# $18^{\text{th}}$ Marian Smoluchowski Symposium on Statistical Physics

## ZAKOPANE, POLAND, SEPTEMBER 3–6, 2005

organized by

Marian Smoluchowski Institute of Physics
Jagellonian University, Kraków

and

Department of Physical Chemistry†
Silesian University of Technology
Gliwice

Institute of Physics
Silesian University
Katowice

and **Workshop on Biophysics of Cancer and Ionic Transport Processes**†

ZAKOPANE, POLAND, SEPTEMBER 7–9, 2005.

Partially supported by Polish Ministry of National Education



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Hotel "Fian" ul. Chałubińskiego 38, 34–500 Zakopane, Poland, tel. +(48) (18) 201 50 71 (Workshop)
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## *Saturday, September 3*
## *Arrival Day*

20:00 *Get–together meeting*

## Proceedings

As usual, proceedings of the Symposium are going to be published as a special issue of *Acta Physica Polonica B* dedicated to Professor Peter Talkner on the occasion of his 60th birthday. Everybody is welcome to contribute, but please note that all submissions will go through a full editorial process, including peer review.

Please, send your submissions to the address of the Organizers

`zfs@th.if.uj.edu.pl`

Your submission should be in the LaTeX (or plain TeX) format, figures in Encapsulated PostScript. We are sorry but we will not be able to handle other formats, including Word. Please, visit the publishers' website `http://th-www.if.uj.edu.pl/acta/` for further instructions for authors.

The submission deadline is **January 2, 2006**.

# *Sunday, September 4*

| | | |
|---|---|---|
| 8:00 | *Breakfast* | |
| | Chairperson: Jerzy Łuczka | |
| 8:50 | **Andrzej Fuliński** | Opening |
| 9:00 | **Peter Hänggi** | 60 years of Peter Talkner |
| 9:30 | **Eli Pollak** | The semiclassical initial value representation series method for computing numerically exact quantum correlation functions |
| 10:30 | *Coffee break* | |
| 11:00 | **Marek Cieplak** | The transition state in protein folding – an exact model |
| 11:45 | **Lutz Schimansky–Geier** | Stochastic neurons driven by signals |
| 12:30 | **Peter Reimann** | Paradoxical brownian motion in a microfluidic device: absolute negative mobility |
| 13:30 | *Lunch* | |
| | *Free time* | |
| 20:00 | *Banquet* | |

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# *Monday, September 5*

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|---|---|---|
| 8:00 | *Breakfast* | |
| | Chairperson: Jose Miguel Rubi | |
| 9:00 | **Joseph Klafter** | Fractons in proteins: can they lead to anomalously decaying time-autocorrelations? |
| 9:45 | **Thorsten Pöschel** | Kinetics of prion aggregate growth |
| 10:30 | *Coffee break* | |
| 11:00 | **Katja Lindenberg** | Trapping reactions with subdiffusive traps and particles |
| 11:45 | **Martin Bier** | How to evaluate the electric noise in a cell membrane? |
| 13:00 | *Lunch* | |
| | Chairperson: Zbigniew J. Grzywna | |
| 14:30 | **Hannes Bolterauer** | Walking molecules: models and simulations for kinesin and myosin |
| 15:15 | Pre–poster session | |
| 16:00 | *Coffee break* | |
| 16:30 | Pre–poster session (continued) | |
| 18:00 | *Dinner* | |
| 20:00 | Poster session | |

## *Tuesday, September 6*

| | | |
|---|---|---|
| 8:00 | *Breakfast* | |
| | Chairperson: Lutz Schimansky–Geier | |
| 9:00 | **Riccardo Mannella** | Short-time dynamics of noise-induced escape |
| 9:45 | **Peter Talkner** | Chiral separation in microflows |
| 10:30 | *Coffee break* | |
| 11:00 | **Anna T. Ławniczak** | Dynamics near onset of congestion in data communication network model |
| 11:45 | **Jose Miguel Rubi** | Noise suppression by noise and its implementation in optical tweezers |
| 13:00 | *Lunch* | |
| | Chairperson: Peter Talkner | |
| 14:30 | **Igor M. Sokolov** | Aging and death of linear response in continuous-time random walks |
| 15:15 | **Paweł F. Góra** | Linear stochastic resonance |
| 16:00 | *Coffee break* | |
| 16:30 | **Tadeusz Kosztołowicz** | Measuring subdiffusion parameters |
| 17:15 | **Sergey Denysov** | Deterministic heat conduction: anomalous diffusion approach |
| 18:00 | *Dinner* | |

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# *Wednesday, September 7*

Please note that Wednesday, September 7, is the starting day of a follow-up Workshop "Biophysics of Cancer and Ionic Transport Processes" organized at a different location in Zakopane.

