43rd Conferences of the Middle European Cooperation in Statistical Physics

MECO43 Book of Abstracts

K. Malarz, M. J. Krawczyk, P. Gawroński (eds.)

Kraków, May 1-4, 2018

FACULTY OF PHYSICS AND APPLIED COMPUTER SCIENCE
AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Table of contents

Preface

The MECO conference has a long tradition which was born with the first meeting in Vienna in 1974. The main theme of this meeting was critical phenomena and renormalisation group. It was a hot topic in field theory and statistical physics at that time. The plan was to bring together scientists from Middle-European countries, from both sides of the iron curtain, to exchange ideas on this fascinating topic and to strengthen scientific **M**iddle-**E**uropean **CO**operation in Statistical Physics. It turned out later that this meeting gave the name and became a seed of an entire series of annual conferences on statistical physics. MECO has continued, with a break of two years, for more than four decades and has evolved from a Middle-European one to a European-scale conference.

Today MECO attracts scientists working in the field of statistical physics and related areas from the whole Europe and other continents. It covers the whole spectrum of topics ranging from statistical mechanics, condensed matter, soft matter, active matter, quantum many body systems and quantum information, frustrated and disordered systems, complex systems, complex networks, classical and quantum critical phenomena, non-equilibrium phenomena to interdisciplinary applications of statistical physics and it follows current developments in these fields and related areas.

The 43th edition of the MECO conference will be held in Krakow at AGH University of Science and Technology in the period of May 1-4, 2018. This is not a very typical period as for MECO which is usually held in February or March. The Local Organising Committee decided to take the risk to organise the MECO conference outside its typical dates since the members of the Committee have some experience with how bad the weather can be in February or March in Krakow. And indeed this year it was really awful. They hope for a good weather in May.

In the program of the MECO43 there are 13 invited lectures, 10 contributed talks and more than 80 posters. The contributions follow all important threads in contemporary statistical physics. This year there are many contributions on interdisciplinary applications of statistical physics including those in finance, social sciences, complex system, biophysics and information theory. The concepts and methods of statistical physics have proved to be extremely useful in all these areas and have contributed to a significant development, new insights and breakthroughs in recent decades. In effect, recently we have experienced a renaissance of statistical physics' ideas and a broadening of the range of applicability of these ideas.

There are two distinguished lectures at MECO43. Wojciech Żurek from the Los Alamos National Laboratory will give a talk *Universality of phase transition dynamics: topological defects from symmetry breaking*. This talk has a special status of *AGH-UST Rector Lecture* and is sponsored by the Rector of our University. Wojciech Żurek is famous for his pioneering work on topological defects formation at phase transition, as well as on quantum decoherence and quantum computing. He has graduated from our University. The second special lecture is by Jean-Philippe Bouchaud from Capital Fund Management. The talk is entitled *Statistical physics in economics and finance: still fringe after 30 years* and it has a special status of *EPJ Prize Lecture*. It has been selected by the Editor Board of European Physical Journal to honour enormous contribution of Jean-Philippe Bouchaud to statistical physics including his work on anomalous diffusion, glassy systems, granular media and the application of statistical physics to finance. The talk is sponsored by EPJ.

The posters will be presented during two poster sessions and will take part in the best poster competition. Three best posters will be awarded prizes in the form of book vouchers sponsored by Springer International Publishing AG.

The MECO43 conference will be held under auspices and honorary patronage of AGH University of Science and Technology Rector—Tadeusz Słomka. The conference is sponsored by AGH-UST, Municipality of Kraków, Springer (EPJ), IOP Institute of Physics (EPL and Journal of Physics A: Mathematical and Theoretical), which are acknowledged here. The conference is organised by the AGH Foundation and Faculty of Physics and Applied Computer Science of AGH University of Science and Technology.

MECO43 Organizing Committee

Honorary Patronage

Prof. Dr. **Tadeusz Słomka**, AGH-UST Rector

International Advisory Board

B. Berche (Nancy), K. Binder (Mainz), A. Cuccoli (Firenze), C. Dellago (Vienna), C. Di Castro (Roma), A. Fedorenko (Lyon), M. Henkel (Nancy), Y. Holovatch (Lviv), A. Gambassi (Trieste), F. Iglói (Budapest), W. Janke (Leipzig), R. Kenna (Coventry), G. Meissner (Saarbrücken), H. Rieger (Saarbrücken), A. Surda (Bratislava), J. Sznajd (Wrocław), S. Trimper (Halle), K. Uzelac (Zagreb)

Local Organizing Committee

Zdzisław Burda [1], Przemysław Gawroński [1], Anna Inglot [2], Malgorzata Krawczyk [1], Krzysztof Kułakowski [1], Krzysztof Malarz [1]

Supporting organizations

[1] AGH University of Science and Technology, Faculty of Physics and Applied Computer Science – Kraków, Poland
[2] Fundation for AGH-UST – Kraków, Poland
[3] Municipality of Kraków
[4] Springer
[5] EPJ
[6] IoP
[7] EPL
[8] Journal of Physics A: Mathematical and Theoretical

Chapter 1

Invited talks

Emergent hyperbolic network geometry

Ginestra Bianconi*† [1]

[1] Queen Mary, University of London – United Kingdom

A large variety of interacting complex systems are characterized by interactions occurring between more than two nodes. These systems are described by simplicial complexes. Simplicial complexes are formed by simplices (nodes, links, triangles, tetrahedra etc.) that have a natural geometric interpretation. As such simplicial complexes are widely used in quantum gravity approaches that involve a discretization of spacetime. Here, by extending our knowledge of growing complex networks to growing simplicial complexes we investigate the nature of the emergent geometry of complex networks and explore whether this geometry is hyperbolic. Specifically we show that an hyperbolic network geometry emerges spontaneously from models of growing simplicial complexes that are purely combinatorial. The statistical and geometrical properties of the growing simplicial complexes strongly depend on their dimensionality and display the major universal properties of real complex networks (scale-free degree distribution, small-world and communities) at the same time. Interestingly, when the network dynamics includes an heterogeneous fitness of the faces, the statistical properties of simplicies of different dimension are described by quantum Bose–Einstein and Fermi–Dirac statistics. Moreover the growing simplicial complex can undergo phase transitions that are reflected by relevant changes in the network geometry.

*Speaker
†Corresponding author: ginestra.bianconi@gmail.com

Statistical physics in economics and finance: still fringe after 30 years. EPJ Prize Lecture

Jean-Philippe Bouchaud*† [1]

[1] CFM Paris, Capital Fund Management – France

Despite many important contributions, 'econophysics' has not yet made a real breakthrough in Economics, at least from the viewpoint of economists.

We will review some (subjectively chosen) of these contributions and their impact on the field, and try to identify the barriers that hobble progress. Some recent developments will be discussed, in particular how macroeconomic/financial Agent Based Models shed interesting light on instabilities and crises.

*Speaker
†Corresponding author: jean-philippe.bouchaud@cfm.fr

Random Delaunay triangulations, circle patterns and 2D quantum gravity

François David* [1]

[1] Institut de Physique Théorique, CEA/DRF and UMR CNRS 3681, Commissariat à l'énergie atomique et aux énergies alternatives: DRF/IPHT, Université Paris-Saclay, Centre National de la Recherche Scientifique: UMR3681, Institut de Physique Théorique – Orme des Merisiers batiment 774, Point courrier 136 CEA/DSM/IPhTCEA/Saclay, F-91191 Gif-sur-Yvette Cedex, France

I present recent results on a model of random planar Delaunay triangulations. It exemplifies the relations between random geometries in the plane, conformally invariant point processes, and topological gravity. Possible connections with discretizations of conformal filed theries and deformations of integrable systems will be explored. This is recent work with B. Eynard and S. Charbonnier, and work in progress with J. Scott.

*Speaker

Stochastic resetting

Martin Evans*† [1]

[1] School of Physics and Astronomy, University of Edinburgh – Edinburgh EH9 3FD, United Kingdom

This talk will review the effect of stochastic resetting on the fundamental dynamical process of diffusion: by repeatedly restarting the diffusive particle one generates a nonequilibrium stationary state. Moreover the first passage time for the diffusive particle to reach some target is drastically changed—it becomes finite whereas for diffusion it is infinite. I will discuss recent developments of the resetting paradigm to long-tailed resetting time distributions and to resetting to a randomly chosen time from the diffusive process's history.

[1] M. R. Evans, S. N. Majumdar, Phys. Rev. Lett. 106, 160601 (2011).
[2] A. Pal, A. Kundu, M. R. Evans, J. Phys. A: Math. Theor. 49, 225001 (2016).
[3] D. Boyer, M. R. Evans, S. N. Majumdar, J. Stat. Mech. 023208 (2017).

*Speaker
†Corresponding author: mevans@staffmail.ed.ac.uk

Exponential number of equilibria and depinning threshold for a directed polymer in a random potential

Yan Fyodorov* [1], Pierre Le Doussal [2], Alberto Rosso [3], Christophe Texier [3,4]

[1] King's College London – Strand Campus, London WC2R 2LS, United Kingdom
[2] Ecole Normale Supérieure de Paris – 24 rue Lhomond, France
[3] Laboratoire de Physique Théorique et Modèles Statistiques, CNRS: UMR8626, Université Paris XI, Paris Sud – Bâtiment 100, Université Paris-Sud, Centre Scientifique d'Orsay, 15 rue Georges Clémenceau, 91405 Orsay cedex, France
[4] Laboratoire de Physique des Solides, Université Paris-Sud – 91405 Orsay, France

Using the Kac–Rice approach, we show that the mean number N_{tot} of all possible equilibria (i.e. force-free configurations, a.k.a. stationary points) of an elastic line (directed polymer), confined in a harmonic well and submitted to a quenched random Gaussian potential in dimension $d = 1 + 1$, grows exponentially $N_{tot} \sim \exp(RL)$ with its length L. The growth rate R is found to be directly related to the generalised Lyapunov exponent (GLE) which is a moment-generating function characterising the large-deviation type fluctuations of the solution to the initial value problem associated with the random Schroedinger operator of the 1D Anderson localization problem. For strong confinement, the rate R is small and given by a non-perturbative (instanton, Lifshitz tail-like) contribution to GLE. For weak confinement, the rate r is found to be proportional to the inverse Larkin length of the pinning theory. As an application, identifying the depinning with a landscape 'topology trivialization' phenomenon, we obtain an upper bound for the depinning threshold F_c, in the presence of an applied force, for elastic lines and d-dimensional manifolds, expressed through the mean modulus of the spectral determinant of the Laplace operators with a random potential. Finally, we extend the method to calculate the asymptotic number of equilibria at fixed energy (elastic, potential and total), and obtain the (annealed) distribution of the energy density over these equilibria (i.e. force-free configurations). The presentation will be based on the extended version of the paper arXiv:1703.10066.

*Speaker

Opinion dynamics approach to conflicts and algorithmic segregation

János Kertész*† [1]

[1] Center for Network Science, Central European University – Hungary

Conflict situations are unavoidable when value is produced in a collaborative environment like Wikipedia. By introducing appropriate measures, we could automatize the filtering of conflict Wikipedia pages and the localization of edit wars. Three categories were identified: single and intermittent conflicts as well as permanent wars. The bounded confidence opinion dynamics model was generalized to cope with this problem. Beside the usual dynamics between agents (the editors) there is a medium representing the opinion of the page the agents work on. If the opinion of the page is too far from that of an editor s/he will change the article, otherwise not. The model shows rich behavior and is able to reproduce the observed patterns; furthermore, it gives hints toward resolution of conflicts. The flow of information reaching us via the online media platforms is optimized not by the information content or relevance but by popularity and proximity to the targetand this introduces an algorithmic bias that is believed to enhance polarization of the societal debate. To study this phenomenon, we used the bounded confidence model in order to account for the algorithmic bias and investigate its consequences. We modified the selection rule of the discussion partners: there was an enhanced probability to choose individuals whose opinions were already close to each other, thus mimicking the behavior of online media, which suggest interaction with similar peers. As a result, we observe: a) an increased tendency towards polarization, which emerges also in conditions where the original model would predict convergence, and b) a dramatic slowing down of the speed at which the convergence at the asymptotic state is reached, that makes the system highly unstable.

*Speaker
†Corresponding author: janos.kertesz@gmail.com

Statistical physics of fitness landscapes

Joachim Krug* [1]

[1] University of Cologne – Albertus-Magnus-Platz, D-50923 Köln, Germany

Biological evolution can be conceptualized as a search process in the space of gene sequences guided by the fitness landscape, a mapping that assigns a measure of reproductive value to each genotype. The relationship between genotype and fitness is generally complex, as it is mediated by the multidimensional organismic phenotype that interacts with the environment and thereby determines reproductive success. Two modeling strategies have been devised to deal with this situation. One is to shortcut the intermediate phenotypic level by assigning fitness directly to genotypes. This leads to probabilistic models that define ensembles of random functions on sequence space, as exemplified by Kauffman's NK model. An alternative approach is provided by Fisher's geometric model (FGM), which describes the phenotype as a vector in an n-dimensional Euclidean trait space with a unique fitness optimum and encodes mutations as random phenotypic displacements. After an overview of the current understanding of real fitness landscapes that is available from empirical studies, I will focus on a particular measure of fitness landscape complexity defined through the exponential growth rate of the expected number of local fitness peaks for large sequence length. Based on this quantity evidence for the existence of distinct universality classes of interaction structures in the NK model will be presented, and the occurrence of spin-glass-like phase transitions in FGM will be explained.

*Speaker

Selected topics on the dynamics of quantum walkers

Jean-Marc Luck*† [1]

[1] Institut de Physique Théorique, Université Paris-Saclay – F-91191 Gif-sur-Yvette Cedex, France

Quantum walks are commonly used as a tool to implement algorithms in quantum information theory. They are also relevant to investigate the dynamics of various systems in the quantum coherent regime, such as ultra-cold atoms. A quantum walker propagates ballistically and its wavefunction exhibits sharp ballistic fronts. This is to be contrasted with the diffusive scaling and the rather dull Gaussian probability profile of a classical random walker. Most physical properties of quantum walkers are qualitatively different from those of classical ones. We shall give a few examples, focussing on continuous-time quantum walkers on the one-dimensional chain. A quantum walker can easily avoid a static trap, so that it survives forever with non-zero probability, at variance with a classical random walker. Bound states formed by two or more interacting quantum walkers, either fermionic or bosonic, also spread ballistically. Their wavefunction generically exhibits many internal fronts in the center-of-mass coordinate, besides the two extremal ones. A special instance of a many-body fermionic bound state dubbed the quantum centipedes can be analyzed via a mapping onto an integrable spin chain. Its spreading velocity remains non-zero even when the number of fermions becomes infinitely large. The return probability of several non-interacting quantum walkers to their global initial state falls off as a power law in time, whose exponent is different from the classical one and depends on details of the initial state and of the dynamics. These results have been obtained in collaboration with Paul Krapivsky and Kirone Mallick.

*Speaker
†Corresponding author: jean-marc.luck@ipht.fr

Universal statistics of records

Satya Majumdar* [1]

[1] LPTMS, Université de Paris-Sud Orsay – France

Records are rather common in everyday life: we are always talking of record rainfall, record temperature, records in sports and stock prices etc. A natural question is: How many records occur in a typical time-series of length n? It turns out that in many natural time-series, the average number of records grow universally with n! Where does this universality come from? In this talk, I will first make a broad review of record statistics, with emphasis on its universal aspects. Later I'll discuss the record statistics in a strongly correlated sequence such as a random walk sequence, that appears naturally in finances, e.g., in studying the records of a stock price. It turns out that for such a strongly correlated sequence, a new and unexpected universality emerges. We will discuss the origin of this emergent universality. Several applications and extensions will be also be discussed.

*Speaker

The dynamics of foraging and starvation

Sidney Redner* [1]

[1] Santa Fe Institute – 1399 Hyde Park Road, Santa Fe, NM 87501, United States

What is the fate of a random-walk forager that depletes its environment as it wanders? Whenever the forager lands on a food-containing site, all the food is consumed and the forager becomes fully sated. However, when the forager lands on an empty site, it moves one time unit closer to starvation. If the forager wanders S steps without encountering food, it starves to death. We show analytically that the lifetime of this starving random walk forager scales linearly with S in one dimension by solving an underlying non-Markovian first-passage problem. In greater than two dimensions, we present evidence that the lifetime grows quasi-exponentially in S. We also investigate the role of greed, in which the forager preferentially moves towards food when faced with a choice of hopping to food or to an empty site in its local neighborhood. Paradoxically, the forager lifetime can have a non-monotonic dependence on greed, with different senses to the non-monotonicity in one and in two dimensions. In one dimension, the forager lifetime exhibits a huge peak when greed is negative, while in two dimensions the maximum lifetime occurs for positive, but not perfect, greed. Many of these results were obtained in collaboration with Olivier Benichou, Uttam Bhat, Marie Chupeau, and Paul Krapivsky.

*Speaker

Two band fermion model and two party political system

Józef Sznajd* [1]

[1] Institute of Low Temperature and Structure Research, Polish Academy of Sciences – Okólna 2, Wrocław, Poland

The linear perturbation renormalization group is used to study spinless two-band fermion chains at half-filling and two party political system described by a sociophysics model based on the $S = 1$ Ising model. The fermionic model consists of two species of spinless fermions, localized f and extended p and takes into account: the kinetic energy of fermions p, the on-site Coulomb repulsion V between p and f fermions, chemical potentials μ_p and μ_f adjusted in such a way that the average of the site occupation $\langle n_i^f \rangle + \langle n_i^p \rangle = 1$ and a weak interchain hopping t_x. The average occupation number, the specific heat and the correlation functions are studied as functions of temperature. For a single chain the occupation number is a smooth function of T and the specific heat displays two maxima. The weak interchain hooping triggers a discontinuity (jump) in the occupation number of fermions as a function of temperature. In other words at some temperature some of the 'free' p fermions are sharply localized.

To describe the influence of the social interplay between electorates of the two major parties on the quality of democracy we propose the three-state Ising-like statistical physics model. The minimal number of parameters that define the model is three: the measure of the unity of views of voters of the two major parties, the field that diferentiates the creeds of the particular party voters, and the measure of a discouragement to take part in public life of citizens who vote for the smaller (third) parties, who in the main vote 'against' and are fully aware that their voices will not have a major impact on the practical outcome of the election. Additionaly as a measure of political strife between electorates of the two major parties we introduce a coupling Q. As an efective measure of democracy in the two-party political system we propose the percentage of the total population that actually voted for one of the two major parties in a given election—index V_D. This index reflects not only the rights but also the inclination of citizens to participate in decision-making, even if theoretically, which can be treated as the essence of democracy. It has been shown that there is a range of Q in which the index V_D changes slightly: it first increases with Q, passes a maximum, then at some characteristic point Q_f starts to fall rapidly, and at Q_c reaches a constant value. We conclude from the model that in the two-party political system a reasonable level of conflict between the electorates of the two major parties can be beneficial for both parties and moreover for the quality of democracy measured by the index V_D. However, for a higher level of conflict (higher degree of polarization), citizen participation decreases rapidly. In other words similarly as in case of fermions, in this case at some value of Q, some of the 'free' citizens sharply lost part of their rights.

*Speaker

Phase transitions in models of opinion dynamics

Katarzyna Sznajd-Weron* [1]

[1] Department of Theoretical Physics, Wroclaw University of Science and Technology – Poland

During this talk I will present an idea of modeling opinion dynamics and show what could be the source of phase transitions in such a models from the perspective of social psychology. Then I will present one of the most interesting models of binary opinions, the q-voter model, and discuss phase transitions that are observed within this model. Finally, I will show what kind of questions, inspired by social theories and experiments, can be asked within the model.

*Speaker

Universality of phase transition dynamics: topological defects from symmetry breaking. AGH-UST Rector Lecture

Wojciech Żurek*† [1]

[1] Los Alamos National Laboratory – United States

In the course of a non-equilibrium continuous phase transition, the dynamics ceases to be adiabatic as a result of the critical slowing down (the divergence of the relaxation time in the neighborhood of the critical point). This enforces a local choice of the broken symmetry and can lead to the formation of topological defects. During recent years, several new experiments investigating formation of defects in phase transitions induced by a quench were reported. Moreover, there have been theoretical advances in the understanding of the time-dependent dynamics of symmetry breaking. I will review [1] some of these advances focusing in particular on this recent surge of activity, and suggest possible directions for further progress.

[1] A. del Campo, W. H. Zurek, Int. J. Mod. Phys. A 29, 1430018 (2014).

*Speaker
†Corresponding author: whzurek@gmail.com

Matrix logistic equation and fractal level densities

Karol Życzkowski*† [1,2], Łukasz Pawela [3]

[1] Jagiellonian University – Kraków, Poland
[2] Center for Theoretical Physics, Polish Academy of Sciences – Warsaw, Poland
[3] Institute of Theoretical and Applied Informatics, Polish Academy of Sciences – Gliwice, Poland

Ensembles of random matrices useful to describe quantized chaotic dynamics in various setting are discussed and compared. Evolution operators for quantum unitary dynamics of a closed system are related to circular ensembles of Dyson, while typical non-unitary quantum maps, resulting from an interaction with an environment, correspond to ensembles of real non-hermitian matrices of the Ginibre ensemble. Furthermore, we discuss models of non-linear quantum evolution and analyze random matrices related to a matrix logistic map which are characterized by a fractal level density. The model considered generalizes also coupled logistic equations and allows one to study its termodynamical limit.

