QMath11 – Mathematical Results in Quantum Physics

Hradec Králové, Czech Republic
September 6–10 2010

Programme
Abstracts
Participants

Auspices

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Doppler Institute for Mathematical Physics and Applied Mathematics
Project CZ.1.07/2.3.00/09.0044 – R+D Human Resources Advancement (2009-2012, MSM/EE)

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One of the main purposes of this *QMath* conference is to celebrate the jubilee of our colleague and friend **Ari Laptev**.

Ari was born on August 10, 1950, in Kiev. He studied at the Leningrad State University when he made his PhD under the supervision of Michael Solomyak. World was different in those times and one can get into trouble even for choosing a spouse from a wrong country. This happened and as a result Ari had to spend five years in conditions which most members of the academic community today can hardly imagine.

His life changed when he came to Sweden in 1987 and could restart his career and demonstrate how brilliant mathematician he was. Two decades later we can see it clearly from over sixty papers, some of which had a profound influence of development of spectral theory, and no less from looking at the results of about dozen PhD students he educated.

It is not only these result from which the his colleagues benefit. Ari organized European congress in 2004 and at present he serves as President of European Mathematical Society, and everybody who had the luck to work with him must admire the energy he puts into service of the community.

On behalf his collaborators, friends, and all conference participants we wish him most of all to keep his attitude to life and science for many years to come, interesting new results and happiness in personal life.

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Schedule

Monday, September 6

Plenary session – AULA		
9:00–9:15 P. Exner, UHK representatives: Conference opening		
9:15–10:15 M. Lewin: Renormalization of Dirac's polarized vacuum		
10:15–10:45 Coffee break		
10:45–11:45 A. Giuliani: Renormalization group for interacting electrons on the honeycomb lattice		
11:50–12:50 R. Sims: Lieb-Robinson bounds in quantum many-body physics		
12:50–14:15 Lunch break		
Invited talks QC – AULA	Contributed talks ST – A1	Contributed talks QFT – A2
14:15–14:55 L. Santos	14:15–14:45 I. Veselic	14:15–14:45 E. Langmann
	14:50–15:20 V. Lotoreichik	14:50–15:20 A. Panati
15:00–15:40 S. Nonnenmacher		
	15:25–15:55 D. Borisov	15:25–15:55 P. Siegl
15:45–16:25 K. Richter		
	16:00–16:30 H. Šediváková	16:00–16:30 J. Dittrich
16:30–17:00 Coffee break		
Contributed talks QI – AULA	Contributed talks ST – A1	
17:00–17:30 M. Fraas	17:00–17:30 I. Popov	
17:35–18:05 C. Zander	17:35–18:05 T. Kalvoda	
18:10–18:40 M. Rezaei Karamati	18:10–18:40 H. Niikuni	

Tuesday, September 7

Plenary session – AULA		
9:00–10:00 B. Schlein: Bulk universality for Wigner matrices		
10:00–10:30 Coffee break		
10:30–11:30 V. Kostrykin: Quadratic forms without semiboundedness		
11:35–12:35 O. Post: Convergence results for thick graphs		
12:35–14:00 Lunch break		
Invited talks MBQM – AULA	Contributed talks QI – A1	Contributed talks PSS – A2
14:00–14:40 G. Hagedorn	14:00–14:30 A. Gábris	14:00–14:30 P. Hrabák
	14:35–15:05 J. Novotný	14:35–15:05 M. Chraibi
14:45–15:25 D. Hasler		
	15:10–15:40 M. Štefaňák	15:10–15:40 H. Lavička
15:30–16:10 W. de Roeck		
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16:15–16:45 Coffee break		
Invited talks QFT – AULA	Contributed talks QI – A1	Contributed talks ST – A2
16:45–17:25 C. Bergbauer	16:45–17:15 D. D'Alessandro	16:45–17:15 M. Keller
	17:20–17:50 T. Brougham	17:20–17:50 J. Lipovský
17:30–18:10 W. van Suijlekom		
	17:55–18:25 N. Unal	
18:25–20:00 Dinner break		
20:00–21:00 Concert		