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| 8:00 | *Breakfast (Geovita, departure from Smoluchowski Symposium)* | |
| 13:00 | *Lunch (FIAN, Zakopane)* | |
| 15:30 | **Mustafa B.A. Djamgoz** | A neuroscience approach to understanding cancer |
| 16:30 | *Coffee break* | |
| 17:00 | **Mustafa B.A. Djamgoz** | Control of cancer cell motility by voltage-gated channels |
| 19:00 | *Dinner* | |

## *Thursday, September 8*

| | | |
|---|---|---|
| 8:00 | *Breakfast* | |
| 9:00 | **Maria E. Mycielska** | Citrate transport in prostate: change in metastasis and control by ion channel activity |
| 9:45 | **Monika Krasowska** | The fractal based techniques in analysis of cancer cells aggregates |
| 10:30 | *Coffee break* | |
| 11:00 | **Danuta Makowiec** | Heart rate variability – multifractal approach |
| 13:00 | *Lunch* | |
| 15:00 | **Przemysław Borys** | Mathematical description of cancer cells motility problems |
| 15:45 | **Anna T. Ławniczak** | Dynamics of spread of epidemics and vaccination strategies in individually based SIR model, illustration of bottom up methodology |
| 16:30 | *Coffee break* | |
| 17:00 | Poster session | |
| 19:00 | *Dinner* | |

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## *Friday, September 9*
## *Departure Day*

8:00 *Breakfast, departure*

# *Invited talks*

Martin Bier, Greensville
***How to evaluate the electric noise in a cell membrane?***
**Abstract:** The possible physiological effect of power frequency fields (60 Hz in the US, 50 Hz in most other countries) is still a hotly debated issue. These relatively slow fields distribute themselves across cell membranes and a common approach has been to compare the strength of these fields to the strength of the electric noise that the membrane generates itself through Brownian motion. However, there has been disagreement among researchers on how to evaluate this equilibrium membrane electric noise. I will present an ab initio modeling of membrane electric fields and show that different manifestations of Brownian noise lead to an electric noise intensity that is many times larger than what conventional estimates have yielded. Finally, the legitimacy of gauging a nonequilibrium external signal against internal equilibrium noise is questioned and an estimate is derived of the noise intensity due to the energetically downhill ion traffic through randomly opening and closing ion channels.

Hannes Bolterauer, Giessen
***Walking molecules: models and simulations for kinesin and myosin***
**Abstract:** We discuss the principal ideas of existing models for kinesin (and Ncd). We find that in order to explain unidirectionality, but also the different directions of walking of Kinesin and Ncd, we cannot use one dimensional models or quasi one dimensional models. Instead we have to describe the two heads as extended objects in an, at least, two dimensional space. Our model of directed binding easily explains the general excepted hand over hand movement in different directions. We establish the Langevin and Fokker–Planck description and try to solve it. We try to give some insight, how to see chemical reactions mechanically.

Przemysław Borys (workshop), Gliwice
***Mathematical description of the cancer cells motility problems***

Marek Cieplak, Warszawa
***The transition state in protein folding – an exact model***
**Abstract:** We present the results of an exact analysis of a model energy landscape of a protein to clarify the notion of the transition state and the physical meaning of the phi values determined in protein engineering experiments. We benchmark our findings to various theoretical approaches proposed in the literature for the identification and characterization of the transition state.

# *Invited talks (continued)*

Sergey Denysov, Dresden
***Deterministic heat conduction: anomalous diffusion approach***
**Abstract:** We consider heat conductivity in classical 1D extended dynamical systems. Many different models have been numerically investigated to identify the physical conditions under which the thermal conductivity $k$ diverges with the system size $L$ and, having assessed that $k \sim L^{\alpha}$, to determine the possibly different universality classes for the divergence rate $\alpha$. We show that such anomalous heat conductivity can be connected with the anomalous diffusion properties of a dynamical system at equilibrium on the base of Levy walk formalism. As an examples we used billiard channels and hard-point gas.
**References:**

[1] S. D., J. Klafter, and M. Urbakh, "Dynamical heat channels", PRL 91 (2003) 194301.
[2] P. Cipriani, S. D., and A. Politi, "From anomalous energy diffusion to Levy walk and heat conductivity in one-dimensional systems", PRL 94 (2005) 244301.

Mustafa B.A. Djamgoz (workshop), London
***A neuroscience approach to understanding cancer***

Mustafa B.A. Djamgoz (workshop), London
***Control of cancer cell motility by voltage-gated channels***

Paweł F. Góra, Kraków
***Linear stochastic resonance***
**Abstract:** A linear transmitter with correlated multiplicative and additive Gaussian white noises may, under certain conditions, display a stochastic resonance. We show how this problem is related to that of a noisy logistic equation.

Peter Hänggi, Augsburg
***60 years of Peter Talkner***

Joseph Klafter, Tel Aviv
***Fractons in proteins: can they lead to anomalously decaying time-autocorrelations?***

# *Invited talks (continued)*

Tadeusz Kosztołowicz, Kielce

***Measuring subdiffusion parameters***

**Abstract:** Subdiffusion occurs in various systems, such as porous media or amorphous semiconductors. Subdiffusion is characterized by a time dependence of the mean square displacement of a random walker $\langle \Delta x^2 \rangle$ which is of the form $\langle \Delta x^2 \rangle = \frac{2D_\alpha}{\Gamma(\alpha+1)} t^\alpha$, where $\alpha$ denotes a subdiffusion parameter and $D_\alpha$ is a subdiffusion coefficient. While the subdiffusion is rather well understood theoretically, there is no effective method to experimentally measure the parameters. Here we propose two methods to measure the subdiffusion parameter $\alpha$ and subdiffusion coefficient $D_\alpha$. The first method can be used when there is a simple subdiffusion while the second one is appropriate for the systems where the subdiffusion is controlled by chemical reactions.