*Speaker
†Corresponding author: karol.zyczkowski@uj.edu.pl

Chapter 2

Contributed talks

Hydrodynamics of granular particles on a line

Andrea Baldassarri* [1], Andrea Puglisi [1], Antonio Prados [2]

[1] Istituto Sistemi Complessi, c/o Dipartimento di Fisica, Sapienza University – P. le Aldo Moro 2, I-00182 Roma, Italy
[2] Universidad de Sevilla – Apartado de Correos 1065, E-41080 Sevilla, Spain

We investigate a lattice model representing an incompressible granular gas on a line. We deduce the hydrodynamic description for the model in the large system limit, including the lowest finite-size corrections. We solve these equations at stationarity for a thermostatted system, that is, when the one-dimensional granular gas is connected to two thermal baths with the same temperature at both its left and right endpoints. The main prediction from hydrodynamics at the steady state is the existence of a 'uniform longitudinal flow' state in the bulk of the system, with the uniform granular temperature and the velocity gradient being directly related. This result is checked by means of extensive Monte Carlo simulations of the system, which show a good agreement with our theory. Possible sources for the observed discrepancies between theory and simulation are discussed.

*Speaker

Can one hear the shape of a country?

James Burridge* [1]

[1] University of Portsmouth – United Kingdom

Language is evolving everywhere, all the time. As a result, people from different parts of a country may use their language in quite different ways. These locally distinct versions are called *dialects*, or just *accents* if the differences are subtler. To map this geographical variation, linguists draw lines called 'isoglosses' which mark boundaries across which some linguistic feature (a word, a pronunciation, or an element of syntax) changes. I present a model for the dynamics of these lines based the assumption that people tend to conform to the language use they hear in the regions where they spend most of their time. I will show that isogloss velocity is given by a modification of the Allen–Cahn equation for the motion of magnetic domain walls in condensed matter physics. This linguistic Allen–Cahn equation predicts that isoglosses are driven down population gradients, feel surface tension, and that their end points tend to collect in boundary indentations such as river mouths and bays. I show how these effects link the shape of a country to the geographical pattern of its dialect areas, matching the observations of linguists. I will also present a new method of characterising spatial-linguistic variation: the 'linguistic director field' inspired by the physics of liquid crystals, and calculate this for English dialects. Finally, I will explore the effects of long range interaction networks and population mixing, and discuss applications outside of linguistics.

[1] J. Burridge, Phys. Rev. X 7, 031008 (2017).
[2] J. Burridge, Royal Soc. Open Sci. 5, 171446 (2018).

*Speaker

Exact results for quenched disorder at criticality

Gesualdo Delfino* [1]

[1] Scuola Internazionale Superiore di Studi Avanzati – via Bonomea 265, I-34136 Trieste, Italy

Gaining theoretical access to the critical properties of disordered systems with short range interactions has been a challenging problem of statistical mechanics. Even in the two-dimensional case, for which conformal symmetry provided a plethora of exact results for pure systems, analytic insight on random critical points has been limited to few perturbative limits. We show how a new way of exploiting conformal invariance in two dimensions leads to exact results for random critical points. In particular, the presence of superuniversal (i.e. symmetry-independent) sectors emerges as a peculiar feature of quenched disorder. For the random bond q-state Potts model this allows for a q-independent correlation length exponent and a varying magnetization exponent, an outcome that appears to solve longstanding numerical and theoretical puzzles. Relying only on symmetry, the formalism equally accounts for critical points with competing interactions, such as the Nishimori point.

[1] G. Delfino, Phys. Rev. Lett. 118, 250601 (2017).
[2] G. Delfino, E. Tartaglia, J. Stat. Mech. 123303 (2017).

*Speaker

Long-range power-law correlated percolation in two and three dimensions

Johannes Zierenberg [1,2], Niklas Fricke [1], Martin Marenz [1], F. Paul Spitzner [1], Viktoria Blavatska [3], Wolfhard Janke*† [1]

[1] Universität Leipzig, Institut für Theoretische Physik – Postfach 100920, 04009 Leipzig, Germany
[2] Max Planck Institute for Dynamics and Self-Organization – Am Fassberg 17, 37077 Göttingen, Germany
[3] Institute for Condensed Matter Physics of the National Academy of Sciences of Ukraine – 79011 Lviv, Ukraine

We report a numerical study of long-range power-law correlated percolation on square and cubic lattices. In particular, we present high-precision results for the percolation thresholds and the fractal dimension of the largest clusters as a function of the correlation strength. The correlations are generated using a discrete version of the Fourier filtering method. We consider two different metrics to set the length scale over which the correlations decay, showing that the percolation thresholds are highly sensitive to such system details. By contrast, we verify that the fractal dimension d_f is a universal quantity and unaffected by the choice of metric. We also show that in the limit of weak correlations, its value coincides with that for the uncorrelated system. In two dimensions, we observe a clear increase of the fractal dimension with increasing correlation strength, approaching $d_f = 2$. The onset of this change does not seem to be determined by the extended Harris criterion.

*Speaker
†Corresponding author: wolfhard.janke@itp.uni-leipzig.de

A new class of entropy-power-based uncertainty relations

Petr Jizba* [1]

[1] Czech Technical University in Prague, Department of Physics, Faculty of Nuclear Sciences and Physical Engineering – Brehova 7, 115 19 Praha 1, Czech Republic

In this talk I will use the concept of entropy power to derive a new one-parameter class of information-theoretic uncertainty relations for pairs of observables in an infinite dimensional Hilbert space. This class constitute an infinite tower of higher-order cumulant uncertainty relations, which allows in principle to reconstruct the underlying distribution in a process that is analogous to quantum state tomography. I will illustrate the power of the new class by studying Schrödinger cat states and the Cauchy-type heavy-tailed wave function. Finally, I will try to cast some fresh light on the black hole information paradox.

[1] P. Jizba, J.A. Dunningham, J. Joo, Ann. Phys. 355, 87 (2015).
[2] P. Jizba, J.A. Dunningham, A. Hayes, Y. Ma, Phys. Rev. E 93, 060104(R) (2016).

*Speaker

A glassy phase in quenched disordered graphene and crystalline membranes

Dominique Mouhanna* [1], Olivier Coquand [1], Karim Essafi [1], Jean-Philippe Kownacki [2]

[1] Laboratoire de Physique Théorique de la Matière Condensée, CNRS: UMR7600, Université Pierre et Marie Curie—Paris VI – LPTMC, Tour 13, Boîte 121, 4, Place Jussieu, 75252 Paris Cedex 05, France
[2] Laboratoire de Physique Théorique et Modélisation, Université de Cergy Pontoise, Centre National de la Recherche Scientifique: UMR8089 – Université de Cergy-Pontoise 2 avenue Adolphe Chauvin, Pontoise 95302 Cergy-Pontoise Cedex, France

We have investigated the flat phase of D-dimensional crystalline membranes embedded in a d-dimensional space and submitted to both metric and curvature quenched disorders using a nonperturbative renormalization group approach. We have identified a second order phase transition controlled by a finite-temperature/finite-disorder fixed point that is unreachable within the leading order of $\epsilon = 4 - D$ and $1/d$ expansions. This critical point divides the flow diagram into two basins of attraction: that associated to the finite-temperature fixed point controlling the long-distance behaviour of disorder-free membranes and that associated to a zero-temperature/finite-disorder fixed point. Our work strongly suggests the existence of a whole low-temperature glassy phase for quenched disordered graphene, graphene-like compounds and, more generally, crystalline membranes.

*Speaker

A master equation approach to Science and Facebook popularity

Zoltán Néda* [1], Levente Varga [1], Tamas Biro [2]

[1] Babeș-Bolyai University – Kogalniceanu 1, RO-400084, Cluj-Napoca, Romania
[2] Wigner Research Center for Physics – 29-33 Konkoly Thege Miklós út, Budapest, XII., H-1121, Hungary

Scientific citations for publications selected with different rules (author, topic, institution, country, journal, etc...) follow several intriguing scaling properties [1,2]. If one considers as basic variable ($s = x/\underline{x}$), the number of citations (x) divided by the their mean value ($\underline{x}$) and plot $f(s)$ (with f the density function) as a function of s, the data collapses [3]. Interestingly, we do find that the distribution of 'shares' for the Facebook posts rescale in the same manner and on the very same curve with scientific citations [4]. These findings suggest that citations are subjected to a similar growth mechanism with Facebook popularity measures, being influenced by a statistically similar social environment and selection mechanism. To further elaborate on this hypothesis a model based on a simple master-equation with growth and reset is considered. Considering a preferential mechanism for the growth process and an exponential growth for the number of publications our model suggests a Tsallis–Pareto distribution for $f(s)$, offering an excellent description for the observed scaling statistics.

[1] F. Radicchi, S. Fortunato, C. Castellano, Proc. Natl. Acad. Sci. 105, 17268 (2008).
[2] F. Radicchi, C. Castelano, Phys. Rev. E. 83, 046116 (2011).
[3] A. Chatterjee, A. Ghosh, B. K. Chakrabarti, PLoS One 11, e0146763 (2016).
[4] Z. Neda, L. Varga, T. S. Biro, PLoS One 12, e0179656 (2017).

*Speaker

Electrical conductivity of a 2D composite with rod-like fillers

Yuri Tarasevich* [1], Nikolai Lebovka [2,3], Nikolai Vygornitskii [3], Valeriya Goltseva [1], Irina Vodolazskaya [1], Andrei Eserkepov [1]

[1] Astrakhan State University – Astrakhan, 414056, Russia
[2] Taras Shevchenko National University – Kiev, 01033, Ukraine
[3] Institute of Biocolloidal Chemistry named after F. D. Ovcharenko, NAS of Ukraine – Vernadskogo 42, Kyiv 03142, Ukraine

Numerical simulations by means of Monte Carlo method have been performed to study the electrical properties of two-dimensional (2D) composite filled with rod-like particles. Both lattice and continuous approaches were utilized. We investigated the effects of particles length and their alignment on electrical properties of 2D composite with high contrast in electrical conductivities [1].

Two mirrored models have been considered: deposition of conducting particles onto an insulating substrate and the embedding of insulating particles into a conducting substrate. For both models, the sharpness of the phase transition insulator-conductor decreases with increasing length of particles. For particles with high aspect ratio, the electrical conductivities increased rapidly at small concentration of particles and in the vicinity of the percolation threshold. Visually, these resemble two-step percolation transitions.

The effect of defects on the behavior of electrical conductivity has also been simulated [2]. The defects in the lattice (impurities) and defects in the particles were considered. We examined both isotropic and anisotropic (all particles are aligned along one given direction) composites. We found that even a very small concentration of impurities has strong impact on the electrical conductivity.

For continuous problems the model with intersections and without intersections rod-like particles were considered. The dependence of percolation thresholds and anisotropy of electrical conductivity versus the order parameter are discussed.

Acknowledgements: We acknowledge the funding from the National Academy of Sciences of Ukraine, Project No. 43/17- H (N.I.L., N.V.V.) and the Ministry of Education and Science of the Russian Federation, Project No. 3.959.2017/4.6 (Yu.Yu.T.).

[1] Yu. Yu. Tarasevich, V. A. Goltseva, V. V. Laptev, N. I. Lebovka, Phys. Rev. E 94, 042112 (2016).
[2] Yu. Yu. Tarasevich, V. V. Laptev, V. A. Goltseva, N. I. Lebovka, Physica A 477, 195 (2017).

*Speaker

Statistical mechanics of global regulation of gene expression

Zdzisław Burda [1], Justyna Cholewa-Wacław [2], Bartłomiej Wacław*† [2]

[1] AGH University of Science and Technology, Faculty of Physics and Applied Computer Science – Mickiewicza 30, PL-30059 Kraków, Poland
[2] University of Edinburgh – United Kingdom

Gene expression is a complicated biological process affected by many factors. Traditionally, interactions between genes are represented as the gene regulatory network—a large network of transcription factors which can be classified either as repressors or activators, each with a few well-defined target genes. Recently, a possibility has been discussed that certain chromatin binding factors do not have specific targets but they affect transcription (the first stage of gene expression) at a global level, as opposed to more local interactions of traditional transcription factors.

We will present a statistical physics model that takes local and global interactions between genes into account. The model assumes that a global modulator X couples to all genes in the gene regulatory network, albeit with different strength. The behaviour of the model can be understood using random matrix theory. We will show that, as the coupling strength between X and other genes decreases, the model exhibits a transition between a phase in which the presence of X can be inferred from correlations between expression levels of other genes, and a phase in which local interactions between the genes overshadow the signal from X.

We will discuss implications of our results for biological experiments aimed at detecting such factors. Lastly, we will show how this approach can be used to identify a particular protein MeCP2, which is a major player in Rett syndrome (a human neurological disorder), as a global modulator of gene expression.

*Speaker
†Corresponding author: bwaclaw@staffmail.ed.ac.uk

The Ising spin glass: new methods for old models and old methods for new models

Martin Weigel* [1], Hamid Khoshbakht [1], Mohammad-Sadegh Vaezi [2], Gerardo Ortiz [3], Zohar Nussinov [2]

[1] Coventry University – Coventry, United Kingdom
[2] Washington University, St. Louis – United States
[3] Indiana University Bloomington – United States

The Ising spin glass in 2D exhibits rich behavior with subtle differences in the scaling for different coupling distributions. We use combinatorial optimization methods to determine exact ground states for systems with up to 10000×10000 spins. A combination of new algorithms al low us to treat samples with fully periodic boundaries and to sample uniformly from degenerate ground states for the $\pm J$ model. To establish a unified framework for studying both discrete and continuous coupling distributions in arbitrary dimensions, we introduce the binomial spin glass. In this model, the couplings are the sum of m identically distributed Bernoulli random variables. In the continuum limit $m \to \infty$, this system reduces to the Edwards–Anderson model with Gaussian couplings, while $m = 1$ corresponds to the $\pm J$ spin glass. Using this model, we derive a rigorous bound for the degeneracy of any energy level. Studying the defect energies in this model, we uncover intriguing subtleties in the behavior of the model with respect to the order in which the thermodynamic ($N \to \infty$) and continuum ($m \to \infty$) limits are taken.

[1] H. Khoshbakht, M. Weigel, arXiv:1710.01670 (2017).
[2] M.-S. Vaezi, G. Ortiz, M. Weigel, Z. Nussinov, arXiv:1712.08602 (2017).

*Speaker

Chapter 3

Posters

Dynamical response of the magnetic system to the time dependent magnetic field with white noise

Ümit Akıncı*† [1], Yusuf Yüksel [1]

[1] Dokuz Eylül University – Tinaztepe Campus, TR-35160 Izmir, Turkey

Noise is simply defined as formed random fluctuations in interested quantity and it occurs almost everywhere such as in acoustics, biology, geology and astronomy. Almost persistent vibration of the ground is called seismic noise, all neurons are under the influence of random bombardment, which is called synaptic noise. Thermal agitations of charge carriers cause thermal noise (Johnson–Nyquist noise) in electronic devices [1,2]. During the magnetizing process of ferromagnetic material, formed jumps in magnetization of the material are called as Barkhausen noise.

Noise can be classified by its power spectral density (i.e. energy distribution with frequency). White noise is constant power spectral density. In the discrete case, white noise can be defined as nothing but random sequence of serially uncorrelated variables with zero mean and finite variance. White noise can represent environment with zero memory, since it has vanishing correlation time. The concept of white noise is frequently used, for instance thermal noise in an ideal resistor is assumed approximately as white noise.

It is impossible to get rid of all external noise completely. Aktough noise is mostly understood as unwanted effect which limits the performance of the device or an experiment, it can generate unexpectedly useful and interesting behaviors. For instance, environmental randomness could cause new type of nonequilibrium transition namely, noise induced transition [3]. Stochastic resonance [4] can be other example. Noisy systems can be described by stochastic differential (or difference) equations. The effects of various types of noises to an Ising-like model has been investigated with the aid of Langevin equation and noise induced phase transition has been observed [5,6,7]. The aim of this work is slightly different than these works.

The effect of the white noise in time dependent magnetic field on the dynamic behavior of the general spin-S Ising model has been investigated within the effective field theory based on Glauber type of stochastic process. Also Monte Carlo simulations have been used. Detailed investigation on probability distribution of dynamical order parameter results that, Gaussian and uniform noise distributions yield the same probability distribution related to the dynamical order parameter, namely Gaussian probability distribution for the spin-1/2 case [8]. Also, it has been shown that, rising strength of the noise can induce dynamical phase transition in the system. Results for general spin-S model will also presented.

[1] J. Johnson, Phys. Rev. 32, 97 (1928).
[2] H. Nyquist, Phys. Rev. 32, 110 (1928).
[3] W. Horsthemke, R. Lefever, Noise-induced transitions. Theory and applications in physics, chemistry and biology, Springer (Berlin 1984).
[4] R. Benzi, A. Sutera, A. Vulpiani, J. Phys. A 14, L453 (1981).
[5] I. Gudyma, A. Maksymov, S. Miyashita, Phys. Rev. E 84, 031126 (2011).
[6] W. Genovese, M. A. Munoz, P.L. Garrido, Phys. Rev. E 58, 6828 (1998).
[7] D. A. Garanin, Phys. Rev. E 95, 013306 (2017).
[8] Ü. Akıncı, Physica A 494, 242 (2018).

*Speaker
†Corresponding author: akinci.umit@gmail.com

Equivalence of two nonequilibrium ensembles based on maximum entropy principle

Mark Auslender* [1]

[1] Department of Electrical and Computer Engineering, Ben Gurion University of the Negev – Israel

The methods of nonequilibrium statistical ensembles based on maximum entropy (MaxEnt) principle were proposed long ago. Earlier one was developed as an extension of the Gibbs ensembles method independently by McLennan [1,2,3] and Zubarev [4] and is textbook well documented [5, 6]. Later method, due to Zubarev and Kalashnikov [7,8], made also use of the Abel's motion quasi-invariant construction, but applies it to the MaxEnt relevant distribution rather than to the entropy variable itself. Both Zubarev et al. developments are referred to as Nonequilibrium Statistical Operator (NSO) method, while the notations NSO-1 and NSO-2 methods for the earlier and the later versions, respectively, are used to distinct them. The weakness of the McLennan–NSO-1 and NSO-2 methods, for which they were criticized by renowned authorities (see historical outlines in [9, 10]), is disappointing uncertainty in choosing the relevant (gross, basic) dynamic variables variables. The advantage of those methods is that they provide expressions for the entropy and entropy production, and nearly automated machinery for deriving the correct macroscropic transport or kinetic equations, once the relevant variables are delineated. Recently a keen interest in McLennan–NSO-1 method for steady states was revived because, on one hand, the method has been rediscovered in physical research on mesoscopic quantum system and, on the other hand, nonequilibrium steady states, introduced in rigorous research on statistical mechanics, have been proved to be in some sense equivalent to McLennan–NSO-1 method ensembles.

In this presentation I will prove the equivalence of McLennan–NSO-1 and NSO-2 methods. It seems to me important since the latter method is an analog of Gell-Mann–Goldberger (GG) scattering theory. In NSO-2 method the MaxEnt relevant distribution is fully analogous to the incoming wave function in GG scattering theory, so NSO satisfies an integral equation similar to that for the scattered wave function there and a proper diagrammatic technique development is feasible, which certainly will benefit the method. In addition, I will discuss the non-Markovian macroscropic transport and kinetic equations, and show a restricted applicability of Markovian limit for them in the cases of heat conduction equation and quantum Boltzmann equation for charge carriers in graphene.

[1] J. A. McLennan Jr., Phys. Rev. 115, 1405 (1959).
[2] J. A. McLennan Jr., Phys. Fluids 3, 493 (1960).
[3] J. A. McLennan Jr., Phys. Fluids 4, 1419 (1961).
[4] D. N. Zubarev, Doklady Akademii Nauk SSSR 140, 92 [English transl. Soviet Phys. – Doklady 6, 776 (1962)].
[5] D. N. Zubarev, Nonequilibrium Statistical Thermodynamics, Consultants Bureau (New York, 1974).
[6] J. A. McLennan, Introduction to Nonequilibrium Statistical Mechanics, Prentice Hall (Englewood Cliffs, 1989).
[7] D. N. Zubarev, V. P. Kalashnikov, Teor. Mat. Fiz. 126 (1970).
[8] D. N. Zubarev, V. P. Kalashnikov, Teor. Mat. Fiz. 7, 372 (1971).
[9] D. N. Zubarev, Condens. Matter Phys. 4, 7 (1994).
[10] R. Luzzi, A. R. Vasconcellos, J. R. Ramos, Int. J. Mod. Phys. 14, 3189 (2000).
[11] H. Ness, Phys. Rev. E 88, 022121 (2013).
[12] H. Ness, Entropy 19, 158 (2017).

*Speaker

Average excursion and bridge for the ABBM model

Andrea Baldassarri* [1]

[1] Istituto Sistemi Complessi, c/o Dipartimento di Fisica, Sapienza University – P. le Aldo Moro 2, 00182 Roma, Italy

I reconsider the exact computation of the average shape of the excursion for ABBM model (averge avalanche shape, or average shape of a fluctuation), showing several different approaches, together with the computation of the aveerage shape for a bridge of the same model (i.e. the average shape of multiple avalanches, with a fixed given duration).

*Speaker

Fast estimation of density of states of frustrated spin systems

Lev Barash* [1,2,3], Jeffrey Marshall [4], Itay Hen [4], Martin Weigel [5]

[1] Landau Institute for Theoretical Physics – Russia
[2] Science Center in Chernogolovka – Russia
[3] National Research University Higher School of Economics – Russia
[4] University of Southern California – United States
[5] Coventry University – United Kingdom

Frustrated spin systems are known to stymie entropic samplers—algorithms designed to statistically estimate the density of states at different energy intervals of physical systems. Intricate or rugged energy landscapes often cause these to yield false convergences to erroneous density estimations. Here, we report on the performance of a population annealing based algorithm on Ising spin glasses demonstrating orders of magnitude scaling advantages over exiting state-of-the-art algorithms. To demonstrate the algorithm's advantages in a verifiable manner, we introduce a scheme that allows us to achieve an exact count of the degeneracies of the ground- and first-excited states of the tested instances. We discuss the practical implications of having a fast algorithm for the calculation of the density of states of frustrated systems.