Wednesday, September 8

Invited talks QI – AULA	Contributed talks ST – A1	Contributed talks MBQM – A2
9:00–9:40 F. Verstraete	9:00–9:30 T. Mine	9:00–9:30 R. Sverdlov
	9:35–10:05 F. Truc	9:35–10:05 I. Sasaki
9:45–10:25 T. Osborne		
	10:10–10:40 M. Tušek	10:10–10:40 C. Yüce
10:30–11:10 T. Cubitt		
	10:45–11:15 I. Lobanov	10:45–11:15 A. Abdesellam
11:15–11:45 Coffee break		
Invited talks PSS – AULA	Contributed talks ST – A1	Contributed talks QC – A2
11:45–12:25 B. Steffen	11:45–12:15 H. Neidhardt	11:45–12:15 J. Bolte
	12:20–12:50 Y. Kordyukov	12:20–12:50 O. Hul
12:30–13:10 M. Fialkowski		
	12:55–13:25 A. Prykarpatsky	12:55–13:25 E. Kanzieper
13:15–13:55 D. Vašata		
13:45–14:30 Lunch break		
14:30–24:00 Excursion		

Thursday, September 9

Plenary session – AULA		
9:00–10:00 S. Warzel: Surprises in the phase diagram of the Anderson model on trees		
10:00–10:30 Coffee break		
10:30–11:30 N. Datta: Relative entropies and entanglement monotones		
11:35–12:35 K. Życzkowski: Quantum entanglement in random systems		
12:35–14:00 Lunch break		
Invited talks ST – AULA	Contributed talks QFT – A1	Contributed talks QI – A2
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	14:50–15:20 W. Dybalski	14:50–15:20 G. Florio
15:00–15:40 T. Hoffmann-Ostenhof		
	15:25–15:55 H. Motavalli	15:25–15:55 M. Sedlák
15:45–16:25 J. Dolbeault		
	16:00–16:30 M. G. Rasmussen	16:00–16:30 A. Frydryszak
16:30–17:00 Coffee break		
Contributed talks ST – AULA	Contributed talks QFT – A1	
17:00–17:30 S. Naboko	17:00–17:30 S. Razavi Govareshk	
17:35–18:05 M. J. Gruber	17:35–18:05 M. Mollai	
18:10–18:40 F. Štampach		
18:25–20:00 Break		
20:00–23:00 Conference dinner		

Friday, September 10

Ari Laptev Birthday Session Plenary session – AULA	
9:00–10:00	E. H. Lieb: Binding, stability, and non-binding of multi-polaron systems
10:00–10:30	Coffee break
10:30–11:30	T. Weidel: Semiclassical estimates and beyond
11:35–12:35	R. Frank: Sharp constants in inequalities on the Heisenberg group
12:35–14:00	Lunch break
Plenary session – AULA	
14:00–14:30	R. Benguria: Spectral problems in spaces of constant curvature
14:30–15:00	B. Helffer: On spectral questions around the superconductivity between HC_2 and HC_3
15:00–15:30	M. Loss: Localization for the Random Displacement Model
15:30–16:00	A. Jensen: Non-exponential decay laws
16:00–16:30	L. Geisinger: Refined semiclassical asymptotics of the Laplace operator on bounded domains
16:30–17:00	Coffee break
Plenary session – AULA	
17:00–17:20	H. Kovařík: Large time behavior of the heat kernel of two-dimensional magnetic Schroedinger operators and its applications
17:20–17:40	E. Langmann: Calogero-Sutherland type systems and conformal field theory
17:40–20:00	Break
20:00–23:00	Ari Laptev and friends: Birthday dinner

Plenary Lectures

P1 Relative entropies and entanglement monotones

N. Datta
University of Cambridge

Two new relative entropy quantities are introduced and their properties, including their relation with the quantum relative entropy, are investigated. The operational meaning of these quantities, in the context of Quantum Information Theory, is discussed. Further, these relative entropies are seen to lead naturally to the definition of two entanglement monotones, which have interesting operational significance.

P2 Sharp constants in inequalities on the Heisenberg group

R. Frank
Princeton University

We derive the sharp constants for the inequalities on the Heisenberg group whose analogues on Euclidean space are the well known Hardy-Littlewood-Sobolev inequalities. Only one special case had been known previously, due to Jerison-Lee more than twenty years ago. From these inequalities we obtain the sharp constants for their duals, which are the Sobolev inequalities for the Laplacian and conformally invariant fractional Laplacians. The methodology is completely different from that used to obtain the Euclidean inequalities and can be used to give a new, rearrangement free, proof of the HLS inequalities. The talk is based on joint work with E. H. Lieb.

