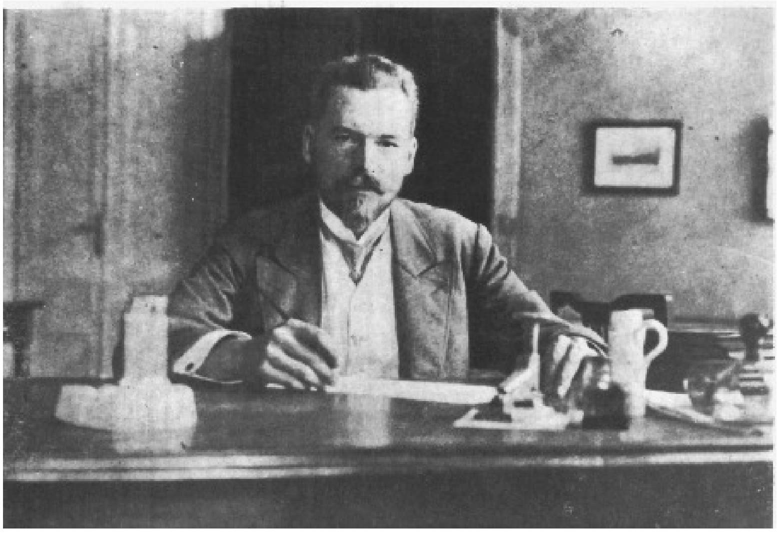
27th Marian Smoluchowski Symposium on Statistical Physics

ZAKOPANE, POLAND, SEPTEMBER 22–26, 2014



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Hotel "Bankowiec" ul. Bulwary Słowackiego 14, 34–500 Zakopane, Poland, tel. +(48) 18 201 40 71
Symposium Organizing Committee: M. Smoluchowski Institute of Physics, Jagiellonian University, Reymonta 4, 30–059 Kraków, Poland
e–mail zfs@th.if.uj.edu.pl WWW http://th-www.if.uj.edu.pl/zfs/smoluchowski/

Monday, September 22
Arrival Day

20^{00} *Get–together Party*

Tuesday, September 23

8^{00} - 8^{45}	*Breakfast*	
	Chairperson: Fernando A. Oliveira	
8^{50} - 9^{00}	**Ewa Gudowska-Nowak** **Aleksander Weron** **Fernando A. Oliveira**	Opening address
9^{00} - 9^{30}	**Constantino Tsallis**	Thermodynamics and statistical mechanics for complex systems – Foundations and illustrations
9^{30} - 10^{00}	**Grzegorz Wilk**	Quasi-power law ensembles
10^{00} - 10^{30}	**Georg Gottwald**	On anomalous diffusion in spatially extended systems
10^{30} - 11^{00}	*Coffee break*	
	Chairperson: Henrik Flyvbjerg	
11^{00} - 11^{30}	**Hyunggyu Park**	Entropy production and fluctuation theorems with odd-parity variables
11^{30} - 12^{00}	**M. Howard Lee**	On the unattainability of the zero of temperature and Bose-Einstein condensate
12^{00} - 12^{30}	**Erica de Mello Silva**	Recurrence relations method and the time evolution of a two-dimensional ultrarelativistic electron gas
13^{00} - 15^{00}	*Lunch*	
	Chairperson: Paweł F. Góra	
15^{00} - 15^{30}	**Maciej A. Nowak**	Random matrix theory as a theory of probability
15^{30} - 16^{00}	**Piotr Garbaczewski**	Nonlocally-induced random motions and their equilibria
16^{00} - 16^{30}	**Władysław Adam Majewski**	Why are Orlicz spaces useful for statistical physics?
16^{30} - 17^{00}	*Coffee break*	
17^{00} - 17^{20}	**Franco Ferrari**	Polymer knots and links: Some analytical, numerical and experimental results
19^{00} - 20^{00}	*Dinner*	

Wednesday, September 24

8^{00} - 9^{00}	*Breakfast*	
	Chairperson: Aleksander Weron	
9^{00} - 9^{30}	**Henrik Flyvbjerg**	Optimal estimation of diffusion coefficients from single-particle trajectories
9^{30} - 10^{00}	**Eldad Kepten**	From DNA to galaxies – stochastic analysis explains chromatin dynamics
10^{00} - 10^{30}	**Gerald Kneller**	Modeling anomalous transport in biological media
10^{30} - 11^{00}	*Coffee break*	
	Chairperson: Piotr Garbaczewski	
11^{00} - 11^{30}	**Alfio Borzi**	A Fokker-Planck strategy to control stochastic processes
11^{30} - 11^{50}	**Janusz Gajda**	Anomalous diffusion with transient subordinators
11^{50} - 12^{20}	**Krzysztof Burnecki**	ARFIMA as a universal model for subdiffusion in living cells
12^{20} - 12^{40}	**Jakub Ślęzak**	On interpretation of ARMA and ARFIMA models
13^{00} - 14^{30}	*Lunch*	
16^{00} - 18^{00}	Poster session	
19^{00}	*Banquet*	

Thursday, September 25

8^{00} - 9^{00}	*Breakfast*	
	Chairperson: J. Miguel Rubi	
9^{00} - 9^{30}	**Sergey Bezrukov**	The notion of entropy potential in transport problems: Limits of applicability
9^{30} - 10^{00}	**Marta Pasenkiewicz-Gierula**	Oxygen diffusion across phospholipid membranes loaded with cholesterol – a computer modeling study
10^{00} - 10^{30}	**Michał Kurzyński**	Maxwell's demons, protein molecular machines, and information in biophysics
10^{30} - 11^{00}	*Coffee break*	
	Chairperson: Sergey Bezrukov	
11^{00} - 11^{30}	**Danuta Makowiec**	Temporal increment distributions of RR-intervals reveal dynamics of cardiac regulation in head-up tilt test
11^{30} - 12^{00}	**Jan Jacek Żebrowski**	Time irreversibility and multifractality of heart rate variability in aortic valve stenosis
12^{00} - 12^{30}	**Zbigniew Struzik**	The other kingdom – non-Gaussian statistics in living complex systems
13^{00} - 15^{00}	*Lunch*	
	Chairperson: Danuta Makowiec	
15^{00} - 15^{30}	**Lutz Schimansky-Geier**	Self-organized escape processes in nonlinear potentials
15^{30} - 16^{00}	**J. Miguel Rubi**	Entropic electrokinetics in confined systems
16^{00} - 16^{30}	**Fernando A. Oliveira**	Upper critical dimension, Galilean invariance, and exact solution for the etching model
16^{30} - 17^{00}	*Coffee break*	
	Chairperson: Lutz Schimansky-Geier	
17^{00} - 17^{30}	**Andrzej Fuliński**	Anomalous Brownian motions: symmetry breaking, power spectra and all that . . .
17^{30} - 18^{00}	**Paulo H. Lana Martins**	Probability distribution function of the order parameter: Mixing fields and universality
18^{00} - 18^{30}	**Alexander Dubkov**	Steady-state correlation characteristics of Brownian and Lévy diffusion in different potential profiles
19^{00} - 20^{00}	*Dinner*	

Friday, September 26
Departure Day

8^{00} - 9^{00}	*Breakfast*		
	Chairperson: Igor M. Sokolov		
9^{00} - 9^{30}	**Krzysztof Kułakowski**	Emerging communities in networks – a flow of ties	
9^{30} - 10^{00}	**Celia Anteneodo**	Unraveling people interactivity by means of electoral vote	
10^{00} - 10^{30}	**Bartłomiej Dybiec**	Social hierarchies: development and maintenance	
10^{30} - 11^{00}	*Coffee break*		
	Chairperson: Krzysztof Kułakowski		
11^{00} - 11^{30}	**Igor M. Sokolov**	Anomalous diffusion on fractal structures: Alexander-Orbach relation and its alternatives	
11^{30} - 12^{00}	**Aleksei Chechkin**	Distributed order diffusion equations: properties, physical background and non-monofractality	
12^{00} - 12^{30}	**Aleksander Weron**	Algorithms for testing of fractional dynamics	
13^{00} - 14^{00}	*Lunch*		
14^{00}	Bus departure		

Invited talks

Celia Anteneodo, Pontifical Catholic University of Rio de Janeiro, Rio de Janeiro, Brazil

Unraveling people interactivity by means of electoral vote

Abstract: Elections embody valuable information on the dynamics through which individuals influence each other and make choices. We analyze proportional elections in Brazil, a country with a diversified and huge electorate of around 100 million people, covering the period 1970-2012, which encompasses distinct political regimes. Through the distribution $P(v)$ of the number of candidates receiving v votes, we perform a comparative analysis of different elections in the same calendar and as a function of time. Inspired in multi-species population dynamics, we propose a model, consisting in a system of nonlinear differential equations with stochastic parameters, that allows to predict and interpret the observed features. We show that the distribution of votes among candidates reveals patterns that reflect the evolution of people interactions. In particular, a statistical property of vote distributions, that appears to be predominantly associated to the electorate, can be used as a measure of its degree of feed-back. Such measure of a population, which is hard to be accessed otherwise, may be useful to know the extent to which people interact and can be influenced, even beyond the context of political elections.

[1] A. M. Calvão, N. Crokidakis, C. Anteneodo, What do vote distributions reveal? arXiv:1406.6322

Sergey Bezrukov, National Institutes of Health, Bethesda MA, USA

The notion of entropy potential in transport problems: Limits of applicability

Abstract: Transport in systems of varying geometry has become the subject of growing attention in recent years since such systems are ubiquitous in biology and technology. In analyzing transport in such systems, the notion of entropy potentials is widely used. Entropy potentials naturally arise in one-dimensional description of equilibrium distributions in multidimensional confined structures. However, their application to transport problems requires some caution. In this talk we discuss such applications and summarize the results of recent studies exploring the limits of applicability. We also consider particular examples of transport problems where the conventional approach breaks due to the abrupt changes in the confining geometry.

Invited talks (continued)

Alfio Borzi, University of Würzburg, Würzburg, Germany

A Fokker-Planck strategy to control stochastic processes

Abstract: An efficient framework for the optimal control of probability density functions (PDF) of multidimensional stochastic processes and piecewise deterministic processes is presented. This framework is based on Fokker-Planck-type equations that govern the time evolution of the PDF of stochastic processes. In this approach, the control objectives may require to follow a given PDF trajectory or to minimize an expectation functional. Theoretical results concerning the forward and the optimal control problems are provided. In the case of stochastic (Ito) processes, the Fokker-Planck equation is of parabolic type and it is shown that under appropriate assumptions the open-loop bilinear control function is unique. In the case of piecewise deterministic processes (PDP), the Fokker-Planck equation consists of a first-order hyperbolic system. Discretization schemes are discussed that guarantee positivity and conservativeness of the forward solution. The proposed control framework is validated with multidimensional biological, quantum mechanical, and financial models.

Krzysztof Burnecki, Wrocław University of Technology, Wrocław, Poland

ARFIMA as a universal model for subdiffusion in living cells

Abstract: As a candidate suitable for extensive statistical analysis of the subdiffusive dynamics in biological cells we propose the autoregressive fractionally integrated moving average (ARFIMA) model. It includes other popular models of subdiffusive dynamics as fractional Brownian and Levy stable motions, which are limiting cases of aggregated ARFIMA. In contrast to them, it can also describe different light- and heavy-tailed noises and a short (exponential) dependence. The discrete time ARFIMA(1,d,1) model is applied to the random motion of an individual fluorescently labeled mRNA molecule inside live E. coli cells as well as to the motion of fluorescently labeled telomeres in the nucleus of live human cells (U2OS cancer). It is found that only the memory parameter d of the ARFIMA model completely detects an anomalous dynamics of the experimental data independently of the observed distribution of random noises.