*Speaker

Ultrafast spin initialization in electrostatic quantum dots

Stanisław Bednarek [1], Jarosław Pawłowski*† [2], Michał Górski [1], Grzegorz Skowron [1]

[1] AGH University of Science and Technology, Faculty of Physics and Applied Computer Science – Mickiewicza 30, PL-30059 Kraków, Poland
[2] Wrocław University of Science and Technology – Wrocław, Poland

The qubit defined on spin of a single electron (or hole) is nowadays one of the most promising candidates for implementing quantum computers [1]. A natural place for creating electron confinement is the gated semiconductor nanostructure in which electrostatic quantum dots are easily formed, giving rise to localized electronic states [2]. Moreover, such qubits have a property, that they can be placed next to each other allowing for easy coupling between adjacent qubits, which is essential for two-qubit operations. To perform these operations, the Rashba spin-orbit interaction is employed, where an electric field can be used to manipulate electron spin. Thus far, many single and two-qubit devices have been successfully realised [3], yet initialization and readout are still a challenge. Currently no fast and accurate spin initialization procedure exists, this is thus worthwhile to look for an efficient solution to this problem.

We propose a method of fast and accurate spin initialization of an electron trapped in an electrostatic quantum dot, generated in a nanodevice composed of a catalytically grown InSb nanowire (material featuring strong spin-orbit coupling) placed near metallic gates, to which control voltages are applied. To manipulate spin, we use the electric control of the spin-orbit coupling. After the procedure, the electron spin becomes oriented in a definite direction with high precision, regardless of its initial orientation. In planar nanostructures, this is also possible to use a variant of this approach, yet the time of initialization is an order of magnitude greater [4].

[1] Ze-Liang Xiang, Sahel Ashhab, J. Q. You, and Franco Nori, Rev. Mod. Phys. 85, 623 (2013).
[2] D. Loss and D. P. DiVincenzo, Phys. Rev. A 57, 120 (1998).
[3] R. Brunner et al., Phys. Rev. Lett. 107, 146801 (2011).
[4] S. Bednarek, J. Pawlowski, M. Górski, G. Skowron, New J. Phys. 19, 123006 (2017).

*Speaker
†Corresponding author: jaroslaw.pawlowski@pwr.edu.pl

Trapline foraging

Eslene Bikoumou* [1], James Burridge [1], Andrew Burbanks [1]

[1] University of Portsmouth – United Kingdom

Many foraging animals, including bees, monkeys, elephants and humming birds, follow repeated loops, or 'traplines' around sequences of foraging sites. Here we introduce a simple model of competition between trapline foragers, where each forager builds their line by adding or removing foraging sites based on their energy return compared to the rest of the line. We show that it is mutually optimal for traplines not to intersect, but that individuals can gain by expanding into other players' sites, creating a situation akin to the Prisoner's Dilemma game. We parameterize trapline generation strategies using a line expansion rate, and discover three classes of sharing behaviour, determined by this rate: trapline separation (cooperative sharing), domination by one player, and total intersection. In two dimensions, if players place a high priority on minimizing travel time between sites, then traplines evolve to form compact domains which feel a form of surface tension at their boundaries. We explore the effect of simple population dynamics for a population with different expansion rates, where foragers who extract more food from their line reproduce more often.

*Speaker

Jamming and attraction of interacting run-and-tumble random walkers

Richard Blythe* [1], Martin Evans [1], Alexander Slowman [1]

[1] School of Physics and Astronomy, University of Edinburgh – Peter Guthrie Tait Road, Edinburgh EH9 3FD, United Kingdom

We study a model of stochastic particle dynamics inspired by the motion of run-and-tumble bacteria (such as E Coli). In this model, particles retain memory of their direction, and hop ('run') on a lattice in this direction unless a hard-core repulsion interactions prevent them from doing so. Meanwhile, particles can also change their direction as a Poisson process ('tumble'). In this model, collisions are inelastic and lead to a nonequilibrium stationary state that has a surprisingly rich structure given the simplicity of the model.

In the case of instantaneous tumbling events, the statistionary distribution comprises three components: a jammed component, where the particles are adjacent and block each other; an attractive component, where the probability distribution for the distance between particles decays exponentially; and an extended component in which the distance between particles is uniformly distributed. When particles are stationary for an exponentially-distributed time whilst tumbling, there is an additional attractive component whose range is much longer than that of the component that applies for instantaneous tumbling. Together these results provide insight into the clustering of active particles that would repel each other if they were at thermal equilbrium with their environment.

[1] A. B. Slowman, M. R. Evans, R. A. Blythe, Phys. Rev. Lett. 116, 218101 (2016).
[2] A. B. Slowman, M. R. Evans, R. A. Blythe, J. Phys. A: Math. Theor. 50, 375601 (2017).

*Speaker

Dynamical transition in TASEP with Langmuir kinetics: mean-field theory

Davide Botto*† [1,2], Alessandro Pelizzola [1,2], Marco Pretti [3], Marco Zamparo [1]

[1] Dipartimento di Scienza Applicata e Tecnologia, Politecnico di Torino – Corso Duca degli Abruzzi 24, 10129 Torino, Italy
[2] Istituto Nazionale di Fisica Nucleare, Sezione di Torino – Via Pietro Giuria 1, 10125 Torino, Italy
[3] Consiglio Nazionale delle Ricerche, Istituto dei Sistemi Complessi – 00185 Roma, Italy

Working within the mean-field framework, we study the dynamical transition in the Totally Asymmetric Simple Exclusion Process with open boundaries. This phenomenon is signalled by a singularity in the slowest relaxation rate, that is the smallest eigenvalue of the relaxation matrix. In the high-density phase, at a critical value of the injection rate, such eigenvalue becomes independent of this parameter, the same holds in low-density at a critical value of the extraction rate due to the particle-hole symmetry. This behavior does not coincide with any static transition related to the steady state. We provide rigorous bounds for the slowest relaxation rate that become tight in the infinite size limit. We generalize these results to the TASEP with Langmuir kinetics, where particles can also attach to an empty site and detach from an occupied one at given rates. We restrict the analysis to the symmetric case of equal binding/unbinding rates and show that a dynamical transition occurs in this case as well.

*Speaker
†Corresponding author: davide.botto@polito.it

Start-stop motion of opinion waves through embedded networks

James Burridge[*] [1], Michal Gnacik[†‡] [1], Steven Kenney[§¶] [1]

[1] University of Portsmouth – Lion Gate Building Lion Terrace Portsmouth PO1 3HF, United Kingdom

The diffusion of linguistic or cultural variables such as lexical choices and social conventions through populations is influenced by the network of social connections between people. In the case of language, domain walls (called 'isoglosses' by linguists) between linguistic features are commonly observed, and the geographical pattern of language variation is influenced by their macroscopic dynamics [2]. The motion of these walls may be understood as an opinion wave, and in the simplest macroscopic models its velocity is a simple function of agents' interaction range and population gradients. In this work, we explore the effects of network structure by modeling social interactions as a one-dimensional embedded network generated by a Markov process, which captures the range, density and reciprocity of connections. We find that the wave periodically stops when certain local network configurations appear, corresponding to certain sequences of states in the Markov chain. We analyse the statistics of these pinning events using martingale methods, and show how they control the mean velocity of wave.

[1] C. Castellano, S. Fortunato, V. Loreto, Rev. Mod. Phys. 81, 591 (2009).
[2] J. Burridge, Phys. Rev. X 7, 031008 (2017).

[*]Corresponding author: james.burridge@port.ac.uk
[†]Speaker
[‡]Corresponding author: michal.gnacik@port.ac.uk
[§]Speaker
[¶]Corresponding author: steven.kenney@port.ac.uk

Physical properties of magnetic clusters

Hassan Chamati*† [1], Miroslav Georgiev [1]

[1] Institute of Solid State Physics, Bulgarian Academy of Sciences – Tsarigradsko Chaussée 72, 1784 Sofia, Bulgaria

The physical properties, such as the energy spectra, susceptibility, etc. at the nanoscale, of magnetic clusters at the nanoscale depend on their size and shape. Thus finite-size, as well as surface effects and the internal degrees of freedom of these nano-objects have huge impact on their characteristics. In particular these pure geometric properties may affect the magnetic interaction among the constituent ions leading to inhomogeneities in the intrinsic magnetic field and thus to high degeneracy in the energy levels of the clusters.

Here we report a systematic approach to study the behavior of magnetic clusters. we introduce an altered version of the Heisenberg Hamiltonian, where the interspin interaction is not constant, but rather vary depending on the way the spins are coupled. The energy spectra of the proposed Hamiltonian are determined and analyzed and the INS amplitudes and the susceptibility are computed.

These properties are compared to available experimental data for some trimers and tetramers, and good agreements were found.

Acknowledgements: Support from the Ministry of Education and Research, Bulgaria (National Science Fund, Grant DN 08-02/2016) is gratefully acknowledged.

[1] M. Georgiev, H. Chamati, Phys. Rev. B (submitted).

*Speaker
†Corresponding author: chamati@issp.bas.bg

Coearsening in the long-range interacting Ising model

Henrik Christiansen* [1], Suman Majumder [1], Wolfhard Janke [1]

[1] University of Leipzig – Germany

Simulations of systems with long range interactions are computationally more challenging than its short range counterpart, e.g., in the long range Ising model all spins have to be considered in the calculation of the local energy change. For several models, this problem has been overcome by the introduction of cluster algorithms for equilibrium simulations. As those cluster methods do not capture the dynamics, one cannot rely on them for simulating kinetics of phase transitions. Here, we present a novel and efficient approach of tackling such problems, concerning nonequilibrium dynamics via Monte Carlo simulations by storing a local 'pseudo heatbath' for the energy calculation. As an illustration, we present results for coarsening of the long range Ising model in $d = 2$ dimensions. In contradiction to all available simulation results in this context (using an cut-off to make the simulation feasible), our results establish agreement with the theoretical predictions.

*Speaker

Obstructed diffusion on a 2D interface: the lattice gas model and experiments in biomembranes

Mislav Cvitković*† [1,2], Ana-Sunčana Smith [1,2]

[1] Ruder Bošković Institute, Division of Physical Chemistry, CLS Group – Bijenička 54 10000 Zagreb, Croatia
[2] Friedrich-Alexander-Universität Erlangen-Nürnberg, Cluster of Excellence: EAM, PULS Group – Nägelsbachstr. 49b, 91052 Erlangen, Germany

Diffusion on two-dimensional interfaces is often obstructed due to interactions of diffusing particles with the interface or with other particles. Interactions with the interface can be local, in which case the particle is trapped in a particular point (trap) for a segment of time. Such traps slow down normal diffusion and induce a regime of anomalous diffusion. The interaction with other particles can be either attractive or repulsive. In both cases diffusion is also slowed down, by forming larger complexes or by crowding the space for movement, respectively. To model the effect of both crowding and trapping on diffusion, we study a 2D lattice gas of hard particles which interact with randomly localized ensemble of traps. We characterize the behaviour of the system on all time scales, and provide an analytical expression for the effective rescaled diffusion coefficient in equilibrium, as a function of concentration of traps and the tracers and binding and unbinding rates to traps. Furthermore, we analyze the experimental single-molecule traces of the Variant Surface Glycoproteins (VSGs) in a reconstituted membrane of *Trypanosoma brucei*, acquired in the group of S. Fenz on Würzburg University. We show that obstructed diffusion of VSGs reveals similar features to those predicted by the lattice gas model in a broad range of VSG concentrations.

*Speaker
†Corresponding author: mcvitkov@irb.hr

Local spontaneous symmetry breaking in a colloidal monolayer: Kibble–Zurek mechanism for a Kosterlitz–Thouless ensemble

Sven Deutschlander [1], Patrick Dillmann [1], Georg Maret [1], Peter Keim* [1]

[1] University of Konstanz – Universitaetsstrasse 10, D-78457 Konstanz, Germany

The Kibble–Zurek mechanism describes the evolution of defects and domains when a system is forced through a phase transition with spontaneously broken symmetry. It is used to describe transitions on such different scales like the Higgs field in the early universe shortly after the Big Bang [1] or in condensed matter systems like quenched quantum fluids [2]. Cooling at a finite rate, a domain structure naturally arises for a system with continuous phase transition. Since diverging correlation length are accompanied with critical slowing down, the system has to fall out of equilibrium for any non-zero cooling rate in the vicinity of the transition; At this fall out time, a fingerprint of critical fluctuations is taken before the symmetry can switch globally.

Within this picture, we investigate the non-equilibrium dynamics in a soft-matter analogue, a two-dimensional ensemble of colloidal particles which in equilibrium obeys the Kosterlitz–Thouless–Halperin–Nelson–Young melting scenario with continuous phase transitions. The ensemble is exposed to finite cooling rates of the pair-interaction parameter (being an inverse system temperature) at very different rates from deep in the isotropic fluid into the poly-crystalline phase. We analyze defect configurations as well as the evolution of orientationally ordered domains quantitatively via video microscopy and show that their frozen-out length scale follows the predicted decay as function of the quench rate if the Kibble–Zurek mechanism is adapted to the Kosterlitz–Thouless universality class [3,4].

[1] T. Kibble, J. Phys.: Math. Gen. 9, 1387 (1976).
[2] W. Zurek, Nature 317, 505 (1985).
[3] S. Deutschländer, P. Dillmann, G. Maret, P. Keim, Proc. Natl. Acad. Sci. 112, 6925 (2015).
[4] A. del Campo, Proc. Natl. Acad. Sci. 112, 6780 (2015).

*Speaker

Collective modes of identical Kuramoto rotators in a ring-like topology

Károly Dénes*† [1], Bulcsú Sándor [1,2], Zoltán Néda [1]

[1] Babes–Bolyai University – Cluj-Napoca, Romania
[2] Goethe–University – Frankfurt, Germany

Systems of locally coupled identical Kuramoto rotators in a 1D ring-like topology are considered. We investigate the emergent stationary collective modes in such systems. These spatio-temporal patterns are interpreted as generalized synchronization modes of the system, or can be viewed as self-closing rotating waves on a circle with a well defined winding number. Our study investigates the predictability of the final stable state when the phases of the rotators are randomly initialized.

First we summarize the known results regarding this type of collective behavior in circular oscillator ensembles using a novel theoretical framework. Interpreting the system as a gradient system we identify all possible stationary states including a new class of unstable asymptotic solutions. The linear stability of the emergent patterns is also determined and it is linked to the winding number, which labels the stationary states, in agreement with the results in [1, 2, 3]. Computer experiments were considered, confirming that the distribution of the probability of appearance for the stable collective modes is well approximated by a Gaussian envelope curve. We also show that variance of the distributions scales linearly with the system size [1].

New results are obtained by numerically studying the dynamics of the system. Using multidimensional geometry we interpret the phase space of the system as various distinct planes confined in a hypercube. We show that the motion of the characteristic point of the system is only possible on the surface of these planes. Unfortunately for the general $d > 3$ case the actual trajectories cannot be directly visualized, so we present different attempts to picture the time-evolution of the system. We show that the complexity of the dynamics is rapidly increasing with the system size. This feature indicates that predictions on the final state of the system made solely from the random initial conditions become more and more difficult as we consider bigger systems. We argue however, that the final stationary mode is always predictable after a certain time-moment of the dynamics. A simple method is proposed for identifying this time-moment, ts. We study numerically the scaling of the average time for the selection process as a function of the system parameters.

[1] D. A. Wiley, S.H. Strogatz, M. Girvan, Chaos 16, 015103 (2006).
[2] T. K. Roy, A. Lahiri, Chaos, Solitons, Fractals 45, 888 (2012).
[3] R. Dodla, A. Sen, G. L. Johnston, Phys. Rev. E 69, 056217 (2004).

*Speaker
†Corresponding author: karoly.denes42@gmail.com

Is there a universal boundary between Tsallis' nonextensive physics and Boltzmann's formalism?

Ewa Drzazga*† [1], Radosław Szczęśniak [1,2]

[1] Institute of Physics, Częstochowa University of Technology – Poland
[2] Institute of Physics, Jan Długosz University in Częstochowa – Poland

In the present communication, we have determined the entropy, the total energy, and the specific heat of the systems consisting of $M > 3$ hydrogen molecules. The calculations were conducted in the framework of the nonextensive Tsallis statistics, where the relation between number of molecules (M) and the entropic index (q) is given by: $q = 1 + 1/M$. By employing the Hubbard Hamiltonian we have determined the electron energy states of the hydrogen molecule. During calculations, we have included the contributions to the energy of the hydrogen molecule coming from the oscillatory (either harmonic or anharmonic), rotational and translational degrees of freedom. In last step, we have taken into account the influence of the external force (F) or the magnetic field (h) on the thermodynamic parameters of the systems. The conducted analysis has shown that in a systems consisting of the hydrogen molecules, it is possible to observe a significant deviation from the predictions of the classical statistical physics unless the system consists of less than a thousand molecules.

*Speaker
†Corresponding author: edrzazga@wip.pcz.pl

Critical behavior of two-dimensional models with Ising spins in the presence of long-range correlated disorder

Maxym Dudka* [1]

[1] Laboratory for Statistical Physics of Complex Systems, Institute for Condenced Matter Physics, National Academy of Sciences of Ukraine – 1 Svientsitskii, 79011 Lviv, Ukraine

Two-dimensional systems are of particular interest in studying phase transitions in condensed matter. This interest is constantly growing due to the progress in experimental techniques of producing and studying low-dimensional materials like graphene, two-dimensional crystals or ultrathin ferromagnetic films. Since a varying degree of impurities is present in every material studied in the laboratory, the effects of quenched structural disorder on phase transitions is a hot topic of research.

Here we consider the critical behavior of two-dimensional Ising model and N-'color' Ashkin–Teller model in a presence of random quenched defects correlated with the distance r according to a power-law r^{-a}. Mapping the problems onto two-dimensional Dirac fermions with correlated disorder we study the critical properties within renormalization group approach. Using two-loop approximation for Ising model with $0.995 < a < 2$ we find new critical behaviour characterized by the correlation length exponent $\nu = 2/a$ [1]. Applying bosonization, we also calculate the averaged square of the spin-spin correlation function and find the corresponding critical exponent η_2. We find for N-'color' Ashkin–Teller model within one-loop order that a 'weakly universal' scaling behavior for $N = 2$ as well as the first-order phase transition for $N > 2$, are transformed by the correlated disorder into a continuous phase transition sharing universality class with previously considered model [2].

[1] M. Dudka, A. A. Fedorenko, V. Blavatska, Yu. Holovatch, Phys. Rev. B 93, 224422 (2016).
[2] M. Dudka, A. A. Fedorenko, Condens. Matter Phys. 20, 13603 (2017).

*Speaker

Thin film growth of two-component mixtures: The interplay of phase diagrams and kinetics

Eelco Empting* [1], Miriam Klopotek† [1], Martin Oettel [1]

[1] University of Tübingen – Germany

Thin film growth at a substrate via deposition of particles from a gas phase or from a molecular beam is generally non-equilibrium, where specific microscopic kinetics determine the macroscopic structural evolution. It is known from experiment with two-component systems that demixing may occur during film growth [1], alluding to the notion that phase diagrams from the bulk may play a central role. In this context, we study the interplay between nonequilibrium kinetics and equilibrium phases in a simple model for thin film growth with a two component-mixture.

We compare kinetic Monte Carlo simulations with bulk phase diagrams from mean-field calculations.

The particles live on a lattice, and in addition to hard-core repulsion, they interact via attraction with their nearest neighbors, the strength of which depends on whether particles are of the same species. This may lead to demixing and gas-liquid coexistence in bulk. We present a spinodal decomposition diagram, which is a generalization of that of regular solution theory.

In our simulations we show how varying the microscopic kinetics leads to drastically different structures, including kinetically limited ones like arrested mixing in the first layer. We can classify such structures as non-equilibrium in contrast to ones near equilibrium that echo the phase diagrams. Other phenomena include how the first monolayer may serve as a structural template for higher layers.

[1] R. Banerjee et al., Phys. Rev. Lett. 110, 185506 (2013).

*Speaker
†Corresponding author: miriam-dagna.klopotek@uni-tuebingen.de

Damped harmonic oscillator: towards the dissipative quantum problems

Katalin Gambár* [1]

[1] Institute of Microelectronics and Technology, Kálmán Kandó Faculty of Electrical Engineering, Óbuda University – Tavaszmező u. 17, H-1084 Budapest, Hungary

Our former studies and results clarified that—by applying relevant physical-mathematical additional potential fields—the Lagrange function of certain dissipative, irreversible transport processes can be constructed. In other words, the Hamilton's principle can give the fundamentals of these theories as well [1-5]. In the mathematical formulation of the Lagrange function, this physical-mathematical potential has a central role holding a consistent mathematical relation with the measurable physical fields. As it is usual, there is a certain free choice in the formulation of the Lagrange functions [6,7]. The complete canonical formalism can be also deduced by exploiting the possibilities of calculus of variation. The developed theory holds the attempt to study the processes in details.

Presently, we intend to present the construction via a simple classical discrete dissipative model, the description of damped harmonic oscillator (DHO). We pointed out that the Hamiltonian, the complete canonical formulation and the phase field construction can be elaborated beyond the equation of motion. It seems that this description may be a step towards the dissipative quantum descriptions [8-11]. The understanding of irreversible behavior of quantum regime would be very fruitful and useful for several parts of physics.

