MECO 37

37TH CONFERENCE OF THE MIDDLE EUROPEAN COOPERATION IN STATISTICAL PHYSICS

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TATRANSKÉ MATLIARE, SLOVAK REPUBLIC

37th Conference of the Middle European Cooperation in Statistical Physics

MECO37

PROGRAMME AND ABSTRACTS

19–21 March 2012, Tatranské Matliare, Slovakia

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Slovak Physical Society

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PROGRAMME

19–21 March 2012, Tatranské Matliare, Slovakia

Sunday, 18 March 2012

15.00–19.00 **Registration** (Hotel Hutník)

19.00–21.00 **Welcome Party**

Monday, 19 March 2012

09.20–10.00 Zoltán Bajnok (*Budapest, Hungary*)
Gauge/Gravity duality: an overview (*Invited lecture***)**

10.00–10.40 Emmanuel Trizac (*Orsay, France*)
Strong-coupling approaches in charged soft matter (*Invited lecture***)**

10.40–11.10 Coffee

11.10–11.30 Wolfhard Janke (*Leipzig, Germany*)
Polymer Adsorption to a Fluctuating Membrane

11.30–11.50 Martin Weigel (*Coventry, UK*)
Fractal geometry and Stochastic Loewner Evolution in disordered systems

11.50–12.10 Géza Ódor (*Budapest, Hungary*)
Extremely large scale simulations of Kardar-Parisi-Zhang type of systems using graphics cards

12.30–14.00 Lunch

14.00–15.30 Poster session

15.30–16.10 Janusz A. Hołyst (*Warsaw, Poland*)
Collective emotions in cyber-communities (*Invited lecture***)**

16.10–16.30 Pádraig Mac Carron (*Coventry, UK*)
Mythological Networks

16.30–17.00 Coffee

17.00–17.20 František Slanina (*Prague, Czech Republic*)
Localization of eigenvectors in random graphs: theory and application in social network analysis

17.20–17.40 Piotr Nyczka (*Wrocław, Poland*)
Phase transitions in the generalized voter model with nonconformity

17.40–18.00 Christian von Ferber (*Coventry, UK*)
Public Transport Networks: Fractal Properties

19.00 Dinner

Tuesday, 20 March 2012

09.20–10.00 Giovanni Gallavotti (*Roma, Italy*) **Resonances and synchronization** (*Invited lecture*)

10.00–10.20 Wim Magnus (*Antwerpen and Leuven, Belgium*)
Classical phase space trajectories: powerful allies for studying Wigner function based quantum transport

10.20–10.40 Reinhard Mahnke (*Rostock, Germany*)
Power laws and skew distributions in evolving systems

10.40–11.00 Jiří Pešek (*Prague, Czech Republic*)
Heat capacity in small non-equilibrium systems

11.00–10.30 Coffee

11.30–12.10 Paola Verrucchi (*Firenze, Italy*)
Dynamics of open quantum systems (*Invited lecture*)

12.10–12.30 Ruggero Vaia (*Firenze, Italy*)
Almost-perfect transfer process through long unmodulated channels

12.30–12.50 Alessandro Cuccoli (*Firenze, Italy*)
Chiral Spin Liquid Phase in Weakly-Coupled Helimagnetic Spin Chains

13.00–14.00 Lunch

14.00 Excursion

19.00 Conference Dinner

Wednesday, 21 March 2012

09.20–10.00 Roman Kotecký (*Warwick, UK and Prague, Czech Republic*)
From gradient Gibbs measures to nonlinear elasticity (*Invited lecture*)

10.00–10.40 Johannes Richter (*Magdeburg, Germany*)
The Paradigmatic J_1–J_2 Models: Quantum Phase Transitions and Low-Temperature Thermodynamics of Frustrated Quantum Spin Systems (*Invited lecture*)

10.40–11.10 Coffee

11.10–11.30 Jacek Wojtkiewicz (*Warsaw, Poland*)
Long Range Order in the ground state of quantum interacting rotors in two dimensions

11.30–11.50 Jozef Strecka (*Košice, Slovakia*)
First- and second-order quantum phase transitions in the exactly solved spin-1/2 Heisenberg-Ising ladder

11.50–12.10 Andrej Gendiar (*Bratislava, Slovakia*)
Phase Transitions On Non-Euclidean Hyperbolic Geometries

12.10–12.30 Pavol Kalinay (*Bratislava, Slovakia*)
Dimensional reduction of evolution equations

12.30–12.50 Yenal Karaaslan (*Izmir, Turkey*)
Investigation of the effect of the off-diagonal Onsager rate coefficient on the relaxation dynamics of anhydrous dihalides of iron-group elements

12.50–14.00 Lunch

14.00–15.30 Poster session

15.30–16.10 Oleg Derzhko (*L'viv, Ukraine*)
Flat-band systems: From magnons to electrons (*Invited lecture*)

16.10–16.30 Rudolf Hilfer (*Stuttgart and Mainz, Germany*)
Dielectric excess wings in glasses

16.30–16.50 Roman Krcmar (*Braunschweig, Germany*)
Fermionic functional renormalization group investigation of Luttinger liquids

16.50–17.20 Coffee

17.20–17.40 Peter Markoš (*Bratislava, Slovakia*)
Disordered two-dimensional electron systems with chiral symmetry

17.40–18.00 Tomáš Lučivjanský (*Košice, Slovakia*)
Influence of the Compressibility on the Anomalous Kinetics of the Annihilation Process

18.00 Closing

19.00 Dinner

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INVITED LECTURES

19–21 March 2012, Tatranské Matliare, Slovakia

Gauge/Gravity duality: an overview

Zoltán Bajnok

Institute for Theoretical Physics, 1117 Budapest, Pázmány Péter sétány 1/A

In 1998 Maldacena conjectured an equivalence between the four dimensional (4D) maximally supersymmetric (conformal) gauge theory and string/gravity theory on the product of two maximally symmetric 5D curved spaces: anti-de Sitter space and the sphere. This a holographic correspondence: the gravitational theory in ten dimensions and the gauge theory on the 4D boundary of the 10D space are two equivalent formulations of the same physical phenomena.

This holography is a kind of duality as it connects strongly-coupled gauge theories to semi-classical string theory, and it relates the deeply quantum string theory (gravity) to perturbative gauge theory. Thus holography provides tools to perform analytical calculations where we could not proceed analytically otherwise. This, however, makes holography hard to prove, it remains a conjecture.

In my talk I will review several confirmations of the conjecture. In the t'Hooft limit the holographic correspondence is described by a 2D integrable quantum field theory. Using integrable techniques such as Bethe Ansatz, finite size corrections and Thermodynamic Bethe Ansatz, we will be able to calculate exactly the spectrum of string theory, on one hand, and the anomalous dimensions of gauge invariant local operators, on the other.

Strong-coupling approaches in charged soft matter

Emmanuel Trizac

LPTMS, Université Paris-Sud, 91405, Orsay, France

We present an overview of our current understanding of the interactions between like-charged macro-molecules, mediated by mobile neutralizing counter-ions. A single dimensionless parameter qualifies the regime as weakly or strongly coupled, and drives qualitatively different features with the possibility of strong attraction between like-charged colloids. Particular emphasis will be put on a recently introduced Wigner strong coupling expansion.

[1] L. Samaj and E. Trizac, Phys. Rev. Lett. **106**, 078301 (2011).

Resonances and synchronization

Giovanni Gallavotti

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A chaotic system under periodic forcing can develop a periodically visited strange attractor. We discuss simple models in which the phenomenon, quite easy to see in numerical simulations, can be completely studied analytically.

Dynamics of open quantum systems

Paola Verrucchi

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Despite being an essential keyword in modern physics, "Open quantum system" is such a generic concept to signify little. Depending on what it opens into, a quantum system can be described as dissipative, or noisy, or out-of-equilibrium, or thermalized, or ... In fact, the behaviour of an open system strongly depends on the specific characterization of its environment, as well as on the interaction with it. However, there are ultimate features which define the common ground for studying the dynamics of open quantum systems: amongst these, the time evolution of entanglement properties plays a fundamental role. In this seminar, I will first describe the essential toolbox for the study of the dynamical evolution of open quantum systems, and will then show how this is implemented in the framework of quantum-state transmission processes and entanglement distribution. Recent proposals for the realization of a non-dispersive quantum channel, as well as of an entangling two-qubit gate, will be finally presented.