Aleksei Chechkin, Kharkov Institute of Physics and Technology, Kharkov, Ukraine and Max Planck Institute for Physics of Complex Systems, Dresden, Germany

Distributed order diffusion equations: properties, physical background and non-monofractality

Abstract: We consider diffusion-like equations with time and space fractional derivatives of distributed order for the kinetic description of anomalous diffusion and relaxation phenomena, whose mean squared displacement does not change as a power law in time. Correspondingly, the underlying processes cannot be viewed as self-affine random processes possessing a unique Hurst exponent. We show that different forms of distributed order equations, which we call “natural” and “modified” ones, serve as a useful tool to describe the processes which become more anomalous with time (retarding subdiffusion and accelerated superdiffusion) or less anomalous, demonstrating the transition from anomalous to normal diffusion (accelerated subdiffusion and truncated Lévy flights). Fractional diffusion equation with the distributed-order time derivative also accounts for the logarithmic diffusion (strong anomaly).

Invited talks (continued)

Alexander Dubkov, Lobachevsky State University, Nizhni Novgorod, Russia

Steady-state correlation characteristics of Brownian and Lévy diffusion in different potential profiles

Abstract: We start with the Kolmogorov equation for the probability density of transitions of an arbitrary stationary Markovian process and develop the method to calculate the correlation characteristics such as the correlation function, power spectral density, and correlation time in a steady state, if it exists. Specifically, the operator formula and the power series expansion for the correlation function are obtained in parallel with the equations to find the power spectral density and the correlation time which require finding the stationary probability distribution.

Further we consider diffusion of Brownian particle in a potential with confinement (finite variance of the particle displacement in a steady state) and obtain the exact quadrature formula for the correlation time of stationary Brownian motion in arbitrary-shaped potential wells. We analyze the dependence of the correlation time on the intensity of driving noise for power-law potential profiles and on the height of a potential barrier for bistable profiles which is similar to the Kramers law. We also study some spectral characteristics of the steady-state motion and find the coefficients of the Taylor series expansion of the correlation function.

Using the above-mentioned method developed for an arbitrary Markovian process, we derive a new formula to calculate the correlation time of stationary Lévy diffusion in a steep potential well. For the symmetric quartic potential with one and two stable states we obtain the exact expressions for the correlation time of Lévy diffusion with index $\alpha = 1$. The correlation time of stationary Lévy diffusion decreases with increasing noise intensity parameter and the steepness of potential well. For the bistable quartic potential we find new Kramers-like law with power-law dependence on the barrier height and the noise intensity parameter.

[1] Dubkov A.A., Malakhov A.N., and Saichev A.I. Correlation time and structure of the correlation function of a nonlinear equilibrium Brownian motion in potential wells of arbitrary profiles. Radiophysics and Quantum Electronics. 2000. V.43. No.4. P.335–346.

[2] Dubkov A. and Spagnolo B. Time characteristics of Lévy flights in a steep potential well. European Physical Journal: Special Topics 2013. V.216. No.1. P.31-35.

Invited talks (continued)

Henrik Flyvbjerg, Technical University of Denmark, Kongens Lyngby, Denmark

Optimal estimation of diffusion coefficients from single-particle trajectories

Abstract: How does one optimally determine the diffusion coefficient of a diffusing particle from a single time-lapse recorded trajectory of the particle? We answer this question with an explicit, unbiased, and practically optimal covariance-based estimator (CVE). This estimator is regression-free and is far superior to commonly used methods based on measured mean squared displacements. In experimentally relevant parameter ranges, it also outperforms the analytically intractable and computationally more demanding maximum likelihood estimator (MLE).

For the case of diffusion on a flexible and fluctuating substrate, the CVE is biased by substrate motion. However, given some long time series and a substrate under some tension, an extended MLE can separate particle diffusion on the substrate from substrate motion in the laboratory frame. This characterization of substrate movement allows removal of bias caused by substrate fluctuations in CVE. The resulting unbiased CVE is optimal also for short time series on a fluctuating substrate. We have applied our estimators to human 8-oxoguanine DNA glycolase proteins diffusing on flow-stretched DNA, a fluctuating substrate, and found that diffusion coefficients are severely overestimated if substrate fluctuations are not accounted for [1]. We also resolved two different states of the protein, a loosely bound state with one diffusion coefficient, and a stronger bound state with a smaller diffusion coefficient.

[1] C. L. Vestergaard, P. C. Blainey, and H. Flyvbjerg, Phys. Rev. E 89, 022726 (2014).

Georg Gottwald, University of Sydney, Sydney, Australia

On anomalous diffusion in spatially extended systems

Abstract: We present a universal view on diffusive behavior in spatially extended systems. For anisotropic systems, strong chaos leads to diffusive behavior (Brownian motion with drift) and weak chaos leads to superdiffusive behavior (Lévy processes with drift). For isotropic systems, the drift term vanishes and strong chaos again leads to Brownian motion. We establish the existence of a nonlinear Huygens principle for weakly chaotic systems in isotropic media whereby the dynamics behaves diffusively in even space dimension and exhibits superdiffusive behavior in odd space dimensions. Furthermore, we establish stochastic limit systems driven by Lévy noise from deterministic multi-scale systems driven by weakly chaotic fast dynamics. We then use these results to devise a method to construct one- and two-sided alpha-stable processes with specified parameter values.

Invited talks (continued)

Eldad Kepten, Bar Ilan University, Ramat Gan, Israel

From DNA to galaxies – stochastic analysis explains chromatin dynamics

Abstract: Recent studies have shown that accurate spatial organization and dynamics of nuclear DNA strands is crucial for cellular genetic activity. However, nuclear dynamics and organization are intimately dependent, both creating and disrupting each other, in ways that are yet to be fully understood. We study the stochastic motion of chromatin loci (DNA with its accompanying proteins) with the use of fluorescent microscopy, in order to identify and characterize the underlying physical and biological mechanisms. By measuring the relative dynamics between thousands of chromatin loci pairs, we are able to extract significant traits, despite the high inherent randomness of the system. Through the application of novel stochastic characterization techniques, an anisotropic distance dependent anomalous diffusion is found, with a varying memory kernel. Such relative dynamics are in contradiction to the naïve expectation in viscoelastic media, and lead us to define a new diffusion mechanism, termed Hubble Diffusion. Hubble diffusion is reminiscent of the fundamental Hubble expansion of space and its biophysical implications will be discussed.

Gerald Kneller, Centre de Biophysique Moléculaire, CNRS Orléans and University of Orléans, Orléans, France

Modeling anomalous transport in biological media

Abstract: Since the pioneering work of Ryogo Kubo it is known that transport coefficients can be expressed as improper integrals over time correlation functions of appropriate dynamical variables. An example is the diffusion coefficient, which can be expressed as improper integral of the velocity autocorrelation function of the diffusing particle. In case of anomalous diffusion, which is observed in a variety of "crowded" biological systems, these integrals diverge or vanish and the theory must be adapted in order to relate fractional diffusion coefficients and transport coefficients in general to the microscopic dynamics of the system under consideration. In the talk I will show how this can be accomplished by means of asymptotic analysis and the origin of anomalous diffusion is discussed in the framework of the Generalized Langevin equation. In this context, the impact of crowding on the diffusion of tagged particle is related to the cage effect, which is known from the theory of liquids. Using simple scaling arguments, I will also discuss under which conditions anomalous diffusion can be described by fractional Fokker-Planck equations.

[1] R. Kubo, Journal of the Physical Society of Japan 12, 570 (1957).
[2] G.R. Kneller, J Chem Phys 134, 224106 (2011).
[3] G.R. Kneller, J Chem Phys 141, 041105 (2014).

Invited talks (continued)

Krzysztof Kułakowski, AGH University of Science and Technology, Kraków, Poland

Emerging communities in networks – a flow of ties

Abstract: Algorithms for search of communities in networks usually consist discrete variations of links. Here we discuss a flow method, driven by a set of differential equations. Two examples are demonstrated in detail. First is a partition of a signed graph into two parts, where the proposed equations are interpreted in terms of removal of a cognitive dissonance by agents placed in the network nodes. There, the signs and values of links refer to positive or negative interpersonal relationships of different strength. Second is an application of a method akin to the previous one, dedicated to communities identification, to the Sierpiński triangle of finite size. During the time evolution, the related graphs are weighted; yet at the end the discrete character of links is restored. In the case of the Sierpiński triangle, the method is supplemented by adding a small noise to the initial connectivity matrix. By breaking the symmetry of the network, this allows to a successful handling of overlapping nodes.

Michał Kurzyński, Adam Mickiewicz University, Poznań, Poland

Maxwell's demons, protein molecular machines, and information in biophysics

Abstract: In the intention of its creator, Maxwell's demon was thought to be an intelligent being able to perform work at the expense of the entropy reduction of a closed operating system. The perplexing notion of the demon's intelligence was formalized in terms of the information processing by Leo Szilard, who simultaneously pointed out that, in order for the system to be consistent with the second law of thermodynamics, the entropy reduction should be compensated for by, at least, the same entropy increase related to the demon's information gain on the operating system state. A mechanical (non-informational) formulation of the problem was proposed by Marian Smoluchowski and popularized by Richard Feynman as the pawl and ratchet machine, which can operate only in agreement with the second law. Andrew F. Huxley and followers adopted this way of thinking to propose numerous Brownian ratchet mechanisms of the biological molecular machines action. Here we show that, for the biological molecular machines properly described by both the Brownian ratchet and the concurrent power stroke models, no entropy reduction takes place. Thus, they cannot be considered as Maxwell's demons in the original understanding. As such, only the protein machines can act, which occur in a number of conformational states organized in a network of transitions that allow the performance of work in a variety of ways. Recently, two experimental realizations of the informational machine have been studied. A computer realization is investigated here of the conformational network, displaying, like networks of the systems biology, a transition from the fractal organization on a small length-scale to the small-world organization on the large length-scale. This model is able to explain a surprising observation to Toshio Yanagida and co-workers that the myosin II head can take several steps along the actin filament per ATP molecule hydrolyzed. From a broader perspective, of especial importance could be the supposition that the mechanism of the action of small G-proteins, having a common ancestor with the myosin II, is, after a malignant transformation, similar. Presumably, also, transcription factors look actively and not passively for their target on the genome.

Invited talks (continued)

M. Howard Lee, University of Georgia, Athens GA, USA

On the unattainability of the zero of temperature and Bose-Einstein condensate

Abstract: The third law of thermodynamics due to Nernst has several facets. The most readily demonstrated is the vanishing of the entropy as temperature goes to zero as in the ideal Fermi gas. Perhaps the most intriguing is its assertion that the zero of temperature is unattainable. Standard proofs seem to rest on the idea that at the zero of temperature the isotherm and adiabat coincide, they are one and the same. But are these premises true? Is it true for an ideal Bose gas under BEC? Using the author's polyogs representation of quantum gases, this issue is re-examined. It is found that the zero of temperature is indeed unattainable but not in the manner it has been described.

Władysław Adam Majewski, University of Gdańsk, Gdańsk, Poland

Why are Orlicz spaces useful for statistical physics?

Abstract: We present the new rigorous approach for description of statistical mechanics of regular statistical systems which is based on Orlicz spaces. The approach has this advantage that statistics as well as thermodynamics are well settled down. We will be concerned with classical systems. Moreover, we indicate how these techniques may be used for the proper description of quantum systems.

Danuta Makowiec, University of Gdańsk, Gdańsk, Poland

Temporal increment distributions of RR-intervals reveal dynamics of cardiac regulation in head-up tilt test

Abstract: Dynamical aspects of cardiovascular regulation are revealed in the head-up tilt test by the properties of the distribution of time-increments between subsequent heart contractions. The Generalized Porta Index (GPI) is introduced and then calculated for the pooled probability density functions. GPI reveals marked differences between the dynamical response to the tilt test of healthy subjects prone to spontaneous fainting and those who are less susceptible.