[1] F. Márkus, K. Gambár, J. Non-Equilib. Thermodyn. 16, 27 (1991).
[2] K. Gambár, F. Márkus, B. Nyíri, J. Non-Equilib. Thermodyn. 16, 217 (1991).
[3] K. Gambár, F. Márkus, Phys. Rev. E 50, 1227 (1994).
[4] K. Gambár, Least Action Principle for Dissipative Processes, in S. Sieniutycz, F. Farkas (eds.), Variational and extremum principles in macroscopic systems, chap. 12., Elsevier (Oxford, 2005).
[5] K. Gambár, M. Lendvay, R. Lovassy, J. Bugyjás, Acta Polytechn. Hung. 13, 173 (2016).
[6] S. Sieniutycz, Conservation Laws in Variational Thermo-Hydrodynamics, Kluwer (Dordrecht, 1994).
[7] P. O. Kazinski, Phys. Rev. E 79, 011105 (2009).
[8] W. Dittrich, M. Reuter, Classical and Quantum Dynamics, Springer, (Berlin, 1992).
[9] F. Márkus, Hamiltonian Principle as a Basis of Quantized Thermal Process, in S. Sieniutycz, F. Farkas (eds.) Variational and extremum principles in macroscopic systems, chap. 12., Elsevier (Oxford, 2005).
[10] M. Razavy, Classical and Quantum Dissipative Systems, Imperial College Press (London, 2005).
[11] B. G. Márkus, F. Márkus, Indian J. Phys. 90, 441 (2016).

*Speaker

Magnetic excitations in the molecular magnets $Pb_3Cu_3(PO_4)_4$ and Ni_4Mo_{12}

Miroslav Georgiev*† [1], Hassan Chamati [1]

[1] Institute of Solid State Physics, Bulgarian Academy of Sciences – Tsarigradsko Chaussée 72, 1784 Sofia, Bulgaria

We propose a modified pairwise spin exchange interaction to study the magnetic properties of molecular spin clusters. This consists in introducing an effective bilinear spin Hamiltonian accounting for the influence of intrinsic molecular field inhomogeneities. Thus, it indirectly accounts for the action of local fields in the vicinity of constituent ions and exchange bridges. Regarding the exchange couplings it allows for distinct spin coupling mechanisms among equivalent magnetic ions. Regarding the scattering processes, it provides a unique identification of the existing spin bonds. The Hamiltonian is used to determine the magnetic excitations of the molecular magnets $Pb_3Cu_3(PO_4)_4$ [1] and Ni_4Mo_{12} [2–4]. We reproduced the magnetic spectra of both compounds obtaining neutron scattering intensity curves for each individual magnetic transition. The results of our analysis are consistent with the experimental results obtained via Inelastic Neutron Scattering. Exploring the spin-half copper trimer $Pb_3Cu_3(PO_4)_4$ we found the ground state associated with Cu1-Cu3 triplet bond and obtained thin energy band corresponding to the Cu1-Cu3 singlet, explaining the flat excitation magnetic peaks. We deduced the singlet level gives rise to the first ground state and excited experimentally observed magnetic peaks. The second ground excitation is the result of a transition between doublet-quartet total spin levels. The analysis of tetrameric spin-one cluster Ni_4Mo_{12} leads to the singlet ground state and the presence of two wide bands in the energy spectrum. These bands explain the width of all ground state peaks and the splitting of the first one. The splitting was found to be more likely a consequence of different spatial orientation of the spin-one bonds.

Acknowledgements: Support from the Ministry of Education and Research, Bulgaria (National Science Fund, Grant DN 08-02/2016) is gratefully acknowledged.

[1] M. Matsuda, K. Kakurai, A. A. Belik, M. Azuma, M. Takano, M. Fujita, Phys. Rev. B 71, 144411 (2005).
[2] V. V. Kostyuchenko, Phys. Rev. B 76, 212404 (2007).
[3] A. Furrer, K. W. Krämer, T. Strässle, D. Biner, J. Hauser, H. U. Güdel, Phys. Rev. B 81, 214437 (2010).
[4] J. Nehrkorn, M. Höck, M. Brüger, H. Mutka, J. Schnack, O. Waldmann, Eur. Phys. J. B 73, 515 (2010).

*Speaker
†Corresponding author: mgeorgiev@issp.bas.bg

Forbidden synchronization clusters formed in numerical simulation of phase oscillators under common noise

Chen Gong* [1], Ralf Toenjes† [1], Chunming Zheng [1], Denis Goldobin [2], Arkady Pikovsky [1]

[1] Interdisciplinary Center for Dynamics of Complex Systems, University of Potsdam – Campus Golm, Building 14, Karl-Liebknecht-Str. 24, D-14476 Potsdam, Germany
[2] Group of Dynamics of Geological Systems, Institute of Continuous Media Mechanics, UB RAS – Perm 614013, Russia

We consider the interaction of an ensemble of limit-cycle oscillators with nonlinear sinusoidal, all-to-all repulsive coupling and identical natural frequencies, which experience common multiplicative noise, as in the model proposed by Gil, Kuramoto and Mikhailov [1]. We find the result of their paper to be in contradition with known mathematical theory introduced by Watanabe and Strogatz [2]. The multi-cluster steady states which were found by Gil et al. as induced by common noise are in fact unstable and only may become stable when numerical errors are large. The clustering is a result of the numerical integration that destroys the Moebius group action which the system's dynamics preserves. We demostrate the scaling law for the clustering effect by numerical integration at various time steps, and demonstrated via solving Fokker Planck equation and via simulation that two unequal-sized cluster state is always unstable (neutral stability for equal sized two clusters). Clustering can be observed howevever in real-world oscillator model such as Van der Pol resulting from the inclusion of higher harmonic coupling.

[1] S. Gil, Y. Kuramoto, A. S. Mikhailov, EPL 88, 60005 (2009).
[2] S. Watanabe, S. H. Strogatz, Physica D 74, 197 (1994).

*Speaker
†Corresponding author: rahleph@googlemail.com

Dynamics of asymmetric interpersonal relations, driven by three selected mechanisms

Forough Hassanibesheli [1], Leila Hedayatifar [1],
Przemysław Gawroński*† [1], Maria Stojkow [1], Dorota Zuchowska-Skiba [1],
Krzysztof Kułakowski [1]

[1] AGH University of Science and Technology, Faculty of Physics and Applied Computer Science – Mickiewicza 30, PL-30059 Kraków, Poland

Three mechanisms are taken into consideration: the removal of cognitive dissonance which drives the community into the Heider balance [1], the direct reciprocity which tends to remove asymmetry of relations [2], and the so-called 'gain and loss of esteem' which couples the velocities of pairs of mutual relations [3]. These mechanisms are built into a system of ordinary differential equations. We prove that for asymmetric stationary states the Heider balance is not attained. A phase diagram is constructed with three phases: the jammed phase where the asymmetry of relations is frozen, the balanced phase with two mutually hostile groups, and the phase of so-called paradise, where all relations are friendly.

[1] K. Kułakowski et al., Int. J. Mod. Phys. C 16, 707 (2005).
[2] M. J. Krawczyk et al., Physica A 439, 66 (2015).
[3] F. Hassanibesheli et al., Physica A 468, 334 (2017).

*Speaker
†Corresponding author: gawron@newton.ftj.agh.edu.pl

Monomer density profiles for phantom ideal ring polymer chains in confined geometries

Joanna Hałun*† [1], Zoryana Usatenko [2]

[1] Institute of Nuclear Physics, Polish Academy of Sciences – Radzikowskiego 152, PL-31342 Kraków, Poland
[2] Institute of Physics, Cracow University of Technology – Podchorążych 1, PL-30084 Kraków, Poland

Taking into account the well known polymer–magnet analogy developed by de Gennes [1] the calculations of the monomer density profiles for a dilute solution of phantom ideal (Gaussian) ring polymer chains in a Θ-solvent confined in a slit geometry of two parallel repulsive walls and for the mixed case of one repulsive and the other one inert wall were performed. Besides, taking into account the Derjaguin approximation [2] the monomer density profiles for phantom ideal ring polymer chains confined in a solution of big colloidal particles with different adsorbing or repelling properties were calculated. The monomer-density relation for the above mentioned case was analyzed and the corresponding universal amplitude ratio B was calculated. The obtained results are in good qualitative agreement with previous numerical results obtained by Monte Carlo simulations [3].

[1] P. G. de Gennes, Scaling Concepts in Polymer Physics, Cornell University Press, (Ithaca, NY, 1979).
[2] B. V. Derjaguin, Kolloid-Z 69, 155 (1934).
[3] R. Matthews, A. A. Louis, J. M. Yeomans, Mol. Phys. 109, 1289 (2011).

*Speaker
†Corresponding author: joannahalun05@gmail.com

Reaching Carnot's efficiency

Viktor Holubec* [1,2], Artem Ryabov†‡ [1]

[1] Charles University, Faculty of Mathematics and Physics, Department of Macromolecular Physics – V Holešovičkách 2, CZ-18000 Praha, Czech Republic
[2] Universität Leipzig, Institut für Theoretische Physik – Postfach 100 920, D-04009 Leipzig, Germany

Recently, a number of studies suggested that the Carnot efficiency may be reached by heat engines (HEs) operating out of quasi-static conditions and thus at a nonzero power. For various distinct classes of models widely used to describe performance of actual HEs, we discuss parameter regimes for which this can happen with a particular focus on the magnitude of the output power. These models comprise quantum thermoelectric devices, linear irreversible HEs, minimally nonlinear irreversible HEs, HEs working in the regime of low dissipation, over-damped stochastic HEs and an under-damped stochastic HE. Although the Carnot efficiency can be in some of these models reached at nonzero and even diverging power, the magnitude of this power is always negligibly small compared to the maximum power attainable in these systems. Our analysis yields conditions under which the Carnot efficiency can be reached out of equilibrium in the individual models and explains new practical aspects inevitably connected with HEs working close to the Carnot efficiency at a large power output. Furthermore, we present a detailed theoretical study of a realistic Brownian HE which can be used for testing our findings in practice adopting available micromanipulation techniques.

*Corresponding author: viktor.holubec@gmail.com
†Speaker
‡Corresponding author: rjabov.a@gmail.com

Analytic finite-size scaling functions in the anisotropic square-lattice Ising model with various boundary conditions

Fred Hucht* [1], Hendrik Hobrecht [1]

[1] University of Duisburg-Essen – Lotharstrasse 1, D-47057 Duisburg, Germany

We present analytic finite size scaling functions for the residual free energy, also known as Casimir potential, and for the Casimir force for the two-dimensional anisotropic Ising model with various boundary conditions and finite aspect ratio. We discuss similarities and differences of the various cases and derive a systematic classification of the respective bulk, surface, interface and corner contributions. We use some of the results to describe critical Casimir forces between colloids in near-critical suspensions.

[1] H. Hobrecht, A. Hucht, Phys. Rev. E 92, 042315 (2015).
[2] A. Hucht, J. Phys. A: Math. Theor. 50, 065201 (2017).
[3] A. Hucht, J. Phys. A: Math. Theor. 50, 265205 (2017).
[4] H. Hobrecht, A. Hucht, J. Stat. Mech. 024002 (2017).

*Speaker

Quantum relaxation and metastability of lattice bosons with cavity-induced long-range interactions

Ferenc Iglói* [1,2]

[1] Institute of Theoretical Physics, Szeged University – Hungary
[2] Wigner Research Centre, Institute for Solid State Physics and Optics – Hungary

The coupling of cold atoms to the radiation field within a high-finesse optical resonator, an optical cavity, induces long-range interactions which can compete with an underlying optical lattice. The interplay between short- and long-range interactions gives rise to new phases of matter including supersolidity (SS) and density waves (DW), and interesting quantum dynamics. Here it is shown that for hard-core bosons in one dimension the ground state phase diagram and the quantum relaxation after sudden quenches can be calculated exactly in the thermodynamic limit. Remanent DW order is observed for quenches from a DW ground state into the superfluid (SF) phase below a dynamical transition line. After sufficiently strong SF to DW quenches beyond a static metastability line DW order emerges on top of remanent SF order, giving rise to a dynamically generated supersolid state.

*Speaker

Entanglement between random and clean quantum spin chains

Róbert Juhász* [1], István Kovács [2], Gergő Roósz [1], Ferenc Iglói [1]

[1] Wigner Research Centre for Physics – Budapest, Hungary
[2] Northeastern University – 360 Huntington Ave., Boston, Massachusetts 02115, United States

The entanglement entropy in clean, as well as in random quantum spin chains has a logarithmic size-dependence at the critical point. Here, we study the entanglement of composite systems that consist of a clean subsystem and a random subsystem, both being critical. In the composite, antiferromagnetic XX chain with a sharp interface, the entropy is found to grow in a double-logarithmic fashion $S \sim \ln\ln(L)$, where L is the length of the chain. We have also considered an extended defect at the interface, where the disorder penetrates into the homogeneous region in such a way that the strength of disorder decays as a power $-\kappa$ of the distance from the contact point. For $\kappa < 1/2$, the entropy scales as $S(\kappa) = \ln 2(1-2\kappa)/6\ln(L)$, while for $\kappa \geq 1/2$, when the extended interface defect is an irrelevant perturbation, we recover the double-logarithmic scaling. These results are explained through strong-disorder RG arguments.

We also studied the half-chain entanglement entropy across a symmetric, extended random defect, where the strength of disorder decays algebraically on both sides of the interface. In the whole regime $\kappa \geq 0$, we found a logarithmic scaling of the entropy, but the variation of the prefactor with κ is non-monotonic and discontinuous at $\kappa = 1/2$.

*Speaker

Generic control of microscopic active particles with magnetic fields

Martin Kaiser [1], Pedro Sanchez * [1], Sofia Kantorovich [1]

[1] Dipolar Soft Matter, Computational Physics, University of Vienna – Austria

Active particles are a subject of great research interest due to their presence in many biological and physical systems. From a generic point of view, these particles are characterized by their ability to transform energy obtained from the surrounding environment into oriented and/or persistent motion. This definition applies to out of equilibrium systems with very different size scales, ranging from systems of microscopic particles to macroscopic self-propelled bodies. Regarding microscopic active particles, among their most notorious examples one can find biological and artificial systems like self-propelled cells and microorganisms, or artificial swimming colloids and nanomotors, respectively. These examples evidence the relevance of the study of active particles in important fields like nanotechnology and biomedicine.

An aspect of particular importance for medical and technological applications of microscopic active particles is the achievement of an effective external manipulation of their motion. Whereas artificial active particles can be designed to provide a controlled response to specific stimuli, this feature is naturally much more complicated to obtain in the case of biological systems. Our work is intended to achieve a generic manipulation on the motion of microscopic swimming particles that can be applied to either artificial or biological bodies. In particular, our work explores theoretically the possibility to use a dispersion of magnetic nanoparticles, added to the carrier fluid as a viscoelastic bath, in order to force the active particles to move along a preferred axis. This approach takes advantage of the self-assembly properties of the magnetic particles under the influence of external magnetic fields. Here, we analyze by means of extensive computer simulations the influence of the field-induced structures of magnetic nanoparticles on the active particles, discussing the conditions that may provide the highest control of their motion.

*Speaker

Corrections to finite-size scaling in the 3D Ising model based on non-perturbative approaches and Monte Carlo simulations

Jevgenijs Kaupužs*† [1]

[1] Institute of Mathematical Sciences and Information Technologies, University of Liepaja – 14 Liela Street, Liepaja LV–3401, Latvia

Corrections to scaling in the 3D Ising model are studied based on non-perturbative analytical arguments and Monte Carlo (MC) simulation data for different lattice sizes L. Our recently published analytical arguments show that the leading correction-to-scaling exponent ω is significantly smaller than the usually reported value about 0.8. This finding has been supported also by Monte Carlo simulations for very large lattice sizes up to $L = 2560$. In particular, a numerical estimation of ω from the susceptibility data has provided the value $\omega = 0.21(29)$. Here we discuss the results, obtained from extended simulation data, including linear lattice sizes up to $L = 3456$. It allows us to obtain refined estimates, which excellently confirm our previous results and findings. We discuss also the influence of ω on the estimation of the critical exponents η and ν, as well as the behavior of corresponding effective critical exponents.

A conception is proposed, according to which the usually reported in literature critical exponents are, in fact, effective exponents, which describe the behavior of a system within a 'perturbative region', where the standard perturbative methods are applicable, the true asymptotic exponents being related to a non-perturbative fixed point.

*Speaker
†Corresponding author: kaupuzs@latnet.lv

Anomalous size effect of fracture strength due to fat-tailed micro-scale disorder

Viktória Kádár*† [1], Ferenc Kun [1]

[1] Department of Theoretical Physics, University of Debrecen – H-4002 Debrecen, P. O. Box 400, Hungary

We investigate the size scaling of the macroscopic fracture strength of heterogeneous materials when microscopic disorder is controlled by fat-tailed distributions. We consider a fiber bundle model where the strength of single fibers is described by a power law distribution over a finite range. Tuning the amount of disorder by varying the power law exponent and the upper cutoff of fibers' strength, in the mean field limit an astonishing size effect is revealed: For small system sizes the bundle strength increases with the number of fibers and the usual decreasing size effect of heterogeneous materials is only restored beyond a characteristic size. We show analytically that the extreme order statistics of the micro-scale disorder is responsible for this peculiar behavior. Analyzing the results of computer simulations we deduce a scaling form which describes the dependence of the macroscopic strength of fiber bundles on the parameters of microscopic disorder over the entire range of system sizes [1]. The results can be exploited for materials' design.

[1] V. Kádár, Zs. Danku, F. Kun, Phys. Rev. E 96, 033001 (2017).

*Speaker
†Corresponding author: kadar.viktoria@science.unideb.hu

A classical short-range spin model with phase transitions in one dimension: the Potts model with a negative number of invisible states

Ralph Kenna*† [1,2], Petro Sarkanych [1,2,3], Yurij Holovatch [2,3]

[1] Applied Mathematics Research Centre, Coventry University – Coventry CV1 5FB, United Kingdom
[2] L4 Collaboration & Doctoral College for the Statistical Physics of Complex Systems – Leipzig-Lorraine-Lviv-Coventry, Europe, United Kingdom
[3] Institute for Condensed Matter Physics, National Academy of Science of Ukraine – UA-79011 Lviv, Ukraine

As is widely known, in his famous 1925 paper, Ernst Ising was looking for a phase transition in a one-dimensional classical system with short-range interactions, an idea suggested by Wilhelm Lenz in 1920. To considerable disappointment, there was none. Although Ising's innovative paper did not deliver a phase transition, it was the start of a vast amount of literature in statistical physics, including a number of papers giving theorems why it is impossible to have a phase transition in such one-dimensional systems. (At least two dimensions are required to have a phase transition in a classical system with short-range interactions.)

Here we report on a way around the no-go theorems; we show how one can induce a phase transition on one-dimensional systems. Usually phase transitions arise through a competition between entropy and energy. The reason behind the no-go theorems is that there is too much entropy in one-dimensional systems—entropy always wins over energy so that the delicate balance that gives a phase transition is never achieved.

We present the exact solution of the 1D Potts model with invisible states. The latter contributes to the entropy of the system but not to its internal energy. Extending to a negative number of invisible states reduces the entropy in the system allowing a balance between the remaining entropy and the energy. This delivers a phase transition in classical one-dimensional short-range systems. A similar result comes from subjecting invisible states to a complex magnetic field. We discuss how to adjust these mathematical constructs to link with physical realisations. Thus, as the 100th anniversary of Ising's paper approaches, we show that he and Lenz were on the right track all along.

*Speaker
†Corresponding author: r.kenna@coventry.ac.uk

Two order parameters for the Kuramoto model on complex networks

Yup Kim* [1], Soon-Hyung Yook [1]

[1] Kyung Hee University – Hoegidong 1, Dongdaemunku, Seoul, South Korea

We investigate the behavior of two different order parameters for Kuramoto model in desynchronized phase. Since the primary role of the order parameter is to distinguish different phases, we focus on the ability to discern the desynchronized phase from the synchronized one on complex networks with the size N. From the exact derivation of the difference between two order parameters, Δ, on a star network, we find that those order parameters disagree in desynchronized phase. We also show that the hub plays an important role and provide an analytic conjecture on the condition that the two order parameters agree with each other as $N \to \infty$. The conjecture is numerically confirmed.

*Speaker

Ising-type phase transitions in simple evolutionary coordination games

Balázs Király*† [1,2]

[1] Budapest University of Technology and Economics – Budafoki út 8, H-1111 Budapest, Hungary
[2] Institute of Technical Physics and Materials Science, Centre for Energy Research, Hungarian Academy of Sciences – P.O. Box 49, H-1525 Budapest, Hungary

In multiplayer evolutionary matrix games player-player interactions are defined by so-called payoff matrices. Recently, the concept of payoff matrix decomposition revealed that all such games are combinations of elementary games of only four distinct classes. Three of these classes—namely self-dependent, cross-dependent, and coordination-type games—span the set of potential games, which become equivalent to classical spin models when strategy updates are governed by the logit rule. In this analogy, coordination-type components correspond to ferromagnetic or antiferromagnetic spin-spin interactions, the symmetric parts of self- and cross-dependent components are analogous to an external magnetic field, while the remaining antisymmetric parts are responsible for the emergence of social dilemmas. This classification scheme allows for a systematic analysis of matrix games that can hopefully provide insights into the characteristics of general evolutionary games. We have recently studied the properties of simple combinations of elementary coordination games to further our understanding of the interplay between elementary game components. In a general n-strategy elementary coordination game, the Ising model is extended by $n-2$ neutral strategies (distinguishable noninteracting spin states) that provide zero payoff regardless of the opponent's choice of strategy. When players are located at the sites of a square lattice and only interact with their nearest neighbors, this game model exhibits an order-disorder phase transition at a strategy number–dependent critical temperature. If the number of neutral strategies is below a threshold value, the transition is continuous and belongs to the Ising universality class, but it is of the first order in other cases. This robustness of the Ising-type critical behavior can also manifest itself in games composed of a small number of elementary coordinations. The four-state clock model, made up of two independent elementary coordinations, is equivalent to a system of two uncoupled identical Ising models and as a result undergoes an Ising-type phase transition. In a similar five-strategy combination of an elementary coordination game and a three-state Potts model, both Ising- and Potts-type critical behaviors can be observed.

*Speaker
†Corresponding author: kiralyb@mfa.kfki.hu

Percolation or jamming—what is first?