Collective emotions in cyber-communities

J.A. Hołyst[1], A. Chmiel[1], J. Sienkiewicz[1], M. Thelwall[2], G. Paltoglou[2], K. Buckley[3] and A. Kappas[3]

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[3] *School of Humanities and Social Sciences, Jacobs University Bremen, Campus Ring 1, 28759 Bremen, Germany, e-mail: a.kappas@jacobs-university.de*

Emotions are an important part of most societal dynamics. As with face to face meetings, Internet exchanges may not only include factual information but also emotional information; how participants feel about the subject discussed or other group members. The development of automatic sentiment analysis has made possible a large scale emotion detection and analysis using text messages collected from the web. Here results of two years studies performed in the frame of EU Project CYBEREMOTIONS (Collective Emotions in Cyberspace) will be presented. The results include an automatic collection and classifying sentiment data in various e-communities, a qualitative and quantitative sentiment data analysis and data driven modeling of collective emotions by ABM, complex networks and fluctuation scaling paradigms, development of emotionally intelligent ICT tools such as affective dialog systems and graphically animated virtual agents that communicate by emotional interactions. Emergence of collective emotions in cyber-communities will be demonstrated by applying four different methods and using independent datasets that include several millions of records: (i) emotional avalanches distribution observed in BBC blogs, and Digg data; (ii) non-random emotional clusters distribution observed in Blogs06, BBC Forum, Digg and IRC channels; (iii) persistent character of sentiment dynamics observed for IRC channels using the Hurst exponent analysis; (iv) causal sentiment triad distribution found in Network Motif Analysis.

[1] A. Chmiel, et al, PLoS ONE **6(7):** e22207, July 2011.

From gradient Gibbs measures to nonlinear elasticity

Roman Kotecký

Warwick University, UK, and Charles University, Prague

The links between macroscopic elasticity with variational principles articulated in terms of nonlinear elastic free energy and equilibrium gradient models are discussed. The non-convexity of the free energy will be discussed and results concerning large deviation principle and asymptotic behaviour in terms of gradient Young-Gibbs measures will be formulated.

The Paradigmatic J_1–J_2 Models: Quantum Phase Transitions and Low-Temperature Thermodynamics of Frustrated Quantum Spin Systems

Johannes Richter

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I give an overview on recent results for the J_1-J_2 spin-1/2 Heisenbergmodel with ferromagneticas well as antiferromagnetic nearest-neighbor coupling J_1 and competing antiferromagnetic next-nearest-neighbor coupling J_2. This model has attracted a lot of attention as a canonical model to study quantum phase transitions driven by frustration. Moreover, recent experiments on quasi-one-dimensional and quasi-two-dimensional frustrated quantum magnets which can be well-described by the J_1-J_2 spin-1/2 Heisenberg model have stimulated a renewed interest in this model. Depending on the dimension and the sign of the nearest-neighbor coupling J_1 a large variety of ground state phases, such asphases with semi-classical magnetic order, non-magnetic quantum phases, or incommensuratespiral phases, exist [1,2,3]. The low-temperature thermodynamics is also strongly influenced by frustration, in particular, near a quantum critical point [4].

[1] R. Darradi et al., Phys. Rev. B **78**, 214415 (2008); J. Richter and J. Schulenburg, Eur. Phys. J. B **73**, 117 (2010).
[2] J. Richter et al., Phys. Rev. B **81**, 174429 (2010).
[3] R. Zinke, J. Richter, and S.-L. Drechsler, J. Phys.: Condens. Matter **22**, 446002 (2010); S. Nishimoto et al., Phys. Rev. Lett **107**, 097201 (2011).
[4] M. Härtel et al., Phys. Rev. B **84**, 104411 (2011); J. Sirker et al., Phys. Rev. B **84**, 144403 (2011).

Flat-band systems: From magnons to electrons

O. Derzhko

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Antiferromagnetic Heisenberg spin systems as well as Hubbard electron systems may have completely dispersionless (flat) lowest-energy one-magnon/one-electron band for many highly frustrated lattices. These one-magnon or one-electron states are localized within a small area of the whole lattice (a trapping cell). In such a case, many-particle ground states can be constructed simply by filling the traps by particles (and taking into account the Pauli principle for Hubbard electrons). The independent localized (ground) states have important consequences for the zero-temperature or low-temperature properties of the strongly correlated systems at hand. For the Hubbard model they may lead to ground-state ferromagnetism in a certain range of (low) electron concentrations [1], whereas for the quantum antiferromagnetic Heisenberg model they lead to a jump in the ground-state magnetization curve at the saturation field [2].

In the present talk I intend to discuss some recent results on localized-state effects for the quantum spin and electron lattice systems focusing mainly on the studies performed in collaboration with J. Richter, A. Honecker, R. Moessner, H.-J. Schmidt, J. Schulenburg, T. Krokhmalskii, and M. Maksymenko.

[1] A. Mielke, J. Phys. A **24**, L73 (1991); **24**, 3311 (1991); **25**, 4335 (1992); Phys. Lett. A **174**, 443 (1993); H. Tasaki, Phys. Rev. Lett. **69**, 1608 (1992); A. Mielke and H. Tasaki, Commun. Math. Phys. **168**, 341 (1993).

[2] J. Schnack, H.-J. Schmidt, J. Richter, and J. Schulenburg, Eur. Phys. J. B **24**, 475 (2001); J. Schulenburg, A. Honecker, J. Schnack, J. Richter, and H.-J. Schmidt, Phys. Rev. Lett. **88**, 167207 (2002); J. Richter, J. Schulenburg, A. Honecker, J. Schnack, and H.-J. Schmidt, J. Phys.: Condens. Matter **16**, S779 (2004).

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ORAL CONTRIBUTIONS

19–21 March 2012, Tatranské Matliare, Slovakia

Polymer Adsorption to a Fluctuating Membrane

W. Janke, S. Karalus, M. Bachmann

Institut für Theoretische Physik, Universität Leipzig, Germany

We analyze the structural behavior of a single polymer chain grafted to an attractive, fluctuating membrane. Our model is composed of a coarse-grained bead-and-spring polymer and a tethered membrane. By means of extensive parallel tempering Monte Carlo simulations it is shown that the system exhibits a rich phase behavior rangingfrom highly ordered, compact to extended random coil structures, and from desorbed to completely adsorbed or even partially embedded conformations. These findings are summarized in a pseudophase diagramindicating the predominant class of conformations as a function of the external parameters temperature and polymer-membrane interaction strength. By comparison with adsorption to a stiff, flat membrane surface it is shown that the flexibility of the membrane gives rise to qualitatively new behavior such as a back-reaction between polymerand membrane fluctuations leading to stretching of adsorbed conformations incorporated by the membrane.

Fractal geometry and Stochastic Loewner Evolution in disordered systems

M. Weigel[1], J. D. Stevenson[3] and H. Khoshbakht[2]

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[3] *University Chemical Laboratories, University of Cambridge, Lensfield Road, Cambridge, United Kingdom*

The description of fractal geometry in critical systems has seen a major leap forward with the advent of the concept of stochastic Loewner evolution (SLE), that provides a unified description of domain boundaries of many lattice spin systems in two dimensions. While such interfaces in a number of pure systems, including various phase boundaries in Potts models, are well-known to be described by SLE_κ, recently a number of numerical studies have found interfaces in disordered systems to be also (partially) consistent with SLE (see, e.g., Ref. [1]).

Here, we study domain walls in random-field Ising models and the Ising spin glass. Using exact ground-state calculations on systems of up to around 10^9 spins, we examine domain walls in these systems and compare with predictions from SLE. For the random-field model, we find strong evidence for conformal invariance and compliance with the domain-Markov property, implying compatibility with Schramm-Loewner evolution with parameter $\kappa = 6$ [2,3]. For the spin-glass, new algorithms allow us to determine the spin-stiffness exponent and fractal dimension of domain walls with unprecedented accuracy [4]. We uncover a strong dependence of SLE properties for the Gaussian and bimodal models on the specific choice of boundary conditions in these systems.

[1] M. Weigel and W. Janke, Phys. Lett. **B 639**, 373 (2006).
[2] J. D. Stevenson and M. Weigel, Comput. Phys. Commun. **182**, 1879 (2011).
[3] J. D. Stevenson and M. Weigel, Europhys. Lett. **95**, 40001 (2011).
[4] H. Khoshbakht, M. Weigel and J. D. Stevenson, in preparation.

Extremely large scale simulations of Kardar-Parisi-Zhang type of systems using graphics cards

Géza Ódor[1], Jeffrey Kelling[2]

[1] *Research Centre for Natural Sciences, Hungarian Academy of Sciencesá MTA TTK (MFA), Konkoly Thege 29-33, H-1121 Budapest, Hungary*
[2] *Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, P.O.Box 51 01 19, 01314 Dresden, Germany*

We show that GPU simulations facilitate to study the effect of quenched disorder in ASEP type of models [1]. In 2+1 dimensions the octahedron model [2] has been implemented onto graphics cards, which permits extremely large scale simulations via binary lattice gases and bit coded algorithms. We confirm scaling behavior belonging to the 2d Kardar-Parisi-Zhang universality class and find growth exponent $\beta = 0.2415(15)$ on $2^{17} \times 2^{17}$ sytems, ruling out $\beta = 1/4$ suspected earlier. The maximum speedup with respect to a single CPU is 430. The steady state has been analyzed by finite size scaling and $\alpha = 0.393(4)$ is found. Correction to scaling exponents are determined and the power-spectrum density is calculated. We determine the universal scaling functions, cumulants and show that the limit distribution can be obtained by the sizes considered [3].