P3 Renormalization group for interacting electrons on the honeycomb lattice

A. Giuliani
Universita' di Roma Tre

In this talk I will review recent advances on the understanding of the ground state properties of interacting electrons on the honeycomb lattice. In the case of weak short range interactions, renormalization group methods allowed us to give a complete construction of the ground state of the half-filled system and to prove analyticity in the coupling constant of the thermodynamic functions and of the equilibrium correlations. In the case that the electrons interact with a three-dimensional quantum electromagnetic field, the ground state can be constructed order by order in renormalized perturbation theory, with the n-th order admitting n!-bounds. Ward Identities are needed in order to control the flow of the effective charges. Lorentz invariance is dynamically restored, thanks to lattice gauge invariance. This talk is based on joint work with V. Mastropietro and M. Porta.

P4 Quadratic Forms without Semiboundedness

V. Kostrykin
Univerität Mainz

The talk reviews some recent results on representation theorems for not semibounded quadratic forms. In particular, we discuss some unexpected properties of the Dirac operator.

The talk is based on a joint work with L. Grubisic, K. Makarov, and I. Veselic.

P5 Renormalization of Dirac's polarized vacuum

M. Lewin
CNRS and University of Cergy-Pontoise

In this talk I will review several results on a model describing relativistic atoms while taking into account some QED effects like the polarization of the vacuum.

I will first present the model and recall previous results, mainly dealing with the existence of ground states and their properties (joint works with Gravejat, Hainzl, Séré and Solovej).

Then, I will explain how to remove the ultraviolet cut-off by means of a renormalization procedure, following a recent work with Gravejat and Séré.

P6 Binding, Stablity, and Non-binding of multi-polaron systems

E. Lieb
Princeton University

A polaron is an electron surrounded by the electric field it generates by polarizing the surrounding atoms of an ionic crystal. It is both a physical model in condensed matter physics and a simple model of non-relativistic quantum field theory. We shall be concerned with the ground state energy of many polarons, i.e., many electrons, and whether there is binding and stability. The answer depends on the electron Coulomb repulsion parameter U and the coupling constant to the field, α. In recent work with R. Frank, R. Seiringer and L. Thomas we have proved that there is stability of matter if $U > \alpha$ (this is sharp), and there is no binding of any kind if $U > U_c(\alpha)$, independent of electron number, N. See arXiv:1004.1196 and arXiv:1004.4892.

P7 Convergence results for thick graphs

O. Post
Humboldt Universität Berlin

Many physical systems have branching structure of thin transversal diameter. One can name for instance quantum wire circuits, thin branching waveguides, or carbon nano-structures. In applications, such systems are often approximated by the underlying one-dimensional graph structure, a so-called "quantum graph". In this way, many properties of the system like conductance can be calculated easier (sometimes even explicitly). We give an overview of convergence results obtained so far, such as convergence of Schrödinger operators, Laplacians, their spectra and resonances, scattering matrices and Dirichlet-to-Neumann maps.

P8 Bulk Universality for Wigner Matrices

B. Schlein
University of Bonn

In this talk I am going to discuss recent results concerning spectral properties of ensemble of Wigner matrices, consisting of $N \times N$ random matrices whose entries are, up to the symmetry constraints, independent and identically distributed random variables. In particular I am going to discuss a proof of the universality of the local eigenvalue statistics.

P9 Lieb-Robinson Bounds in Quantum Many-Body Physics

R. Sims
University of Arizona

We give an overview of recent results on Lieb-Robinson bounds and some of their applications in the study of quantum many-body models in condensed matter physics.

P10 Surprises in the phase diagram of the Anderson model on trees

S. Warzel
TU Munich

We revisit the phase diagram of the Anderson model on the Bethe lattice. In particular, we present a proof of the existence of continuous spectrum at weak disorder outside the spectrum of the Laplacian. (This is joint work with M. Aizenman.)