Grzegorz Kondrat*† [1], Zbigniew Koza [1], Piotr Brzeski [1]

[1] University of Wrocław – Pl. Uniwersytecki 1, PL-50137 Wrocław, Poland

The interplay between jamming and percolation in adsorption of extended objects is still not completely understood. Some systems jam before the total spanning network can form. It was recently proposed that in the case of rectangular aligned objects percolation would not appear for long enough particles. I discuss this issue and sketch the proof of the universal behavior of this system.

*Speaker
†Corresponding author: gkon@ift.uni.wroc.pl

Many particle effects in generalized simple exclusion process

Miroslav Kotrla*† [1], František Slanina [1]

[1] Institute of Physics of the Czech Academy of Sciences – Na Slovance 1999/2, 182 21 Prague 8, Czech Republic

We study transport of particles in a linear system which follows the total simple exclusion process rules, and allows multiple occupancy of sites and several particle sizes. The problem is studied by numerical Monte Carlo simulations as well as by analytical calculations using mean field approximation. In the case of simulations, we developed a new cellular automaton controlled by particle occupancy.

We calculate particle flux as a function of the particle density. We started with particles of one type, and we obtained basic diagram for different multiple occupations. There is a good agreement between the mean field calculations and Monte Carlo simulation. Next, we study the system with two different types of particles, in particular we consider particles of different sizes, small and big particles. We analyzed flux of small particles and flux of big particles as functions of densities of small and big particles. The most important finding is the current reversal effect, which enables clear sorting according to particle size.

*Speaker
†Corresponding author: kotrla@fzu.cz

Time evolution of the Wigner function for the generalized Schrödinger cat state

Damian Kołaczek* [1], Maciej Wołoszyn [1], Bartłomiej Spisak† [1]

[1] AGH University of Science and Technology, Faculty of Physics and Applied Computer Science – Mickiewicza 30, PL-30059 Kraków, Poland

We consider the superposition of two coherent states which form the Schrödinger cat state that is enriched by additional parameter related to the amplitude of the interference term. This parameter can be used to model imperfection of the state caused by partial decoherence during its preparation. Wigner function approach is applied to the problem of dynamics of such state in quantum phase space. For this purpose an appropriate class of the Wigner functions is constructed, and they represent initial conditions for the equation of motion which is taken in the Moyal form. The main aim of the project is to investigate influence of quality of the initial state preparation on the dynamical localization in the phase space when the scattering processes are taken into consideration.

*Speaker
†Corresponding author: bjs@agh.edu.pl

Ising model with a power-law spin length distribution on different graphs

Mariana Krasnytska*† [1,2], Bertrand Berche [2,3], Yurij Holovatch [1,2]

[1] Institute for Condensed Matter Physics, National Academy of Sciences of Ukraine – Lviv, Ukraine
[2] L4 Collaboration & Doctoral College for the Statistical Physics of Complex Systems – Leipzig-Lorraine-Lviv-Coventry, Europe
[3] Institut Jean Lamour, CNRS/UMR 7198, Groupe de Physique Statistique, Université de Lorraine, CNRS, Institut Jean Lamour – Nancy, France

Considering the critical behavior on networks, special attention had been paid to the the case of scale-free networks, which are characterized by a power law decay of the node degree distribution [1]. It is well established by now, that fundamental features of criticality, scaling and universality, have to be reconsidered when a system resides on a scale-free network, see e.g. [2].

In our study we consider the Ising model with power-law spin length distribution on different types of graphs, namely, a complete graph, the Erdős–Rényi graph and an annealed scale free network. As we show in our study the critical behaviour of the Ising model with varying spin lengths on a complete graph and on the Erdős–Rényi graph asymptotically coincides with the behaviour of the Ising model on an annealed scale-free network, but thermodynamic functions asymptotics are defined by the decay exponent of the spin length distribution. An interplay of two power laws in the case where the model lives on a scale free network leads to a rich phase diagram with a variety of phase transitions in few different universality classes [3]. We discuss possible applications of the model considered.

[1] R. Albert, A.-L. Barabási, Rev. Mod. Phys. 74, 47 (2002).
[2] M. Krasnytska, B. Berche, Yu. Holovatch, R. Kenna, J. Phys. A 49, 135001 (2016).
[3] M. Krasnytska., B. Berche, Yu. Holovatch (unpublished).

*Speaker
†Corresponding author: kras.marjana@gmail.com

Who wins on conflicts?

Malgorzata Krawczyk* [1], Krzysztof Kułakowski [1]

[1] AGH University of Science and Technology, Faculty of Physics and Applied Computer Science – Mickiewicza 30, PL-30059 Kraków, Poland

The idea of the network resistance to attack is well established in literature, and an influence of numerous characteristics of the network topology has been investigated [1-8]. Up to our knowledge the process of regeneration of a network after its split has not been discussed directly. Here we investigate the evolution of the network structure under periodic splitting and regeneration, which reflects the network resistance to attack. The process of splitting once has been considered in [9]. There, the largest hub has been identified as a leader, and links are cut successively as to cut off a rival hub, which is the second largest hub in a distance not smaller than three links. Here the splitting is intended to mimic a conflict between leaders. The regeneration is the growth with or without preferential attachment. Accordingly, we can expect scale-free or exponential topology of the network. During the growth, some information can be preserved in the network structure. In [10] marks of the shape of the cluster, on which the growth process was initialized, have been encoded in the node-node distance distribution. Here we expect that successive splittings modify the topology of the core cluster with the hub. Our aim is to detect these modifications. To refer to the topology of social networks, the calculations are performed for scale-free and exponential networks with enhanced clusterization coefficient [11]. We measure the parameters of the largest hub: the degree, the closeness centrality and the betweenness centrality. These characteristics have been attributed to measure prestige in a social network [12]. Our numerical results indicate, that both kinds of centrality are strictly correlated. Also, during the consecutive splits and regeneration all the three parameters increase in the long run. These results indicate, that conflicts can be profitable for a leader in a social network. On the other hand, the clustering coefficient of the hub decreases during the simulated process. This result suggests an analogy to the ability of a leader to profit communication through weak ties [13]. Our conclusions can be relevant for an identification of techniques of 'management by conflict' [14,15].

[1] R. Albert, H. Jeong, A.-L. Barabasi, Nature 406, 378 (2000).
[2] R. Cohen, K. Erez, D. ben-Avraham, S. Havlin, Phys. Rev. Lett. 85, 4626 (2000).
[3] P. Holme, B. J. Kim, C. N. Yoon, S. K. Han, Phys. Rev. E 65, 056109 (2002).
[4] P. Crucitti, V. Latora, M. Marchiori, A. Rapisarda, Physica A 320, 622 (2003).
[5] M. Kurant, P. Thiran, P. Hagmann, Phys. Rev. E 76, 026103 (2007).
[6] M. E. J. Newman, G. Ghoshal, Phys. Rev. Lett. 100, 138701 (2008).
[7] S. Trajanovski, S. Scellato, I. Leontiadis, Phys. Rev. E 85, 066105 (2012).
[8] S. Sur, N. Ganguly and A. Mukherjee, Physica A 420, 98 (2015).
[9] M. J. Krawczyk, K. Kulakowski, J. A. Holyst, PLoS One 13, e0193715 (2018).
[10] K. Malarz, K. Kulakowski, Physica A 345, 326 (2005).
[11] P. Holme, B. J. Kim, Phys. Rev. E 65. 126107 (2002).
[12] S. Wasserman, K. Faust, Social Network Analysis (Cambridge UP, 1994).
[13] M. Granovetter, Amer. J. Sociology 78, 1360 (1973).
[14] R. L. Kimmons, Project management basics; a step by step approach (Marcel Dekker, NY 1990), p. 15.
[15] G. Borger, http://edition.cnn.com/2017/02/06/opinions/does-trump-management-by-conflict-equal-chaos/

*Speaker

All balanced states are equally probable

Malgorzata Krawczyk [1], Sebastian Kałużny [1], Krzysztof Kułakowski*† [1]

[1] AGH University of Science and Technology, Faculty of Physics and Applied Computer Science – Mickiewicza 30, PL-30059 Kraków, Poland

A social network is modeled by a complete graph of N nodes, with interpersonal relations represented by links. In the frames of Heider balance theory, we prove that the probability of each balanced state is the same [1]. This means in particular, that the probability of the paradise state, where all relations are positive, 2^{1-N}. The proof is performed within two models. In the first, relations are changing continuously in time, and the proof is performed only for $N = 3$ with the methods of nonlinear dynamics. The second model is the Constrained Triad Dynamics [2]. In the latter case, the proof makes use of the symmetries of the network of system states [3] and it is completed for $N < 8$.

[1] M. J. Krawczyk, S. Kałużny, K. Kułakowski, EPL 118, 58005 (2017).
[2] T. Antal, P. Krapivsky, S. Redner, Phys. Rev. E 72, 036121 (2005).
[3] M. J. Krawczyk, Physica A 390, 2181 (2011).

*Speaker
†Corresponding author: krzysztof.kulakowski@fis.agh.edu.pl

Ring polymer chains in a slit geometry of two parallel walls with Dirichlet-Neumann boundary conditions

Piotr Kuterba*† [1], Zoryana Usatenko [2]

[1] Faculty of Mathematics and Computer Science, Jagiellonian University – Kraków, Poland
[2] Institute of Physics, Cracow University of Technology – Kraków, Poland

We have investigated a dilute solution of ring polymer chains with the excluded volume interaction in a good solvent immersed in a confined geometry of two parallel walls with Dirichlet–Neumann boundary conditions (D-N b.c.). The case of Dirichlet b.c. corresponds to the situation that one surface is repulsive for polymer chains and the Neumann b.c. means that the other one is at the adsorption threshold. Polymer solution in a slit is in equilibrium contact with an equivalent solution in the reservoir outside the slit, because the exchange of polymer coils is allowed. We follow the thermodynamic description of the problem as it was given in [1, 2]. We have used the field-theoretical $\phi^4 O(n)$-vector model in the limit $n \to 0$ to calculate the dimensionless depletion interaction potential and the depletion force in the framework of the massive field theory approach in fixed space dimensions $d = 3$ up to one-loop order. The obtained results for a dilute solution of ring polymer chains with the excluded volume interaction in a good solvent indicate that the depletion force in the case of D-N b.c. becomes repulsive in contrast to the case of linear polymer chains (see [2]) and gives some additional insight in comparison to Gaussian model of phantom ideal ring polymer chains (see [3]) and is in agreement with the scaling predictions proposed by de Gennes some time ago [4]. Besides, it should be mentioned that the presented results give possibility better to understand the complexity of physical effects arising from confinement and chain topology and can find practical application in new types of micro- and nano-electromechanical devises.

[1] F. Schlesener, A. Hanke, R. Klimpel, S. Dietrich, Phys. Rev. E 63, 041803 (2001).
[2] D. Romeis, Z. Usatenko, Phys. Rev. E 80, 041802 (2009).
[3] Z. Usatenko, J. Halun, J. Stat. Mech. 013303 (2017).
[4] P. G. de Gennes, Macromolecules 15, 492 (1982).

*Speaker
†Corresponding author: piotr.kuterba@uj.edu.pl

Efficient search with Lévy flights emerges from locally optimal stochastic optimization

Łukasz Kuśmierz*† [1], Alireza Goudarzi [1], Taro Toyoizumi [1]

[1] RIKEN Brain Science Institute – 2-1 Hirosawa, Wako, Saitama 351-0198, Japan

A growing body of evidence shows that many animals commonly exhibit Lévy flights (LFs) during their search behavior. For example, human saccades (Brockmann and Geisel, 2000) and free word association (Costa et al., 2009) involve power-law distributions of displacement steps, summarizing frequent nearby explorations and infrequent jumps to distant locations. Although there are multiple putative explanations as to why LFs might emerge from case specific search constraints, a general theory explaining this behavior is lacking. We show that Newton's optimization method with noisy measurements generically leads to heavy tails of the step-size distribution. The resulting stochastic process is a LF with the tail index $\alpha = 1$. Additionally, the magnitude of large jumps in our model strongly depends on the local curvature of the optimized function, with rarer jumps close to targets. This suggests that noisy Newton's optimization method may be an efficient way of combining global random exploration with locally optimal exploitation. We thus examine the circumstances under which the heavy-tailed steps can be advantageous for the search. Since search patterns of many organisms resemble those of LFs, our results suggest that they may be employing second order derivatives. We further discuss implications of our results for models of mental search and learning.

*Speaker
†Corresponding author: nalewkoz@gmail.com

Generalized XY model with geometrical frustration

Matus Lach*† [1], Milan Zukovic‡ [1]

[1] Institute of Physics, P. J. Safarik University – Park Angelinum 9, 040 01 Kosice, Slovakia

It is well known that the two-dimensional XY model exhibits an unusual infinite order phase transition belonging to the Kosterlitz–Thouless (KT) universality class [1]. Introduction of a nematic coupling into the XY Hamiltonian leads to an additional phase transition belonging in the Ising universality class [2]. Recently, it has been shown that the higher order harmonics can lead to a qualitatively different phase diagram, with additional ordered phases originating from the competition between the ferromagnetic and pseudonematic couplings [3]. The new phase transitions were identified to belong to the 2D Potts, Ising, or KT universality classes.

In the present study we investigate effects of geometrical frustration on such a generalized XY model by considering it on a triangular lattice with antiferromagnetic couplings. The simplest generalization involves the bilinear and biquadratic terms and such a model has been shown to display, besides the antiferromagnetic and antinematic phases, also an additional chiral phase above the KT line [4]. We extend this model by including the pseudonematic term of the order higher than the biquadratic one and study how the phase diagram and overall critical behavior is affected. Recent investigations of the ground-state properties of such a model suggested a rich and interesting behavior with potential interdisciplinary applications [5]. We demonstrate that at finite temperatures already the third-order (bicubic) term leads to the change of the phase diagram topology, compared with the bilinear-biquadratic model.

[1] J. M. Kosterlitz, D. J. Thouless, J. Phys. C 6, 1181 (1973).
[2] D. H. Lee, G. Grinstein, Phys. Rev. Lett. 55, 541 (1985).
[3] F. C. Poderoso, J. J. Arenzon, Y. Levin, Phys. Rev. Lett. 106, 067202 (2011).
[4] J.-H. Park, S. Onoda, N. Nagaosa, J. H. Han, Phys. Rev. Lett. 101, 167202 (2008).
[5] M. Žukovič, Phys. Rev. B 94, 014438 (2016).

*Speaker
†Corresponding author: matus.lach@student.upjs.sk
‡Corresponding author: milan.zukovic@upjs.sk

Vertical drying of a two-dimensional colloidal film containing rod-like particles: Monte Carlo simulations

Nikolai Lebovka*† [1,2], Yuri Tarasevich * [3], Nikolai Vygornitskii [2], Volodymyr Gigiberiya [2]

[1] Taras Shevchenko National University – Kiev, 01033, Ukraine
[2] Institute of Biocolloidal Chemistry named after F. D. Ovcharenko, NAS of Ukraine – 42 Vernadskogo, Kyiv 03142, Ukraine
[3] Astrakhan State University – Astrakhan, 414056, Russia

The vertical drying of a colloidal film containing rod-like particles was studied by means of kinetic Monte Carlo (MC) simulation. Both continuous model [1] and lattice approach [2] have been utilized. During the evaporation, an upper interface moved down in the vertical direction with a linear velocity, u. In the continuous model [1], rod-like particles have been treated as zero-thickness sticks with random positions and orientations. The initial isotropic state was produced using a model of random sequential adsorption (RSA). The sticks undergo both translational and rotational Brownian motions. The MC simulations were run at different initial number concentrations (the numbers of sticks per unit area), pi, and solvent evaporation rates, u.

In the lattice model [2], the problem was approached using a two-dimensional square lattice, and the rods were represented as particles occupying k adjacent sites (so-called linear k-mers). The initial isotropic state was produced using a model of the RSA (orientation of the particles along horizontal and vertical directions are equiprobable). In this model, overlapping of the rods was forbidden. During the evaporation, an upper interface moves down with a linear velocity of u. In contrast with continuous model, rods undergo only translation Brownian motion whilst rotational diffusion was ignored. The MC simulations were run at different initial concentrations, pi, ($pi \in [0, pj]$, where $pj(k)$ is the jamming concentration), lengths of k-mers ($k \in [1, 12]$), and solvent evaporation rates, u.

For completely dried films, the spatial distributions of the particles and the electrical conductivities of the films in both the horizontal and vertical directions were examined in the frameworks of both models.

Significant evaporation-driven self-assembly and stratification of the particles in the vertical direction was observed. The extent of stratification increased with increasing values of solvent evaporation rate. The anisotropy of the electrical conductivity of the film can be finely regulated by changes in the values of pi and u.

Acknowledgements: We acknowledge the funding from the National Academy of Sciences of Ukraine, Project No. 43/17- H (N.I.L., N.V.V.) and the Ministry of Education and Science of the Russian Federation, Project No. 3.959.2017/4.6 (Yu.Yu.T.).

[1] N. I. Lebovka, Yu. Yu. Tarasevich, N. V. Vygornitskii, Phys. Rev. E 97, 022136 (2018).
[2] N. I. Lebovka, N. V. Vygornitskii, V. A. Gigiberiya, Yu. Yu. Tarasevich, Phys. Rev. E 94, 062803 (2016).

*Speaker
†Corresponding author: lebovka@gmail.com

Driven Brownian motion of hard spheres in a one-dimensional periodic potential

Dominik Lips* [1], Artem Ryabov [2], Philipp Maass† [1]

[1] Universität Osnabrück, Fachbereich Physik – Germany
[2] Charles University, Faculty of Mathematics and Physics – Czech Republic

We study the overdamped Brownian motion of hard spheres (rods) in a one-dimensional cosine potential, where a small static bias is driving the particles in one direction. The amplitude of the cosine potential is considered to be large compared to the particles' thermal energy, leading to an effective hopping of the particles between neighbouring wells of the potential. The model thus is expected to reflect properties of the asymmetric simple exclusion process (ASEP). By performing computer simulations, we find the current in the system to exhibit surprising features as a function of the filling factor (number of particles per potential well) and the particle diameter: (i) When increasing the diameter at fixed filling factor from zero (point particles) to the size of the period length of the cosine potential ('commensurable diameter'), the current runs through a maximum and minimum, and it approaches the one of non-interacting particles both for the point-particle limit and for commensurable diameter. This means that for commensurable diameter, the current is always the same as for non-interacting particles. (ii) At fixed diameter, the current behaves as in the ASEP for only a limited range of filling factors. For diameters close to the commensurable one, the current nearly equals that of non-interacting particles in a regime of small filling factors, and this regime extends if the diameter approaches the period length of the potential. We show that the enhancement of the current compared to the non-interacting case at small particle diameters results from multi-occupation of potential wells and that the effects close to commensurable diameter are originating from a particle-exchange symmetry.

*Speaker
†Corresponding author: maass@uos.de

Asymmetry of transition times of a tagged particle in driven Brownian motion of hard spheres

Dominik Lips*† [1], Artem Ryabov * ‡ [2], Philipp Maass§ [1]

[1] Universität Osnabrück, Fachbereich Physik – Barbarastraße 7, D-49076 Osnabrück, Germany
[2] Charles University, Faculty of Mathematics and Physics, Department of Macromolecular Physics – V Holešovičkách 2, CZ-18000 Praha 8, Czech Republic

Driven diffusion of hard spheres (rods) in a one-dimensional cosine potential under a static bias should reflect properties of the asymmetric simple exclusion process on a lattice, if the amplitude of the cosine potential is considered to be large compared to the particles' thermal energy. Based on Brownian dynamics simulations of this model, we study transition times of a tagged particle between potential wells against and along the bias direction in the non-equilibrium steady state. These are defined as the time intervals between first passages of neighboring potential minima. Here, the first passage refers to the first crossing of the minimum after the tagged particle has entered a well (i.e., passed a saddle point). The transition times in and against bias direction exhibit a counterintuitive asymmetry: While one may expect that the mean transition time in bias direction is shorter, the opposite is true. We relate this surprising asymmetry to the collective motion of the particles. Differences in the distributions of the times in and against bias direction depend sensitively on the filling factor (number of particles per potential well) and the rod length. Our analysis sheds light on the transport behavior of the model, which from the perspective of the two features of site exclusion and hopping motion should be similar to the ASEP, but, due to the additional length scale given by the rod length, shows significantly richer properties.

*Speaker
†Corresponding author: dlips@uos.de
‡Corresponding author: rjabov.a@gmail.com
§Corresponding author: maass@uos.de

Glass transition induced by the spatially correlated stochastic dynamics

Maciej Majka * [1]

[1] Jagiellonian University – Kraków, Poland

While the stochastic dynamics driven by the time correlated noise has focused the attention of researchers for a few decades, much less is understood about the systems with Spatially Correlated Noise (SCN). In principle, this type of correlations affects the multi-particle dynamics, and it can be found e.g. in glasses, colloidal suspensions and active matter. Recently, it has been shown that the thermodynamically consistent fluctuation-dissipation relation for SCN can describe the self-assembly effects in colloids [1]. This suggests that the SCN-driven dynamics could be potentially used instead of the full-scale microscopic simulations to model the behavior of the complex soft-matter systems [1,2]. In this presentation, I will discuss another class of problems that fall under this approach i.e. the vitrification. Glasses are well known for their inherent presence of strong spatial correlations, called the dynamic heterogeneity. By analysing the model of the multi-particle colloidal system driven by SCN, I will show that the growing length-scale of noise correlations can lead to the rise in the viscosity by the four orders of magnitude [3]. This behaviour shares several analogies with the transition observed in the Mode Coupling Theory. The mechanism behind this phenomenon is discussed analytically, i.e. I will show that the fluctuation-dissipation relation for this system leads to the friction matrix and the spectrum of this matrix can develop a singularity responsible for jamming. The results suggest that there is a causal relation between the increased correlation length and the rise in viscosity in the actual glass transition.