[1] Henrik Schulz, Geza Odor, Gergely Odor, Mate Ferenc Nagy, Computer Physics Communications **182**, 1467 (2011).
[2] G. Odor, B. Liedke and K.-H. Heinig, Phys. Rev. E **79**, 021125 (2009); ibid. **81**, 031112 (2010)
[3] J. Kelling and G. Odor, Phys. Rev. E **84**, 061150 (2011).

Mythological Networks

P. Mac Carron[a], C. von Ferber[b], and R. Kenna[c]

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[a] *e-mail: maccarrp@uni.coventry.ac.uk,* [b] *e-mail: C.vonFerber@coventry.ac.uk,*
[c] *e-mail: r.kenna@coventry.ac.uk*

We investigate the structure of the social network of characters in mythological epics. Epics for three different cultures have been chosen, some of which have a de.nite historical basis, others their historicity is questioned. These networks are compared to other collaboration networks, from scientic co-authorship networks to the network of characters in the Marvel Universe, in an effort to discover where they are positioned along the spectrum from the real to the imaginary.

Localization of eigenvectors in random graphs: theory and application in social network analysis

František Slanina

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In the analysis of social networks, localization of eigenvectors is successfuly used to extract information on small compact groups [1]. In this contribution, we aim at putting this method on a solid ground by analysing spectral and localization properties of random graphs. First, we develop a variational scheme which is shown to coincide with the previously used replica method [2]. Second, using exact numerical diagonalization, we investigate localization in two classes of random matrices corresponding to random graphs. The first class comprises the adjacency matrices of Erdős-Rényi (ER) random graphs. The second one corresponds to random cubic graphs, with Gaussian random variables on the diagonal. We establish the position of the mobility edge, applying the finite-size analysis of the inverse participation ratio. The fraction of localized states is of the order 10^{-4} on the ER graphs and seems to tend to a constant when the average degree increases. On the contrary, on cubic graphs the fraction of localized states is large and tends to 1 when the strength of the disorder increases, implying that for sufficiently strong disorder all states are localized. The distribution of the inverse participation ratio in localized phase has finite width when the system size tends to infinity and exhibits complicated multi-peak structure.

[1] F. Slanina and Z. Konopásek, Adv. Compl. Syst. **13**, 699 (2010)
[2] F. Slanina, Phys. Rev. E **83**, 011118 (2011)

Phase transitions in the generalized voter model with nonconformity

P. Nyczka and K. Sznajd-Weron

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There are two widely recognized types of nonconformity: anti-conformity and independence. From a social point of view, it is very important to distinguish between independence and anti-conformity. The term 'independence' implying the failure of attempted group influence. Independent individuals evaluate situations independently of the group norm. On the contrary, anti-conformists are similar to conformers in the sense that both take cognizance of the group norm – conformers agree with the norm, anticonformers disagree. We show how the both types of nonconformity can be introduced into opinion dynamics models with binary opinions taking as an example the generalized voter model. We discuss the differences and similarities between aniconformity and independence from different perspectives – a simple physical microscopic models and social reality.

Public Transport Networks: Fractal Properties

C. von Ferber[1], Yu. Holovatch[2], T. Holovatch[1,3] and V. Palchykov[2,4]

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[2] *Institute for Condensed Matter Physics NAS Ukraine, Sviensitskii St, Lviv, Ukraine, e-mail: hol@icmp.lviv.ua*
[3] *Institut Jean Lamour, Université de Lorraine, Vandoeuvre les Nancy, France e-mail: holovatch@gmail.com*
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Public transport networks (PTNs) are often discussed without reference to their geographical embedding. The fact that this subject has so far been mostly left aside by previous studies of PTNs with respect to their complex network behaviour, is due mainly to the lack of easily accessible data on the locations of stations and routes. For the present work we have analysed such data for stations of the Berlin PTN as well as for those of the underground networks of London and Paris.

For routes optimizing the time of passenger travel one may expect distance to grow linearly with the path length L. Surprisingly, the empirical data show quite a different behavior. For all means of transport analyzed within this study the dependence of the mean square distance $\langle R^2 \rangle$ on L is well described by a power law with an exponent that is significantly smaller than two. For most transport routes this power law appears to be close to that known for the self-avoiding walk with Flory's exponent in two dimensions corresponding to a fractal dimension of $D = 4/3$. For comparison, the fractal dimensions D of some regional railway networks (not individual routes) reported by Benguigui (1992) are of the order 1.5 to 1.8.

Furthermore, the analysis of the distribution of station intervals along routes displays a range with power law behaviour. This indicates that the routes may in part also be described as Levy-flights. The latter property may result from the fact that the routes are planned to adapt to fluctuating demand densities throughout the served area as well as to optimise travel time for the individual passenger.

Investigation of the effect of the off-diagonal Onsager rate coefficient on the relaxation dynamics of anhydrous dihalides of iron-group elements

Gul Gulpinar, Yenal Karaaslan

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The effect of the off-diagonal Onsager rate coefficient on the relaxation process of iron-group dihalides has been investigated within the framework of statistical equilibrium theory and the thermodynamics of irreversible processes. For this purpose linearized kinetic equations of the total and staggered magnetization is utilized to study the effect of the off-diagonal kinetic coefficient on the temperature dependence of the relaxation times near the first order, critical and multicritical points of the spin-1/2 metamagnetic Ising model. In accordance with the previous results in the literature, we have observed a non-critical maxima of one the relaxation times below the critical temperature according to the values of off-diagonal coefficient.

Classical phase space trajectories: powerful allies for studying Wigner function based quantum transport

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Some time ago, it has been shown that the Lagrange-Charpit method can be used to solve the Boltzmann equation by incorporating classical trajectories into a forward algorithm. This method can be used as well to extract the time dependent Wigner function of bosons and fermions, provided that the initial distribution function complies with identical-particle statistics. In view of this extension, we merely need to recast the Wigner-Liouville equation in the form of a Boltzmann equation by adding a local, classical Boltzmann force term to both sides of the Wigner-Liouville equation.

Unfortunately, the application of the same numerical algorithm – based on the Lagrange-Charpit method as before – to solve the transformed Wigner equation, was hampered by severe numerical accuracy problems. The latter were related to intractably high oscillations occurring in the non-local Wigner kernel that was to be (re)evaluated in each iteration cycle.

Recently however, we observed that the local force field, while being entirely arbitrary in recasting the original Wigner-Liouville equation, can be chosen as an effective local field mimicking optimally the effect of the Wigner kernel and providing substantial stabilization of the numerical code.

As an example that cannot be treated by classical statistical mechanics, we have calculated the tunneling current flowing though a double-barrier resonant tunneling diode using the stabilized, effective-field based algorithm, and compared the result with the unstable characteristics obtained from implementation of the genuine, unoptimized force field.

Power laws and skew distributions in evolving systems

R. Mahnke[1] , M. Brics[2] and J. Kaupužs[3]

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Power-law distributions and other skew distributions, observed in various models and real systems, are considered. A model, describing evolving systems with increasing number of elements, is considered to study the distribution over element sizes. Stationary power-law distributions are found. Certain non-stationary skew distributions are obtained and analyzed, based on exact solutions and numerical simulations. As another example of power–law behavior, critical exponents determined from highly accurate experimental data very close to the λ-transition point in liquid helium are discussed in some detail.

In [1] some interesting ideas are developed how skew distributions such as power law, log-normal and Weibull distributions emerge in general evolving systems and what makes the difference between them. However, we have found several problematic points in this consideration [2]. Therefore, we have reconsidered this problem and have found an example, where the Weibull distribution really emerges [3].

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Heat capacity in small non-equilibrium systems

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Heat capacity is a crucial characteristic of thermodynamic systems which has originally been introduced to quantify the amount of heat absorbed by the system when adapting to slow changes in the environment temperature, under prescribed conditions like fixed volume or pressure. We propose a generalization of this notion from equilibrium to non-equilibrium steady states, within the framework of stochastic Markov systems. The idea is to properly identify the reversible part of heat exchange along slow transformations between by nature dissipative steady states, and to establish it as a well-defined (finite) quantity in the quasistatic limit. The steady heat capacity defined upon this theoretical construction is shown to coincide with the equilibrium heat capacity under detailed balance conditions, and it obtains non-equilibrium corrections for weakly driven systems which can (up to leading order) be written in terms of equilibrium linear response. Far from equilibrium it exhibits novel features, e.g., its values can become negative. We manifest these peculiar properties via a number of simple models like two-/three-level systems and the driven diffusion in one/two dimensions. We also discuss how the generalized heat capacity can in principle be obtained from measuring the heat transfer along slow cyclic processes or from low-frequency dependent calorimetric experiments. Experimental challenges in application of our theory to realistic mesoscopic systems are demonstrated via the example of the current-driven resistively shunted Josephson junction.