P11 Semiclassical estimates and beyond

T. Weidl
Stuttgart University

I give a review on results on Lieb-Thirring type estimates during the past decade. Starting from sharp values on the Liebt-Thirring constants I will discuss, among others, logarithmic bounds and improved Li-Yau estimates with correction terms of sharp order with some applications to heat kernel estimates.

P12 Quantum entanglement in random systems

K. Życzkowski
Jagiellonian University

We analyze quantum entanglement in composite random systems. Due to the measure concentration phenomenon a typical random pure state of a bi-partite system is almost maximally entangled. Taking various measures on the set of pure states one can induce by partial trace various probability measures in the set of mixed states on a reduced system. Recent results on random states generated according to the Bures measure and random graph states, which lead to Marchenko-Pastur or higher order Fuss-Catalan distributions of level density are reviewed.

Special session in honour of Ari Laptev

Invited speakers

L1 Spectral Problems in Spaces of Constant Curvature

R. Benguria
P. Universidad Catolica de Chile

In this talk I will present a review of recent results concerning spectral problems of operators in S^n and H^n. In particular, I will concentrate on low eigenvalues of the corresponding Laplace Beltrami operators, and also on Brezis-Nirenberg type problems and others.

L2 Refined semiclassical asymptotics of the Laplace operator on bounded domains

L. Geisinger
Stuttgart University

Let $-\Delta$ denote the Dirichlet Laplace operator on a bounded domain in $\mathbb{R}^d$. We study the trace of the negative part of $-\Delta - \mu$ in the semiclassical limit as μ tends to infinity. We give a new proof that yields not only the first term of the asymptotics but also the second term involving the surface area of the boundary of the domain.

The proof works under very general conditions on the domain; in particular we do not require smoothness of the boundary. Furthermore the method can be applied to non-local, non-smooth symbols, like fractional powers of the Laplacian.

(This is joint work with R. L. Frank.)

L3 On spectral questions around the superconductivity between HC_2 and HC_3

B. Helffer
Univ Paris-Sud

Superconductivity for Type II superconductors in external magnetic fields of magnitude between the second and third critical fields is known to be restricted to a narrow boundary region. The profile of the superconducting order parameter in the Ginzburg-Landau model is expected to be governed by an effective one-dimensional model. This is known to be the case for external magnetic fields sufficiently close to the third critical field. In this text we prove such a result on a larger interval of validity. This is based on a fine spectral analysis. This a joint work with Soeren Fournais and Mikael Persson.

L4 Non-exponential decay laws

A. Jensen
Aalborg University

Perturbation of an embedded eigenvalue usually leads to an exponential decay law, often subsumed under the term "the Fermi Golden Rule". I will consider the case of perturbation of an eigenvalue embedded at a threshold, which under certain conditions will lead to a non-exponential decay law. Joint work with V. Dinu and G. Nenciu, Bucharest, Romania.

L5 Localization for the Random Displacement Model

M. Loss
Georgia Tech

Consider a quantum mechanical particle interacting with a potential consisting of an array of potential wells randomly displaced from a periodic configuration. One expects that for low energies such a particle should display localization. In this talk I will explain the main ingredients of a proof of localization, i.e., characterizing the minimal energy configurations, the Lifshitz - tail estimate and the Wegner estimate. This is joint work with J. Baker, F. Klopp, S. Nakamura and G. Stolz.

Contributed talks

L6 Large time behavior of the heat kernel of two-dimensional magnetic Schroedinger operators and its applications

H. Kovařík
Dipartimento di Matematica, Politecnico di Torino

We study the heat semigroup generated by two-dimensional Schroedinger operators with compactly supported magnetic field. We show that if the field is radial, then the large time behavior of the associated heat kernel is determined by its total flux. We also discuss some applications to eigenvalue estimates for magnetic Schoedinger operators in two dimensions.

L7 Calogero-Sutherland type systems and conformal field theory

E. Langmann
KTH Stockholm

I plan to give a general introduction to Calogero-Sutherland type systems. I also plan to present some of our own results, including the solution of the elliptic Calogero-Sutherland model and recent generalizations of this work.