[1] M. Majka, P. F. Góra, Phys. Rev. E 94, 042110 (2016).
[2] M. Majka, P. F. Góra, J. Phys. A: Math. Theor. 50, 054004 (2017).
[3] M. Majka, P. F. Góra, arXiv:1707.07076 (2017).

*Speaker

Percolation thresholds for complex neighbourhoods in two-, three- and four-dimensionial space

Krzysztof Malarz* [1]

[1] AGH University of Science and Technology, Faculty of Physics and Applied Computer Science – Mickiewicza 30, PL-30059 Kraków, Poland

In this paper the percolation thresholds for neighbourhoods containing up to next-next-next-next nearest neighbours for square, cubic and four-dimensionial simple cubic lattices are presented. The results of computer simulations based on Hoshen–Kopelman algorithm with its possible modifications for message passing interface on massively parallel architectures will be presented.

Acknowledgements: This work was financed partially by PL-Grid infrastructure and partially supported by AGH-UST statutory tasks No. 11.11.220.01/2 within subsidy of the Ministry of Science and Higher Education.

[1] M. Kotwica, P. Gronek, K. Malarz, arXiv:1803.09504 (2018).
[2] K. Malarz, Phys. Rev. E 91, 043301 (2015).
[3] Ł. Kurzawski, K. Malarz, Rep. Math. Phys. 70, 163 (2012).
[4] M. Majewski, K. Malarz, Acta Phys. Pol. B 38, 2191 (2007).
[5] K. Malarz, S. Galam, Phys. Rev. E 71, 016125 (2005).

*Speaker

Generalized (non-Markovian) FPK equations corresponding to nonlinear random differential equations excited by colored noise. Hänggi's ansatz revisited

Konstantinos Mamis* [1], Gerassimos Athanassoulis† [1]

[1] School of Naval Architecture and Marine Engineering, National Technical University of Athens – 9 Iroon Politechniou st., Zografos 157 80, Athens, Greece

Determining the non-Markovian response of a random differential equation (RDE) excited by colored noise is a problem of importance, since most of the cases encountered in physics and engineering can be described by such an RDE [1]. Recent works [2,3] have dealt with this problem using the response-excitation theory. In the present work, a different approach is considered, commencing from the formulation of the stochastic Liouville equation corresponding to a nonlinear RDE [4,5,6]. In order to treat the non-local term that makes the stochastic Liouville equation a non-closed one, we first derive and apply an extension of the classical Novikov–Furutsu theorem, able to treat jointly random initial conditions and colored excitations with non-zero mean, assuming they are jointly Gaussian. The remaining non-locality, after the application of the extended Novikov–Furutsu theorem, is further approximated using a Volterra–Taylor functional expansion. This leads to an approximate generalized Fokker–Planck–Kolmogorov equation (genFPK), that governs the response probability density function in both transient and long-time regimes. The obtained genFPK includes, as special cases, the effective FPKs presented by [7,8,9]. An additional merit of employing a Volterra–Taylor expansion is that the genFPK given by Hänggi et al. [10] for the long-time response of the bistable case is rigorously derived, thus providing a clear understanding of what was previously called Hänggi's ansatz.

[1] N. G. van Kampen, Brazil. J. Phys. 28, 90 (1998).
[2] D. Venturi, T. P. Sapsis, H. Cho, G. E. Karniadakis, Proc. R. Soc. A 468, 759 (2012).
[3] G. A. Athanassoulis, I. C. Tsantili, Z. G. Kapelonis, Proc. R. Soc. A 471, 20150501 (2015).
[4] P. Hänggi, Zeitschrift fur Physik B 31, 407 (1978).
[5] J. M. Sancho, M. San Miguel, Zeitschrift fur Physik B 36, 357 (1980).
[6] A. M. Cetto, L. de la Peña, Revista Mexicana de Física 31, 83 (1984).
[7] J. M. Sancho, M. San Miguel, S. L. Katz, J. D. Gunton, Phys. Rev. A 26, 1589 (1982).
[8] R. F. Fox, Phys. Rev. A 33, 467 (1986).
[9] E. Peacock-Lopez, B. J. West, K. Lindenberg, Phys. Rev. A, 37, 3530 (1988).
[10] P. Hänggi, T. J. Mroczkowski, F. Moss, P. V. E. McClintock, Phys. Rev. A 32, 695 (1985).

*Speaker
†Corresponding author: mathan@central.ntua.gr

On the specific heat of $BaVS_3$ at 68 K

Ferenc Márkus*† [1], Bence G. Márkus [2]

[1] Department of Physics, Budapest University of Technology and Economics – Budafoki út 8., H-1111 Budapest, Hungary
[2] Department of Physics, Budapest University of Technology and Economics and MTA-BME Lendület Spintronics Research Group – P.O. Box 91, H-1521 Budapest, Hungary

It is experimentally verified that the barium vanadium sulfide ($BaVS_3$) has an orthorhombic to monoclinic structural transition during the metal-insulator phase transition at the temperature approximately TMI = 68 K [1-3]. Detailed measurements [4, 5] are elaborated to determine the changes in the physical features, like thermal conductivity and specific heat. Since the specific heat is a sensitive indicator of phase transitions it is worth to focus on its behavior. A high, but not narrow—we may say wide—peak appears at TMI in the specific heat [5]. No adequate explanation exists for this behavior right now. The breadth of the peak has quality and sample dependence.

The wide peak may suggest oscillations of electrons around the ions during the structural transition. This damping oscillation mechanism can fairly contribute to the internal energy. The mechanism is presented for free electron gas with the added oscillations calculating the internal energy and the specific heat. The quantitative model reflects well that this oscillations may produce such temperature dependence of specific heat as it is measured.

Acknowledgements: This work was supported by the Hungarian National Research, Development and Innovation Office (NKFIH) Grant No. K119442.

[1] S. Fagot, P. Foury-Leylekian, S. Ravy, J. P. Pouget, M. Anne, G. Popov, M. V. Lobanov, M. Greenblatt, Solid State Sci. 7, 718 (2005).
[2] S. Fagot, P. Foury, S. Ravy, J. P Pouget, G. Popov, M. V. Lobanov, M. Greenblatt, Physica B 359, 1306 (2005).
[3] T. Ivek, T. Vuletić, S. Tomić, A. Akrap, H. Berger, L. Forró, Phys. Rev. B 78, 035110 (2008).
[4] H. Imai, H. Wada, M. Shiga, J. Phys. Soc. Japan 65, 3460 (1996).
[5] L. Demkó, I. Kézsmárki, M. Csontos, S. Bordács, G. Mihály, Eur. Phys. J. B 74, 27 (2010).

*Speaker
†Corresponding author: markus@phy.bme.hu

Emerging long-period orbits and self-similarity in repulsively coupled classical oscillators

Hildegard Meyer-Ortmanns* [1], Darka Labavic [2]

[1] Jacobs University – Campus Ring 1, D-28759 Bremen, Germany
[2] Université de Lille, UMR 8523, Laboratoire de Physique des Lasers Atomes et Molécules – F-59000 Lille, France

We consider a deterministic system of repulsively coupled Kuramoto oscillators, which are exposed to a fixed distribution of natural frequencies. As expected for antagonistic couplings, the attractor space is quite rich. We identify rather long transients that it takes the deterministic trajectories to find their stationary orbits in the attractor space. The stationary orbits show a variety of different periods, which can be orders of magnitude longer than the periods of individual oscillators. The smaller the width of the distribution about the common natural frequency is, the longer are the emerging time scales on average [1]. Among the long-period orbits we find self-similar temporal sequences of temporary patterns of phase-locked motion on different time scales. The ratio of time scales is determined by the ratio of widths of the distributions [2]. The effects are particularly pronounced if we perturb about a situation, in which a self-organized Watanabe–Strogatz phenomenon is known to happen, going along with a continuum of attractors and a conserved quantity. We compare the phase space for different values of the bifurcation parameter, deeply in the multistable phase and closer to the critical point, where the monostable regime turns into the multistable one. As we know from earlier results [3], noise can kick the system from one metastable state to the next. In case of disorder via the natural frequencies the motion is fully deterministic, but also leads to phenomena like the breaking of time translation invariance [4], as it was formerly observed in [3] under the action of noise.

[1] D. Labavic, H. Meyer-Ortmanns, Chaos 27, 083103 (2017).
[2] D. Labavic, H. Meyer-Ortmanns, Indian Academy of Sciences Conference Series 1, 101 (2017).
[3] F. Ionita, H. Meyer-Ortmanns, Phys. Rev. Lett. 112, 094101 (2014).
[4] S. Esmaeili, D. Labavic, M. Pleimling, H. Meyer-Ortmanns, Europhys. Lett. 118, 40006 (2017).

*Speaker

Studying properties of microgels: from fuzzy to core-shell model

Elena Minina*† [1,2], Sofia Kantorovich [1,2], Christos Likos [1]

[1] University of Vienna, Faculty of Physics – Austria
[2] Ural Federal University – Russia

Microgels are spherical colloidal particles consisting of the polymer network. Due to their nature, microgels are able to swell and shrink as a response to their external environment. This ability makes them promising materials for many applications including drug delivery and design of artificial muscles. The desire to control microgels, therefore, has motivated studying their properties. In this work, we study microgels properties by means of molecular dynamics computer simulations. To this aim, we developed coarsegrained models of fuzzy and core-shell microgels based on the beadspring model and random cross-linking procedure. Our models capture the swelling behaviour of microgels that we verified by embedding microgels in solvents of different quality. To examine structural properties of microgels, we focus on the polymer network analysis and density profiles of microgels of different size and with various fraction of homogeneously distributed cross-linkers inside the core and on the shell for core-shell microgels.

*Speaker
†Corresponding author: elena.minina@univie.ac.at

Skyrmion phase in the frustrated Heisenberg antiferromagnet with Dzyaloshinskii–Moriya interaction

Mariia Mohylna* [1], Milan Zukovic [1]

[1] Institute of Physics, Faculty of Science, P. J. Šafárik University – Park Angelinum 9, 041 54 Košice, Slovakia, Slovakia

An antisymmetric Dzyaloshinskii–Moriya (DM) spin exchange interaction can lead to the formation of twisted magnetic structures [1,2]. These have attracted much interest mainly after the experimental observation of nontrivial magnetic configurations, called magnetic skyrmion lattices, which have important potential technological applications [3]. In ferromagnetic systems, the skyrmion phase arises from the competition of the ferromagnetic and DM interactions and it is stabilized by a magnetic field and thermal fluctuations. Recently, a closely related antiferromagnetic skyrmion phase was discovered in the frustrated classical antiferromagnetic Heisenberg model [4].

In the present work we study the classical Heisenberg antiferromagnetic model on a triangular lattice with DM exchange interaction in the presence of external magnetic field by means of hybrid Monte Carlo simulations. By considering a topological order parameter, associated with the number of skyrmions, we are able to detect the appearance of the antiferromagnetic skyrmion phase. This phase, which consists of three interpenetrating skyrmion crystals, is found to be wedged between a spiral phase at lower and a paramagnetic phase at higher temperatures. The skyrmion phase stability is studied in the model parameter space.

[1] I. Dzyaloshinskii, J. Phys. Chem. Solids 4, 241 (1958).
[2] T. Moriya, Phys. Rev. 120, 91 (1960).
[3] N. Romming, C. Hanneken, M. Menzel, J. E. Bickel, B.Wolter, K. von Bergmann, A. Kubetzka, R. Wiesendanger, Science 341, 636 (2013).
[4] H. D. Rosales, D. C. Cabra, P. Pujol, Phys. Rev. B 92, 214439 (2015).

*Speaker

Equal-time and lagged correlations in human electroencephalograms

Jeremi Ochab*† [1], Maciej A. Nowak [1,2], Wojciech Tarnowski [1], Dante Chialvo [3]

[1] Institute of Physics, Jagiellonian University – Łojasiewicza 11, PL-30348 Kraków, Poland
[2] Mark Kac Center for Complex Systems Research, Jagiellonian University – Kraków, Poland
[3] Center for Complex Systems & Brain Sciences, Univ. Nacional de San Martin – Argentina

Pearson correlation matrices have been long used in biology or perhaps most notably in finance. Together with the backing of random matrix theory (RMT) they are fit to denoise and offer insight into collective behaviour of multichannel signals such as, for instance, recordings of electrical brain activity. In this respect electroencephalography (EEG) has the advantage of large temporal resolution, resulting in a small N/T ratio (number of channels/length of time series) and hence also enhanced eigen-inference.

We explore the information apparent in eigenspectra of these correlation matrices (among others using recent advances in RMT on lagged correlations [1]) and find indications of some common measurement artefacts and brain rhythms (usually in the largest eigenvalues and corresponding eigenvectors), as well as overall highly skewed distributions depending on the task the subjects performed.

Additionally, we numerically compare these characteristics with autoregressive family time series models on the one hand and with Kuramoto and 2-D Ising models on the other. The last one has only recently been studied [2] in terms of equal-time correlation matrix eigenspectra, but not from the perspective of lagged correlation matrices.

[1] M. A. Nowak, W. Tarnowski, J. Stat. Mech. 2017, 063405 (2017).
[2] T. Vinayak et al., EPL 108, 20006 (2014).

*Speaker
†Corresponding author: jeremi.ochab@uj.edu.pl

Directional turning in models of flocking behaviours

Eoin Ó Laighléis* [1], Richard Blythe [1], Martin Evans [1]

[1] School of Physics, University of Edinburgh – James Clerk Maxwell Building, University of Edinburgh, Edinburgh EH9 3JZ, United Kingdom

Ordered collective motion of individuals, or 'flocking' for short, is often observed in both natural and artificial systems. With relatively simple pairwise interactions, many of the complex properties of observed flocks can be replicated. In many 1-d systems with constant particle speeds, there exists a bistable state with non-zero average velocity. This corresponds to an aggregate of particles travelling in the same direction with infrequent stochastic transitions between 'left-facing' and 'right-facing' aggregates. We examined this flocking behaviour in an attempt to find minimal requirements for the existence of this bistable state and worked towards an analytic analogue of the model to further examine its mathematical structure.

*Speaker

Fast and accurate detection of spread source in large complex networks

Robert Paluch*† [1], Janusz Hołyst [1,2], Krzysztof Suchecki [1], Bolesław Szymański [3], Xiaoyan Lu [3]

[1] Faculty of Physics, Warsaw University of Technology – Koszykowa 75, PL-00662 Warszawa, Poland
[2] National Research University of Information Technologies, Mechanics and Optics – St. Petersburg 197101, Russia
[3] Rensselaer Polytechnic Institute – 110 Eighth Street, Troy, NY 12180-3590, United States

Spread over complex networks is a ubiquitous process with increasingly wide applications. Locating spread sources is often important, e.g. finding the patient one in epidemics, or source of rumor spreading in social network. Pinto, Thiran and Vetterli introduced an algorithm (PTVA) to solve the important case of this problem in which a limited set of nodes act as observers and report times at which the spread reached them. PTVA uses all observers to find a solution. Here we propose a new approach in which observers with low quality information (i.e. with large spread encounter times) are ignored and potential sources are selected based on the likelihood gradient from high quality observers. The original complexity of PTVA is $\mathcal{O}(N^{\alpha})$, where $\alpha \in (3,4)$ depends on the network topology and number of observers (N denotes the number of nodes in the network). Our Gradient Maximum Likelihood Algorithm (GMLA) reduces this complexity to $\mathcal{O}(\log(N)N^2)$. Extensive numerical tests performed on synthetic networks and real Gnutella network with limitation that id's of spreaders are unknown to observers demonstrate that for scale-free networks with such limitation GMLA yields higher quality localization results than PTVA does.

*Speaker
†Corresponding author: paluch@if.pw.edu.pl

Scaling in the space-time of the Internet

Istvan Papp* [1], Mounir Afifi [1], Levente Varga [1], Istvan Gere [1], Zoltán Néda† [1]

[1] Babeș-Bolyai University – Kogalniceanu 1, RO-400084, Cluj-Napoca, Romania

The Internet on router level, is a complex network embedded in a geographical space. Beside it's topological scaling properties (scale-free degree distribution) [1,2], it exhibits also a dynamical scaling: the communication speed on the Internet depends in a nontrivial manner as a function of the geographical distance[3]. Several 'ping' and 'traceroute' experiments prove that the average speed is increasing with the distance, following a roughly square root trend. To explain this novel scaling law and other measurable topological properties of the Internet a realistic model has to be built. Such a model must be based on realistic assumptions on the wiring process and has to reproduce the measured topological properties of the Internet, including the observed scaling of the communication speed versus distance. In our work, we present experimental results concerning the Internet topology, dynamical scaling and a simple model that can reproduce the measured features. We use both an original experimental protocol based on ping and the freely available results of the CAIDA UCSD IPv4 Routed /24 Topology Dataset [4].

[1] A.-L. Barabási, R. Albert, Science 286, 509 (1999).
[2] S.-H. Yook, H. Jeong, and A-L. Barabási, Proc. Natl. Acad. Sci. 99, 13382 (2002).
[3] L. Varga, A. Kovács, G. Tóth, I. Papp, Z. Néda, PLoS One 11, e0148913 (2016).
[4] The CAIDA UCSD IPv4 Routed /24 Topology Dataset - 2017, http://www.caida.org/data/active/ipv4_routed_24_topology_dataset.xml

*Speaker
†Corresponding author: zneda@phys.ubbcluj.ro

Scaling laws of sub-critical fragmentation

Gergő Pál*† [1,2], Ferenc Kun [2]

[1] Institute for Nuclear Research, Hungarian Academy of Sciences – H-4001 Debrecen, P.O. Box 51, Hungary
[2] Department of Theoretical Physics, University of Debrecen – H-4002 Debrecen, P.O. Box 400, Hungary

Dynamic fragmentation usually occurs when a large amount of energy is imparted to a solid body within a short time giving rise to a rapid breakup into a large number of pieces. On much longer time scales slow fragmentation emerges as the consequence of repeated low energy (sub-critical) collisions of objects which is responsible for the gradual size reduction of solids observed for diverse systems such as aerosol particles in the atmosphere, pebbles in river beds, or asteroids in the Solar system. In order to understand the statistical features of sub-critical fragmentation phenomena we performed Discrete Element (DEM) simulations of the repeated impact of cubic objects against a hard wall varying the velocity and the number of impacts in a broad range. We show that depending on the impact velocity the system has two phases: at low velocities small pieces are chopped from the sample surface resulting in slow abrasion which is bounded by a finite residual mass in the limit of high impact numbers. For sufficiently high velocities repeated impact gives rise to a faster mass reduction ending with the complete destruction of the sample in a finite time. The transition between these abrasion and spallation processes occurs at a critical impact velocity analogous to phase transitions. In the abrasion phase the shape of the largest residual piece tend to a nearly spherical shape by removing first the sharp corners then edges and finally by shrinking. We determine scaling laws of the fragmenting system characterizing the effect of the velocity and number of impact on the evolution of mass and shape of pieces.

*Speaker
†Corresponding author: gergo.pal@phys.unideb.hu

Approximate reconstruction of heterogeneous microstructures using super-spheres

Ryszard Piasecki* [1], Wiesław Olchawa [1], Daniel Frączek [2], Ryszard Wiśniowski [1]

[1] Institute of Physics, University of Opole – Oleska 48, PL-45052 Opole, Poland
[2] Department of Materials Physics, Opole University of Technology – Katowicka 48, PL-45061 Opole, Poland

We report a low-cost approximate reconstructing of heterogeneous materials without the use of stochastic optimization method. The approach of broad applicability uses the so-called overall entropic descriptor (OED) that quantifies an average spatial inhomogeneity at discrete length-scales. The ED extracts dissimilar structural information to that given by two-point correlation function. The information contributed by the target OED-curve was utilized for this purpose. The origin of that curve can be diverse. Typically, the needed target-curve is computed for a digitized tomography image taken for a representative real sample. In our case, the surrogate sandstone microstructure is analysed. For a given volume fraction, a number of low-cost trial configurations is generated efficiently by the interpenetrating spheres of a radius R_1. The radius is determined via the two-exponent power-law linked to OED. Having selected the best of them to further improving, the so-called phase entropic descriptors (PEDs) and the corresponding target curves can be used. Now, *super-spheres* with the shape deformation parameter $0 < p < \infty$ that allows controlling the spatial inhomogeneity come into play. Thus, by inspection of the p-values around of unity ($p = 1$ describes sphere) and for the radius-values nearby of R_1, an optimal prototypical microstructure can be found. This needs only a quantitative evaluation of the statistical 'distance' between the target PEDs-curves and the corresponding improved ones. In general, an entropic descriptor-based method offers a compromise between computational efficiency and the reconstruction accuracy.

*Speaker

Action of fractal brownian motion and Hamiltonian of chromatin

Kirill Polovnikov [1], Sergey Nechaev [2], Mikhail Tamm* [3,4]

[1] Skoltech Institute of Science and Technology, Lomonosov Moscow State University – Moscow, Russia
[2] Interdisciplinary Center J.-V. Poncelet – Moscow, Russia
[3] Moscow State University – GSP-1, Leninskie Gory, Moscow, 119991, Russia
[4] National Research University Higher School of Economics – Russia

In recent years there have seen plethora of new theoretical and experimental studies of chromosome structure and dynamics, both in eukaryotic and prokaryotic cells. Combination of theoretical considerations (e.g., necessity that chromosome parts disentangle easily during the transcription) and experimental observations (presence of distinct chromosome territories, locus-locus contact maps obtained by the Hi-C method, experiments on dynamics of single loci) make us believe that during the interphase chromatin of higher organisms is rather dense while being packed in a peculiar hierarchical way, approving a concept of so-called fractal globule [1].

In particular, it can be seen from experimental and simulation data that at large enough length scales conformation of chromosome is self-similar, space-filling and reveals Gaussian statistics, thus can be described by fractal Brownian motion (fBm) with Hurst exponent $H = 1/3$ [2]. However, a classical dense polymer state, a concentrated polymer solution (melt of blobs), at equilibrium corresponds to fBm with $H = 1/2$. Fortunately, observations decisively discard equilibrium melt: indeed, duration of the interphase is much lower than the relaxation time towards equilibrium for the chromatin length [3].

