel Herrmann** (Université Henri Poincaré Nancy I)

*Large deviations and a Kramers' type law for self-stabilizing diffusions*

We investigate exit times from domains of attraction for the motion of a self-stabilized particle travelling in a geometric (potential type) landscape and perturbed by Brownian noise of small amplitude. Self-stabilization is the effect of including an ensemble-average attraction in addition to the usual state-dependent drift, where the particle is supposed to be suspended in a large population of identical ones. A Kramers' type law for the particle's exit from the potential's domains of attraction and a large deviations principle for the self-stabilizing diffusion will be presented. It turns out that the exit law for the self-stabilizing diffusion coincides with the exit law of a potential diffusion without self-stabilization with a drift component perturbed by average attraction. We will point out that the self-stabilization may substantially delay the exit from domains of attraction, and that the exit location may be completely different. Some examples will be presented.

**Agnessa Kovaleva** (Space Research Institute, Russian Academy of Sciences, Moscow)

*Approximation of residence time and exit location for Lagrangian systems with small additive noise*

We consider the large deviations asymptotics of mean residence time for the Lagrangian systems with linear dissipation and additive noise. The logarithmic asymptotics of residence time is found as a sum of two terms, related to kinetic and potential energy of the system, respectively. The exit location on the boundary of the reference domain and the terminal state of the unconstrained coordinates at the moment of exit is defined. Applicability of the techniques developed to dynamics and control of systems is illustrated by examples.

**Peter Kloeden** (Johann Wolfgang Goethe-Universität Frankfurt)

*Random attractors and the preservation of synchronization under noise and discretization*

It is shown that the synchronization of dissipative systems involving one-sided dissipative Lipschitz conditions persists when they are disturbed by additive noise no matter how large the intensity of the noise provided asymptoticallystable stationary stochastic solutions are used instead of asymptotically stable. THe same holds for nuemrical discretization for an drift-implicit Euler scheme with constant time step. For Stratonovich stochastic differential equations (SDE) with a one-sided dissipative Lipschitz drift and linear multiplicative noise synchronization occurs only when the driving noises are the same. Otherwise, the synchronization is modulo exponential factors involving Ornstein–Uhlenbeck processes corresponding to the driving noises. In all cases the SDE are transformed to corresponding random ordinary differential equations for which pathwsie estimates can be obtained. The theory of random dynamical systems is used to established existence of the limiting solutions.

T. Caraballo and P.E. Kloeden, The persistence synchronization under environmental noise, *Proc. Roy. Soc. London* **A461** (2005), 2257–2267

T. Caraballo, P.E. Kloeden and A. Neuenkirch, Synchronization of systems with linear noise, *Stochastics & Dynamics* (to appear)

P.E. Kloeden, A. Neuenkirch and R. Pavani, Synchronization of noisy dissipative systems under discretization, *J. Difference Eqns. & Applns.* (to appear)

**Raphaël Lefevere** (Université Denis Diderot, Paris 7)

*Normal heat conduction in weakly anharmonic chain of oscillators*

We show how to compute the heat conductivity of weakly anharmonic chain of oscillators out of equilibrium. The computation boils down to analyzing the collision kernel of the Boltzmann equation for phonons. In particular, it involves the localization of the resonnances between phonons.

**Benjamin Lindner** (Max Planck Institute for the Physics of Complex Systems, Dresden)

*Correlations in sequences of first-passage times*

The statistics of many stochastic processes is characterized by a first-passage time to an absorbing boundary, e.g. the classical Kramers problem in chemical physics or the stochastic firing of a nerve cell (neuron). Much effort has been devoted to the calculation such first-order statistics as the mean first-passage time or its inverse (escape rate). First-passage times occur, however, often in sequences in which intervals are in general correlated. In my talk I will show how particular features of a stochastic dynamics, as for instance colored-noise driving or internal feedback, can give rise to serial correlations of first-passage times and how to calculate the correlation coefficient in simple cases. In the neural context, I will also discuss how negative correlations increase the information transfer of time-dependent stimuli.