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Almost-perfect transfer process through long unmodulated channels

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More than 99 %-fidelity end-to-end quantum-state and entanglement transfer can be achieved in the ballistic regime of an one-dimensional array of N sites, with N arbitrarily large. The interactions J between nearest-neighbors are uniform all over the chain, except for those involving the first and last bond, say J_0, and the second and last-but-one bond J_1, with $J_0 < J_1 < J$, a setting that preserves mirror-symmetry. The optimal extremal couplings correspond to suitable values $J_0 \sim 2N^{-1/3}$ and $J_1 \sim 2^{3/4}N^{-1/6}$ and the ballistic transmission time $t \simeq N/J$ is the minimum attainable. The quality of quantum transfer keeps being high in a large neighborhood of the optimized values, so there is no need to finely tune J_0 and J_1 in an experiment. It also shown that, allowing only for one extremal weaker bond, it is still possible to obtain an average transmission fidelity exceeding 90 % at an optimal value $J_0 \sim N^{-1/6}$. The general framework can describe the end-to-end response in different models, such as fermion or boson hopping models and XX spin chains.

Chiral Spin Liquid Phase in Weakly-Coupled Helimagnetic Spin Chains

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The critical properties of planar spin models composed by weakly interacting helimagnetic chains has been studied by extensive classical Monte Carlo simulations. In the two-dimensional system a clear separation is observed between the chiral phase transition, which displays the typical features of the Ising universality class, and the Kosterlitz-Thouless spin transition towards quasi-long-range order, the latter being located at a temperature well below the former one. A well defined temperature region is thus found where the vector chirality order parameter, kjk=Sj $\times$ Sk, takes nonzero value in the absence of long- or quasi-long-range order, so that a vector chiral spin liquid phase turns out to be present. The investigation of the same model for different interchain coupling strength shows that the weakness of the interchain exchange interaction plays an essential role for the stabilization of the spin-liquid phase in the intermediate temperature region, as predicted by the Villain's conjecture. The same spin-chirality decoupling is observed in preliminary results for the three-dimensional system, and the obtained phase diagram may be relevant for the physics of multiferroic materials.

Long Range Order in the ground state of quantum interacting rotors in two dimensions

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It is rigorously proven that the ground state of interacting quantum rotors in two dimensions exhibits the magneticlong-range order in the ferromagnetic case. The assumptions are that the interaction is between nearest neighbours and it is strong enough, and that rotors are sufficiently heavy. The proof is based on the Reflection Positivity technique.

First- and second-order quantum phase transitions in the exactly solved spin-1/2 Heisenberg-Ising ladder

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Ground-state phase diagrams of spin-1/2 Heisenberg-Ising two-leg ladder with the XXZ Heisenberg intra-rung interaction and two different Ising inter-rung interactions are examined within the framework of an exact mapping equivalence with the quantum Ising chain of composite spins in an effective longitudinal and transverse field. In an absence of the external magnetic field, the ground-state phase diagram constitutes two classical (ferromagnetic and stripe rung) phases and three quantum (Neel, stripe leg and paramagnetic) phases, which are separated one from each other either by the lines of discontinuous or continuous quantum phase transitions. The quantum reduction of staggered magnetization is examined in Neel and stripe-leg phases in dependence on a mutual ratio between the Ising and Heisenberg interactions. In the quantum paramagnetic phase, the short-range spin-spin correlations are exactly calculated in order to prove the spin-liquid character of this phase with the dominating rung singlet-dimer state. It is shown that the non-zero external field may cause an appearance of another peculiar quantum "staggered bond" phase when it breaks the rung singlet-dimer state into the triplet state in a staggered fashion at moderate values of the external magnetic field. An existence of the "staggered bond" phase consequently leads to a presence of the intermediate plateau at a half of the saturation magnetization in the zero-temperature magnetization process.

Phase Transitions On Non-Euclidean Hyperbolic Geometries

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Within the quantum-classical correspondence, we formulate 1D quantum and 2D classical spin lattice systems on a variety of hyperbolic geometries. The former system modifies the spin coupling in Hamiltonians under study so that $J \to J\cosh(j\lambda)$ with j and λ being a spin lattice site index and a non-negative parameter of the hyperbolic deformation, respectively. In the latter case, each hyperbolic surface having a constant negative Gaussian curvature is formed by tessellation of any uniform polygons with various lattice coordination numbers. Applying generalized numerical algorithms the Density Matrix Renormalization Group and the Corner Transfer Matrix Renormalization Group, we accurately classify phase transitions by calculating the critical exponents. Despite similarities in the lattice geometry, these systems exhibit rather different behavior. The entanglement entropy, spontaneous magnetization, and correlation functions are calculated in this respect. Whereas the critical exponent weakly depends on λ for the quantum systems, the mean-field universality class is always present in the classical systems regardless of the curvature of the hyperbolic geometry (notice that the Hausdorff lattice dimension remains infinite for all the hyperbolic surfaces studied). Finally, a smooth flattening out the hyperbolic geometries toward the Euclidean space at the phase transitions is analyzed in detail.

Dimensional reduction of evolution equations

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Outline of a perturbative mapping method, reducing dimensionality of evolution equations onto one (or few) reaction coordinate(s), is presented. The method is briefly resumed on an example of anisotropic diffusion in a 2D channel with varying cross section $A(x)$ onto the longitudinal coordinate x. The diffusion equation is integrated over the transverse coordinate y and the result of the mapping is a series of corrections to the Fick-Jacobs equation, which is the zero-th order approximation in our formulation. The corrections are generated within a rigorous recurrence procedure, controlled by a small parameter $\epsilon = D_x/D_y < 1$, the ratio of the longitudinal and the transverse diffusion constant.

The next extensions of the method are presented; it was used for mapping of the difusion in a longitudinal, as well as a transverse field. A specific case is the dimensional reduction of the phase space in the 1D Fokker-Planck (Kramers) equation onto the spatial coordinate x. The mass of the particles m becomes the small parameter and the velocity v plays the role of the transverse coordinate. The zero-th order approximation is represented by the 1D Smoluchowski equation, as expected. It is corrected by the mass dependent corrections in the higher orders. At the end, some general remarks on the choice of the small parameter and its impact on the structure of the relevant Hilbert space of the full-dimensional problem are given.

Dielectric excess wings in glasses

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The theory of fractional time [1], based on temporal coarse graining of translation (semi-)groups, leads to a mathematical model for the excess wing of the dielectric α-peak in glasses [2]. Applications of the theory to anomalous transport, non-Fickian diffusion, nonexponential relaxation, critical phenomena or non-Gaussian random walks have found increasing scientific attention in recent years [3–5]. Such applications raise a crucial question: How does the noninteger order α of the fractional derivatives or integrals arise from fundamental theory? Many works, particularly in the engineering literature, ignore this question and treat the fractional order as a phenomenological parameter, that cannot be measured in experiment. The first example of an answer to the question above was obtained within the classification theory of continuous phase transitions [6–8]. The second example concerns fractional time derivatives, and it answers the related question: How can fractional time derivatives arise in equations of motion? This question was investigated extensively by several different methods in [9–15]. The first mathematically rigorous identification of a fractional order α within a microscopic theory was discovered in [16]. It has remained the only rigorous identification, and was discussed extensively in [17–19]. Experimental evidence for fractional time derivatives is found in dielectric excess wings of glass forming liquids such as 5-methyl-2-hexanol, glycerol, propylen carbonate or methyl-m-toluate, that exhibit a high frequency excess wing in a broadband dielectric relaxation experiment [1, 20, 21].

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Fermionic functional renormalization group investigation of Luttinger liquids

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Luttinger liquid parameters are extracted from ground state energy calculations using a fermionic functional renormalization group (fRG) scheme [1, 2] This method has been been advocated as a useful tool for the description of one-dimensional Fermi systems [3] . It allows calculations of correlation functions for rather large inhomogeneous systems with and without spin degrees of freedom. As a consequence, determination of impurity exponents is possible, a goal at present hardly achievable with other methods.

A new way of interaction renormalization within fRG is proposed and compared to the alternative method introduced previously by Andergassen *et al.* [4]. Calculations using both methods are compared to Bethe Ansatz and perturbation theory results, in particular ground state energy, chemical potential, compressibility, and Luttinger parameter K. It is demonstrated that a consistent extraction of Luttinger liquid parameters from the numerically calculated ground state within fRG meets several severe numerical issues partly related to the fact that the truncated fRG is not a conserving approximation.