However, physics of the long-ranged interactions (short-ranged would be likely screened in that dense system) establishing such a space-filling conformation remain obscure. Here we propose an effective quadratic Hamiltonian with tunable exponent that results in a fBm-type compact polymer conformation with arbitrary Hurst exponent, $H < 1/2$. We show that these soft long-ranged interactions are consistent with statistics and dynamics of chromatin in bacteria, while relatively damped dynamics in eukaryotes is well quantitatively described by addition of intrinsic viscoelasticity of the cytoplasm through the fractional Langevin equation model [4]. Using our microscopic approach, we analyze the correlated dynamics of two loci and characteristic relaxation time of chromatin. Interestingly, the latter coincides with duration of the interphase, pointing on possible regulation of the cell cycle by chromatin dynamics.

As a result, we suggest a microscopic framework allowing to discriminate between the impacts of inter-monomer interactions and influence of 'pink' cytoplasm viscoelasticity. We argue that a combination of one-point and two-point locus tracking data would allow to recover both static and dynamic characteristics of chromosomes *in vivo*. Moreover, we derive the action of a fractal Brownian particle, which manifests coupling between particle's velocities through the scale-free kernel. This action naturally generalizes the kinetic energy term in the Lagrangian for cases of stationary-incremented Gaussian processes with scale-free memory.

[1] A. Grosberg, Y. Rabin, S. Havlin, A. Neer, Europhys. Lett. 23, 373 (1993).
[2] K. Polovnikov, S. Nechaev, M. V. Tamm, arXiv:1707.07153 (2017).
[3] A. Rosa, R. Everaers, PLoS Computat. Biol. 4, e1000153 (2008).
[4] K. Polovnikov, M. Gherardi, M. Cosentino-Lagomarsino, M. V. Tamm, arXiv:1703.10841 (2017).

*Speaker

The dynamics of polymers in active environments

Stefanie Put* [1], Carlo Vanderzande [1]

[1] University of Hasselt – Belgium

We examine the dynamics of a polymer in which the monomers are subjected to an active force. The polymer resides in a viscoelastic medium. The time evolution of the active force follows a dichotomous Markov process. This is a simple model for the action of ATP-dependent proteins on DNA. We present an exact solution of our model for Rouse dynamics. Examples of calculated quantities are the mean squared displacement of a tagged monomer and the time-dependent correlation of the position of two monomers. When the force is applied to all monomers the Rouse modes are uncoupled, while otherwise coupling between the modes arises. We also examined all these characteristics when the force acts like force dipoles distributed over pairs of monomers. With simulations we determined the distribution of the displacement of a monomer and found evidence for non-Gaussian behaviour.

*Speaker

Actin filaments growing against a fluctuating barrier with elastic properties

Raj Kumar Sadhu*† [1], Sakuntala Chatterjee [1]

[1] S. N. Bose National Centre for Basic Sciences – Block JD, Sector 3, Salt Lake City, Kolkata 700106, West Bengal, India

Actins are cytoskeletal proteins whose polymerization can generate significant force and propel the cell forward. In many *in vitro* experiments, this force is measured by applying a load against the polymerization direction. The shape of the resulting force-velocity curve is found to be convex or concave, depending on the details of the experimental set up or theoretical modeling. We study the force generation by a set of parallel actin filaments pushing against a membrane, where we explicitly take into account shape fluctuations of the membrane, which has been neglected in many recent theoretical studies. We find that the relative time-scale between the membrane and filament dynamics plays a crucial role in determining the shape of the force-velocity curve and by tuning this time-scale it is possible to have a convex or concave shape. In the case when the elastic energy associated with shape fluctuations of the membrane is incorporated in the model, a competition between the polymerization force and elastic force ensues. For small membrane tension, the polymerization force wins and the system has no steady state. The membrane velocity increases with tension in this regime. Beyond a certain threshold value of the membrane tension, the system reaches a steady state and velocity decreases with tension after reaching a peak. Our analytical calculations show good agreement with our simulation results.

[1] R. K. Sadhu, S. Chatterjee, Phys. Rev. E 93, 062414 (2016).
[2] R. K. Sadhu, S. Chatterjee, Phys. Rev. E 97, 032408 (2018).

*Speaker
†Corresponding author: rajkumar.sadhu@bose.res.in

Network analysis of Bylyny—Traditional East Slavic epic narratives

Petro Sarkanych* [1,2,3], Yurij Holovatch [1,3], Ralph Kenna [2,3], Pádraig Mac Carron [4]

[1] Insitute for Condensed Matter Physics, National Academy of Sciences of Ukraine – Lviv, Ukraine
[2] Applied Mathematics Research Centre, Coventry University – United Kingdom
[3] L4 Collaboration & Doctoral College for the Statistical Physics of Complex Systems – Leipzig-Lorraine-Lviv-Coventry, Europe
[4] Maynooth University – Ireland

Universality is one of the essential concepts in statistical physics. It means that the typical behaviour of a macroscopic system consisting of many interacting agents is independent of the system's structural details. This concept gains more and more popularity, not only in purely physical problems, but also in general scientific and cultural contexts. In this work the concepts and methods of statistical physics and complex networks science are used for the detection and quantitative description of universal properties of social networks of Bylyny characters. Bylyny are heroic epics of eastern Slavs. We consider the epics covering the heyday of the Kyivan Rus (end of the tenth century to the middle of the twelfth century). By this analysis, we continue a series of works initiated in Refs. [1, 2], where such quantitative methods were used to analyse several prominent European epics. The method we are using allows obtaining additional reasoning on some hypotheses about the origin of Bylyny characters and their connection to the historical figures. By comparing our results [3] with those previously obtained, one can detect common (universal) characteristics of various epic narratives. These properties remain unchanged in time and are shared by different cultures. Thus, epics have universal properties, allowing for an additional classification based on their quantitative analysis.

[1] P. Mac Carron, R. Kenna, EPL 99, 28002 (2012).
[2] P. Mac Carron, R. Kenna, Eur. Phys. J. B 86, 407 (2013).
[3] P. Sarkanych, Yu. Holovatch, R. Kenna, P. Mac Carron. J. Phys.Stud. 20, 4801 (2016).

*Speaker

On the cross-over between diffusion-limited and reaction-limited particle systems

Dmytro Shapoval* [1], Maxym Dudka [1], Xavier Durang [2], Malte Henkel [3,4]

[1] Institute of Condensed Matter Physics, NAS of Ukraine – Lviv, Ukraine
[2] Department of Physics, University of Seoul – South Korea
[3] Laboratoire de Physique et Chimie Theoriques, Universite de Lorraine Nancy – France
[4] Centro de Fisica Teórica e Computacional, Universidade de Lisboa – Portugal

Relaxation phenomena far from equilibrium continue to raise important questions in fundamental and applied research. Diffusion-limited chemical reactions provide test cases of particular interest, since their evolution is dominated by fluctuations on all time and length scales [1]. We consider the coagulation-diffusion process of a single species of particles A, which can diffuse on an underlying lattice and upon encounter undergo a reaction $A + A \to A$. Since there is a difference in the behavior of the kinetics of this process in the reaction-limited and the diffusion-limited cases, we are interested in the cross-over between these two regimes. The change between diffusion-limited and reaction-limited cooperative behaviour in reaction-diffusion system is studied through the cross-over of the coagulation-diffusion process between a chain and the Bethe lattice. Treating the model on the Bethe lattice gives an analytic way to study the cross-over between the chain and large dimensions, with a lot of experimental motivation [2]. Here we adopt empty interval method for the Bethe lattice in the ben Avraham–Glasser approximation [3], analyzing transform to a chain for first time within this approach. We discuss the continuum limit and analyze the system in the presence of a stochastic reset which makes the system relax into a non-equilibrium stationary state. This approach provides a good tool to analyze the stationary behaviour.

[1] D. C. Mattis, M. L. Glasser, Rev. Mod. Phys. 70, 979 (1998); D. ben Avraham and S. Havlin, Diffusion and Reactions in Fractals and Disordered Systems, Cambridge University Press (Cambridge 2000).
[2] J. Allam, M. T. Sajjad, R. Sutton, K. Litvinenko, Z. Wang, S. Siddique, Q.-H. Yang, W. H. Loh, T. Brown, Phys. Rev. Lett. 111, 197401 (2013).
[3] D. ben Avraham and M. L. Glasser, J. Phys. Condens. Matter 19, 065107 (2006).

*Speaker

Hydrodynamic ratchet: rectification of Brownan motion by inertial hydrodynamic effects

František Slanina* [1]

[1] Institute of Physics ASCR – Na Slovance 2, CZ-18221 Prague, Czech Republic

We investigate analytically a microfluidic device consisting of a tube with non-uniform but spatially periodic diameter, where a fluid driven back and forth by a pump carries colloidal particles. Although the net flow of the fluid is zero, the particles move preferentially in one direction due to ratchet mechanism, which occurs by simultaneous effect of inertial hydrodynamics and Brownian motion. We show that the average current is strongly sensitive to particle size, thus facilitating colloidal particle sorting.

*Speaker

A unification model for anomalous diffusion with finite moments

Oleksii Sliusarenko* [1], Silvia Vitali [1,2], Vittoria Sposini [1,3], Paolo Paradisi [1,4], Aleksei Chechkin [3], Gianni Pagnini [1,5]

[1] Basque Center for Applied Mathematics – Alameda de Mazarredo 14, 48009 Bilbao, Bizkaia, Basque Country, Spain
[2] Alma Mater Studiorum University of Bologna – Viale Berti Pichat 6, 40127 Bologna, Italy
[3] University of Potsdam – D-14476 Potsdam, Germany
[4] Istituto di Scienza e Tecnologie dell Ínformazione 'A. Faedo' – Area della Ricerca CNR, via G. Moruzzi 1, 56124 Pisa, Italy
[5] Ikerbasque, Basque Foundation for Science – Bilbao, Basque Country, Spain

We suggest a novel model that features both anomalous (but non-diverging) time-scaling of the mean-squared displacement, and power-law alpha-stable-like tails of the coordinate probability density function. Based on a non-ergodic Langevin equation, it accounts for random properties of the medium resulting in a population of different relaxation times and diffusion coefficients. With an introduction of maximal value of the effective diffusion coefficient, we are able to construct a Lévy-flight-like process with non-diverging higher-order moments that yet possesses typical properties of a Lévy flight (e.g., power-law asymptotes of the position probability density function, its time scaling). We present a rigorous comparison with the Lévy walks models. We suggest that this analysis, applied to experimental data, could help in selecting the best modeling approach.

*Speaker

Percolation properties of random sequential adsorption samples of large linear k-mers on a square lattice.

Mikhail Slutskiy* [1], Lev Barash† [2]

[1] National Research University Higher School of Economics – Moscow, Russia
[2] Landau Institute for Theoretical Physics – Chernogolovka, Russia

Percolation properties of random sequential adsorption samples of large linear k-mers on a square lattice. We study behavior of percolation and jamming thresholds for isotropic random sequential adsorption samples by means of numerical simulations. We consider large linear k-mers on a square lattice with both periodic and rigid boundary conditions. We present a parallel algorithm which is very efficient in terms of speed and memory usage, and describe the scaling properties of the algorithm. We verify the recent results of [1] and obtain the ratio of percolation and jamming concentrations for lengths of k-mer up to 10000.

[1] G. Kondrat et al., Phys. Rev. E 96, 022154 (2017).

*Speaker
†Corresponding author: barash@itp.ac.ru

Kardar–Parisi–Zhang universality in the phase distributions of one-dimensional exciton-polaritons

Davide Squizzato* [1], Leonie Canet [1], Anna Minguzzi [1]

[1] University Grenoble Alpes and CNRS, LPMMC – F-38000 Grenoble, France

Exciton-polaritons under driven-dissipative conditions exhibit a condensation transition [1] which belongs to a different universality class than equilibrium Bose–Einstein condensates. Recently it was shown that the long-distance physics of the phase-dynamics is ruled by the Kardar–Parisi–Zhang equation and a numerical verification was given in (1+1)-dimensions [2, 3]; however, the experimental accessibility of the KPZ mapping is still under debate. In this talk we present some recent results we get by numerically solving the generalized Gross–Pitaevskii equation with realistic experimental parameters. We show that one-dimensional exciton-polaritons display fine features of KPZ dynamics beyond the scaling exponents, i.e. their phase distribution follows the Tracy–Widom form predicted for KPZ growing interfaces. We moreover evidence a crossover to the stationary Baik–Rains statistics, recently observed also in turbulent liquid-crystals experiments [4]. We finally show that these features are unaffected on a certain timescale by the presence of a smooth disorder often present in experimental setups, in agreement with theoretical predictions [5]. This analysis suggests new experimental protocols for the observation of KPZ properties in exciton-polaritons.

*Speaker

Series expansion method for the inhomogeneous exclusion process with application to mRNA translation

Juraj Szavits-Nossan* [1], Luca Ciandrini [2], M. Carmen Romano [3]

[1] School of Physics and Astronomy, University of Edinburgh – Peter Guthrie Tait Road, Edinburgh, EH9 3FD, United Kingdom
[2] DIMNP UMR 5235, Université Montpellier – Pl. E. Bataillon, Bat. 24, 34095 Montpellier Cedex 5, France
[3] Department of Physics, University of Aberdeen – King's College, Old Aberdeen AB24 3UE, United Kingdom

We develop a series expansion method for the nonequilibrium steady state of the inhomogeneous totally asymmetric simple exclusion process (TASEP), which addresses a long outstanding problem in nonequilibrium statistical physics. The series expansion is performed in entrance and exit rates governing particle exchange with the reservoirs and the corresponding particle current is computed analytically up to the cubic order. We apply this method to the TASEP-based model of mRNA translation, which allow us to unveil, for the first time, simple design principles of nucleotide sequences determining protein production rates.

*Speaker

Think then act or act then think?

Katarzyna Sznajd-Weron* [1], Arkadiusz Jędrzejewski [1]

[1] Wrocław University of Science and Technology – Poland

As noted by social psychologist David Myers '*If social psychology has taught us anything during the last 25 years, it is that we are likely not only to think ourselves into a way of acting but also to act ourselves into a way of thinking.*' It seems natural that our attitudes and opinions impact the way we behave. However, it has been shown in many social experiments that attitudes are often poor predictors of behaviors. On the other hand, it has been shown empirically that often behavior determines attitudes [1]. This startling conclusion inspired us to build a microscopic model with private and public opinions, which combines idea introduced within the q-voter model with noise [2] with the so called four-dimensional model of social response [3]. According to the latter model each individual is characterized by two binary dynamic variables: private and public opinions. Both individual's opinions can change in time due to the social influence. The question is what should be changed first—public or private opinion? We investigate two versions of the same model, which differ only by the order of opinions updating: public opinion is updated before private or vice versa [4]. We show how results on the macroscopic level depends on the order of opinions updating and discuss the importance of our finding from three points of view: theory of phase transitions, agent-based modeling of social systems and social psychology.

[1] D. G. Myers, Social Psychology, 10th edition, The McGraw-Hill Companies (2010).
[2] P. Nyczka, K. Sznajd-Weron, J. Cislo, Phys. Rev. E 86, 011105 (2012).
[3] P. R. Nail, G. MacDonald, D. A. Levy, Psychological Bulletin 126, 454 (2000).
[4] A. Jędrzejewski, G. Marcjasz, P. R. Nail, K. Sznajd-Weron, Think then act or act then think?, working paper (2018).

*Speaker

Structure formation in exponential networks with hard constraints

Mikhail Tamm* [1,2]

[1] Moscow State University – GSP-1, Leninskie Gory, Moscow, 119991, Russia
[2] National Research University Higher School of Economics – Russia

Exponential networks are the analogue of canonical ensemble in the network science: given some Hamiltonian of microscopic interaction between nodes or links of a network, the exponential network ensemble is just a corresponding Gibbs measure over all possible networks. It is known that introduction of interactions to such networks (e.g., an additional multiplicative Gibbs weight for each closed triangle in the network) can lead to a first-order condensation transition (known also as Strauss transition [1,2]), which is a network analogue of the vapor-liquid transition in standard statistical physics. The resulting condensate, which occupies a finite fraction of the network volume, is an almost complete graph, node degrees for the nodes in the condensate are comparable with the total size of the system.

The behavior of such exponential networks becomes much richer if on top of the 'soft' interactions described above one introduces additional hard constraints, e.g. conservation of node degrees. This additional conservation law makes the global equilibrium state, the one with the condensate of hugely connected nodes, unaccessible. Unable to reach that state, the system finds a different optimum—a structured condensate, consisting of many small loosely connected droplets [3,4]. Following the aforementioned analogy between liquid-gas transition and Strauss transition, one may think of this structured phase as a network analogue of surfactant micelles or block-copolymer microstructures, which also arise from the interplay between soft energetic interactions and hard chemical constraints. We speculate that similar mechanism may be behind structure formation in some real networks, e.g. connectome.

[1] D. Strauss, SIAM Rev. 28, 513 (1986).
[2] J. Park, M. E. J. Newman, Phys. Rev. E 72, 026136 (2005).
[3] M. V. Tamm, A. B. Shkarin, V. A. Avetisov, O. V. Valba, S. K. Nechaev, Phys. Rev. Lett. 113, 095701 (2014).
[4] V. Avetisov, M. Hovhannisyan, A. Gorsky, S. Nechaev, M. Tamm, O. Valba, Phys. Rev. E 94, 062313 (2016).

*Speaker

Modified asymmetric exclusion process with internal particle states

Mikhail Tamm* [1,2], Pavel Lakidon [1], Maria Zvereva [1]

[1] Moscow State University – Russia
[2] National Research University Higher School of Economics – Russia

Totally asymmetric simple exclusion process (TASEP) is an archetypic model of the transport phenomena in 1D: a linear lattice occupied by particles which hop in one direction at random provided that their hopping does not violate the excluded-volume constraint, i.e. the condition that there is no more than one particle per lattice site at any given time.

We consider a following generalization of this model. Let particles have two internal states: ground and active. Activation of a particle (i.e., going from ground to active state) is a Poissonian stochastic process happening with a given fixed rate regardless of the particle's surroundings. Only active particles can move and relaxation (i.e., going from active to ground state) happens only when an active particle hops forward. If a particle tries to hop but is prevented from that by the presense of a neighbor in the adjacent cell, it remains active. This definition generates a one-parametric class of models depending on the ratio of activation and hopping/relaxation rates. If activation is much faster than hopping, all particles are always active and the model reduces to classical TASEP.

But if hopping is much faster than activation, new interesting behavior arises. The positions of particles in the steady state become highly correlated: if a particle is particularly slow to activate, a long queues of active ones tends to forming behind it, then when it finally jumps, all the queue immediately jumps, too, resulting in a long uninterrupted chain of ground-state particles, etc. We numerically study the properties of the steady state of this system on a ring (flow-density diagram, cluster size distribution, correlation functions, etc.) and construct a 'cluster mean-field' theory which qualitatively reproduces the numerical results.

*Speaker

Monte Carlo simulation of diffusion-driven self-assembly of rod-like particles: lattice approach

Yuri Tarasevich* [1], Nikolai Lebovka† [2,3], Volodymyr Gigiberiya [2], Nikolai Vygornitskii [2], Valeri Laptev [1,4]

[1] Astrakhan State University – Astrakhan, 414056, Russia
[2] Institute of Biocolloidal Chemistry named after F. D. Ovcharenko, National Academy of Sciences of Ukraine – Vernadskogo 42, 03142 Kyiv, Ukraine
[3] Taras Shevchenko National University – 01033 Kyiv, Ukraine
[4] Astrakhan State Technical University – Astrakhan, Russia

Diffusion-driven self-assembly in a two-dimensional system of rod-like particles has been simulated by means of the Monte Carlo technique using a lattice approach [1,2]. The particles were considered as linear k-mers of two mutually perpendicular orientations (kx- and ky-mers) on a square lattice. A random sequential adsorption (RSA) model was used to produce an initial distribution of k-mers. The concentration of k-mers, p, was varied in the range from 0.1 to the jamming concentration, pj. Translational diffusion of the k-mers was simulated as a random walk, while rotational diffusion was ignored. To characterize the spatial-temporal dynamics of the system under consideration, several quantities have been monitored, e.g., local anisotropy, number of contacts between particles, number of clusters etc. The 'blind' and 'myopic' diffusion rules have been applied [3]. In the first one (blind case, algorithm I) one of the k-mers is selected at random and it chooses the next step from among all neighbour sites. This algorithm preserves detailed balance condition [4]. The second one (myopic case algorithm II) the k-mers are 'intellectual' and the walker chooses from among all unblocked sites. This algorithm does not preserve the detailed balance condition.

We can conclude that both algorithms produce similar final steady-state patterns at least for $k > 7$. For shorter k-mers, this conclusion is questionable because the algorithm I is essentially slower than the algorithm II and steady states are hardly reachable during acceptable time of simulation. We investigated effect of particles' length, lattice size, initial concentration, anisotropy and distribution on diffusion-driven reorganization and pattern formation. The formation of stripe domains takes longer time the larger the lattice size. The boundary conditions can significantly affect the final state of the system. When periodic boundary conditions are applied along both directions of the square lattice, concentration of particles (packing densities) is sufficiently large, particles' length excides the critical value,the system with similar numbers of kx- and ky-merstends toward a well-organized steady statein the form of diagonal stripes.

Acknowledgements: We acknowledge the funding from the National Academy of Sciences of Ukraine, Project No. 43/17-H (N.I.L., N.V.V.), the Ministry of Education and Science of the Russian Federation, Project No. 3.959.2017/4.6 (Yu.Yu.T., V.V.L.) and from the Russian Foundation for Basic Research, Project No. 18-07-00343 (Yu.Yu.T.).