Paulo H. Lana Martins, Universidade Federal de Mato Grosso, Cuiaba, Brazil

Probability distribution function of the order parameter: Mixing fields and universality

Abstract: We briefly review the use of the order parameter probability distribution function as a useful tool to obtain the critical properties of statistical mechanical models using computer Monte Carlo simulations. Some simple discrete spin magnetic systems on a lattice, such as Ising, general spin-S Blume–Capel, and Baxter–Wu will be considered as examples. The importance and the necessity of the role of mixing fields in asymmetric magnetic models will be discussed in more detail, as well as the corresponding distributions of the extensive conjugate variables.

Maciej A. Nowak, Jagiellonian University, Kraków, Poland

Random matrix theory as a theory of probability

Abstract: On the base of the concepts of classical probability calculus (CPC), I will present random matrix theory as a matrix-valued analog of CPC. In particular, I will discuss central limit theorems, matrix-valued convolutions and the analogs of the Langevin and Smoluchowski-Fokker-Planck equations. Finally, I will highlight the role of such matrix-valued probability calculus for the recent applications in bio-techno-info-technologies.

Invited talks (continued)

Fernando A. Oliveira, Universidade de Brasília, Brasília, Brazil

Upper critical dimension, Galilean invariance, and exact solution for the etching model

Abstract: We generalize the etching model [1] from $1 + 1$ to $d + 1$ dimensions. The dynamic exponents of this model are compatible with those of the KPZ universality class. We investigate the roughness dynamics with surfaces up to $d = 6$. We show that the data from all substrate lengths and for all dimension can be collapsed into one common curve. We determine the dynamic exponents as a function of the dimension. Our results suggest that $d = 4$ is not an upper critical dimension for the etching model, and that it fulfills the Galilean Invariance [2]. Moreover for d=1 we obtain the exact exponents for the model and we show that they belong to the KPZ universality class [3].

[1] B. A. Mello, A. S. Chaves, and F. A. Oliveira, Phys. Rev. E **63**, 041113 (2001).
[2] E. A. Rodrigues, B. A. Mello, and F. A. Oliveira to be published.
[3] W. S. Alves, F. A. Oliveira and I. V. L. Costa, to be published.

Hyunggyu Park, Korean Institute for Advanced Study, Seoul, Korea

Entropy production and fluctuation theorems with odd-parity variables

Abstract: Total entropy production is conventionally separated into system entropy change and heat flowing into a thermal reservoir. In the presence of odd-parity variables under the time reversal, however, we explicitly find an extra entropy-like term whose physical origin is still in mystery. We also show that the separation of the total entropy production into the housekeeping (adiabatic) and its complementary functionals respectively holding the fluctuation theorems is not generic. This is due to the non-transient housekeeping contribution caused by the asymmetry of the steady-state distribution with respect to the odd-parity variables.

Invited talks (continued)

Marta Pasenkiewicz-Gierula, Jagiellonian University, Kraków, Poland

Oxygen diffusion across phospholipid membranes loaded with cholesterol – a computer modeling study

Abstract: A profile of the oxygen diffusion-concentration product across lipid bilayers can be determined by electron paramagnetic resonance spin label (SL-EPR) methods. Its knowledge is significant because (1) it allows calculating the membrane permeability coefficient for oxygen, and (2) provides better understanding of chemical processes occurring within the lipid bilayer which involve molecular oxygen. In this comparative molecular dynamics (MD) simulation study, three computer models of lipid bilayers differing in 1-palmitoyl-2-oleoyl-phosphatidylcholine (POPC) and cholesterol (Chol) content, were used. The first bilayer was a pure Chol bilayer, the second was POPC-Chol bilayer at a 1:1 molar ratio, and the third was a pure POPC bilayer and constituted a reference system. The Chol and POPC-Chol bilayers modeled the cholesterol bilayer domain (CBD), which is a Chol bilayer embedded in the PC membrane saturated with Chol. Each of the three simulation boxes comprised two hydrated lipid bilayers and diffusing oxygen molecules (O2). In the initial structures, the oxygen molecules were placed in the intra-bilayer water layer. After systems' equilibration, the profile of O2 concentration along the bilayer normal in each system was calculated. To calculate the profile of the diffusion coefficient, each of the bilayers was divided into distinct zones and for each zone, the coefficient was calculated from the linear part of the relevant 50-ps mean square displacement (MSD) curve. The differences in the oxygen concentration profiles in the three systems are greater than the differences in the oxygen diffusion profiles. These profiles cannot be compared with experimental ones, as experimentally, only the profile of the concentration-diffusion product can be determined. Thus, the product was calculated and compared with the available experimental data.

J. Miguel Rubi, Universitat de Barcelona, Barcelona, Spain

Entropic electrokinetics in confined systems

Abstract: We show that the dynamics of particles suspended in an electrolyte confined between corrugated charged surfaces exhibits new and surprising phenomena such as particle separation, mixing for low-Reynolds micro- and nano-metric devices and negative mobility. Such phenomena originate from the interplay between the electrostatic double layer and the confinement; the new effects become more important when the width of the channel is comparable to the Debye length. We outline the relevance of the predicted effects in a wide variety of systems, from nano- and micro-fluidic devices to biological systems.

[1] P. Malgaretti, I. Pagonabarraga, and J. M. Rubi, Phys. Rev. Lett. (in press).

Lutz Schimansky-Geier, Humboldt Universität zu Berlin, Berlin, Germany

Self-organized escape processes in nonlinear potentials

Abstract: We describe the emergence and interactions of breather modes and resonant wave modes within a two-dimensional ring-like oscillator chain in a microcanonical situation. Our analytical results identify different dynamical regimes characterized by the potential dominance of either type of mode. The chain is initially placed in a meta-stable state which it can leave by passing over the brim of the applied Mexican-hat-like potential. We elucidate the influence of the different wave modes on the mean-first passage time. A central finding is that also in this complex potential landscape a fast noise-free escape scenario solely relying on nonlinear cooperative effects is accomplishable even in a low energy setting.

Invited talks (continued)

Erica de Mello Silva, Universidade Federal de Mato Grosso, Cuiaba, Brazil
Recurrence relations method and the time evolution of a two-dimensional ultrarelativistic electron gas
Abstract: In this work we deal with a two-dimensional high-density relativistic electron gas at zero temperature and long wavelength limits. The model is the relativistic generalization of the non-relativistic high-density electron gas model from the theory of semiconductors. We consider the extreme relativistic case to study the time evolution of the system through the recurrence relations method (RRM), an equation-of-motion approach based on the generalized Langevin equation (GLE), and obtain the susceptibility, the spectral density, and the structure factor exactly.

Igor M. Sokolov, Humboldt Universität zu Berlin, Berlin, Germany
Anomalous diffusion on fractal structures: Alexander-Orbach relation and its alternatives
Abstract: Diffusion on fractal structures (typically subdiffusion with mean squared displacement growing slower than the first power of time) is one of paradigmatic examples of anomalous diffusion. The exponent α of anomalous diffusion is typically connected with the fractal and with the spectral dimension of the fractal substrate via the Alexander-Orbach (AO) relation, $\alpha = d_s/d_f$, which, however, is known not to hold universally. We present a somewhat non-standard approach to AO relation based on spectral decomposition for the corresponding Master equations, and discuss what are the alternatives to AO relation if it breaks down. The findings are illustrated by an elucidating exactly solvable example of anomalous diffusion on a Cantor dust.

Zbigniew Struzik, University of Tokyo, Tokyo, Japan
The other kingdom - non-Gaussian statistics in living complex systems
Abstract: Gaussian statistics rules! There is no doubt that the law of large numbers underlies the very essence of our trust in scientific results. Reproducibility of scientific observations is an expected outcome, and 'normal' statistic is the bedrock of science as we have come to know and practice it.

Yet, a different kingdom exists, swarming with 'black swans' and 'dragon kings': a kingdom of strongly non-Gaussian phenomena, where sheer unpredictability is what everyone expects.

In recent decades, it has become evident to many that the apparently intractable complexity of living systems is related to such 'non-normal' behavior. This 'non-normal' behavior has been observed in the dynamics of the cardiac regulatory system, in networks of spiking neurons, in human behavior, from individual interactions to system-wide movements of economic quantities.

In the talk, I will review the evidence and where available the mechanisms of the underlying complexity of such 'non-normal' behavior. In particular, I will discuss the growing evidence that such unpredictable dynamics is probably not system specific in the type of the adaptive dynamical characteristics it displays. On the contrary, it appears instead that the parsimonious model of critical behavior is one that is both deeply rooted in statistical physics and in nonlinear dynamics approaches to complex phenomena.

Indeed, it is also identified in a number of biological phenomena, and growing evidence is being gathered, suggesting operational benefits of systems 'poised' at criticality.

Invited talks (continued)

Constantino Tsallis, Centro Brasileiro de Pesquisas Fisicas and National Institute of Science and Technology for Complex Systems, Rio de Janeiro, Brazil and Santa Fe Institute, Santa Fe NM, USA.

Thermodynamics and statistical mechanics for complex systems – Foundations and illustrations

Abstract: The possible distinction between inanimate and living matter has been of interest to humanity for thousands of years. Clearly, such a rich question can not be answered in a single manner, and a plethora of approaches naturally do exist. However, during the last two decades, a new standpoint, of thermostatistical nature, has emerged. It is related to the proposal of nonadditive entropies in 1988, in order to generalize the celebrated Boltzmann–Gibbs additive functional, basis of standard statistical mechanics. Such entropies have found deep fundamental interest and uncountable applications in natural, artificial and social systems. In some sense, this perspective represents an epistemological paradigm shift. These entropies crucially concern complex systems, in particular those whose microscopic dynamics violate ergodicity. Among those, living matter and other living-like systems play a central role. We briefly review here this approach, and present some of its predictions, verifications and applications.

Grzegorz Wilk, National Centre for Nuclear Research, Warszawa, Poland and Jan Kochanowski University, Kielce, Poland

Quasi-power law ensembles

Abstract: The quasi-power law ensembles will be discussed from the nonextensive Tsallis distribution (with parameter q) perspective. In particular, a number of possible processes resulting in such distribution will be presented in more detail with special attention devoted to their possible interrelations. The apparent puzzle seen in multiparticle data, the analysis of which indicates that q_1 from the multiplicity distributions (connected with Tsallis entropy S_q) seems to be related to q_2 from Tsallis distributions f_q by $q_1 + q_2 = 2$, will be discussed. The possible replacement of Tsallis entropy by Shannon entropy with specially chosen constraints will be also discussed (together with connection of these constraints with additive or multiplicative type of dynamical processes under consideration). Finally, following recent observation of log-periodicity in some multiparticle distributions, a suitable dressing Tsallis distribution in such log-oscillating factors will be discussed, its origin connected with the possibility of nonextensivity parameters q becoming complex.

Talks

Bartłomiej Dybiec, Jagiellonian University, Kraków, Poland

Social hierarchies: development and maintenance

Abstract: First, basic definitions of social hierarchies are presented. Next, using one of possible definitions a model of development and maintenance of hierarchy is presented. It is demonstrated that social position is very fragile and vitally depends on constant supply of new information.