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Disordered two-dimensional electron systems with chiral symmetry

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We review the results of our recent numerical investigations on the electronic properties of disordered two dimensional systems with chiral unitary, chiral orthogonal, and chiral symplectic symmetry. Of particular interest is the logarithmic scaling of the smallest Lyapunov exponents in the vicinity of the chiral quantum critical point in the band center at $E = 0$,

$$z_1(E, L) = F\left(\frac{\ln L}{\ln \xi(E)}\right) \tag{1}$$

where the correlation lenghts $\xi(E)$ depends on the energy as

$$\ln \xi(E)/\xi_0 = A|\ln(E_0/E)|^{\kappa} \tag{2}$$

The possible non-universality of the critical exponent κ for certain chiral unitary models is discussed.

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Influence Of The Compressibility On The Anomalous Kinetics Of The Annihilation Process

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Annihilation reactions, where the reactans are influenced by some external advective field, are one of the most studied nonlinear statistical systems. This type of processes can be observed in miscellaneous chemical, biological or physical systems. In low space dimensions usual description by means of kinetic rate equation is not sufficient and the effect of density fluctuations must be taken into account. Using perturbative renormalization group we study the influence of random velocity field on the kinetics of single-species annihilation reaction at and below its critical dimension $d_c = 2$. The advecting velocity field is modelled by the self-similar in space Gaussian variable finite correlated in time (Obukhov-Kraichnan model). Effects of the compressibility of velocity field are taken into account and the model is analyzed near its critical dimension by means of three-parameter expansion in ϵ, Δ and η. Here ϵ is the deviation from the Kolmogorov scaling, Δ is the deviation from the (critical) space dimension 2 and η is the deviation from the parabolic dispersion law. Depending on the value of these exponents and the value of compressiblity parameter α, the studied model can exhibit various asymptotic (long-time) regimes corresponding to the infrared fixed points of the renormalization group. The possible regimes are summarized and the decay rates for the mean particle number are calculated in the leading order of the pertubartion theory.

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POSTERS

19–21 March 2012, Tatranské Matliare, Slovakia

Dislocations in lamellar phases confined in wedges

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Mesoscopic model for binary water-amphiphile mixture in contact with external walls is developed from microscopic description. The grand potential is a functional of the amphiphile concentration and a vector field representing average orientation of amphiphiles in mesoscopic regions. For parameters corresponding to stability of lamellar phases of different periods λ deformations occurring in caped wedges with different angles are determined. For $4l < \lambda < 7l$, where l is the thickness of the monolayer, we find strong dependence of the kind of defects in the stable configurations on the period of the lamellar phase, on the angle of the wedge, and on the type of surfaces. For small λ/l the bilayers are just terminated, whereas for larger λ/l the bilayer branches and at the defect from one bilayer two bilayers emerge. The defects in stable or metastable structures occur either near the mid plane of the wedge and near the cap when the lamellas are parallel to the wedge walls, or near the wedge walls when the lamellas are parallel to the wedge cap. In some cases transition between the first structure, stable for small wedge angles, and the second structure, stable for large angles is found.

Suppression of Finite Size Effects by Sine Deformation

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The ground-state properties of various quantum-mechanical finite-sized systems strongly depend on the imposed boundary conditions (BC). The periodic BC are numerically more preferable to the open/free BC due to faster convergence of observables if approaching the thermodynamic limit. On the other hand, the advantage of the open BC rests in the numerical feasibility of studying substantially larger system sizes, e.g. by RG techniques, despite the translational invariance is violated. We proposed the so-called sine deformation (SD) which preserves the advantage of the both BC [1]. It has been successfully applied to a variety of Hamiltonians such as the fermionic tight-binding model, the (extended) Hubbard model, and the Heisenberg model. The SD uses open BC while all the terms in the Hamiltonian are modified by a sine-shaped smoothing function. Having studied dependence of the ground-state energy per lattice site of the fermionic systems on increasing lattice size, we found out that imposing SD accelerated the ground-state energy convergence in analogy to the periodic BC. At the same time, the finite-size effects of the system are substantially suppressed if compared with the open BC. The system affected by SD tends to preserve the translational invariance. The ground state under SD is equivalent to the case of the periodic BC only for the tight-binding and the Heisenberg models in one dimension. However, even after introducing the Fermionic interaction (the Hubbard model) and/or extending the systems to higher dimensions, the above-mentioned properties remain valid. The obtained ground-state energy, the correlation function, and the mean occupancy are more accurate with respect to the thermodynamic limit than those obtained by the open BC. The SD has been primarily designed for the requirements of the DMRG and functional RG although its impact is much broader.

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Competition of strength and stress disorder in creep rupture

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We investigate the fracture of heterogeneous materials under a constant external load. Based on a fiber bundle model of sub-critical fracture with localized load sharing we show that the interplay of threshold disorder and of the inhomogeneous stress field gives rise to a rich dynamics with intriguing novel aspects. In the model fibers fail either due to immediate breaking or to a slow damage process. When the disorder is strong a high amount of damage occurs randomly diffused over the system, however, for weak disorder a single growing crack is formed which proceeds in a large number of localized bursts. The micro-structure of cracks is characterized by a power law size distribution which is analogous to percolation in the regime of diffusive damage, however, it becomes significantly steeper when a single crack dominates. Simulations showed that the size distribution of breaking bursts and that of the waiting times in between have a power law functional form with a load dependent cutoff. The burst size exponent proved to be independent of the damage process, however, it strongly depends on the external load with a minimum value of 1.75. The waiting time distribution is sensitive to the details of the damage process with an exponent decreasing from 2.0 to 1.4 as bursts get more and more localized to an advancing crack front.

Spin-ice-like phase in a modified XY model

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We study a modied XY model on the square lattice with magnetic and nematic nearest-neighbor interactions among classical spins which has been introduced earlier [D. H. Lee and G. Grinstein, Phys. Rev. Lett. 55, 541 (1985); S. E. Korshunov, JETP Lett. 41, 263 (1985)]. We concentrate on the previously unexplored case of competing magnetic and nematic interactions. Using a combination of Monte Carlo simulations and of nite size scaling, we show that the phase diagram of the model contains, in addition to the previously studied paramagnetic, ferromagnetic, and nematic phases, also a spin-ice-like phase. The individual phases can be classied making use of a close relation between the continuous XY model and a discrete 16-vertex model. We have published this work in Phys. Rev. B 84, 224420 (2011).

Inflection graphs and their models

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Inflection graphs are highly complex networks representing relationships between inflectional forms of words in human languages. For so-called synthetic languages, such as, for example, Latin or Polish, they have particularly interesting structure due to abundance of inflectional forms. We construct the simplest form of inflection graphs, namely a bipartite graph in which one group of vertices correspond to dictionary headwords and the other group to inflected forms encountered in a given text. Each inflected form is connected to its corresponding headword, which in some cases in non-unique. The resulting sparse graph decomposes into a large number of connected components, to be called word groups. Distribution of sizes of connected components of this graphs exhibit some remarkable properties, resembling cluster distribution in a lattice percolation near the critical point. We propose a simple model which produces graphs of this type, reproducing the desired cluster distribution.

Separation of components in lipid membranes induced by shape transformation

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Vesicles composed of a two component membrane with each component characterized by a different spontaneous curvature are investigated by minimization of the free energy consisting of the Helfrich elastic energy and the entropy of mixing. The results show that mixing and demixing of the membrane components can be induced by stretching a vesicle or changing its volume, if one of the components forms a complex with macromolecules on the outer monolayer. The influence of the elastic coefficients on the separation of components is also examined.

Critical Behavior of Complex Susceptibility of a Spin-1/2 and Spin-1 Mixed Ising Ferrimagnet on Square Lattice

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In this study, the complex order parameter susceptibility of a mixed spin-1/2 and spin-1 Ising ferrimagnetic system with different anisotropic is derived by making use of a method which combines equilibrium theory of critical phenomena and theory of irreversible thermodynamics. The temperature dependency of the ac order parameter susceptibility near the second order phase transition temperatures is analyzed according to various values of phenomenological rate coefficients (γ_{ij}). It is found that order parameter susceptibility represents a diverging behavior near the both sides of the critical temperature. These findings are in a good agreement with experimental data obtained for ferrimagnetic systems.

Universality of the Ising and the S = 1 model on Archimedean lattices: An accurate Monte Carlo determination

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The Ising model $S = 1/2$ and the $S = 1$ model are studied by efficient Monte Carlo schemes on the $(3, 4, 6, 4)$ and the $(3, 3, 3, 3, 6)$ Archimedean lattices. The algorithms used, a hybrid Metropolis-Wolff algorithm and a parallel tempering protocol, are briefly described and compared with the simple Metropolis algorithm. Accurate Monte Carlo data are produced at the exact critical temperatures of the Ising model for these lattices. Their finite-size analysis provide, with high accuracy, all critical exponents which, as expected, are the same with the well known 2d Ising model exact values. A detailed finite-size scaling analysis of our Monte Carlo data for the $S = 1$ model on the same lattices provides very clear evidence that this model obeys, also very well, the 2d Ising model critical exponents. As a result, we find that recent Monte Carlo simulations and attempts to define effective dimensionality for the $S = 1$ model on these lattices are misleading. Accurate estimates are obtained for the critical amplitudes of the logarithmic expansions of the specific heat for both models on the two Archimedean lattices.