Topical sessions

1 Spectral theory

Invited speakers

ST1 Symmetry and symmetry breaking of extremal functions in some interpolation inequalities

J. Dolbeault
Université Paris Dauphine

In some classes of weighted interpolation inequalities due to Caffarelli, Kohn and Nirenberg, the set of admissible parameters for which the inequalities are true is splitted by a continuous surface into two regions, one for which the optimal constants are achieved by symmetric functions and another one in which the competition of the nonlinearity and the weight results in a symmetry breaking phenomenon. Most of the known results are based on spectral information combined with variational methods and elliptic techniques for nonlinear analysis.

ST2 Spectral minimal partitions

T. Hoffmann–Ostenhof
ESI and University of Vienna

We give a survey about recent developments concerning spectral minimal partitions. This subject is related to spectral theory. In particular we will give a characterization for the case that there is equality in Courants nodal theorem. This is joint work with Bernard Helffer, Susanna Terracini and Virginie Bonnaillie-Noel.

ST3 Effective Hamiltonians for Constrained Quantum Systems

S. Teufel
Uni Tuebingen

We consider the Schroedinger operator on a Riemannian manifold A with a potential that localizes certain states close to a submanifold C. When scaling the potential in the directions normal to C by a parameter $\varepsilon << 1$, the solutions concentrate in an ε-neighborhood of C. This situation occurs for example in quantum wave guides and for the motion of nuclei in electronic potential surfaces in quantum molecular dynamics. We derive an effective Schroedinger operator on the submanifold C that approximates the spectrum and the dynamics of the full operator on A up to terms of order ε^3.

Contributed talks

ST4 Homogenization of the waveguides with frequent alternation boundary condition

D. Borisov
Bashkirs State Pedagogical University

We consider Laplacian in a planar strip with Dirichlet boundary condition on the upper boundary and with frequent alternation boundary condition on the lower boundary. The alternation is introduced by the periodic partition of the boundary into small segments on which Dirichlet and Neumann conditions are imposed in turns. We show that under the certain condition the homogenized operator involves either Dirichlet or Neumann boundary condition on the lower boundary and prove the uniform resolvent convergence. The spectrum of the perturbed operator consists of its essential part only and has a band structure. We construct the leading terms of the asymptotic expansions for the first band functions. We also construct the complete asymptotic expansion for the bottom of the spectrum.

ST5 Absolutely continuous spectrum for periodic magnetic fields

M. J. Gruber
TU Clausthal

The spectral theory of Schrdinger operators with periodic magnetic fields (non-zero flux) still poses surprisingly many unsettled questions. We review the main methods and results pertaining to the measure theoretic nature of the spectrum (absolutely continuous vs. pure point) and present new results for AC spectrum.

ST6 Resonant cyclotron acceleration of particles by a time periodic singular flux tube

T. Kalvoda
Czech Technical University in Prague

We study the dynamics of a nonrelitivistic charged particle moving on a punctured plane under the influence of a homogeneous magnetic field and driven by a periodically time-dependent singular flux tube through the hole. We exhibit an effect of resonance of the flux and cyclotron frequencies in the framework of classical as well as quantum mechanics. In particular, we show that in both statements of the problem an infinite growth of the energy is possible.

ST7 Absolutely continuous spectrum for substitution trees

M. Keller
Friedrich Schiller University Jena

We study a class of rooted trees with a substitution type structure. These trees are not necessarily regular but exhibit a lot of symmetries. The spectrum of the corresponding graph Laplace operator is purely absolutely continuous and consists of finitely many intervals. We show stability of absolutely continuous spectrum under small random perturbations. Moreover for such trees which are not regular the absolutely continuous spectrum is stable under small deterministic perturbations by radially symmetric potentials. (This is joint work with Daniel Lenz and Simone Warzel.)

ST8 Adiabatic spectral asymptotics on foliated manifolds

Y. Kordyukov
Institute of Mathematics RAS, Ufa

In this talk we are going to discuss some recent results concerning the asymptotic behavior of the eigenvalue distribution function of the Laplace operator on a compact Riemannian foliated manifold when the metric on the ambient manifold is blown up in directions normal to the leaves (in the adiabatic limit). In particular we will address the noncommutative Weyl formula and related problems on the distribution of integer points.