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Franco Ferrari, University of Szczecin, Szczecin, Poland

Polymer knots and links: Some analytical, numerical and experimental results

Abstract: The physics of polymer knots and links is a multidisciplinary subject. On one side, it is a playground for field theoretical techniques, like the renormalization group method and, more recently, for topological field theories. On the other side, the investigations of the statistical mechanics of polymer rings have also a feedback in field theories. Examples are a few advances in treating field theories with constraints and a class of identities that allow to simplify complicated interactions in scalar field theories. Moreover, models of polymer knots and links have a range of applications that go beyond the physics of polymers and become relevant in other disciplines, in which the topological properties of quasi one-dimensional objects play an important role. This is the case of maghetohydrodynamics and of some systems of quasiparticles with non-trivial statistics in solid state physics. Nowadays, the behavior of single polymer knots can be checked experimentally and it is possible to create polymer melts containing a very high percentage of polymer rings entangled together. Properties that are too difficult to be studied directly via experiments may be investigated thanks to reliable numerical simulations. In this talk, some of the recent experimental, analytical and numerical results in the physics of polymer knots and links will be presented.

Andrzej Fuliński, Jagiellonian University, Kraków, Poland

Anomalous Brownian motions: symmetry breaking, power spectra and all that . . .

Abstract: Brownian motions (BMs) in crowded composite environments, e.g. living cells or organelles, can be disturbed by other parallel processes going in their vicinity, and in turn may disturb other processes. Such (pseudo-)random interactions might be one of the sources of anomalous behavior of BMs. Presence of mutual random influences can be looked for by analysis of various observables other than dispersion of BM trajectories. The examination of series ("trajectories") of increments of original measured traces of motion of single particles seems particularly promising. Several easy to implement procedures are discussed.

Janusz Gajda, Wrocław University of Technology, Wrocław, Poland

Anomalous diffusion with transient subordinators

Abstract: We discuss two distinct phenomena within anomalous diffusion framework. First we describe how to model the phenomenon of transition from strict subdiffusive regime to normal diffusion. We derive corresponding generalized Fokker-Planck equation and provide its stochastic Langevin equivalent. Next we briefly discuss the problem of description of the phenomenon of transition from slower subdiffusion to faster subdiffusion on the example of subordinated fractional Brownian motion.

Talks (continued)

Piotr Garbaczewski, University of Opole, Opole, Poland

Nonlocally-induced random motions and their equilibria

Abstract: Lévy processes are examples of non-locally induced random motions. We address an issue of confining the Cauchy process in a spatially finite trap (interval in 1D). Its computer assisted solution clearly exemplifies the nonlocality of the Cauchy dynamics and allows to grasp a difference between somewhat different meanings attributed to the phrase "spectral properties of the stochastic process", respectively by statistical physicists and mathematicians.

Jakub Ślęzak, Wrocław University of Technology, Wrocław, Poland

On interpretation of ARMA and ARFIMA models

Abstract: ARMA and ARFIMA models' popularity among statisticians is caused by their simplicity and accessibility of estimation and prediction tools. However, their usage in natural sciences is limited because they are often considered to be purely empirical models, weakly related to the biological or physical background. Here, we interpret ARMA and AFIMA as sampled trajectories governed by the linear stochastic dynamics systems. This correspondence is not approximate, but strict, and yields exact formulas relating physical and biological constants governing the system with ARMA and ARFIMA coefficients. We show direct applications of the proposed approach, presenting ARMA and ARFIMA arising from classical models like Langevin equation or stochastic RLC circuit equation.

[1] P. Brockwell (2004) "Representations of Continuous-Time ARMA Processes", Journal of Applied Probability, Vol. 41, 375-382.
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[3] K. Burnecki, G. Sikora, A. Weron (2012) "Fractional process as a unified model for subdiffusive dynamics in experimental data", Physical Review E 86, 041912.

Talks (continued)

Aleksander Weron, Wrocław University of Technology, Wrocław, Poland

Algorithms for testing of fractional dynamics

Abstract: In this talk we present a systematic methodology how to identify origins of fractional dynamics. We consider three stochastic mechanisms leading to it, namely fractional Brownian motion, fractional Lévy stable motion and ARFIMA process . The methodology is based on statistical tools for identification and validation of the fractional dynamics, in particular on ergodicity test, self-similarity index estimator based on sample p-variation and memory parameter estimator based on sample mean-squared displacement. A list of algorithms needed for this will be discussed. We illustrate the methodology on various empirical data and provide a practical guide for experimentalists how to efficiently use stochastic modeling for a large class of anomalous diffusion data.

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Jan Jacek Żebrowski, Warsaw University of Technology, Warszawa, Poland

Time irreversibility and multifractality of heart rate variability in aortic valve stenosis

Abstract: Arterial valve replacement surgery is conducted when the arterial valve leading out of the heart into the main artery becomes narrowed. A number of factors may lead to this condition but in recent years the number of arterial stenosis patients is growing rapidly and the valvular disease are expected to be the next great epidemic. We studied a group of 385 arterial stenosis patients of whom 16 had died in the postoperational period (up to 30 days of the operation). Each patient had a heart rate variability recording made prior to the operation in addition to the full set of medical diagnostics including echocardiography. We formed 16 age, sex and BMI adjusted control pairs for each person who died in the postoperative period. Our aim was to find indications of the risk of arterial valve replacement surgery based on the medical data and heart rate variability properties. Besides standard, linear heart rate variability methods we used indexes of time irreversibility introduced by Guzik (G%), Porta (P%), Ehlers (index E) and Hou (index D). In addition, we analyzed the multiscale multifractal properties of the heart rate variability using the Hurst surface. The nonlinear analysis method show clear indications of the risk of arterial valve replacement surgery in an increase of multifractality and an increase of time irreversibility of the heart rate variability measured prior to the operation.

Posters

1.

Michał Balcerek, Agnieszka Wyłomańska, Wrocław University of Technology, Wrocław, Poland

Stochastic analysis of indoor air quality data

Abstract: Analysis of stochastic processes and time series is very important in various fields of industry. It is common that such processes can be split in several sub-processes with different characteristics (e.g. pure jump process and continuous process or two processes with different variance). Here we present few splitting techniques applied to real air quality data.

In the following part we analyze obtained sub-processes by using various techniques like: p-variation analysis [1], dynamical functional analysis [3], MSD analysis [2] and thus we attempt to narrow down possible models. Furthermore, we compare fitted models in sub-processes with similar characteristics.

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[3] M. Magdziarz and A. Weron, Phys. Rev. 84, 051138 (2011).

2.

Jakub Barbasz[†], Michał Cieśla[‡], [†]IKiFP Polish Academy of Sciences, Kraków, Poland, [‡]Jagiellonian University, Kraków, Poland

Random packing of disks on mesh

Abstract: The random packing of disks on two dimensional mesh was studied numerically using random sequential adsorption algorithm. Obtained coverages were analyzed to get saturated packing ratio, available surface function as well as density autocorrelation function. Moreover, the structure of saturated packing was studied using fast Fourier transform and wavelet decomposition to determine properties of underlying surface.

3.

Fernando Barbosa, Universidade de Brasília, Brasília, Brazil

Stability dynamics in pattern formation for a nonlocal population dynamics

Posters (continued)

4.

Piotr Bełdowski, University of Technology and Life Sciences, Bydgoszcz, Poland

Proton conductivity in amphiphile channels as governed by entropy and temperature changes conformed to local environment

Abstract: Articular cartilage (AC) is a natural viscoelastic device which shows remarkable tribological properties and can work without any fault for life time. The mechanism governing its work has been under debate since 1930s and yet has not been resolved. This work presents a possible mechanism of physiology of AC. We assume the presence of proton channels in amphiphile-water systems described by mesoscopic Smoluchowski-type dynamics as a nanoscale lubrication regime. These nanoscale effects, namely: proton waves induced by H-bond breaking, can influence AC lubricating properties. We hypothesize that an enthalpic interaction between geometric and electrostatic confinement and the related to entropic counterpart is characteristic of proton channel crowding. Geometry of these channels (the conformation of amphiphile structures) plays an important role as it can either facilitate protons motion or impede it and thus can give different effects of the stage of AC work. Entropy and temperature fluctuations are taken under consideration to obtain the most favorable passage for protons. Decreasing of entropy near channel confinement and higher order of protons' organization in nanostructures is a consequence of assumed structures. These findings may help to understand a mechanism of AC function and take a next step in developing new techniques for its treatment.

Posters (continued)

5.

Bongsik Choi, Korea Advanced Institute of Science and Technology, Daejeon, Korea

Dynamics of two-dimensional homogeneous simple fluid: The generalized Langevin equation approach

Abstract: We present an extensive numerical study on the dynamics of i) homogeneous simple fluid system and ii) single diatomic particle interacting with simple fluid particles. The data obtained from the Molecular dynamics (MD) simulations were analyzed in terms of a generalized Langevin equation (GLE) of Mori type [1-2].

The memory kernel was estimated on the basis of the total force-momentum correlation functions and the total force auto-correlation functions both of which can directly be estimated from the MD simulation data, and the consistency of the obtained memory kernel and the fluctuating forces was tested in terms of the fluctuation-dissipation theorem.

One of the characteristic features of two-dimensional fluid is an existence of anomalous diffusive motion in intermediate density region where diffusion coefficient by the Green-Kubo relation becomes divergent [3].

On the other hand, if the fluid system moves to high density and low temperature, it is natural to expect that the system becomes solid and diffusion coefficient goes to zero.

Therefore, two-dimensional fluid system shows variety of diffusion behavior from anomalous- to subdiffusive motion.

Several previous works have studied on diffusion as well as viscosity including near disordering transition region for various model systems [4-8].

We first investigated the region of density and temperature where the fluid system exhibit anomalous, normal, and sub-diffusional behavior using both the Green-Kubo formula and the Einstein-Enkog relation. [9]

In the anomalous diffusion region, diffusion coefficient shows divergent behavior as time increases, whereas in the sub-diffusion region, it converges to zero.

Only in the normal diffusion region which is located between the anomalous- and sub-diffusion region in density vs. temperature plane, normal diffusive behavior, nonzero value of the diffusion coefficient are obtained.

According to the well known Einstein relationship, diffusion coefficient multiplied by friction coefficient is proportional to absolute temperature with the Boltzmann constant as the proportionality constant (kT). We show that certain relationship exists between the diffusion coefficient and the friction coefficient even in the anomalous diffusion region both analytical and numerical means.

From the GLE, we can derive the relationship between the diffusion coefficient obtained by time integration of the VACF and the friction coefficient obtained by time integration of the memory kernel. We predicted that if asymptotic behavior of each quantity fits to certain algebraic form, product of the two remains constant even in the anomalous diffusion region and furthermore this constant value is smaller than kT analytically. We confirmed from the numerically constructed GLE that both the diffusion coefficient and the friction coefficient satisfy algebraic forms, and product of the two agrees well with the analytically predicted value.

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Posters (continued)

6.

Michał Cieśla†, Paweł Karbowniczek‡, †Jagiellonian University, Kraków, Poland, ‡Cracow University of Technology, Kraków, Poland

Random packing of star-like objects

Abstract: We study the random sequential adsorption of unoriented star-like objects build from 3 to 50 hard one dimensional needles on flat two dimensional surface. We focus on understanding the kinetics of packing process described by a power law $\Theta_{max} - \Theta(t) \sim t^{-1/d}$. In our analysis, $-1/d$ exponents as well as a low density behavior are presented. Packing and its structure are analyzed by means of the jamming limit Θ_{max} and a radial two point autocorrelation function.

7.

Katarzyna Dziedzic-Kocurek, Michał Cieśla, Jan Stanek, Jagiellonian University, Kraków, Poland

Mobility of interacting inorganic nanoparticles

Abstract: The effective speed of life processes at the cellular level exceeds by few orders its value based on theoretical calculation, where classically evaluated efficiency of diffusional transport of the macromolecules in cytoplasm is applied. This problem has been partly, at least formally, solved in the last decade by introducing the concept of the "local" or "microscopic" viscosity η, which now becomes to be function of the radius of the migrating particles [1]. In fact, we have already shown, that submicrometer Fe_2O_3 particles in apparently solid gelatin gel exhibit robust Brownian movement [2]. Thus, the microscopic viscosity depends on the ratio of the size of migrating particles and the surrounding objects. In particular, if the diffusing particles are smaller than the structural blocs, for example amides vs. organelles in cells or Fe_2O_3 particles vs. collagen chains, for the bounded diffusion estimation the local viscosity of the medium should be applied.