Critical properties and amplitudes for the Ising model on Archimedean lattices: a Monte Carlo simulation study

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Using the exact critical temperatures, obtained recently by the Feynman-Vdovichenco combinatorial approach (A. Codello, J. Phys. A: 43, 385002, 2010), we study the critical properties and estimate certain critical amplitudes for the Ising model on several Archimedean lattices. Our results are obtained my means of an appropriate Monte Carlo scheme implementing both the Wolff and Metropolis algorithms. After a general illustration of critical expectation related to the 2d Ising universality class, we estimate the critical amplitudes of the specific heat expansions. Furthermore, we estimate the critical Binder cumulants of the order parameter and discuss the effects of boundary conditions on them.

Investigation of the influence of crystal field disorder on the critical relaxation theory of Blume Capel Ferromagnetic Model

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The relaxation dynamics of a Blume-Capel model with a quenched diluted crystal field is formulated by a method combining the statistical equilibrium theory and the thermodynamics of linear irreversible processes. Using a mean-field approximation for the magnetic Gibbs free-energy production, a generalized force and a current are defined within the irreversible thermodynamics. Next the kinetic equation for the magnetization is studied for the particular two-valued distribution $P(\Delta_i) = (1/2)(\delta[\Delta_i - (1+\alpha)] + \delta[\Delta_i - (1-\alpha)])$, depending upon the value of α. Finally, the temperature dependence of the relaxation time in the neighborhood of the phase-transition points is obtained by solving the kinetic equation of the magnetization

The relaxation dynamics in a mixed spin-1 and spin-2 Ising ferromagnetic system with different single ion anisotropies

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Kinetic equations of a mixed spin Ising system is formulated near the equilibrium using a molecular field approximation and a method which combines thermodynamics of irreversible processes and equilibrium theory of statistical mechanics of cooperative phenomena. Kinetic equations describing the relaxation of the sublattice magnetization are obtained by introducing kinetic coefficients which satisfy the Onsager relation. By solving these equations, the temperature variance of the two relaxation times and dynamical susceptibility is obtained. One of the relaxation times has a divergence at the second-order phase transition. Wheras the other relaxation time represent a cusp near the critical point. The real and imaginary parts of the complex susceptibility exhibits a critical divergence at the low frequency limit.

Critical and Tricritical Frequency Variance of the Relaxation Theory of a Metamagnetic System

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We have discussed a simple kinetic formulation of Ising metamagnet based on nonequilibrium thermodynamics. The Argand diagrams of staggered and total ac susceptibilities near the critical and tricritical points of a two-sublattice Ising metamagnet with nearest- and next-nearest-neighbor interactions is represented. Critical and tricritical Argand diagrams of the complex staggered susceptibility embody two distinct semicircles in the ordered phase and only one semicircle in the disordered phase. In addition, the frequency dependence of both ac susceptibilities is represented. Findings of the study is well suited to previous theoretical and experimental studies.

Examination of the relaxation processes of spin-1 and spin-3/2 mixed Ising model with two distinct crystal field interaction

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The kinetics of a spin-1 and spin-3/2 Ising system containing biquadratic interactions near equilibrium states is discussed within mean field approximation by making use of Onsager's theory of irreversible thermodynamics. Two relaxation times are calculated and their temperature variances are examined. The critical slowing down of the system is characterized by a diverging relaxation time near the critical and tricritical points. Moreover, the critical and multicritical behaviors of the relaxation processes are also obtained analytically via the mean field critical exponents.

Multicritical Argand Analysis of the Complex Magnetic Response Functions of Iron Group Dihalides

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Ac total and ac staggered magnetic response functions are analyzed in complex plane for constant temperature values in the neighborhood of multicritical points (CEP and DCP) of a metamagnetic system. The calculations of ac total and ac staggered susceptibilities of a metamagnetic system on a cubic lattice to which an ac oscillating magnetic field is applied is carried out within theory of irreversible processes. Unlike the critical and tricritical cases the Argand diagrams of complex susceptibilities embody two distinct semicircles both in the ordered and disordered phases. In addition, the frequency dependence of both ac susceptibilities is represented. Finally, comparison of the obtained results to previous experimental and theoretical data is given.

Current-carrying state of a *d*-wave superconductor

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In the limit of vanishing temperatures, we investigate the properties of the *d*-wave superconducting state in presence of finite homogeneous supercurrents. We generalize the variational technique developed for the description of superconductivity in the repulsive Hubbard model to the case with a finite momentum of the Cooper pairs $2\boldsymbol{q}$. This approach takes into account both, the change of the pairing interaction, as well as the change of the gap function in presence of a finite Cooper-pair momentum. We study the evolution of the superconducting state with increasing $\boldsymbol{q}$ and we find that the order of the transition to the normal state depends on the direction of $\boldsymbol{q}$.

Synchronization in a two-mode oscillator ensemble

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Synchronization of a large ensemble of oscillators is a puzzling collective phenomenon and it has been investigated for a long time by means of statistical physics methods. Synchronization appears usually as a result of phase-minimizing interactions between the units. For non-identical oscillators, as a function of the coupling strength interesting phase-transition type behavior is observable [1,2]. A recently introduced synchronization model assumes that spontaneous synchronization might arise also as a byproduct of simple optimization processes [3-5]. In this system the oscillators are stochastic elements capable of emitting pulses and detecting the pulse emitted by the others. They have two operational modes, characterized by different oscillating periods. Shifting between these modes is induced by a simple optimization rule: the average output intensity of the oscillators is kept around a fixed G threshold. This simple dynamical rule realizes the coupling of the units and triggers a complex collective behavior. As a function of the ratio of the periods of the two modes and the G threshold value, a rich collective behavior is observed. Here, by large-scale computer simulations we map the parameter space of this puzzling system and identify those domains where synchronization appears. Finite-size effects are also investigated. An experimental realization of the system is also discussed. Work supported by PN-II-ID-PCE-2011-3-0348.

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Comparison of grafted and non-grafted polymer adsorption in different ensembles

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After we recently found first-order like signatures in the microcanonical entropy at the adsorption transition of a finite single free polymer in good solvent [1], and knowing that many studies on polymer adsorption in the past have been performed for grafted polymers, we attempt a comparison of the thermodynamic behavior for both cases with the present work [2]. This comparison not only covers the adsorption transition but all transitions a coarse-grained off-lattice model undergoes close to an attractive substrate are analyzed for both cases and compared over a wide parameter range. Due to the impact of grafting especially on the translational but also on the conformational entropy of desorbed chains, the adsorption transition is affected the strongest. The results are obtained by a combined canonical and microcanonical analysis of parallel tempering Monte Carlo data.

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Simulating flexible polymers in a potential of randomly distributed hard disks

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Recently, we performed equilibrium computer simulations of a two-dimensional pinned flexible polymer exposed to a quenched disorder potential consisting of hard disks [1]. Throughout the study, we applied two conceptionally different algorithms, an off-lattice growth algorithm and a multicanonical Monte Carlo method, in order to cross-check the results obtained. We measured the end-to-end distribution and the tangent-tangent correlations and investigated the scaling behavior of the mean square end-to-end distance for short chains. While the influence of the potential in the low-density case is merely marginal, it was possible to show that it dominates the configurational properties of the polymer for high densities.

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About the advantage and disadvantage of lane changing in a twolane spring-block traffic model

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Each time we are stacked in the middle of a traffic jam there is a feeling that the cars in the other lane are advancing better. In such situations the question what would be the better strategy: to change or not to change the lane naturally arises in our mind. This question is studied, analyzed and responded by computer simulations using the spring-block approach of the highway traffic.

In this work two lanes are simulated in traffic jam conditions using the spring-block model of highway traffic (F. Járai-Szabó, B. Sándor, Z. Néda, Cent. Eur. J. Phys. 9(4), 1002-1009, 2011; F. Járai-Szabó, Z. Néda, arXiv:1111.1803v1, 2011). The lane changing probability of cars in the system is defined and it is considered as a parameter of the simulations. The advance of two selected cars is studied and compared to each other. On one hand, the first selected car (usually the last car in a lane) is a lane changer. During simulations it changes the lane if there is an opportunity for a better advance. On the other hand, the second car that initially stands near the first one is never changing lanes. By large scale computer simulations the winning probability of the lane-changer car is studied as a function of the lane changing probability of other cars in the row. An interesting phase-transition is detected and conclusions are drawn regarding the conditions when lane changing is advantageous for drivers.