**Gabriel Lord** (Heriot-Watt University, Edinburg)

*Freezing Waves in Neurons*

This talk will present results on how a stochastic travelling wave and wave speed may be computed: freezing the wave so it does not move in the computational domain. This will be compared to the standard approach where the wave is allowed to move. As a test case we take the Nagumo equation for nerve propagation.

This technique is then applied to obtain results on wave propagation and effects of noise in the dendritic tissue of a neuron we will introduce the Baer-Rinzel and/or spike-diffuse-spike models with stochastic forcing.

**Arkady Pikovsky** (University of Potsdam)

*Synchronization and desynchronization of oscillators by common noise*

We discuss the effect of common noise on ensembles of dynamical systems and the criteria for their synchronization/desynchronization. An analytic approach developed for phase oscillators shows that they always synchronize. Possible relevance for reliability properties of neurons is discussed.

**Peter Reimann** (University of Bielefeld)

*Velocity Dependence of Atomic Friction: beyond the thermally activated hopping regime*

We propose a theoretical model for friction force microscopy experiments with special emphasis on the realistic description of dissipation and inertia effects. At high velocities, its main prediction is a non-monotonic dependence of the friction force upon the sliding velocity of the AFM-tip relative to an atomically flat surface. At low velocities, thermally activated hopping is expected to dominate but the experimentally observed stick-slip motion is quantitatively incompatible with this expectation.

## Registered participants

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|---|---|
| Osman Akcatepe | (Vienna University of Technology) |
| Michael Allman | (Warwick University) |
| Nils Berglund | (MAPMO–CNRS, Orléans) |
| Wolf-Jürgen Beyn | (University of Bielefeld) |
| Anton Bovier | (Weierstrass Institute for Applied Analysis and Stochastics & Technical University Berlin) |
| Dirk Blömker | (University of Augsburg) |
| Peter Brune | (University of Paderborn) |
| Tomás Caraballo | (University of Sevilla) |
| Lee DeVille | (University of Illinois at Urbana–Champaign) |
| Christof Eck | (University of Bielefeld) |
| Bastien Fernandez | (CPT–CNRS, Marseille) |
| Sebastian von Gehlen | (University of Bielefeld) |
| Sebastian Getfert | (University of Bielefeld) |
| Thilo Gross | (Max-Planck Institute for the Physics of Complex Systems, Dresden) |
| Samuel Herrmann | (Université Henri Poincaré Nancy I) |
| Jens Kemper | (University of Bielefeld) |
| Peter Kloeden | (Johann Wolfgang Goethe-Universität Frankfurt) |
| Agnessa Kovaleva | (Space Research Institute, Russian Academy of Sciences, Moscow) |
| Raphael Kruse | (University of Bielefeld) |
| Raphaël Lefevere | (Université Denis Diderot, Paris 7) |
| Emil Lewandowski | (University of Bielefeld & Maria Curie-Sklodowska University, Lubin) |
| Benjamin Lindner | (Max Planck Institute for the Physics of Complex Systems, Dresden) |
| Gabriel Lord | (Heriot-Watt University, Edinburg) |
| Nina Neumärker | (University of Bielefeld) |
| Johan Nilsson | (Lund University) |
| Arne Ogrowsky | (University of Paderborn) |
| Arkady Pikovsky | (University of Potsdam) |
| Peter Reimann | (University of Bielefeld) |
| Jens Rottmann-Matthes | (University of Bielefeld) |
| Stefan Siegmund | (Johann Wolfgang Goethe-Universität Frankfurt) |
| Tomoyuki Suzuki | (Osaka) |
| Vera Thümmler | (University of Bielefeld) |
| Julian Tugaut | (Université Henri Poincaré Nancy I) |
| Wei Liu | (University of Bielefeld) |

*(as of 29 November 2007)*