The first method exploits a membrane system containing two vessels with a thin membrane in between which separates the initially homogeneous solute of the transported substance from the pure solvent. The substance of interest is transported in a solvent from one vessel to another across a thin membrane which plays here only an auxiliary role. Instead of the mean square displacement, our method refers to the temporal evolution of the thickness $\delta$ of the so-called near-membrane layer which is defined as the distance from the membrane where the substance concentration $C(x,t)$ drops $\kappa$ times with respect to the membrane surface i.e. $C(\delta,t) = \kappa C(0,t)$, where $x = 0$ is the position of a thin membrane. Solving the subdiffusion equation $\frac{\partial^\alpha C(x,t)}{\partial t^\alpha} = D_\alpha \frac{\partial^2 C(x,t)}{\partial x^2}$ for the membrane system we show that the time evolution of near-membrane layers evolves in time according to the formula $\delta(t) = \sqrt{D_\alpha} \left[ (H^{1\,0}_{1\,1})^{-1} \left( \frac{\alpha\kappa}{2} \middle| \begin{smallmatrix} 1 & 1 \\ 0 & 2/\alpha \end{smallmatrix} \right) \right]^{\alpha/2} t^{\alpha/2}$, where $H$ denotes the Fox function. The time evolution of near membrane layers can be easily measured, and thus comparing the theoretical functions with the experimental ones one can extract the values of parameters $\alpha$ and $D_\alpha$. Using the method we showed that there is a subdiffusive transport of sugars in an agarose gel. The second method is useful for the systems where chemical reactions $nA + mB \to ((\text{inert}))$ occur. Assuming that the reactants $A$ and $B$ are initially separated and $B$ is static (as for example in the corrosion process), the subdiffusion-reaction equations take the form $\frac{\partial^\alpha a}{\partial t^\alpha} = D_\alpha \frac{\partial^2 a}{\partial x^2} - k a^n b^m$, $\frac{\partial^\alpha b}{\partial t^\alpha} = -k a^n b^m$, where $a$ and $b$ denote the concentrations of reactants, $k$ is the reaction rate. Using the scaling method we show that the reaction front $x_f$ (which is defined as a point where the reaction term $k a^n b^m$ reaches its maximum) evolves in time as $x_f \sim t^{\alpha/2}$. The point $x_f$ can be identified with the limit of corrosion (which is experimentally measured), and thus the subdiffusion parameter $\alpha$ can be easily extracted from the experimental data. Applying this method, we show that the transport of some organic acids inside the tooth enamel is of subdiffusive character.

# *Invited talks (continued)*

Monika Krasowska (workshop), Gliwice
***The fractal based techniques in analysis of cancer cells aggregates***
**Abstract:** The generalized fractal dimension Dq and its Legendre transform (f($\alpha$)), partitioned iterated function system – semifractals (PIFS-SF) and lacunarity, were used to analyze quantitative differences in secretory membrane activities. Two rat prostate cancer cell line (Mat-LyLu and AT-2) as well as two human breast cancer cell lines (MDA-MB-231 and MCF-7) were analyzed. Mat-LyLu and MDA-MB-231 showed the strong metastatic membrane potential whereas AT-2 and MSF-7 the weak metastatic membrane potential. Each cell's endocytic activity was determined by horseradish peroxidase uptake. Digital images of patterns of vesicular staining were evaluated by statistical and multifractal analysis. The comparing of all method and the possible physical/physiological meaning of calculated measures are presented.

Katja Lindenberg, S.B. Yuste, San Diego
***Trapping reactions with subdiffusive traps and particles***
**Abstract:** Reaction dynamics involving subdiffusive species is an interesting topic with only few known results, especially when the motion of different species is characterized by different anomalous diffusion exponents. We present features of the reaction dynamics of a (sub)diffusive particle surrounded by a sea of (sub)diffusive traps in one dimension. Under some reasonable assumptions we find rigorous results for the asymptotic survival probability of the particle in most (but not all) cases.

Anna T. Ławniczak, Guelph
***Dynamics near onset of congestion in data communication network model***
**Abstract:** Packet switching network (PSN) technology has facilitated unprecedented growth of data communication networks. It is a complex technology organized at various hierarchical layers according to the International Standard Organization (ISO) OSI (Open Systems Interconnect) Reference Model. The Network Layer of the ISO OSI Reference Model is responsible for delivering packets from their sources to their destinations and for dealing with congestion if it arises in a network. We present an abstraction of the Network Layer of the ISO OSI Reference Model that we developed. Using our model we investigate how onset of traffic congestion is affected for various routing algorithms by changes in network connection topology. We explore packets traffic spatio-temporal dynamics near the phase transition point from free flow to congestion for various network connection topologies and routing algorithms. We present selected simulation results.

# *Invited talks (continued)*

Anna T. Ławniczak (workshop), Guelph

***Dynamics of spread of epidemics and vaccination strategies in individually based SIR model, illustration of bottom up methodology***

**Abstract:** We present an individually based fully discrete simulation model to study spatio-temporal dynamics of spread of epidemics of SIR (susceptible-infected-removed) type, i.e. influenza epidemics. Our model incorporates the random nature of disease transmission, the discreteness and heterogeneity of distribution of host population. The crucial feature of this model is the fact that for each individual the set of all individuals with whom he/she interacts may change with time. We derive a mean-field description of our simulation model. We study the role of mixing of individuals on the spread of SIR epidemics in realistic population distribution of Southern and Central Ontario using census data obtained from Statistics Canada. We investigate effects of spatial heterogeneities in distribution of infected and vaccinated individuals on the dynamics of SIR epidemics. We discuss vaccination strategies that differ only in spatial distribution of vaccinated individuals. We present various simulation results. Our work is of relevance to study epidemics of SIR type including influenza epidemics. The presented work is joint work with Prof. H. Fuks et al. The individually base methodology and bottom up approach is relevant for other biological applications in particular for studying some aspects of cancer growth dynamics.