This work was supported by Romanian National Research Council (CNCS-UEFISCSU), project number PN II-RU PD_404/2010.

Competition between quenched disorder and long-range connections: A numerical study of diffusion

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The problem of random walk is considered in one dimension in the simultaneous presence of a quenched random force field and long-range connections the probability of which decays with the distance algebraically as $p_l \simeq \beta l^{-s}$. The dynamics are studied mainly by a numerical strong disorder renormalization group method. According to the results, for $s > 2$ the long-range connections are irrelevant and the mean-square displacement increases as $\langle x^2(t)\rangle \sim (\ln t)^{2/\psi}$ with the barrier exponent $\psi = 1/2$, which is known in one-dimensional random environments. For $s < 2$, instead, the quenched disorder is found to be irrelevant and the dynamical exponent is $z = 1$ like in a homogeneous environment. At the critical point, $s = 2$, the interplay between quenched disorder and long-range connections results in activated scaling, however, with a non-trivial barrier exponent $\psi(\beta)$, which decays continuously with β but is independent of the form of the quenched disorder. Upper and lower bounds on $\psi(\beta)$ are established and numerical estimates are given for various values of β. Beside random walks, accurate numerical estimates of the graph dimension and the resistance exponent are given for various values of β at $s = 2$.

Goldstone mode singularities and critical exponents in n-vector models

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Goldstone mode singularities and critical exponents in the φ^4 model and corresponding n–vector models are considered within the approach called the GFD (grouping of Feynman diagrams) theory [1,2]. Monte Carlo (MC) evidences of [3,4] and recent simulation results support the statement of the GFD theory [2] that the Goldstone mode power–law singularities below the critical point are described by certain nontrivial exponents. The critical–point singularities of the 3D Ising model ($n = 1$) also can be well described by the critical exponents $\eta = \omega = 1/8$ and $\nu = 2/3$, proposed by certain conjecture of the GFD theory. The consistency with MC data for very large lattices ($L \leq 1536$) is demonstrated in [5]. More recent simulation results show that the GFD theory provides remarkably better interpretation of specific heat data than the perturbative RG theory ($\eta \simeq 0.0335$, $\omega \simeq 0.8$, $\nu \simeq 0.63$). A non-perturbative proof concerning corrections to scaling in the two–point correlation function of the φ^4 model shows that predictions of the GFD theory rather than those of the perturbative RG theory can be correct. We demonstrate also that the known very accurate experimental specific heat data, obtained in zero–gravity conditions very close to the λ–transition point in liquid helium, can be well described by an expansion in powers of $t^{-\alpha}$ with the critical exponent $\alpha \approx -1/13$, estimated as a fit parameter at very small reduced temperatures t. It confirms our conjecture at $n = 2$.

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Dephasing-enhanced transport in strongly-correlated non-equilibrium quantum spin chains

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We present numerical evidence of dephasing enhanced spin transport in the non-equilibrium stationary state of the one-dimensional anisotropic Heisenberg model subjected to strong boundary driving. In contrast to previous examples of environment-assisted transport, where dephasing assists transport by disrupting single particle interference effects, the mechanism presented here only exists in the strongly interacting regime, exemplifying that it is a genuine non-equilibrium many-body phenomenon. We show that the enhancement is due to energy-dissipating dephasing processes transferring excitations from localized bound modes to mobile states, and that an optimal dephasing rate exists. Our results are based on large scale matrix product simulations of the quantum master equation. Beyond the Heisenberg model we find that dephasing enhancement is not dependent on integrability and conjecture that it will persist in more realistic models of interacting electrons like the Hubbard model.

Mass-velocity correlation in impact fragmentation

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We study the impact fragmentation of two-dimensional disordered solids focusing on the spatial distribution and mass-velocity correlation of fragments. Depending on the energy of impact the breakup process can have two different outcomes: at low impact energy the sample gets damaged, however, to achieve fragmentation the imparted energy has to surpass a critical value. Based on large scale computer simulations we show that the position of fragments inside the original body with respect to the impact site determines their mass and velocity in the final state. A novel relation of the mass and velocity of fragments is revealed: In the damage phase fragment mass and velocity are strongly correlated. In the fragmented regime for small fragments the velocity proved to be independent of the mass, however, in the limit of large fragments a strong mass-velocity correlation occurs. The correlation function decays as a power law with a universal exponent in an excellent agreement with recent experimental findings. Our results have interesting implications for the understanding of the formation of meteoroid clouds and planetesimal accretion in the solar system.

Self-consistency of two-particle vertices in the Anderson model of disordered electrons

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We study effects of multiple scatterings of electrons and quantum coherence in extended disordered systems within a diagrammatic expansion of averaged two-particle functions. We use Bethe-Salpeter equations in the electron-hole and electron-electron channels so that electron-hole symmetry for two-particle vertices is preserved. The parquet approach is used to introduce self-consistency on the two-particle level. We then simplify momentum convolutions in the limit of high spatial dimensions and end up with a mean-field-like equation for a local two-particle vertex that allows us to calculate diffusion and transport properties of disordered electrons. Finally, we demonstrate how vanishing of diffusion emerges in this diagrammatic approach to the Anderson model of non-interacting disordered electrons.

Complex temporal structure of activity in on-line electronic auctions

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We analyze empirical data from the internet auction site Aukro.cz. The time series of activity shows truncated fractal structure on scales from about 1 minute to about 1 day. The distribution of waiting times as well as the distribution of number of auctions within fixed interval is a power law, with exponents 1.5 and 3, respectively. Possible implications for the modeling of stock-market fluctuations are briefly discussed.

Rigorous criterion for observing reentrant transitions in the spin-1/2 Ising-Heisenberg model on diamond-like decorated Bethe lattices

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Generalized decoration-iteration transformation is combined with the method of exact recursion relations in order to obtain the rigorous results for the spin-1/2 Ising-Heisenberg model on diamond-like decorated Bethe lattices. Apart from the classical ferromagnetic phase, the investigated quantum spin model with the ferromagnetic XXZ Heisenberg interaction may also exhibit a disordered spin-liquid ground state on behalf of the geometric frustration triggered by a competition between the easy-plane XXZ Heisenberg interaction and the easy-axis Ising-type interaction, respectively. It is evidenced that the finite-temperature phase boundary between the spontaneously ordered and disordered phases basically depends on a coordination number q of the underlying Bethe lattice. It is shown that the finite-temperature phase boundary approaches the zero-temperature phase transition between the ordered and disordered phases with a negative slope for the Bethe lattices with the coordination number $q > 4$, with a positive slope for the Bethe lattices with the coordination number $q > 4$ and with an infinite gradient for the Bethe lattice with the particular value of the coordination number $q = 4$. Owing to this fact, reentrant phase transitions can be observed in a close vicinity of the zero-temperature transition between the ordered and disordered phases for the diamond-like decorated Bethe lattices with a sufficiently high coordination number $q > 4$. In addition to the finite-temperature phase diagrams, our attention is also focused on temperature variations of the spontaneous magnetization, which provide an independent confirmation of the observed reentrance.

Acknowledgment: This work was partially supported under the grant VEGA 1/0234/12.

Ground-state energy and elementary excitations of the spin-1/2 Heisenberg-Ising bond alternating chain with Dzyaloshinskii-Moriya interaction

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Ground-state energy and elementary excitation spectrum are exactly calculated for the spin-1/2 Heisenberg-Ising bond alternating chain with the Dzyaloshinskii-Moriya interaction present along the Heisenberg bonds using the rotation, Jordan-Wigner, Fourier and Bogolyubov transformations. At first, the rotation transformation is used to eliminate the Dzyaloshinskii-Moriya interaction from the Hamiltonian, then the Jordan-Wigner transformation is applied to rewrite the spin Hamiltonian in terms of Fermi operators and finally, the Fourier and Bogolyubov transformations are employed to bring the Hamiltonian into the diagonal form. It is shown that the ground-state energy of the investigated quantum spin chain exhibits at a quantum critical point, which appears under special condition that relates a strength of the Ising interaction to the ones of Heisenberg and Dzyaloshinskii-Moriya interactions, an interesting non-analytical behaviour accompanied with a gapless excitation spectrum. In the rest of the parameter space, there is always a non-zero energy gap between the ground state and excited states. In an absence of the Dzyaloshinskii-Moriya term, our results reproduce exact results previously obtained by Lieb, Schultz and Mattis [1] for the isotropic version and by Yao, Lin and Gong [2] for the anisotropic version of the spin-1/2 Heisenberg-Ising bond alternating chain.