We attempt to elucidate the influence of the interparticle interaction of hematite nanoparticles ($d = 120nm$) suspended in dense solute of sucrose on their Brownian movement [3]. It turned out that for the nanoparticle concentration $n = 40\mu m^{-3}$, which corresponds to the average interparticle distance about $250nm$, the mobility of the nanoparticles starts to slow down, as seen by narrowing of the Mössbauer spectra line width. The result is in an agreement with the hydrodynamic diameter ($d = 260(10)nm$) obtained by the DLS (Dynamic Light Scattering) measurement. This phenomena is explained by consideration of the adsorption of sucrose molecules on the hematite nanoparticles which increases their hydrodynamical radius and decreases the local viscosity of the solvent as well as with a simple theoretical model of Lorenz Gas in thermal bath.

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Posters (continued)

8.

Jana Čisárová, Jozef Strečka, Safarik University, Kosice, Slovak Republic

Exact solution of a coupled spin-electron linear chain composed of localized Ising spins and mobile electrons.

Abstract: Exact solution of a hybrid model on linear chain with localized Ising spins and mobile electrons is provided. With the use of the generalized decoration-iteration transformation the studied hybrid model is mapped onto an effective spin-$1/2$ Ising model on a linear chain, which is then solved exactly using the transfer-matrix method. The groundstate phase diagram is obtained as a function of chemical potential and kinetic energy of the mobile electrons. In addition, the temperature dependencies of several thermodynamic properties (electronic density, compressibility and specific heat) are discussed for various values of the chemical potential. The ground state phase diagram reveals existence of three phases with different number of mobile electrons per unit cell, one of which is ferromagnetic, one is paramagnetic and one is antiferromagnetic. For the parameters from the vicinity of the ground-state boundaries the specific heat curves with up to four peaks are observed.

Posters (continued)

9.

Rogelma Ferreira, Universidade Federal do Recôncavo da Bahia, Bahia, Brazil

Pattern-non-pattern transition for a nonlocal population dynamics

Abstract: The processes of self-organization in populations are currently of great importance to understand the patterns of growth, migration, interaction and evolution in ecological systems [1,2]. A fundamental understanding of these processes is the dynamic nature of the pattern-no-pattern transition, which needs to be better investigated. In this work we construct a new approach to describe the dynamics of this transition in populations from a thermodynamic order parameter point of view. We based on a different look on the pattern-no-pattern transition as function of non homogeneity of the individuals in a population. These different densities define an order parameter that effectively shows the presence of patterns in the system. By adopting this new order parameter the study of patterns in populations can be quantified and predicted through the non-uniformity of population density function. This method can be useful for experimental measurements in this field while approaches this phenomenon of the conventional idea of phase transition [3].

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Posters (continued)

10.

Jakub Gac, Warsaw University of Technology, Warszawa, Poland

Extraction of stochastic dynamics from persistent and antipersistent time series with persistence parameter varying in time

Abstract: We present a method for the reconstruction of the dynamics of processes with discrete time. The time series from such a system is described by a stochastic recurrence equation, the continuous form of which is known as the Langevin equation. The deterministic f and stochastic g components of the stochastic equation are directly extracted from the measurement data with the assumption that the noise has finite moments and has a zero mean and a unit variance. This method has been presented in our last papers [1,2]. In present work we analyze the persistent and antipersistent time series [3]. That means that the noise terms present in stochastic data are not independent but are characterized by the Hurst exponent different from 0.5 (or persistence parameter, defined in [3], different from 1). Moreover, we take into account the situation when the Hurst exponent and persistence parameter vary in time. As an example of the application of our method to real data, the results for human heart rate variability are presented while HRV seems to posses the properties of stochastic time series with varying persistence parameter.

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11.

Boris Grafov, Institute of Physical Chemistry and Electrochemistry of Russian Academy of Sciences, Moscow, Russia

Non-asymptotic form of the Einstein stochastic diffusion equation

Abstract: The Fokker–Planck representation of Brownian motion is dual [1]. On one hand we have the Fokker–Planck equation for velocity of Brownian particle. On the other hand we have the Fokker–Planck equation for position (spatial co-ordinate) of Brownian particle. The last equation is often named the Einstein stochastic diffusion equation (ESDE). With respect to time the ESDE is an asymptotic equation. The aim of this report is to find the non-asymptotic form of ESDE. The non-asymptotic form of ESDE is of interest for the first passage time theory [2] and for the general theory of Brownian motion near equilibrium [3]. Author is grateful to Russian Foundation for Basic Research for their supporting the electrochemical noise investigations (project no. 14-03-00332-a).

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Posters (continued)

12.

Krzysztof Iskra[†], Marek Siłuszyk[†], Michael V. Alania[†,‡], [†]Siedlce University, Siedlce, Poland, [‡]Tbilisi State University, Tbilisi, Georgia

On the structure of the interplanetary magnetic field turbulence and long period variations of the galactic cosmic rays

Abstract: The relationship of the rigidity spectrum of the Galactic Cosmic Rays (GCR) intensity variations determined by the exponent γ and the structure of the interplanetary magnetic field (IMF0 turbulence have been investigated using data of neutron monitors and the components B_x, B_y, B_z of the IMF for the period of 1967-2012.

The exponent ν of the power spectral density of the IMF turbulence in the range of the frequencies $10^{-6}-10^{-5}$ Hz increases when the rigidity spectrum of the GCR intensity variations is hard and decreases when it is soft. A correlations between rigidity spectrum exponent γ exponent ν and average amplitude P of the power spectrum density (PSD) of the IMF turbulence in different periods of solar activity have been found. These features should be caused by the essential rearrangement of the structure of the IMF turbulence during the 11-year cycle of solar activity. The changes of the IMF turbulence can be considered as one of the important reasons of the 11-year variation of the GCR intensity for the energy > 1 GeV.

We use data of the all components B_x, B_y, B_z of the IMF for the considered period to calculate the exponent ν and power P of the PSD of the IMF. We assume that the changes of the turbulence of the IMF in the range of frequencies $10^{-6} - 10^{-5}$ Hz (responsible for the scattering of the GCR particles of the energy 5-50 GeV) and the module of the IMF versus solar activity are considered as the general reasons of the long period variations of the GCR intensity.

The properties of the Probability Distribution Function (PDF) of the IMF strength differences $\delta B\tau = B(t+\tau) - B(t)$ over varying time scales $\tau = 1, 2, 3, 4, 5, \ldots$ days are studied. We found that at large time scales $\tau > 4$ days the skewness and kurtosis of the PDF of the IMF turbulence almost equal zero so, one can state that the PDFs are almost Gaussian and anisotropy and inhomogeneous of the IMF turbulence at first approximation can be ignored.

As a result, in this case IMF turbulence could be fully described by the parameters of PSD; the power P and the exponent ν successfully could be used to calculate diffusion coefficient according to the quasi linear theory. We show that the parameters of the PSD of the IMF have the 11-year cycling character and play a important role in configuration of the long period variations of the GCR intensity.

Posters (continued)

13.

Michał Jarema, Wrocław University of Technology, Wrocław, Poland

Poling of octupolar molecules: concepts and perspectives

Abstract: The use of organic molecules of multipolar (and in particular octupolar) symmetry in nonlinear optics, proposed by Joseph Zyss in 1991, has opened a new path in molecular engineering toward avoiding limitations of dipolar systems. However, inducing non-centrosymmetric ordering of multipolar molecules lacking dipole moment presents a challenge and requires finding relevant symmetry-adapted orienting schemes. A scheme based on electrostatic field poling of octupolar molecules in nano-scale (nano-octupoling) was discussed recently in works of Zyss, Mituś and Pawlik. A study of a two-dimensional model of poled non-interacting octupoles predicts the effective ordering to vanish at temperatures above millikelvin range, which precludes experimental realization of nano-octupoling at room temperatures.

The current work summarizes recent studies oriented onto relaxing current demanding poling conditions. The work has a methodological aspect of exploring and modeling different possibilities of improvement. However, a constant attention is given to the quantitative technological limitations in attempt to predict conditions for experimental realization.

Conditions for obtaining homogeneously ordered octupolar phase in the ground state have been found, what is promising for obtaining orientational order at higher temperatures. Different sources of poling potentials as well as different symmetries of multipolar molecules are examined. Also the possibility of relaxing poling conditions by a slight breaking of octupolar symmetry is discussed. The comparison of energy scales reveals the importance of intermolecular interaction. The electrostatic interactions are studied by analytical statistical mechanics methods, accompanied by on- and off-lattice Monte Carlo simulations, carried out for a range of densities and temperatures. The possible improvements of the model, by accounting for interaction with the surrounding complex-system polymer matrix are discussed.

14.

Agnieszka Kaczkowska, University of Gdańsk, Gdańsk, Poland

Modeling heart rate regulation in patients after heart transplantation by Seidel-Herzel model of baroreflex

Abstract: Modeling heart period variability provides insights into the role played by various systems regulating the timing of subsequent heart contractions. The well-known model, proposed by Seidel and Herzel in 1995, allows to enclose in a loop the traffics from baroreceptors with the efferent nerves of autonomic nervous system. In particular, the model considers auto- nomic system impact (of vagal and sympathetic parts separately) to a phase of a heart contraction.

Under absence of direct sympathetic and vagal communication to the heart in a patient after the heart transplantation, the heart rhythm is driven by effects of respiration (i.e., pulmonary volume change) and circulating catecholamines with the blood (which presence results from sympathetic activation in adrenal medulla and in blood vessels). Including of these phenomena into the Seidel-Herzel model can help us to understand the influence of so- called intrinsic heart variability on the overall heart period variability.

Posters (continued)

15.

Paweł Karbowniczek, Cracow University of Technology, Kraków, Poland

Random sequential adsorption of elongated objects composed of hard needles

Abstract: We present the random sequential adsorption (RSA) of unoriented objects composed of hard needles on a two-dimensional substrate. In our study, we consider boomerang and z-shaped particles. In the asymptotic time regime the particle density exhibit a power law behavior $\rho(t) \sim t^{\alpha}$, rather than the Feder's law, since hard needles have no jamming limit. Our investigations show strong influence of the internal angles of complex particles on the α exponent. Furthermore, we demonstrate packing structure by analyzing the radial distribution function g(r) and a low density behavior of the adsorption probability function.

16.

Anna Kharcheva, Lobachevsky State University, Nizhni Novgorod, Russia

The correlation time of stationary superdiffusion in the form of Lévy flights in bistable symmetric quartic potential

Abstract: As well known, the anomalous diffusion in nonlinear dynamical systems subjected to noise with Lévy stable distribution is called Lévy flights and can be described by Fokker-Planck equation with the fractional space derivative. Unlike the usual Brownian diffusion, the stationary probability density functions of Lévy flights even in monostable potentials are bimodal, and, starting with the quartic potential, the variance of particle displacement is finite. In such a situation, in principle, one can find the correlation function and the power spectral density of superdiffusion in a steady state and, in particular, the correlation time. However, analytical calculations of temporal characteristics of Lévy flights meet some difficulties because the Markovian theory of first-passage times assumes the presence of some boundary conditions which are not so evident for discontinuous Markovian process having long jumps. Based on the method, described in [1-2], and the form of stationary probability density function, recently found in [3], from the fractional Fokker-Planck equation we arrive at the exact equation to calculate the correlation time of steady-state Lévy flights in bistable symmetric quartic potential. The exact analytical solution of resulting third-order differential equation in Fourier image can be obtained only in the case of driven noise with Cauchy stable distribution. As our analysis shown, the correlation time of stationary Lévy flights decreases with increasing both the noise intensity and the steepness of a potential according to a power law. A comparison with the result for monostable symmetric quartic potential [2] confirms our calculations, and a role of potential barrier on this temporal parameter is revealed.