Danuta Makowiec (workshop), Gdańsk

***Heart rate variability – multifractal approach***

**Abstract:** Healthy human heart rate has long be known to exhibit 1/f-type fluctuations. The intristic dynamics of the physiological regulatory system is supposed to be responsible for the complexity of heart rate – the interaction between the activity of sympathetic and parasympathetic nervous systems. It is also known that the heart rate variability exhibit a multifractal to monofractal transition if the parasympathetic system is blocked and absence of this transition when the sympatetic system is blocked. The measurment of heart rate variability is a noninvasive and cheap method and so that the multifractal annalysis becomes a source of reliable information on cardiac regulatory system.

# *Invited talks (continued)*

Riccardo Mannella, Pisa

***Short-time dynamics of noise-induced escape***

**Abstract:** Using the method of optimal fluctuation, we study the early stage of noise-induced escape from a metastable potential well, on time scales less than or of the order of the relaxation time. In the overdamped limit (related to the Smoluchowsky equation), we find both the activation energy and prefactor as functions of time. Simulations perfectly agree with our theory. For an arbitrary damping (related to the Kramers equation), we find only the activation energy, which however is sufficient to predict the stair-case like growth of the flux with time, provided the damping parameter is smaller than the doubled frequency of eigenoscillation in the well. The stair-case like dynamics is a generic feature of the short-time dynamics of the escape flux in underdamped systems. It is valid for any potential shape, both for an absorbing and transparent boundaries, and for all most typical shapes of the boundary, in particular a wall and the boundary of the basin of attraction. Simulations perfectly confirm major theoretical predictions.

Maria Mycielska, Mustafa B.A. Djamgoz (workshop), London

***Citrate transport in human prostatic epithelial cells: Change with metastatic potential and control by ion channel activity***

**Abstract:** Prostate is a unique organ that produces, accumulates and releases large amounts of the organic anion citrate into prostatic fluid. This is due to unusual control of mitochondrial aconitase by hormones and Zn2+ in prostatic epithelial cells. Interestingly, the amount of citrate decreases significantly in cancer, due to possible changes in aconitase regulation and/or citrate transport. We have recently characterised citrate transport in normal prostate epithelial cells as primarily outward and K+-dependent [1]. Citrate transport was electrogenic and had higher affinity for the trivalent form of citrate. In contrast, metastatic cells also expressed a Na+-dependent inward citrate transporter [2]. However, expression of the Na+-dependent component in metastatic cells was abolished by 24 - 48 h treatment with tetrodotoxin, a highly specific blocker of the voltage-gated Na+ channel (VGSC), known to be associated with metastatic prostate cancer [3]. It is concluded that expression of K+- vs Na+-dependent citrate transporters in prostate cancer cells is controlled by VGSC activity, consistent with the notion that VGSC expression is an early event in prostate cancer and that the VGSC functions as a 'gate' in prostate cancer progression to metastatic mode.

**References:**

[1] Mycielska ME & Djamgoz MB (2004) Citrate transport in the human prostate epithelial PNT2-C2 cell line: electrophysiological analyses. J Physiol 559, 821-833.

[2] Mycielska ME, Palmer CP, Brackenbury WJ & Djamgoz MBA (2005a). Expression of Na+-dependent citrate transport in a strongly metastatic human prostate cancer PC-3M cell line: regulation by voltage-gated Na+ channel activity. J Physiol 563, 393-408.

[3] Laniado ME, Lalani EN, Fraser SP, Grimes JA, Bhangal G, Djamgoz MB & Abel PD. (1997). Expression and functional analysis of voltage-activated Na+ channels in human prostate cancer cell lines and their contribution to invasion in vitro. Am J Pathol. 150, 1213-1221.

# *Invited talks (continued)*

Thorsten Pöschel, Berlin
***Kinetics of prion aggregate growth***
**Abstract:** The formation of fibril aggregates in prion related diseases such as scrapie, mad-cow disease, Creutzfeld–Jacob disease, and kuru is investigated analytically and by means of numerical experiments. Based on the nucleated polymerization model we derive a set of rate equations for the number of fibrils, their total mass and the number of prion monomers. In difference to the generally accepted rate-kinetics model the time dependence of the prion monomer concentration is taken into account. The theoretical results for the evolution of the disease agree with experimental data, whereas disregarding the time dependence of the monomer concenentration leads to qualitatively different results. We derive the size distribution of the prion polymers which is shifted significantly towards shorter lengths as compared to earlier results, and conclude that the disease is more infectious than generally assumed.