ST9 Resonances in Quantum Graphs

J. Lipovský
Nuclear Physics Institute Academy of Sciences of the Czech Republic

We consider a quantum graph with finite number of internal edges and some infinite leads equipped with Hamiltonian acting as negative second derivative. If the graph contains a loop of edges with lengths equal to integer multiples of l_0 and suitable coupling conditions are applied then eigenvalues $(n\pi/l_0)^2$ occur embedded in the continuous spectrum. We use Kuchment's flower-like model for describing these eigenvalues arised from correlations of lengths of the edges for a general graph. When changing the ratio of the lengths, the poles of the resolvent (formerly eigenvalues) may become resonances. In the general case we determine the total number of poles of the perturbed resolvent (with their multiplicities taken into account) in the neighbourhood of former eigenvalue. Furthermore, we derive a criterion for the asymptotics of resonances to be of a non-Weyl character. We construct examples of graphs with nontrivial coupling which do not preserve Weyl's law.

ST10 Spectral properties of leaky star graph

I. Lobanov
Saint Petersburg State University of Information Technologies, Mechanics and Optics

A delta-perturbation supported by a family of straight lines on the plane intersecting at one point is studied. Several integral representations of the eigenvalue equation are obtained. Estimates for the bottom of the spectrum are provided. Asymptotic expansions for the lowest eigenvalue as angles between lines tend to extremal values are calculated.

ST11 Weak disorder in the Kronig-Penney model: stability of the absolutely continuous spectrum and eigenvalues in gaps

V. Lotoreichik
Unversity ITMO, St Petersburg

One-dimensional Schrödinger operator with δ-interactions on a discrete set X is considered. Conditions for the stability of the essential and the absolutely continuous spectra under perturbations of the set X are given. Using Schatten-von Neumann estimates of the resolvent difference of perturbed and unperturbed operator we compare their generalized discrete spectra. The results are applied to the investigation of eigenvalues in gaps for the Kronig-Penney model with a weak disorder.

ST12 Self-adjoint extensions of the Aharonov-Bohm Hamiltonian on Riemannian manifolds

T. Mine
Kyoto Institute of Technology

We consider the magnetic Schrödinger operator on a Riemannian manifold. We assume the magnetic field is given by the sum of a regular field and the Dirac δ measures supported on a discrete set. We give a complete characterization of the self-adjoint extensions of the minimal operator, in terms of the boundary conditions.

ST13 On the singular behaviour of spectral density for Schrodinger operators with Wigner-non-Neumann perturbation

S. Naboko
St. Petersburg State University

The analysis of the spectral density behaviour near singular points of the absolutely continuous spectrum of the Schrodinger operators with a periodic potential perturbed by a Wigner-non-Neumann type potential to be presented.It is based on the asymptotic methods and discrete linear system theory. The location of the singular points is subordinated by a sort of Bohr-Sommerfeld quantization condition.The talk is based on the common work with S.Simonov.

ST14 Boundary triplets and a result of Jost and Pais: An abstract approach

H. Neidhardt
WIAS Berlin

In 1951 was published by R. Jost and A. Pais (Phys. Rev.82, 840-851, 1951), a remarkable paper which relates the so-called Jost solution of the scattering problem for Schrödinger operators in 1D with a certain perturbation determinant. The result was generalized by F. Gesztesy, M. Mitrea and M. Zinchenko very recently to higher dimensions in a series of papers. We give an abstract version of this result in the framework of boundary triplets for symmetric operators. The main ingredients are the notions of perturbation determinant for extensions and of the abstract Weyl function both defined in this framework. The talk is based on a common work with M. Malamud from Donetsk (Ukraine).

ST15 On the degenerate spectral gaps of the one-dimensional Schroedinger operators with periodic point interactions

H. Niikuni
The University of Tokyo

We discuss the spectrum of the one-dimensional Shrödinger operator which possesses three point interactions in the basic period cell and investigate its band structure. We suppose that each point interaction on a lattice is given by a rotation or is defined by the Dirac delta function. Under some particular assumption on a lattice, we discuss the coexistence problem. Namely, we determine whether or not the jth spectral gap is degenerate for a given natural number j.