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Posters (continued)

17.

Tadeusz Kosztołowicz, Jan Kochanowski University, Kielce, Poland

Boundary conditions at a thin membrane for the process of particles' transport describing by a fractional subdiffusion equation

Abstract: Subdiffusion is a particular case of anomalous diffusion. It occurs in media in which particles' movement is hindered due to the internal structure of a medium such as, for example, in gels or porous media [1]. The microscopic model of subdiffusion which describes the movement of a single particle is based on the assumption that the average waiting time for a particle to take its next step is infinite. Equations describing subdiffusion are partial differential equations with a fractional time derivative [2]. It turned out that boundary conditions at a partially permeable wall (which represents a thin membrane) have not been determined unambiguously for the fractional subdiffusion equation [3,4]. A method for derivation of Green's function (that is the time evolution of a probability density of finding a particle at a particular point in the system) for one-dimensional diffusive system with a thin membrane is presented. To this end, the model of particle's diffusion in the membrane system based on difference equations describing particle's random walk with both discrete time and space variables is used. After finding the generating function for these equations we translate discrete variables into continuous variables under assumption that the membrane thickness is small but finite. Next, we derive the boundary conditions at a thin membrane using Green's function. Then, we use these boundary conditions in order to determine solutions to the fractional subdiffusion equations for the chosen initial conditions. We also present the possibilities of using the obtained functions in modeling subdiffusive processes in biological systems.

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Posters (continued)

18.

Natalia Kruszewska†, J. Miguel Rubi‡, Adam Gadomski†, †University of Technology and Life Sciences, Bydgoszcz, Poland, ‡Universitat de Barcelona, Barcelona, Spain

Entropy driven channel activation process

Abstract: Looking at polycrystal grain growth as a process depending on motions of unreacted particles (of nano- or mesoscale) randomly moving between matured grains, and as a process depending on geometry of the grains [1], we expect that Fick-Jacobs transport equation [2,3], with confinements, can be helpful in understanding the properties of many (soft-matter) polycrystal materials in terms of dynamics, viscoelasticity, thermal or electrical conductivity, etc. The motions of unreacted particles can be stated as free-energy driven diffusion process characterized by a presence of entropic barriers which can be described, in probabilistic way, by mesoscopic non-equilibrium thermodynamics (MNET)[2,3]. This approach provides a derivation of a generalized Fick-Jacobs formula for the constrained dynamics of the mesoscopic degree of freedom. In [3] Rubí and Reguera have shown that entropically originating confinement can be involved into MNET in natural way in a definition of chemical potential. Basic confinements in the problem of particles' motion between growing grains are grain boundaries, thus, local curvatures emerging during the grain growth [1]. Grain boundaries create sometimes narrow (funnel-like) and sometimes wide channels. When a particle push through the channel, the channel can be opened or closed for the passage; for some analogy, see [4]. A state, when the channel starts to be opened for such a passage, is called activation. A very interesting problem to take on is to apply the Fick-Jacobs transport equation to the channel activation process which takes place in such confined by grain boundaries media. We show how the activation depends on a size of the channel, a characteristic angle of the "funnel", energy supplied to the randomly walking particles, etc.

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Posters (continued)

19.

Katarzyna D. Lewandowska†, Tadeusz Kosztołowicz‡, Mateusz Piwnik‡, †Medical University of Gdańsk, Gdańsk, Poland; ‡Institute of Physics, Jan Kochanowski University, Kielce, Poland

Subdiffusion-reaction process with $A \to B$ reactions versus subdiffusion-reaction process with $A + B \to B$ reactions

Abstract: We consider subdiffusion-reaction process with reactions of a type $A+B \to B$ in comparison to the subdiffusion-reaction process with $A \to B$ reactions which was studied by I.M. Sokolov, M.G.W. Schmidt, and F. Sagués in *Phys. Rev. E* **73**, 031102 (2006). In the first process we assume that particles A are mobile whereas B — static and that particles B are distributed homogeneously. In both processes a rule that reactions can only occur between particles which continue to exist is taken into account. Although in both processes a probability of the vanishing of particle A due to a reaction is independent of both time and space variables we show that subdiffusion-reaction equations describing these processes as well as their Greens' functions are qualitatively different. The reason for this difference is as follows. In the case of the former reaction, particles A and B have to meet with some probability before the reaction occurs in contradiction with the case of the latter reaction. We base the method considered in this paper on a random walk model in a system with both discrete time and space variables. Then, the system with discrete variables is transformed into a system with both continuous time and space variables. As an example we use these models to find the Greens' functions for a subdiffusive-reaction system which is bounded by a partially absorbing wall. This example shows how the model can be used to analyze the subdiffusion-reaction process in a system with partially absorbing or reflecting thin membranes. Employing a simple phenomenological model, we also derive equations related to the reaction parameters used in the considered models.

20.

Marek Litniewski, Institute of Physical Chemistry PAN, Warszawa, Poland

Relative diffusion in two dimensions. Breakdown of the standard diffusive model for simple liquids

Abstract: Using molecular dynamics simulations for a liquid of identical soft spheres we analyze [1] relative diffusion constant $D_{\Sigma n}(r)$ and the self diffusion constant D_n where r is the interparticle distance and $n = 2, 3$ denotes the dimensions number. We demonstrate that for the periodic boundary conditions, D_n is a function of the system size and the relation: $D_{\Sigma n}(r = L/2) \approx D_n(L)$, where L is the length of the cubic box edge, holds both for $n = 2$ and 3. The simulations show also that for $n = 2$ both $D_{\Sigma n}(r)$ and $D_2(L)$ increase logarithmically with its argument. According to both theoretical and simulation models $D_2(L \to \infty)$ should diverge [2] question this result. However, we found that the diffusive process for large two dimensional systems is very sensitive to perturbations. The sensitivity increases with L and even a very low perturbation limits the increase of $D_2(L \to \infty)$. Due to the functional form of $D_{\Sigma 2}(r)$ the standard assumption for the Smoluchowski type models of reaction kinetics at three dimensions: $D_{\Sigma n}(r) \approx 2D_n(L)$ leads to giant errors if applied for $n = 2$.

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Posters (continued)

21.

Maria Antonietta Lodato, Dominique Persano Adorno, Nicola Pizzolato, Bernardo Spagnolo, University of Palermo, Palermo, Italy

Noise can enhance stability in Si bulk?

Abstract: In recent years, an increasing interest has been directed towards the possible constructive influence of noise and fluctuations on the dynamical response of different nonlinear systems, focusing on cooperative effects between the external noise and the intrinsic interactions of the systems. Indeed, previous theoretical investigations have shown that, under specific conditions, the addition of external fluctuations to systems, characterized by the presence of intrinsic noise, may affect the dynamics of the system in a counterintuitive way, inducing an enhancement of stability and resulting in a less noisy response [1]. This possibility has been successfully explored, for example, in the dynamics of magnetic spin systems [2] and in the electron spin relaxation process inside semiconductor structures [3]. The possibility of reducing the electronic diffusion noise, by adding a random fluctuating contribution to the driving oscillating electric field, has been found in III-V semiconductor crystals [4], whereas this opportunity, to the best of our knowledge, has not been yet tested in covalent semiconductor materials.

Aim of the present work is to investigate the noise-induced effects on the electron transport dynamics in low-doped n-type Si crystals. To simulate the dynamics of electrons in the bulk, by taking into account the band structure, the scattering processes, as well as the heating effects, a Monte Carlo approach is used. The effects caused by the addition of an external noise source are investigated by studying the modifications in the correlation function of electron velocity fluctuations and in its spectral density. The system is driven by a high-frequency periodic electric field in the presence of two different kind of external fluctuations: a Gaussian correlated or a Random Telegraph noise source.

Our findings show that, critically depending on the external noise features, the dynamical response of electrons driven by the periodic electric field can benefit from the constructive interplay between the fluctuating field and the intrinsic noise of the system. In particular, we found that also in Si bulk the presence of the fluctuating component can reduce the total noise power up to 10% in a wide range of noise amplitude. Furthermore, we found a non-linear behavior of the integrated spectral density with characteristic times.

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Posters (continued)

22.

Maciej Majka, Jagiellonian University, Kraków, Poland

Versatile analytical theory for effective interactions in binary colloids

Abstract: The efficient and general method of predicting effective interactions in binary colloids with arbitrary interactions is still an open problem. Existing theories, stemming from DFT and closure relations techniques are accurate, but usually simulation dependent. We propose a new analytical method to predict effective interactions for binary systems with a general choice of big-small and small-small interaction potentials. Our method is based on translating the two-component partition function into path-integral problem leading to multiple Gaussian integrals. Analyzing the resultant expressions we identify a relatively simple contribution which is able to reproduce many desired characteristics of binary systems. Our approach is applicable for interactions which have a well-defined Fourier Transforms. We present our results in application to several model binary systems, which satisfy this condition. One system is the mixture of Gaussian particles for which the effective interaction as a driving force for de mixing is analyzed. Similar results are indicated for binary mixtures of Yukawa particles, which is another system under scrutiny. Finally, we reproduce the 'repulsion-through-attraction' and 'attraction-through-repulsion' effects for binary mixtures of hard-core particles with repulsive/attractive Yukawa interaction tails.

23.

Aneta Michna[†], Michał Cieśla[‡], Zbigniew Adamczyk[†], [†]IKiFP Polish Academy of Sciences, Kraków, Poland, [‡]Jagiellonian University, Kraków, Poland

The replacement of adsorbed PDAMAC molecules by positively charged latex particles - pseudo-Vroman effect

Abstract: The adsorption of positively charged latex particles on mica covered by cationic polyelectrolyte poly(diallyldimethylammonium chloride) (PDADMAC) was studied experimentally and theoretically. Initially, the bulk characteristics of the PDADMAC and latex particles were acquired using the DLS and microelectrophoretic measurements. From these measurements, the hydrodynamic diameters, zeta potentials as well as the amounts of electrokinetic charges per polyelectrolyte molecule or particle were calculated as the function of ionic strength. Subsequently, the kinetics of adsorption of PDADMAC and polystyrene particles on bare mica were evaluated under in situ conditions using the streaming potential measurements. The latter allowed one to derive the calibration dependencies of the zeta potentials of mica covered by positive particles or positive polyelectrolyte on the particle / polyelectrolyte coverages, respectively. Using these data, the replacement kinetics of positive PDADMAC molecules by positive latex particles were quantitatively analyzed in ionic strength 10-2 M and pH 5.8. Furthermore, the dependence of zeta potential of mica covered by PDADMAC-latex layer as a function of PDADMAC coverage was determined.

It was concluded that the earlier adsorbed PDADMAC macromolecules were displaced by less mobile latex particles on the mica surface. This mechanism was additionally supported by simple theoretical model based random sequential adsorption of bimodal mixtures. Furthermore, our investigations proved that the streaming potential method is a useful tool for determining physicochemical characteristics of polyelectrolyte and particle monolayers on solid surfaces.

Posters (continued)

24.

Dominique Persano Adorno, Piero Alaimo, Nicola Pizzolato, Bernardo Spagnolo, University of Palermo, Palermo, Italy

Noise induced phenomena in InP semiconductors

Abstract: The results of a study concerning the intrinsic noise in low-doped n-type InP crystals operating under fluctuating electric fields are shown. To simulate the dynamics of electrons in the bulk, we employ a Monte Carlo approach, by taking into account the main details of band structure, scattering processes, as well as heating effects. The noise features are investigated by computing the velocity fluctuations correlation function, its spectral density and the total noise power, for different values of amplitude/frequency of the driving field and for different parameters of the external noise source. Preliminary findings obtained in InP crystals driven by an electric field fluctuating for the superimposition of a correlated noise source are discussed and compared with those previously obtained in GaAs bulks. Our results confirm that the diffusion noise in low-doped semiconductors can be reduced by the addition of a fluctuating component to the driving electric field, but this effect critically depends on the characteristic times of the external noise. In particular, the correlation time of the electric field fluctuations is crucial for the noise reduction effect giving rise to a Stochastic Resonance like phenomenon.