Eli Pollak, Rehovoth
***The semiclassical initial value representation series method for computing numerically exact quantum correlation functions***

Peter Reimann, Bielefeld
***Paradoxical brownian motion in a microfluidic device: absolute negative mobility***
**Abstract:** Exploiting rather than fighting the unavoidable thermal fluctuations is a thriving new paradigm in the field of nanosciences with fascinating applications, including transport and sorting of colloidal particles and biomolecules. Here, we demonstrate a new and most paradoxical migration mechanism in a microfluidic device, which is based on a subtle interplay between thermal noise, a periodic and symmetric microstructure, and a biased AC electric field: a particle transport, which is always opposite to the net acting force (absolute negative mobility). This phenomenon can be applied for bioanalytical purposes like separation and fractionation.

# *Invited talks (continued)*

Jose Miguel Rubi, Barcelona

***Noise suppression by noise and its implementation in optical tweezers***

**Abstract:** The presence of noise in physical systems is an unavoidable feature, and as one moves from macroscopic to microscopic scales that presence becomes more and more prominent. To withdraw the noise, it is costumary to reduce as much as possible all the external noise sources that affect the system since it still seems paradoxical that adding noise might result in a less noisy system. We have shown that the intrinsic noise displayed by some systems can substantially be reduced through its nonlinear interplay with externally added noise and we have established sufficient conditions for this phenomenon to occur. The 'Noise Suppression by Noise' (NSN) phenomenon [1] has recently been observed in optical traps [2]. The phenomenon offers new perspectives to improve the accuracy of experiments performed in mesoscopic systems, as mesoscopic conductors, ion channels or biomolecules, for which the presence of fluctuations is important.

**References:**

[1] J.M.G. Vilar and J.M. Rubi, Phys. Rev. Lett. 86, 950, 2001

[2] Y. Seol, K Visscher and D.B. Walton, Phys. Rev. Lett, 93, 160602, 2004

Lutz Schimansky–Geier, Berlin

***Stochastic neurons driven by signals***

**Abstract:** We consider excitable systems driven by noise and periodic signals. One can distinguish between two kind of models dependently whether the resting state has real eigenvalues or complex ones. Whereas in the first case the waiting time densities between two independent spikes are convoluted exponentials with a single maximum we find a richer behaviour with a multipeaked structure for the second case which are called resonate and fire neurons. Analytic calculations of a harmonic oscillator fit well with numeric simulations for certain approximations.

In the second part the excitable system is driven by periodic external signals. We find $n : m$ synchronization regions with the external driving which are characterized by high Peclét numbers of the nearly pariodic oputput of the excitable system.

**References:**

T. Verechtchaguina, L. Schimansky-Geier, and I. M. Sokolov Phys. Rev. E 70, 031916 (2004); T. Prager and L. Schimansky–Geier, Phys. Rev. Lett. 91, 230601 (2003); Rev. E 71, 031112 (2005); B. Lindner and L. Schimansky-Geier Phys. Rev. E 61, 6103-6110 (2000)

# *Invited talks (continued)*

Igor M. Sokolov, Berlin

***Aging and death of linear response in continuous-time random walks***

**Abstract:** We give a heuristic derivation of the generalized Master equation for decoupled continuous-time random walks biased by a time-dependent external filed, which changes the probabilities of jump directions at time instants of jumps. This equation is used to calculate a response of a CTRW system to a time-dependent field. We concentrate on the mean displacement and on the mean squared displacement of a particle in a sinusoidal field. The relation of these results to other types of aging phenomena is discussed.

Peter Talkner, Augsburg

***Chiral separation in microflows***

**Abstract:** Molecules that only differ by their chirality, so called enantiomers, often possess different properties with respect to their biological function. Therefore, the separation of enantiomers presents a prominent challenge in molecular biology and belongs to the "Holy Grail" of organic chemistry. We suggest a new separation technique for chiral molecules that is based on the transport properties in a microfluidic flow with spatially variable vorticity. Because of their size the thermal fluctuating motion of the molecules must be taken into account. These fluctuations play a decisive role in the proposed separation mechanism.

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# *Posters*

Marcello Borromeo, Perugia

***Biharmonic ratchets***

**Abstract:** Transport in a one-dimensional symmetric device can be activated by the combination of thermal noise and a bi-harmonic drive. In the case of an overdamped Brownian particle diffusing on a periodic one-dimensional substrate, We distinguish two apparently different regimes: Harmonic mixing, where the two drive frequencies are commensurate and of the order of some intrinsic dynamical relaxation rate and vibrational mixing, where one harmonic drive component is characterized by a high frequency but finite amplitude-to-frequency ratio. Its effect on the device response to either a static or a low-frequency additional input signal is accurately reproduced by rescaling each spatial Fourier component of the substrate potential, separately. Contrary to common wisdom based on the linear response theory, we show that extremely high-frequency modulations can indeed influence the response of slowly (or dc) operated devices. Finally, the mixing of two high-frequency beating signal is also investigated both numerically and analytically.

Przemysław Borys, Gliwice

***The Fokker Planck equation for chaotic maps***

**Abstract:** The Fokker Planck equations for Langevin dynamics, random walk and deterministic diffusion out of periodic maps are derived, and compared.