ST16 Spectral problems and quantum features of fluid in nanotube

I. Popov
St.-Petersburg State University of Information

Fluid flows through nanostructures are intensively studied now. Experiments show that these flows have many specific features, which cannot be explained in classical terms only. Particularly, flow through nanotube is extremely fast in comparison with its classical analog. We suggest a model based on the possibility of existence of molecular clusters (Frenkel crystallites) in the fluid [1]. There are some experimental evidences of such phenomenon. Under this assumption one needs to take into account quantum effects. Particularly, the boundary condition, which plays the crucial role for the flow in nanostructures, takes the form of sliding condition instead of the no-slip condition for the classical flow. The parameters of the boundary conditions are determined by solving of quantum scattering problem for the particle of the fluid by the wall potential. The character of this solution is related with the existence of bands in the spectrum corresponding to surface waves along the nanotube boundary. Main features of the flow are described in the framework of the model. For very narrow nanotubes another phenomena have an influence on the flow- possibility of existence of solitons in nanotube walls. These soliton solutions are similar to Davidov solitons in molecular chains. This model of flow is also described.

[1] S.A.Chivilikhin, V.V.Gusarov, I.Yu.Popov, A.I.Svitenkov. Model of fluid flow in a nano-channel. *R*ussian J. of Math. Phys., **15** (3), 410–412 (2008)

ST17 A generalized Hodge type analysis of Delsarte-Lions permutation operators in multidimension

A. Prykarpatsky
Ivan Franko Drohobych State Pedagogical University

A review on spectral and differential-geometric properties of Delsarte transmutation operators in multi-dimension is addressed. Their differential, geometrical and topological structure in multi-dimension is analyzed, the relationships with generalized De Rham-Hodge theory of differential complexes are stated. Some applications to integrable dynamical systems theory in multi-dimension will be presented.

ST18 Effective Hamiltonian in curved quantum waveguides as a consequence of strong resolvent convergence

H. Šediváková
Czech Technical University in Prague

The Dirichlet Laplacian in a curved two-dimensional strip built along a plane curve is investigated in the limit when the uniform cross-section of the strip diminishes. We show that the Laplacian converges in a strong resolvent sense to the well known one-dimensional Schroedinger operator whose potential is expressed solely in terms of the curvature of the reference curve. In comparison with previous results we allow curves which are unbounded and whose curvature is not differentiable. This is a joint work with David Krejčiřík.

ST19 On the eigenvalue problem for a particular class of Jacobi matrices

F. Štampach
Czech Technical University in Prague

A function F with simple and nice algebraic properties will be defined on a subset of the space of complex sequences. A relation between the function F and the eigenvalue problem for the Jacobi matrix of a special type will be illustrated. Especially, it will be shown the spectrum of infinite Jacobi matrix whose parallels to the diagonal are constant and the diagonal depends linearly on the index coincides with zeros of the Bessel function of the first kind as function of its order.

ST20 Weyl Law for Laplacian with constant magnetic field on noncompact hyperbolic surfaces with finite area

F. Truc
Institut Fourier , Grenoble

We consider a magnetic Laplacian $H(A)$ on a noncompact hyperbolic surface M with finite area. A is a real one-form and the magnetic field dA is constant in each cusp. When the harmonic component of A satisfies some quantified condition, it turns out that the spectrum of $H(A)$ is discrete and that the eigenvalue counting function satisfies the classical Weyl formula, even when $dA = 0$. Moreover the order of the remainder term is the same as in the sharp asymptotic formula recently established by W. Müller in the context of automorphic forms.

ST21 On the two-dimensional Coulomb-like potential with a central point interaction

M. Tušek
Czech Technical University in Prague

We provide an exact mathematical meaning to the formal differential expression $-\Delta_{x,y} - C\sqrt{x^2+y^2}$, $C > 0$ as a quantum mechanical observable. The resulting one-parametric family of operators comprises not only the two-dimensional Coulomb-like Hamiltonian but also the Hamiltonians with the additional point interaction. Spectral properties of these Hamiltonians as well as their Green functions are investigated in detail. The problem is also reformulated into the momentum representation. This contribution is based on the joint work with Pavel Šťovíček.

ST22 Fractional moment method for non-monotone models

I. Veselić
TU Chemniztz

The fractional moment method is a tool to show exponential decay of the averaged Green's function (in an appropriate sense) and thus Anderson localisation for many classes of ergodic, random difference operators on a lattice. Typically the method heavily relies on the monotone dependence of the operator on the random parameters. For certain models it is possible to extend the method to non-monotone parameter dependence.