25.

Mateusz Piwnik[†], Tomasz Klinkosz[‡], Tadeusz Kosztołowicz[†], Katarzyna D. Lewandowska[‡], [†]Jan Kochanowski University, Kielce, Poland, [†]Medical University of Gdańsk, Gdańsk, Poland

Subdiffusive model of released substance from a cylindrical medium

Abstract: We study a process of released substance from a medium in the shape of cylinder. In both the cylinder and a surrounding medium occurs subdiffusion. The theoretical model uses the linear partial differential equations with a fractional time derivative and specific boundary conditions at the cylinder surface. We obtain concentration profiles and a time evolution of an amount of substance which released from the cylinder. We also briefly discuss the obtained results.

26.

Grzegorz Sikora, Wrocław University of Technology, Wrocław, Poland

Fractional processes in experimental data modeling

Posters (continued)

27.

Marek Siłuszyk[†], Krzysztof Iskra[†], Michael V. Alania[†,‡], [†]Siedlce University, Siedlce, Poland, [‡]Tbilisi State University, Tbilisi, Georgia

Estimation of the rigidity spectrum of the stochastic variations of the galactic cosmic ray intensity

Abstract: We have considered the exponents ν_y and ν_z of the power spectral density (PSD) of the B_y and B_z components of the interplanetary magnetic field (IMF) turbulence ($PSD \sim f^{\nu}$, where f is a frequency). The exponents ν_y and ν_z were calculated in the resonant frequency range $\Delta f = f_2 - f_1 = 3 \times 10^{-6}$ ($f_1 = 1 \times 10^{-6}$Hz, $f_2 = 4 \times 10^{-6}$Hz), responsible for the scattering of GCR particles to which neutron monitors respond.

Data of neutron monitors have been used to calculation exponent γ of the power law rigidity R spectrum ($\delta D(R)/D(R) \propto R^{-\gamma}$) of the galactic cosmic ray (GCR) intensity variations.

Base on the strong inverse correlations between γ and ν_y and between γ and ν_z we find rigidity spectrum of the long-period variations of the galactic cosmic ray intensity in minima epoch of solar activity

We believe that inverse relations between changes of γ and ν_y and between γ and ν_z as a universal feature in descending and ascending epoch of solar activity.

28.

Małgorzata Snarska[†], Michał Cieśla[‡], [†]Cracow University of Economics, Kraków, Poland, [‡]Jagiellonian University, Kraków, Poland

Simple trading model with wealth condensation

Abstract: Understanding the mechanisms beneath wealth inequalities in modern markets is still cumbersome for many financial and economic models, where choices of rational investors follow utility theory and markets are efficient in a way they do not allow any further gains from trade. In reality however perfect rationality paradigm is rarely present. Investors' utilities are usually range dependent. In this poster we use Kahneman and Tversky Prospect Theory (1979), ie. allow some set of investors to behave less rationally and show how this simple agent based model with deterministic trading rules leads to a pareto-like wealth distribution.

Posters (continued)

29.

Jakub Spiechowicz, University of Silesia, Katowice, Poland

Brownian motors in micro-world: Enhancement of efficiency by noise

Abstract: We propose a noisy dc drive mechanism for efficiency enhancement of Brownian motors operating in the micro-scale domain. We show that biased noise $\eta(t)$ can induce normal and anomalous transport processes of similar kind as a static force F transporting inertial Brownian particles in a *symmetric* periodic structure and subjected to a *symmetric* unbiased time-periodic driving. However, within selected parameter regimes, noise $\eta(t)$ of the mean value $\langle\eta(t)\rangle = F$ can be several times more effective than the deterministic load F, both in normal and anomalous transport regimes. The suggested strategy to replace F by $\eta(t)$ may provide a new operating principle in which micro- and nanomotors could be powered by biased noise.

30.

Bartlomiej J. Spisak, Maciej Wołoszyn, AGH University of Science and Technology, Kraków, Poland

Dynamical localization of quantum states in the one-dimensional disordered environment. View from the phase-space perspective

Abstract: The dynamics of the quantum states in the one-dimensional disordered environment can be described by the kinetic equation for the Wigner function which mimics the distribution function in the phase-space, although it takes on both positive and negative values. The phase-space approach is applied to study the dynamics of gaussian wave packets in systems with random distribution of scattering centres described by a set of delta functions which form a disordered potential. The gaussian wave packet injected into the system is scattered by disordered potential and its time evolution generates negative values of the Wigner function in some regions of the phase-space. These negative values can be regarded as a manifestation of the correlation between different regions of the phase-space occupied by the Wigner function and they are treated as an indicator of non-classicality of the state. In this contribution we discuss the effect of the correlation on the dynamical localization of the gaussian wave packet.

31.

Jozef Strečka, Safarik University, Kosice, Slovak Republic

Thermal entanglement of the exactly solved spin-$1/2$ Ising-Heisenberg orthogonal-dimer chain

Abstract: The spin-$1/2$ Ising-Heisenberg orthogonal-dimer chain is exactly solved by combining a partial trace over spin degrees of freedom of the horizontal Heisenberg dimers with computation procedure based on the transfer-matrix technique. The ground-state phase diagram of the considered quantum spin chain constitute a few quantum phases with a non-zero bipartite entanglement along with a few unentangled classical phases. The concurrence is rigorously calculated for the horizontal Heisenberg dimers in order to quantify the relevant bipartite entanglement at zero as well as non-zero temperatures. While the maximal entanglement is detected in the quantum antiferromagnetic ground state characterized by a tensor product over singlet-dimer states, the entanglement measures vary continuously over the parameter region inherent to a more peculiar modulated antiferromagnetic ground states. In addition, it is shown that the concurrence displays a marked temperature dependence for both non-trivial quantum ground states, which exhibit a very different threshold temperature above which the thermal entanglement disappears.

Posters (continued)

32.

Anna Strzelewicz[†], Monika Krasowska[†], Gabriela Dudek[†], Aleksandra Rybak[†], Michał Cieśla[‡], [†]Silesian University of Technology, Gliwice, Poland, [‡]Jagiellonian University, Kraków, Poland

Structure and transport properties of polymeric membranes with different granulation of magnetic powder

Abstract: Membranes with polymeric matrix and magnetic powder are investigated. Examined membranes are inhomogeneous i.e. there are some molecular clusters of different size which definitely can influence the membrane properties. The transport properties of membranes depends on many parameters such as: used polymeric matrix, type of powder, its amount and granulation. Structure of pattern formed by magnetic particles in membrane matrix is studied. Description of the system bases on the phenomenological, and molecular (random walk on a fractal lattice) approaches. Two parameters are calculated: the fractal dimension of the random walk d_w, and the fractal dimension of the membrane structure d_f. The research have been carried out to determine the influence of granulation of magnetic powder dispersed inside of the membrane on the transport properties.

33.

Jakub Ślęzak, Wrocław University of Technology, Wrocław, Poland

Recognition of the diffusion change for short-length data

Abstract: Our research was motivated by the data comprising trajectories of G-protein coupled receptors. These trajectories are very short and have non-stationary increments, which impedes their statistical analysis. In order to deal with this difficulty we propose a methodology which allows for detection of the trapping, change of diffusion constant and other properties significant in analysis of particles' interactions even for short recordings. Our approach is general and can be used in analysis of wide range of physical systems.

34.

Viliam Štubňa, Safarik University, Kosice, Slovak Republic

Exact results for a mixed spin $1/2$ and $3/2$ Ising model with multi-spin interactions

Abstract: In this contribution we investigate the influence of many-body interaction in the Ising model with mixed spin-$1/2$ and spin-$3/2$ on a decorated square lattice. For this purpose, except of the conventional pair interaction, the multi-spin interaction involving three lattice sites is taken into account. Influence of a single ion anisotropy is also included. Using a generalized form of decoration – iteration transformation we have obtained the mapping relation to Onsager's partition function for the simple square lattice. Based on this result we have derived exact results for all relevant physical quantities of our system. In this work we mainly analyze numerical results for phase diagrams and we also investigate some interesting physical features of ordered and disordered phases observed in the system.

Posters (continued)

35.

Paulina Trybek[†], Mateusz Rubinkiewicz[‡], Michał Nowakowski[‡], Łukasz Machura[†], [†]University of Silesia, Katowice, Poland, [‡]Collegium Medicum, Jagiellonian University, Kraków, Poland.

Multifractal analysis of sEMG signal of the complex muscle activity

Abstract: We propose the Multifractal Detrended Fluctuation Analysis (MDFA) for description of the properties of the kinesiological surface electromyographic signals (sEMG). We consider the signals obtained from three states of the muscle activity: at maximum contraction, during complex movements (at actual work) and in the relaxed state. In addition the difference between the well trained person and an amateur is presented. We set together the signals from an amateur and a professional, both performing complex movements on a laparoscopic trainer. Based on the parameters describing multifractal spectra like the Hurst exponent or the spectrum half-width we demonstrate the dissimilarity between each state of work for the selected group of muscles.

36.

Agata Wawrzkiewicz, Silesian University of Technology, Gliwice, Poland

On the structural-based modeling of the BK channel gate activity

Abstract: We consider modeling of the gating dynamics of the voltage and Ca^{2+}-activated potassium channels (BK). Models found in literature describe well main characteristics of the channel gate activity, however they are formulated without direct reference to the details of channels' structure. The main aim of the current work is to examine thoroughly BK channel structure and propose a model, where components corresponding to main channel subunits involved in gating mechanism are implemented. This approach renders simplicity in interpretation of model assumption and limits the number of parameters. The model is anticipated to describe properly dwell-time distributions, mean durations of channel states at different channel activation levels, and long-term memory effect measured by the Hurst R/S analysis, to boot.

37.

Dorota Wejer, University of Gdańsk, Gdańsk, Poland

Transfer of information between heart period intervals and systolic blood pressure for recordings obtained from the head-up tilt

Abstract: The head-up tilt table test is an accepted method for provoking the activation of main cardiovascular regulatory mechanisms. The test is dynamic and therefore demands dynamical methods to measure interactions in the cardiovascular system. In particular, observation of the development of the vasovagal syncope provides valuable insights into the phenomenon of the cardiovascular regulation. We suggest a measure of causal relationships between changes of heart period intervals (ΔRR) and systolic blood pressure (SBP) based on the information, i.e. transfer entropy. Transfer entropy is based on dynamic information and detects asymmetry in the interaction of subsystems, especially influence of SBP on ΔRR. It could be non-invasive measure of the baroreflex gain. Time series SBP and ΔRR are represented by symbolic dynamics. Significant differences are observed in the dynamical response to the tilt test of healthy subjects prone to spontaneous fainting and those who are less susceptible to fainting.

Posters (continued)

38.

Marcin Zagórski, Institute of Science and Technology, Klosterneuburg, Austria

Quantifying positional information in neural tube development

Abstract: In early vertebrate development, different types of neurons are specified in the neural tube. The emerging spatial dorsoventral pattern of neural progenitor domains is controlled by morphogens - signaling molecules which are secreted by cells in restricted source regions at the boundaries of the neural tube. These morphogens form a graded concentration profile across the tissue and result in the graded activation of downstream signaling effectors. These signaling activity gradients provide the target cells with positional information about the distance from the morphogen source. Based on experimentally measured profiles of two opposing morphogen signaling gradients we quantify the positional information available to the cells in the neural tube at different stages of development. Specifically, we estimate the mutual information between ventrally secreted Shh and dorsally secreted BMP by using both direct and Gaussian approximation techniques. We conclude that morphogen signals provide the highest precision early in development and the amount of information available to the differentiating cells decreases over time.