Olgierd Cybulski, Warszawa

***Honeycomb conjecture for the Laplacian eigenvalues – tiling a plane in a dynamical process***

**Abstract:** We present a reaction-diffusion system consisting of N components. The evolution of the system leads to the partition of the plane into cells, each occupied by only one component. For large N, the stationary state becomes a periodic array of hexagonal cells. We present a functional of the densities of the components, that decreases monotonically during the evolution, and attains its minimal value in the stationary state. This value is equal to the sum of the first Laplacian eigenvalues for all cells. Thus, the resulting partition of the plane is determined by minimization of the sum of the eigenvalues, and not by the minimization of the total perimeter of the cells as in the original honeycomb problem. The functional which is minimized can be identified as the sum of Renyi entropy productions for individual components. Defined in this way, total entropy production decreases towards its stationary value. Both the minimization of the total entropy production, and the minimization of the sum of the Laplacian eigenvalues, lead to the same shapes of cells.

# *Posters (continued)*

Aleksandra Dudkowska, Danuta Makowiec, Gdańsk
***The influence of stochastic input in the Seidel–Herzel model of human cardiorespiratory system***

Kazimierz Dworecki, Sławomir Wąsik, Kielce
***Experimental investigation of the subdiffusion in a membrane system***
**Abstract:**We study diffusion in a membrane system consisting of two cells separated by a horizontally located nuclear membrane. We have filled the upper cuvette of the membrane system with an aqueous solution of polyethylene glycol 2000 (in a gel form) while in the lower one there has been water gel (2% agarose gel). The diffusion can be characterised by a form of time evolution of the so-called near-membrane layer (NML), where the concentration of diffusing substance drops k times. When the thickness of NML, grows in time as $t^g$ with $g = 0.5$ we deal with normal or gaussian diffusion, when. If $g > 0.5$ there is a superdiffusive and when $a < 0.5$ subdiffusive behaviour. To observe the time evolution of NML we have employed the laser interferometric technique: the interference fringes pattern has provided quantitative measurement of the substance concentration $C(x,t)$ at position $x$ and at time $t$. Recording the interferograms with a given time step, we have constructed the profile of polyethylene glycol concentration. Our results show that the thickness of NML grows in time $t$ as $t^g$, with $g < 0.5$, manifesting a subdiffusive character of the process. The concentration profiles $C(x,t)$ scales as $t^b(F(x/t^g))$, where the exponents $b$, and $g$ are fixed.

Bartłomiej Dybiec, Ewa Gudowska–Nowak, Kraków
***Stochastic resonance: the role of $\alpha$-stable noises***
**Abstract:** The behavior of SR quantifiers in the generic model system perturbed by periodic force and $\alpha$-stable noises is studied. The special attention is given to the examination of influence of the noise parameters on the shape of SNR and SPA curves.

# *Posters (continued)*

Andrzej Grabowski, Warszawa

***The SIS model for assessment of epidemic control in a social network***

**Abstract:** The phenomenon of epidemic spreading in a population with a hierarchical structure of interpersonal interactions is described and investigated numerically. The SIS model with incubation time and temporal immunity to a disease, is used. In our model localization of individuals in different social groups, effectiveness of different interpersonal interactions and the mobility of a contemporary community are taken into account. The influence of different control methods on the spreading process is investigated as a function of different initial conditions. Effectiveness and cost of mass preventive vaccinations, target vaccinations and the sick leaves are compared. Critical range of vaccinations, sufficient for the suppression of an epidemic as well as the probability that endemic state occurs, are calculated. Our results of numerical calculations have similar character as the solutions of the master equation for the spreading process.

Piotr Garbaczewski, Zielona Góra

***Entropy methods in random dynamics***

Agnieszka Gil–Świderska, Siedlce

***On the relationship of the galactic cosmic rays anisotropy and the interplanetary magnetic field***

**Abstract:** We study a relationship of the galactic cosmic rays (GCR) 3-D anisotropy components and the interplanetary magnetic field (IMF) for 1994, when the second harmonic of the solar wind velocity's heliolongitudinal asymmetry is clearly revealed. The values of the GCR 3-D anisotropy components were calculated using the Global Spectrograph Method based on the more than 20 neutron monitors hourly data. A correlation is found between the fluctuations of the components of the GCR 3-D anisotropy and the IMF. The effect of the sector structure of the IMF in the GCR 3-D anisotropy is revealed.

Jan Iwaniszewski, Toruń

***Stochastic resonance in the presence of resonant activation***

**Abstract:** Consider a brownian particle moving in a bistable potential. When an additional weak periodic force drives the particle one expects the appearance of the stochastic resonance phenomenon – a synchronization of transitions between the metastable states with the applied signal. On the other hand, when the potential is perturbed stochastically the resonant activation effect may appear, i.e., the maximal increase of transition rates between potential wells for finite correlation time of the perturbation. We discuss how the variation of the transition rates caused by potential fluctuations modify the stochastic resonance phenomenon.

# *Posters (continued)*

Jan Iwaniszewski, Tomasz Zakrzewski, Toruń

***Charge transport through quantum dots system with periodically modulated coupling***

**Abstract:** We consider current flow through a double quantum dot in the presence of periodic modulation of the interdot tunneling coupling. It is shown, that depending on the conditions, the modulation can significantly increase as well as suppress electron transfer through the system.

Paweł Jakubczyk, Warszawa

***Line tension in adsorption at heterogeneous substrates***

Agnieszka Kamińska, Kraków

***Solution to the Chapman–Kolmogorov equation for a kangaroo process***

**Abstract:** General solution of the Chapman–Kolmogorov equation for a jumping process called "kangaroo process" is derived. A special case of algebraic dependences is discussed in details. In particular, simple asymptotic formulas for probability distribution are presented. It is demonstrated that there are two different classes of limiting stationary distributions.