[1] N. I. Lebovka, Yu. Yu. Tarasevich, V. A. Gigiberiya, N. V. Vygornitskii, Phys. Rev. E 95, 052130 (2017).
[2] Yu. Yu. Tarasevich, V. V. Laptev, A. S. Burmistrov, N. I. Lebovka, J. Stat. Mech.: Theory and Experiment 2017, 093203 (2017).
[3] R. B. Selinger, H. E. Stanley, Phys. Rev. A 42, 4845 (1990).
[4] S. Patra, D. Das, R. Rajesh, M. K. Mitra, Phys. Rev. E 97, 022108 (2018).

*Speaker
†Corresponding author: lebovka@gmail.com

Probing non-orthogonality of eigenvectors in non-Hermitian matrix models

Wojciech Tarnowski* [1], Maciej A. Nowak [1]

[1] Jagiellonian University – Gołębia 24, PL-31007 Kraków, Poland

Eigenvalues of Hermitian random matrices behave like charged particles in 2D electrostatics, which is an example of a strongly correlated system, but completely integrable. This analogy can be extended to non-Hermitian setting, where eigenvalues are no longer confined to the real axis, while the integrable structure still exists. During recent years we are witnessing a rapid progress in understanding of integrability of products of non-Hermitian matrices. Besides eigenvalues, non-Hermitian matrices possess another important property—non-orthogonality of their eigenvectors, which was underappreciated in previous studies. We develop a formalism for calculation of the local averages of the overlaps between eigenvectors (so called quenched overlaps) in the limit of large size of a matrix. The setting generalizes the quaternionic Green's function approach to one-point functions in Random Matrix Theory. We successfully apply it to the class of matrices with enhanced unitary symmetry, which generalizes Gaussian matrices.

*Speaker

New constant of motion for coevolving voter model

Joanna Toruniewska* [1], Krzysztof Kułakowski [2], Krzysztof Suchecki [1], Janusz Hołyst [1]

[1] Warsaw University of Technology – Poland
[2] AGH University of Science and Technology, Faculty of Physics and Applied Computer Science – Mickiewicza 30, PL-30059 Kraków, Poland

In the coevolving voter model a topology of the network changes in response to the voter dynamics on the network. In detail, nodes can change their state and links can rewire in order to connect nodes of the same state with probability p. In this model there is an absorbing transition to a frozen phase above a critical value of rewiring probability.

The main aim of this study was to understand statistical relations between observables related to the network topology (link magnetization) and observables related to the internal nodes variables (spins). Concerning voter model, in our mean-field calculation we treat mean degree of nodes (μ) with positive and negative spins, as separate variables, which do not have to be equal. This allows to discuss the magnetization of nodes (n) and the magnetization of links (m) as potentially independent variables. Yet our analytical studies shows that these two magnetizations are coupled. Linear combination of both types of magnetization averaged over many realizations starting from the same initial conditions is a constant of motion $\Lambda \equiv (1-p)\mu m(t) + pn(t)$.

Moreover in the active phase mean value of magnetization of nodes and links tend to the same value and mean degrees of nodes possessing different spins also become equal. Obtained results were confirmed by numerical simulations.

Acknowledgements: The work was partially supported as RENOIR Project by the European Union Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 691152.

*Speaker

Non-linear sigma model and Berry phase

Steffen Trimper* [1]

[1] Martin Luther University, Institute of Physics – D-06099 Halle, Germany

Motivated by the study of quantum topological material we analyze the topological behavior of the mesoscopic non-linear-sigma. Representing the local magnetic moments in terms of a two component complex field and taking into account the SU(2) symmetry the non-linear sigma model offers a kind of a vector potential which plays the role of the Berry phase. Within a special representation of the complex field and the spin current density we find analytically inhomogeneous solutions for the magnetization field. The energy as well as the skyrmion density of that metastable state offer a characteristic spatial dependence. The Berry potential is related to a magnetic field which is likewise spatial dependent and totally different from electrodynamics. For certain configurations like a dipolar, quadruple, triangular, hexagonal skyrmions we calculate explicitly the magnetic order parameter field, the inhomogeneous energy density and the internal magnetic field which is related to the topological invariant. The investigation as extended by considering the Lagrangian and the underlying dynamics, which can be derived using the Noether-theorem. The Dzyaloshinski–Moriya coupling, is also included into the considerations.

*Speaker

Linear and ring polymer chains with the excluded volume interaction in confined geometries

Zoryana Usatenko* [1], Joanna Hałun [2], Piotr Kuterba [3], Hassan Chamati [4], Krzysztof Danel [5]

[1] Institute of Physics, Cracow University of Technology – Podchorążych 1, Kraków, Poland
[2] Institute of Nuclear Physics, Polish Academy of Sciences – Kraków, Poland
[3] Faculty of Physics, Astronomy and Applied Computing, Jagiellonian University – Kraków, Poland
[4] Institute of Solid State Physics, Bulgarian Academy of Sciences – Sofia, Bulgaria
[5] Institute of Chemistry, University of Agriculture – Kraków, Poland

The investigation of a dilute solution of long-flexible linear and ring polymer chains in confined geometries like slit of two parallel walls with different adsorbing or repelling properties in respect to polymer chains as well as in a solution of mesoscopic spherical colloidal particles of one sort or two different sorts is discussed. Taking into account the well known polymer–magnet analogy developed by de Gennes [1] between the field theoretical $\varphi^4 O(n)$—vector model in the limit $n \to 0$ and the behaviour of long—flexible polymer chains with the excluded volume interaction in a good solvent the calculations of the corresponding dimensionless depletion interaction potentials and the depletion forces [2-4] as well as the monomer density profiles [5,6] were performed in the framework of the massive field theory approach in fixed space dimensions $d = 3$ up to one loop order. The presented results indicate about the interesting and nontrivial behaviour of linear and ring polymer chains in confined geometries and give possibility better to understand the complexity of physical effects arising from confinement and chain topology which plays a significant role in the shaping of individual chromosomes and in the process of their segregation, especially in the case of elongated bacterial cells. The obtained results are in good qualitative agreement with the scaling predictions proposed by de Gennes [1] , the previous theoretical investigations and with the numerical results obtained by Monte Carlo simulations for linear and ring polymer chains and can find practical application in production of new types of nano- and micro-electromechanical devices.

[1] P. G. de Gennes, Scaling Concepts in Polymer Physics (Cornell University Press, Ithaca, NY, 1979).
[2] D. Romeis, Z. Usatenko, Phys. Rev. E 80, 041802 (2009).
[3] Z. Usatenko, J. Halun, J. Stat. Mech.: Theory and Experiment 2017, P013303 (2017).
[4] Z. Usatenko, P. Kuterba, H. Chamati, D. Romeis, Eur. Phys. J.: Special Topics 226, 651 (2017).
[5] Z. Usatenko, J. Chem. Phys. 134, 024119 (2011); J. Mol. Liq. 164, 59 (2011).
[6] J. Halun, Z. Usatenko (unpublished results).

*Speaker

An improved radiation model and its applicability for understanding commuting patterns in the USA

Levente Varga*† [1], Géza Tóth [2], Zoltán Néda [1]

[1] Babeş-Bolyai University – Cluj-Napoca, Romania
[2] Hungarian Central Statistical Office – Budapest, Hungary

Several empirical models aimed at describing human mobility have been proposed in the past. Most of them are based on an unjustified analogy, with concepts and models borrowed from physics: gravity and vector or scalar fields. Recently however, statistical physicists introduced a new category of models motivated by simple and reasonable socioeconomic assumptions. The Radiation Model (RM) [1] and the Radiation Model with Selection (RMwS) [2] are two of such successful approaches. In these models, the salary a job pays and the commuting distance to it are the most important variables. In RM, the main hypothesis is that a worker will commute to the closest distance where he/she can improve his/her current income. If we assume now that the jobseekers are selective in their choices and they are willing to accept better offers only with a probability smaller than one, we get the RMwS model. Alternatively, the assumption behind this generalization can be interpreted as a fact that the jobseekers are aware only of a fraction of the available job offers. Recently a novel variation of the RM model was proposed, where one takes into account also the distance dependent travel costs. This new model, the Travel Cost Optimized Radiation Model (TCORM) [3] was already successfully tested for commuting patterns in Hungary. Here we use a much larger commuter dataset from USA, and critically compare the performance of the RM, RMwS and TCORM approximations. We find that the TCORM offers an improved description for the experimentally measured commuting patterns.

[1] F .Simini, M. C. González, A. Maritan, A. L. Barabási, Nature 484, 96 (2012).
[2] F. Simini, A. Maritan, Z. Néda, PLoS One 8, e60069 (2013).
[3] L. Varga, G. Tóth, Z. Néda, Regional Statistics 6, 27 (2016).

*Speaker
†Corresponding author: vlewir@gmail.com

Vehicular motion on a hilly road

Hans Weber*† [1], Jevgenijs Kaupužs‡ [2], Reinhard Mahnke [3]

[1] Department of Physics, Luleå University of Technology – SE-97187 Luleå, Sweden
[2] Institute of Mathematical Sciences and Information Technologies, University of Liepaja – Liepaja LV–3401, Latvia
[3] Institute of Physics, Rostock University – D-18051 Rostock, Germany

In recent decades, many mathematical models for traffic flow have been proposed, in particular Follow-the-Leader models. In most models roads are considered to be horizontally flat. But vertically undulated roads (hilly roads) are bottlenecks in freeway traffic networks. In a hilly road vertically sag curves will be present. A sag curve is at the bottom of a valley as the gradient turns uppward or if an upphill grade becomes steeper. This causes different acceleration behavior of drivers compared to a road where sag curves are absent. Traffic flow optimization is important to determine how vehicles should behave at sags in order to minimize total delay. We consider the motion of a point-like car on a one-dimensional hilly road under the influence of gravitation and friction. Based on a Newtonian description we investigate the equations of motion of a particle to discuss the speed and position of a car of mass m on a undulating path $f(x)$.

*Speaker
†Corresponding author: Hans.Weber@ltu.se
‡Speaker

Stochastic models of hyaluronic acid dynamics in a presence of phospholipids

Piotr Weber [1], Piotr Bełdowski*† [2], Adam Gadomski‡ [2]

[1] Gdańsk University of Technology, Atomic and Optical Physics Division, Department of Atomic, Molecular and Optical Physics, Faculty of Applied Physics and Mathematics – Narutowicza 11/12, PL-80233 Gdańsk, Poland

[2] UTP University of Science and Technology in Bydgoszcz, Institute of Mathematics and Physics – Kaliskiego 7, PL-85796 Bydgoszcz, Poland

Hyaluronic acid and common phospholipids play an important role in lubrication mechanism of articular cartilage. Pathological changes occurring in osteoarthritis modify concentration and structure of both species. The consequence is inefficient cross-linking of hyaluronan resulting in poor viscoelastic properties. This work presents the dynamics of hyaluronan cross-linking in presence of phospholipids as a stochastic process. There are two well known such models that introduce anomalous dynamics. The first is the fractional Brownian motion (FBM) and the second is continuous time random walk (CTRW). Mechanisms leading to anomalous dynamics for both processes are very different. In FBM, strong correlations between the increments are responsible for such dynamics. FBM is a special case of fractional Levy stable motion (FLSM) parametrize by a self-similarity index and a stability index. In continuous time random walk, random walker waits between jumps. Distribution of waiting time has inverse power asymptiotics leading to anomalous dynamics. These models are used to describe dynamics of macromolecules and gives a framework to explain experimental data. There are tests which give indication of the most probable stochastic process, CTWR, FBM or FLSM, are responsible for observed non-Markovian evolution. The results of molecular dynamics simulations of hyaluronic acid and phospholipids complexes were analyzed to understand the process. We can observe that for hyaluronic acid dynamics in a presence of phospholipids has anomalous character. Using the above mentioned tests we can indicate which model, CTWR, FBM or FLSM, better characterizes obtaining data from simulations. Our results suggests that the shape of molecules play an important role in the selection of the model underlying anomalous dynamics.

*Speaker

†Corresponding author: piotr.beldowski@utp.edu.pl

‡Corresponding author: adam.gadomski@utp.edu.pl

Dimerization in the anisotropic bilinear-biquadratic Heisenberg model

Michael Weyrauch* [1]

[1] Physikalisch-Technische Bundesanstalt – Bundesallee 100, D-38116 Braunschweig, Germany

Two recent publications report different boundaries for the dimerized phase of the bilinear-biquadratic spin-1 Heisenberg model with quadratic Zeeman anisotropy. We address these discrepancies for the biquadratic model with quadratic Zeeman term and explain the differences. Based on our numerical results the phase boundaries of the dimerized phase are determined. A revised phase diagram is developped. We use a matrix product state algorithm which implements SU(2) symmetry explicitly. The implementation and numerical prcision of this algorithm are adressed.

*Speaker

Phase-space dynamics of charge carriers in aperiodic potentials

Maciej Wołoszyn*† [1], Bartłomiej Spisak [1]

[1] AGH University of Science and Technology, Faculty of Physics and Applied Computer Science – Mickiewicza 30, PL-30059 Kraków, Poland

Results of the Wigner Ensemble Monte Carlo calculations are presented for the case of quantum transport in aperiodic potentials. The analyzed models allow discussing how the transport phenomena are related to the scattering and tunneling processes on potential barriers or scattering centers distributed according to the assumed rules, which may include quasi-periodic or random cases. For this kind of dynamics, the applied method of calculations allows comparing the properties of various kinds of such systems and their periodic counterparts, in terms of the trajectories in the phase space (based on the expectation values of position and momentum) and the diffusion exponents.

*Speaker
†Corresponding author: woloszyn@agh.edu.pl

Rényi entropy of the totally asymmetric exclusion process

Anthony Wood*† [1], Richard Blythe [1], Martin Evans [1]

[1] School of Physics, University of Edinburgh – James Clerk Maxwell Building, University of Edinburgh, Edinburgh EH9 3JZ, United Kingdom

I will present our analytic work on the totally asymmetric exclusion process (TASEP), where we have calculated a measure known as the Rényi entropy. This is a generalisation of the more common Shannon entropy, that has a neat interpretation for equilibrium systems. Away from equilibrium (the case for any real system e.g. biological processes), a physical interpretation remains elusive. However, we suspect the nonanalyticities of a given system's Rényi entropy may serve as an indicator as to whether a system is in or out of equilibrium.

In order to calculate this entropy, we map configurations in the TASEP (that has a probability distribution with a combinatorial-like structure, in contrast with the usual equilibrium Boltzmann weights) to a problem involving a biased discrete 2D random walk, which we make a generalisation to in order to analytically explore the entropy in different phases. Importantly, we find a different structure to what one would find at equilibrium, suggesting an inherent difference between the probability distributions of systems in and out of equilibrium.

*Speaker
†Corresponding author: s1538277@sms.ed.ac.uk

Analytical structure of the effective potential and quantum criticality for imbalanced Fermi mixtures

Piotr Zdybel*† [1]

[1] Faculty of Physics, Institute of Theoretical Physics, University of Warsaw – Pasteura 5, PL-02093 Warsaw, Poland

We study the analytical structure of the effective action for spin- and mass-imbalanced Fermi mixtures at the onset of the superfluid state. Of our particular focus is the possibility of suppressing the tricritical temperature to zero, such that the transition remains continuous down to $T = 0$ and the phase diagram hosts a quantum critical point. We analytically identify such a possibility in a narrow parameter regime in dimensionality $d = 3$. We demonstrate that, at mean-field level, the occurrence of a quantum critical point in $d = 2$ is excluded. We show that the Landau expansion of the effective potential remains well-defined in the limit $T \to 0^+$ except for a subset of model parameters which includes the standard BCS limit.

*Speaker
†Corresponding author: piotr.zdybel@fuw.edu.pl

Pair approximation for the q-voter model with independence on complex networks

Arkadiusz Jędrzejewski*† [1]

[1] Department of Theoretical Physics, Wrocław University of Science and Technology – Wrocław, Poland

We investigate q-voter model with stochastic noise arising from independence on complex networks. Using the pair approximation, we provide comprehensive, mathematical description of its behavior and derive formula for the critical point. The analytical results are validated by carrying out Monte Carlo experiments. The pair approximation prediction exhibits substantial agreement with simulations, especially for networks with weak clustering and large average degree. Nonetheless, for the average degree close to q, some discrepancies originate. It is the first time the presented approach has been applied to the nonlinear voter dynamics with noise. Up till now, the analytical results have been obtained only for a complete graph. We show that in the limiting case the prediction of pair approximation coincides with the known solution on a fully connected network. In the work, we were mainly interested in the time evolution and stationary values of the up-spin concentration. It turns out that the qualitative behavior of a system on studied weakly clustered complex networks is similar as on a complete graph and depends on the model parameter q, that is to say, for $q < 6$, the system undergoes continuous phase transitions, whereas for $q > 5$, phase transitions are discontinuous. However, the quantitative behavior also depends on the average node degree of an underlying network. What is interesting is that networks which have very different arrangements of edges and node degree distributions lead to the same results when they have the same value of the average node degree.

[1] A. Jędrzejewski, Phys. Rev. E 95, 012307 (2017).

*Speaker
†Corresponding author: arkadiusz.jedrzejewski@pwr.edu.pl

Designing and controlling multistable dynamical systems: from theory to applications

Bulcsú Sándor*† [1,2], Claudius Gros [1]

[1] ITP, Goethe-University Frankfurt – Frankfurt am Main, Germany
[2] Physics Department, Babes-Bolyai University – Cluj-Napoca, Romania

Dynamical systems theory provides an effective toolkit for modeling the complex behavior of various physical, biological and social systems. The attractors in the phase space guarantee the long-term dynamical stability of the respective system, also allowing for a certain level of robustness against external perturbations. Furthermore, multistable systems [1] are able to show several different dynamical behavior due to the coexistence of stable attractors, viz without changing a single controlling parameter.

We propose a novel class of dynamical systems, for which coexisting attractors may be generated by constructing potential functions with multiple minima [2]. We show that stable fixpoints can be destabilized by introducing anti-dissipative regions around the local minima of the potential, leading to periodic or irregular oscillations in terms of limit cycles or chaotic attractors, respectively. The proposed class of systems can also be used as prototypes for generating complex dynamics on multiple attractors.

Finally, as an application of multistability we demonstrate on simple simulated and real rolling robots, how switching between coexisting attractors can be used to exploit self-organized behavioral primitives [3, 4]. Adding an external control signal to the system arbitrary sequences of motion patterns may be generated by jumping between the basins of the respective attractors.

[1] A. N. Pisarchik, U. Feudel, Phys. Rep. 540, 167 (2014).
[2] B. Sándor, C. Gros, Sci. Rep. 5, 12316 (2015).
[3] B. Sándor, T. Jahn, L. Martin, C. Gros, Frontiers in Robotics and AI 2, 31 (2015).
[4] L. Martin, B. Sándor, C. Gros, Frontiers in Neurorobotics 10, 12 (2016).

*Speaker
†Corresponding author: sbulcsu@gmail.com

Appendix A

List of participants

- Akıncı Ümit
- Auslender Mark
- Baldassarri Andrea
- Barash Lev
- Bednarek Stanisław
- Bełdowski Piotr
- Bianconi Ginestra
- Bikoumou Eslene
- Botto Davide
- Bouchaud Jean-Philippe
- Bożek Piotr
- Bulcsu Sandor
- Burda Zdzisław
- Burridge James
- Chamati Hassan
- Christiansen Henrik
- Coghi Francesco
- Cvitković Mislav
- David François
- Delfino Gesualdo
- Dénes Károly
- Drzazga Ewa
- Dudka Maxym
- Empting Eelco

- Evans Martin
- Fyodorov Yan
- Gambár Katalin
- Gawroński Przemysław
- Georgiev Miroslav
- Gillan Rebecca
- Gnacik Michał
- Gong Chen Chris
- Górski Michał
- Hałun Joanna
- Holovatch Yurij
- Hucht Fred
- Iglói Ferenc
- Janke Wolfhard
- Jędrzejewski Arkadiusz
- Jizba Petr
- Juhasz Robert
- Kádár Viktória
- Kaupuzs Jevgenijs
- Keim Peter
- Kenna Ralph
- Kenney Steven
- Kertész János
- Kim Yup
- Király Balázs
- Kołaczek Damian
- Kondrat Grzegorz
- Kotrla Miroslav
- Krawczyk Malgorzata
- Krug Joachim
- Kułakowski Krzysztof
- Kuśmierz Łukasz
- Kuterba Piotr

- Lach Matúš
- Lips Dominik
- Luck Jean-Marc
- Majka Maciej
- Majumdar Satya
- Malarz Krzysztof
- Mamis Konstantinos
- Márkus Ferenc
- Meyer-Ortmanns Hildegard
- Minina Elena
- Mohylna Mariia
- Mouhanna Dominique
- Neda Zoltan
- Ó Laighléis Eoin
- Ochab Jeremi
- Pál Gergő
- Paluch Robert
- Papp Istvan
- Pawłowski Jarosław
- Piasecki Ryszard
- Polak Marta
- Put Stefanie
- Redner Sidney
- Ryabov Artem
- Sadhu Raj Kumar
- Sanchez Pedro
- Sarkanych Petro
- Shapoval Dmytro
- Skowron Grzegorz
- Slanina Frantisek
- Sliusarenko Oleksii
- Slutskiy Mikhail
- Squizzato Davide

- Szavits-Nossan Juraj
- Szczęśniak Radosław
- Sznajd Józef
- Sznajd-Weron Katarzyna
- Tamm Mikhail
- Tarasevich Yuri
- Tarnowski Wojciech
- Toruniewska Joanna
- Trimper Steffen
- Usatenko Zoryana
- Varga Levente
- Wacław Bartłomiej
- Weber Hans
- Weigel Martin
- Weyrauch Michael
- Wołoszyn Maciej
- Wood Anthony
- Zdybel Piotr
- Żurek Wojciech
- Życzkowski Karol

Author Index