39.

Yani Zhao, University of Szczecin, Szczecin, Poland

Thermal properties of polymer knots in the presence of short-range interactions

Abstract: Polymer rings forming complex topological configurations are studied in connection with several applications ranging from biochemistry to mechanical engineering. A brief account on the latest experimental results in the subject will be reviewed. The most difficult problem in dealing with the statistical mechanics of polymer knots is to distinguish their topological configurations. In this talk the results of extensive simulations of single polymer knots on a simple cubic lattice and with lengths up to thousand segments will be presented. To equilibrate the knots and for the Monte Carlo sampling, which is based on the Wang-Landau algorithm, a set of pivot moves is used. To preserve the topology of the knots after each move, two recently developed techniques have been employed. One is the so-called PAEA method. It is able to detect the changes of topology exactly and is very fast. The other method uses the Vassiliev knot invariant of degree 2 represented in the form of contour integrals. This invariant has the great advantage of allowing large pivot moves, which are able to accelerate the Monte Carlo sampling procedure. As an application of these methods, the calculation of the specific energy, the radius of gyration and the heat capacity of several types of polymer knots in a solution with poor or good solvents will be presented. Some consequences on the thermodynamics of polymer knots will be drawn. The problem of sampling certain rare knot conformations and of detecting pseudo phase transitions associated with these conformations will be discussed. A comparison with the previously known result will be made.

Posters (continued)

40.

Tomasz Żórawik, Marcin Magdziarz, Wrocław University of Technology, Wrocław, Poland

Stochastic representation of generalized Fokker-Planck equations

Abstract: Fractional Fokker-Planck equation plays an important role in modeling subdiffusive dynamics. In this presentation we consider a generalized version of this equation, with an arbitrary distribution of both increments and waiting times. A multi-dimensional setting is also analyzed. We show that in the case of space-time-dependent drift, diffusion coefficients and a time-dependent jump coefficient the corresponding stochastic process can be obtained by subordinating a system of Langevin equations driven by appropriate Brownian and Lévy noises. We present results of computer simulation of sample paths.

List of participants

Celia Anteneodo	Rio de Janeiro, Brazil	celia.fis@puc-rio.br
Michał Balcerek	Wrocław, Poland	mbalcerek@poczta.onet.pl
Jakub Barbasz	Kraków, Poland	ncbarbas@cyf-kr.edu.pl
Fernando Barbosa	Brasília, Brazil	fb3n@yahoo.com.br
Piotr Bełdowski	Bydgoszcz, Poland	piobel000@utp.edu.pl
Sergey Bezrukov	Bethesda MD, USA	bezrukos@mail.nih.gov
Alfio Borzi	Würzburg, Germany	alfio.borzi@mathematik.uni-wuerzburg.de
Kzysztof Burnecki	Wrocław, Poland	krzysztof.burnecki@pwr.edu.pl
Aleksei Chechkin	Kharkov, Ukraine Dresden, Germany	achechkin@kipt.kharkov.ua
Bongsik Choi	Daejeon, Korea	tych010@gmail.com
Michał Cieśla	Kraków, Poland	michal.ciesla@uj.edu.pl
Jana Čisárová	Kosice, Slovakia	jana.cisarova@upjs.sk
Alexander Dubkov	Nizhni Novgorod, Russia	dubkov@rf.unn.ru
Bartlomiej Dybiec	Kraków, Poland	bartek@th.if.uj.edu.pl
Franco Ferrari	Szczecin Poland	franco@feynman.fiz.univ.szczecin.pl
Rogelma Ferreira	Bahia, Brazil	rogelma.maria@gmail.com
Henrik Flyvbjerg	Kongens Lyngby, Denmark	henrik.flyvbjerg@nanotech.dtu.dk
Andrzej Fuliński	Kraków, Poland	andrzej.fulinski@uj.edu.pl
Jakub Gac	Warszawa, Poland	j.gac@ichip.pw.edu.pl
Janusz Gajda	Wrocław, Poland	janusz.gajda@pwr.edu.pl
Piotr Garbaczewski	Opole, Poland	pgar@uni.opole.pl
Georg Gottwald	Sydney, Australia	georg.gottwald@sydney.edu.au
Paweł F. Góra	Kraków, Poland	pawel.gora@uj.edu.pl
Boris Grafov	Moscow, Russia	boris.grafov@yandex.ru
Ewa Gudowska-Nowak	Kraków, Poland	gudowska@th.if.uj.edu.pl
Krzysztof Iskra	Siedlce, Poland	iskra@uph.edu.pl
Michał Jarema	Wrocław, Poland	michal.jarema@pwr.edu.pl
Agnieszka Kaczkowska	Gdańsk, Poland	akaczkowska@mif.pg.gda.pl
Paweł Karbowniczek	Kraków, Poland	pkarbowniczek@ifpk.pk.edu.pl
Eldad Kepten	Ramat Gan, Israel	eldad.kepten@biu.ac.il
Anna Kharcheva	Nizhni Novgorod, Russia	anya-kharcheva@yandex.ru
Gerald Kneller	Orléans, France	gerald.kneller@cnrs-orleans.fr
Tadeusz Kosztołowicz	Kielce, Poland	tadeusz.kosztolowicz@ujk.edu.pl
Natalia Kruszewska	Bydgoszcz, Poland	nkruszewska@utp.edu.pl
Krzysztof Kułakowski	Kraków, Poland	kulakowski@fis.agh.edu.pl
Michał Kurzyński	Poznań, Poland	kurzphys@amu.edu.pl
Łukasz Kuśmierz	Kraków, Poland	lukasz.kusmierz@uj.edu.pl
M. Howard Lee	Athens GA, USA	mhlee@uga.edu
Katarzyna Lewandowska	Gdańsk, Poland	kale@gumed.edu.pl
Marek Litniewski	Warszawa, Poland	mark@ichf.edu.pl
Lech Longa	Kraków, Poland	lech.longa@uj.edu.pl
Łukasz Machura	Katowice, Poland	lukasz.machura@us.edu.pl

List of participants (continued)

Marcin Magdziarz	Wrocław, Poland	marcin.magdziarz@pwr.edu.pl
Władysław Adam Majewski	Gdańsk, Poland	fizwam@ug.edu.pl
Maciej Majka	Kraków, Poland	maciej.majka@uj.edu.pl
Danuta Makowiec	Gdańsk, Poland	fizdm@univ.gda.pl
Paulo H. Lana Martins	Cuiaba, Brazil	pmartins@fisica.ufmt.br
Maciej A. Nowak	Kraków, Poland	nowak@th.if.uj.edu.pl
Fernando A. Oliveira	Brasília, Brazil	fao@fis.unb.br
Hyunggyu Park	Seoul, Korea	hgpark@kias.re.kr
Marta Pasenkiewicz-Gierula	Kraków, Poland	marta.pasenkiewicz-gierula@uj.edu.pl
Ryszard Piasecki	Opole, Poland	piaser@uni.opole.pl
Mateusz Piwnik	Kielce, Poland	mateusz_piwnik@o2.pl
J. Miguel Rubi	Barcelona, Spain	mrubi@ub.edu
Lutz Schimansky-Geier	Berlin, Germany	alsg@physik.hu-berlin.de
Grzegorz Sikora	Wrocław, Poland	grzegorz.sikora@gmail.com
Erica de Mello Silva	Cuiaba, Brazil	erica@fisica.ufmt.br
Marek Siłuszyk	Siedlce, Poland	marek.siluszyk@uph.edu.pl
Igor M. Sokolov	Berlin, Germany	igor.sokolov@physik.hu-berlin.de
Bernardo Spagnolo	Palermo, Italy	bernardo.spagnolo@unipa.it
Jakub Spiechowicz	Katowice, Poland	j.spiechowicz@gmail.com
Bartlomiej Spisak	Kraków, Poland	bjs@agh.edu.pl
Jozef Strečka	Kosice, Slovakia	jozef.strecka@upjs.sk
Zbigniew Struzik	Tokyo, Japan	zbi.struzik@gmail.com
Jakub Ślęzak	Wrocław, Poland	jakub.slezak@pwr.edu.pl
Viliam Štubňa	Kosice, Slovakia	viliam.stubna@student.upjs.sk
Paulina Trybek	Katowice, Poland	paulina.trybek@gmail.com
Constantino Tsallis	Rio de Janeiro, Brazil Santa Fe NM, USA	tsallis@cbpf.br
Agata Wawrzkiewicz	Gliwice, Poland	agata.wawrzkiewicz@polsl.pl
Dorota Wejer	Gdańsk, Poland	dorota.wejer@ug.edu.pl
Aleksander Weron	Wrocław, Poland	aleksander.weron@pwr.edu.pl
Karina Weron	Wrocław, Poland	karina.weron@pwr.edu.pl
Grzegorz Wilk	Warszawa, Poland	wilk@fuw.edu.pl
Ewa Witkowska	Kraków, Poland	ewa.witkowska@uj.edu.pl
Zbigniew Włodarczyk	Kielce, Poland	zbigniew.wlodarczyk@ujk.edu.pl
Marcin Zagórski	Klosterneuburg, Austria Kraków, Poland	marcin.zagorski@ist.ac.at
Yani Zhao	Szczecin, Poland	yanizhao@fermi.fiz.univ.szczecin.pl
Jan Jacek Żebrowski	Warszawa, Poland	zebra@if.pw.edu.pl
Tomasz Żórawik	Wrocław, Poland	tzorawik@gmail.com

27^{th} Marian Smoluchowski Symposium on Statistical Physics

Tuesday 23/09	**Wednesday** 24/09	**Thursday** 25/09	**Friday** 26/09
8^{00} - 8^{45} Breakfast	8^{00} - 9^{00} Breakfast	8^{00} - 9^{00} Breakfast	8^{00} - 9^{00} Breakfast
9^{00} - 10^{30} C. Tsallis G. Wilk G. Gottwald	9^{00} - 10^{30} H. Flyvbjerg E. Kepten G. Kneller	9^{00} - 10^{30} S. Bezrukov M. Pasenkiewicz-Gierula M. Kurzyński	9^{00} - 10^{30} K. Kułakowski C. Anteneodo B. Dybiec
10^{30} - 11^{00} Coffee break	10^{30} - 11^{00} Coffee break	10^{30} - 11^{00} Coffee break	10^{30} - 11^{00} Coffee break
11^{00} - 12^{30} H. Park M. H. Lee E. de M. Silva	11^{00} - 12^{40} A. Borzi J. Gajda K. Burnecki J. Ślęzak	11^{00} - 12^{30} D. Makowiec J. J. Żebrowski Z. Struzik	11^{00} - 12^{30} I. M. Sokolov A. Chechkin A. Weron
13^{00} - 15^{00} Lunch	13^{00} - 14^{30} Lunch	13^{00} - 15^{00} Lunch	13^{00} - 14^{00} Lunch/Departure
15^{00} - 16^{30} M. A. Nowak P. Garbaczewski W. A. Majewski		15^{00} - 16^{30} L. Schimansky-Geier J. M. Rubi F. A. Oliveira	
16^{30} - 17^{00} Coffee break	15^{30} - 16^{00} Coffee break	16^{30} - 17^{00} Coffee break	
17^{00} - 17^{40} F. Ferrari	16^{00} - 18^{00} Poster session	17^{00} - 18^{30} A. Fuliński P. H. L. Martins A. Dubkov	
19^{00} - 20^{00} Dinner	19^{00} - Banquet	19^{00} - 20^{00} Dinner	

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