Robert Kosiński, Warszawa

***Simple model of spreading of two epidemics: phase transition and pattern formation***

**Abstract:** Spreading of two different diseases in small world network, with restriction that an individual can be ill only with one disease in the same time, is investigated in the frame of SIRS model. In the special range of control parameters the presence of the second disease can significantly decrease the number of individuals, who passed the first disease. The speed of propagation of the wave-front of the epidemic is calculated analytically and good agreement with numerical calculation is obtained. The influence of additional long range connections on epidemic spreading and phase transition is investigated. It is found that in special conditions spatio-temporal patterns, in particular spiral waves, can emerge in the system. Small number of additional long-range connections increases the probability of emerging of spiral waves.

# *Posters (continued)*

Katarzyna Lewandowska, Tadeusz Kosztołowicz, Gdańsk, Kielce

***Subdiffusion in caries process***

**Abstract:** Caries in a dental enamel, which is composed of hydroxyapatite (HAP), begins when organic acid (HB) diffuses from the dental plaque inwards the enamel. The process of diffusion could start when a concentration of organic acid, which are produced by metabolic activity of microorganisms in the dental plaque, and pH of the dental plaque reach appropriate levels. The carious lesion is caused by a reaction of the diffusing HB with the static HAP according to the formula $HAP + 7HB \rightarrow (\text{inert})$. This reaction induces dissolution of HAP and thus the loss of minerals in enamel. This loss can reach about 70 per cent of its initial content. When the acids are transported in the dissociated form (what depends on pH of the dental plaque), one expects a normal diffusion of the hydrogen ions inside the enamel due to the small size of the ions. An external structure of the enamel can be treated as a porous medium, so the transport of large undissociated acids molecules can be subdiffusive.

Theoretical considerations are based on the following equations which describe the subdiffusion associated with chemical reaction of static HAP and transported acid

$$\frac{\partial^\alpha A(x,t)}{\partial t^\alpha} = D\frac{\partial^2 A(x,t)}{\partial t^2} - kA^7(x,t)C(x,t)$$

$$\frac{\partial^\alpha C(x,t)}{\partial t^\alpha} = kA^7(x,t)C(x,t)$$

where $A$ denotes the concentration of the acid, $C$ the concentration of HAP, $D$ is the subdiffusion coefficient of the acid, $k$ is the reaction rate, and $\frac{\partial^\alpha}{\partial t^\alpha}$ is the Riemann–Liouville fractional derivative. We identify the carious limit with the reaction front $x_f (d_f \approx x_f)$, which is defined as a point where the reaction term reaches its maximum: $A^7(x_f,t)C(x_f,t) = \max$. We find that the limit of carious lesion $d_f$ evolves in time as $d_f \sim t^{\alpha/2}$ with $\alpha < 2$ for the subdiffusion (the case of $\alpha = 1$ corresponds to the normal diffusion). Comparing the theoretical results with the experimental ones, we show that in some cases there is a subdiffusive transport of acid inside the enamel and we estimate the values of subdiffusion parameter $\alpha$ for the acids under considerations.

# *Posters (continued)*

Marek Litniewski, Warszawa

***Molecular dynamics simulations of fluorescence quenching for distance dependent sink terms and different quencher concentrations***

**Abstract:** Molecular dynamics simulations of the fluorescence quenching (A* + B $\rightarrow$ A + B, where A* is an excited state of A) for realistic sink terms (of the electron transfer mechanism and of the Forster model for the energy transfer) are performed. Several concentrations of quencher (B) and different strengths of the solute-solvent interactions for spherical molecules are considered. The results are compared with the Smoluchowski model that assumes infinitely low concentrations but takes the interparticle interactions into account by incorporating the potential of mean force. It is shown that the agreement between the rate coefficient from the model and from simulations depends on the strength of the solute-solvent interactions as well as on the speed of reaction. If the solute-solvent interactions are not very strong, the Smoluchowski approach appears to be surprisingly good tool to describe the kinetics of the process. The influence of the quencher concentration on the rate of the quenching is also analyzed. In the long time limit the increase in quencher concentration decreases the rate coefficient but the effect is weak and at the moment it becomes noticeable, the surviving probability of A* is already low. As a result, the influence of the quencher concentration on the process appears to be much smaller than the inaccuracies coming from another simplifications included in the Smoluchowski approach.

Marcin Magdziarz, Wrocław

***Anomalous diffusion schemes of nonexponential relaxation. The role of the inverse-time stochastic process***

**Abstract:**The paper presents the random-variable formalism of the anomalous diffusion processes. The emphasis is on a rigorous presentation of asymptotic behaviour of random walk processes with infinite mean random time intervals between jumps. We elucidate the role of the so-called inverse-time stochastic process, the main mathematical tool that allows us to modify the dynamics of standard (exponential) relaxation processes and give rise to the nonexponential decay of modes. In particular we show that the Brownian motion in combination with an appropriate inverse-time process leads not only to exponential but also to the nonexponential relaxation. In order to make the model accessible to the physical sciences audience, we discuss the case of the Mittag–Leffler relaxation which is associated with the frequency-domain Cole–Cole pattern.