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Phase diagrams and thermodynamics of the mixed-spin Ising model on decorated planar lattices with a spin-phonon interaction

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The mixed spin-1/2 and spin-S Ising model on a decorated square lattice partially amenable to lattice vibrations is exactly treated by making use of the canonical coordinate transformation and the decoration-iteration transformation in the spirit of the harmonic approximation. It is shown that the magnetoelastic coupling gives rise to an effective three-site four-spin interaction, which competes with the nearest-neighbour interaction and is thus responsible for a unusual spin frustration of the decorating spins. Apart from the usual ferromagnetic (ferrimagnetic) phase one consequently finds a striking partially ordered and partially disordered phase, where a perfect antiferromagnetic alignment of the Ising spins from the nodal sites of a square lattice is accompanied with a partial disorder of the decorating spins.

Exact results for the ground-state and finite-temperature phase diagrams are presented for the particular case of the mixed spin-1/2 and spin-1 Ising model on a decorated square lattice along with thermal dependences of the spontaneous magnetization and the specific heat. It is demonstrated that diverse thermal variations of the heat capacity may result from the mutual interplay of lattice and magnetic contributions to the overall specific heat, which may include besides the logarithmic singularity an additional round maximum emerging either in the low- or high-temperature tail of the specific heat. In addition, the effect of magnetoelastic coupling and uniaxial single-ion anisotropy on the critical behaviour is investigated in detail.

Acknowledgment: This work was partially supported under the grant VEGA 1/0234/12.

Exact solvability of Rabi models

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The (standard) **Rabi** model in quantum optics describes one of the simplest possible interactions between a two-state atom and a phonon (photon). Alternatively, it is a special case of what is called the **Single-mode spin-boson** model, some called it the **Jaynes-Cummings** model without rotating wave approximation, dimer-oscillator model and other pseudonyms. There were many trials to solve this model exactly, until recently *D. Braak (PRL 2011)* succeeded to do so. He performed the **Bargmann** transformation in order to simplify the bosonic operators and he got a set of two differential equations. Using its expanded solutions, *Braak* introduced two analytic functions, given by the symmetries of the problem. All roots of these functions are eigenenergies, thus they yield the complete spectrum of the Hamiltonian. This fact is closely connected with the analyticity condition. Eigenstates in Bargmann space are also at disposal. Proceeding in full analogy, we managed to solve also the **two-photon Rabi** model exactly, introducing four symmetry-functions. Their number follows from the eigenvalues of the parity operator. According to *E. Solano*, this seems to be a novel class of exactly solvable models, without knowing sufficient number of integrals of motion. We have just some quantum numbers instead, defining each eigenstate uniquely.

Polymer adsorption on structured surfaces: field theoretic approach

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Investigation of polymer chains adsorption onto structured surface like as a chemical step (where one part of a surface is repulsive for polymers and other part is at the adsorption threshold) was performed. The two-point correlation function of ideal polymer chain in the half-space bounded by structured surface with two different adsorption energies c_1 and c_2 (with $c_1 \neq c_2$) and the "closest form" for the free propagator of the model were obtained in analytical form. Besides, the force which ideal polymer chain with free end exerts on the structured surface, when the other end is fixed at the surface in the case when surface is at the beginning repulsive from $-\infty$ to 0 (or inert) and later is inert from 0 to ∞ (or repulsive), was calculated. The obtained results indicate that the process of homopolymer adsorption onto structured surfaces should be described by different scaling laws than universal scaling laws predicted in the literature for homopolymer adsorption on homogeneous surfaces.

Influence of electrodynamic environment on small area Josephson junctions

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It is known that for small-area Josephson junctions the phase fluctuations induced by the electrodynamic environment of the junction can crucially affect its behaviour with the quality factor of the circuit playing an important role. We used semi-analytical and numerical methods to study the influence of the electrodynamic environment on the junction properties in more detail. The temperature dependence and quality-factor dependence of the I-V characteristics and voltage noise were obtained. Special attention was paid to the sources of the voltage noise. We have identified three different components of the voltage noise, namely the thermal (Johnson) noise of the circuit equivalent resistance, noise resulting from sharp voltage pulses caused by 2π jumps in phase, and the dichotomous noise. The dichotonous noise is prevailing in the region where the bistability between the so called running and locked solutions is observed and it is responsible for a significant increase of the voltage noise maximum with increasing quality factor. Moreover, we have shown that the influence of the electrodynamic environment can lead to a discontinuous change of the voltage noise observed in preliminary experiments [1].

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Critical and ground-state properties of a selectively diluted Ising antiferromagnet on triangular and honeycomb lattices

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An effective-field theory with correlations is employed in order to study critical and ground-state properties of a selectively diluted Ising antiferromagnet on triangular and honeycomb lattices. The selective dilution with nonmagnetic impurities is carried out by random removal of magnetic ions from individual sublattices of the respective lattices with different probabilities. While the pure triangular Ising antiferromagnet is known to display no long-range ordering due to high degree of geometrical frustration [1], the dilution of different sublattices with generally unequal probabilities results in relieving of the frustration which can lead to a long-range order. We explore the sublattice dilution parameters space and obtain a rather intricate three-dimensional phase diagram displaying reentrant phenomena in both the low- and high-dilution regions. Furthermore, the selective dilution is shown to considerably affect the degree of saturation of the ground-state sublattice magnetizations. In a vast region of the parameters space the sublattice magnetizations fall short of saturation and the degree of unsaturation is found to be proportional to both the degree of frustration and dilution. However, due to compensating effects of the two factors (the increasing dilution decreases frustration), the highest unsaturation is observed at the intermediate dilution range, in the vicinity of the phase boundaries. The selectively diluted Ising antiferromagnet on the honeycomb lattice is obtained as a special case when one sublattice of the triangular lattice is completely removed by dilution. We establish the phase diagram including the percolation threshold below which no long-range order can exist.

This work was supported by the Scientific Grant Agency of Ministry of Education of Slovak Republic (Grant No. 1/0234/12).

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Episodes of transient nonlinearity in the Slovakian stock market

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Recent empirical studies suggest that stock market indices depart from the random walk hypothesis by showing a certain degree of long-term or short-term dependent relationships, thus violating the weak-form efficient market hypothesis (EMH) [1]. Since the weakest form of EMH implies that the returns should be serially uncorrelated, its validity can also be assessed by looking for evidence of significant linear and nonlinear serial autocorrelations in the returns [2]. Due to the time variation and transient nature of the market efficiency, we study the dynamics of such dependencies in a rolling window framework [3], using historical daily data of the Slovakian stock market (SAX) index. We focus on detection of episodes with statistically significant two- and three-point correlations in the returns, signifying the appearance of transient inefficiency that could offer some potential for a short-term predictability. The rolling window approach enables us to capture the correlation dynamics for various window lengths and analyze the distributions of such episodes [4]. It is found that for larger window lengths these distributions comply with the power-law. We also measure the predictability itself by a hit rate, which quantifies the consistency between the signs of the actual values of the returns and their predictions obtained from a simple correlation-based predictor. We find that during these relatively brief episodes the returns can be predicted to a certain degree and the predictability is sensitive to the window length.

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Universal logarithmic corner contribution to the number of surface clusters at the percolation transition

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Geometrical percolation is the simplest and probably the most influential model displaying continuous phase transitions. As a prominent testbed of critical phenomena, the understanding of its behavior may help to grasp the essence of criticality in more complex systems as well. Here we study the following simple question in general d dimensions. For cubic subsystems with linear size ℓ, how the number of surface clusters grows with ℓ?

Naturally, the number of clusters – crossed by the surface of the subsystem – is expected to grow linearly with the area of the surface, known as the *area area*. However, Yu *et al.* [Phys. Rev. B **77**, 140402 (2008)] observed numerically a logarithmic correction to the area law at the critical point in $d = 2$, with a prefactor of $b^{(2)} = -0.06(1)$ for both site and bond percolation. In our studies we addressed the following questions. i) What is the origin of these logarithmic corrections? ii) Is there a logarithmic correction also in higher dimensions? iii) Can $b^{(d)}$ be positive in higher dimensions? In the poster we present our results for these questions and show, that the logarithmic correction appears due to the corners of the subsystem.

Remarkably, this cluster counting problem emerges also in quantum systems, where the ground state is built up from independent spin clusters. An interesting example is the random transverse-field Ising model, which is often called as the realization of the 'quantum percolation' universality class. Recently, we have found in this model similar universal logarithmic corrections with the application of the strong disorder renormalization group method [`arXiv:1108.3942`]. Besides the many similarities between the classical and quantum case, we give a list of both the important differences and the most interesting open questions.

Critical point of the Majority vote model films

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In this work we performed numerical simulations to evaluated the critical point as function of the layer number for the majority vote model. We used an alternative approach for the evaluation of the critical points, based on the combination of the second, third and fourth order cumulants for several system sizes. Comparisons with existing results for the Ising model are discussed.

Scale-free enumeration of self-avoiding walks on percolation clusters

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The abstract has not been sent.

Isolated critical point of a para-ferrimagnetic phase transition in a field

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The abstract has not been sent.

MECO37

37th Conference of the Middle European Cooperation in Statistical Physics

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Notes