# *Posters (continued)*

Danuta Makowiec, Aleksandra Dudkowska, Gdańsk
***Long-range dependencies in heart rate signal***
**Abstract:** The RR series extracted from human electrocardiogram signal (EKG) will be considered as fractal stochastic process. The manifestation of long-range dependencies is the presence of power laws in scale dependent process characteristics. It is widely known that the exponents of these laws: $\beta$ – describing power spectrum decay, $\alpha$ – responsible for decay of detrended fluctuations or H related to, so-called, roughness of a signal, can differentiate hearts of healthy people from hearts with failure. There is a strong expectation that by investigating the whole spectrum of exponents present in a signal, so-called, local exponents, in place of mentioned global exponents, we will be able to study differences between hearts in details.

Krzysztof Małysiak, Karol Jelonek, Gliwice
***On the visual cortex dynamics***

Anna Ochab–Marcinek, Kraków
***Coexistence of resonant activation and noise-enhanced stability in a noise-driven Michaelis–Menten reaction***
**Abstract:** We investigate a stochastic version of a simple enzymatic reaction that follows the generic Michaelis–Menten kinetics.

At sufficiently high concentrations of reacting species, the molecular fluctuations can be approximated as a realization of a Brownian dynamics for which the model reaction kinetics takes on the form of a stochastic differential equation. After eliminating a fast kinetics, the model can be rephrased into a form of a one-dimensional overdamped Langevin equation.

We discuss physical aspects of environmental noises acting in such a reduced system pointing out the possibility of a phase coexistence where the noise-enhanced stability and noise-induced activation may be observed.

Krzysztof Pawełek, Artur Cieślar–Pobuda, Gliwice
***Nerve membranes – FitzHugh–Nagumo model***

# *Posters (continued)*

Marek Siłuszyk, Krzysztof Iskra, M.V. Alania, Siedlce, Tbilisi

***The features of the long-period variations of the galactic cosmic ray intensity for different solar magnetic cycles***

**Abstract:** The roles of the regular and stochastic interplanetary magnetic field (IMF) in galactic cosmic ray (GCR) variations have been studied based on the modeling of GCR transport, and neutron monitors and the spacecrafts experimental data. There are considered the both ascending and descending epochs of solar activity for different periods of the Sun's global magnetic field polarities. It is demonstrated that the significant evolution in the energy range of the IMF turbulence versus solar activity is responsible for the temporal changes of the rigidity spectrum of the GCR intensity long period variations.

Bozena Szabat, Paulina Hetman, Karina Weron, Wrocław

***Wait-and-switch model of the non-Debye relaxation. Generalization of the Nutting law***

**Abstract:** A "wait-and-switch" relaxation mechanism in terms of a random walk is presented. We introduce a probabilistic model leading to the Burr relaxation function - generalization of the Nutting law. A relationship between the random local characteristics of a macroscopic system and the experimentally observed relaxation power laws is discussed.

Marcin Tabaka, Warszawa

***How to simulate gene expression?***

**Abstract:** Biochemical reactions, that take place at the level of a single cell, include small numbers of molecules. Consequently, molecular fluctuations may dominate the dynamics. For example, the gene expression process is controlled by only a few (10–400) molecules of the transcription factor. They determine when and how often a given gene is transcribed. For this reason, simulation of gene expression should be based on stochastic methods of chemical kinetics. We present a new approach to modeling such processes, in which the spatial motion of discrete molecules is taken into account.

# *Posters (continued)*

Anna Wawrzyńczak–Szaban, Renata Modzelewska, M.V. Alania, Siedlce, Tbilisi

***Features of the galactic cosmic ray 3-D anisotrophy during the forbush effects***

**Abstract:** We study the temporal changes of the three dimensional (3-D) anisotropy of galactic cosmic rays (GCR) for different recurrent and sporadic Forbush effects. Temporal changes of the radial, tangential and polar components of the 3-D anisotropy of GCR were calculated by means of the hourly data of neutron monitors using the Global Spectrographic Method. The steady-state model based on the Parker's transport equation has been applied to describe the expected distributions of the radial, latitudinal and heliolongitudinal gradients and 3-D anisotropy of GCR. It is shown that the anomaly behaviors of the GCR 3-D anisotropy during the Forbush effects is caused by the extreme changes of the spatial gradients of GCR.

Aleksander Woziński, Toruń

***Correlated dichotomic noises in the barrier crossing problem***

**Abstract:**Escape of an overdamped particle driven by two correlated dichotomic noises from a triangle potential well is studied. A general description of statistical properties of the noises is developed in terms of master equation and correlation functions. Using the kinetics of these noises, an equation for the mean first-passage time can be deduced, which enables us to investigate the impact of non-zero covariance on the barrier crossing rate. In various cases, both the acceleration and the slowing down of the escape process can be observed.

Ryszard Zygadło, Kraków

***Free Brownian motion of relativistic particles***

**Abstract:** The relativistic generalization of a free Brownian motion theory is presented. The global characteristics of the relaxation are explicitly found for the velocity and momentum (stochastic) kinetics. It is shown that the thermal corrections, to the both relaxation times T (of stationary autocorrelations) and transient relaxation time of momentum, appear slowing down the processes. The transient relaxation time of the velocity does not depend explicitly on temperature and it is proportional to the initial energy of a relativistic Brownian particle.

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