2 Many body quantum systems

Invited speakers

MBQS1 Diffusion of quantum particles: Rigorous renormalization group approach

W. De Roeck
Universität Heidelberg

We consider a quantum particle interacting with a field of phonons at positive temperature. Under mild assumptions we prove that the particle diffuses in the long time limit, at small but fixed coupling strength. This result is achieved by a renormalization scheme in real space and time. The first step of this renormalization scheme consists in showing that, in the limit of vanishing coupling and for rescaled times, the particle motion is described by a quantum Boltzmann equation. Our result holds in dimension > 3 for non-equilibrium initial phonon states and > 2 for equilibrium initial phonon states. This is work in collaboration with A. Kupiainen building on earlier work (arXiv:0906.5178) with J. Fröhlich.

MBQS2 Ground state properties in non-relativistic QED

D. Hasler
Ludwig Maximilians University

We consider an atom in the framework of non-relativistic qed. We investigate the ground state and the ground state energy as functions of the coupling constant. Depending on the scaling limit of the ultraviolet cutoff these functions exhibit very different properties.

MBQS3 Non–Adiabatic Transitions in a Simple Born–Oppenheimer Model

G. A. Hagedorn
Virginia Tech

We begin with a brief description of the Time–Dependent Born–Oppenheimer Approximation of molecular quantum mechanics. We then discuss non–adiabatic transitions for the special situation described by

$$i\,\epsilon^2\,\frac{\partial\psi}{\partial t} \;=\; -\,\frac{\epsilon^4}{2}\,\frac{\partial^2\psi}{\partial x^2} \;+\; h(x)\,\psi$$

in the small ϵ (Born–Oppenheimer) limit, where $h(x)$ is a 2×2 matrix. We assume the eigenvalues of $h(x)$ have an avoided crossing with a small ϵ–independent gap and that the total energy is above the maximum of both these eigenvalues. We compute the leading order behavior for the nuclear wave function associated with the non–adiabatic transition that is generated as the nuclei move through the avoided crossing. This component is of order $\exp\left(-C/\epsilon^2\right)$. It propagates asymptotically as a free Gaussian in the nuclear variables, and its momentum is shifted. The total transition probability for this transition and the momentum shift are both larger than what one would expect from a naïve approximation and classical energy conservation.

Contributed talks

MBQS4 On the ground state energy for massless Nelson models

A. Abdesselam
University of Virginia

I will present new results obtained in joint work with D. Hasler, on the ground state energy of Nelson's model in the massless case.

MBQS5 On the ionization energy of the semirelativistic Pauli-Fierz model

I. Sasaki
Shinshu University

We consider the semi-relativistic Pauli-Fierz model which is defined by the relativistic kinetic energy $\sqrt{[\sigma \cdot (\mathbf{p} + e\mathbf{A}(\hat{\mathbf{x}}))]^2 + M^2} - M$, instead of the non-relativistic one $[\sigma \cdot (\mathbf{p} + e\mathbf{A}(\hat{\mathbf{x}}))]^2/2M$, in the Pauli-Fierz Hamiltonian. We show that the ionization energy of the semi-relativistic Pauli-Fierz model is strictly positive for all values of a coupling constant and particle mass $M \geq 0$. The total Hamiltonian contains the nuclear potential $V(\mathbf{x})$, and it is assumed that the semi-relativistic Schrödinger operator $\sqrt{\mathbf{p}^2 + M^2} - M + V(\mathbf{x})$ has a negative energy ground state.

MBQS6 Completely local interpretation of many-body quantum phenomena

R. Sverdlov
Raman Research Institute

The purpose of this talk is to come up with a framework that "converts" existing concepts from configuration space to ordinary one. This is done by modeling our universe as a big "computer" that simulates configuration space. If that "computer" exists in ordinary space and is ran by "classical" laws, our theory becomes "local", "deterministic" and "classical" by default. This concept will first be applied to a version of quantum field theory in which elementary particles have size (that is, a theory that does not yet exists). After that, we will do the same with Pilot Wave model of discrete jumps, due to Dürr et el.

MBQS7 Rotating Ultracold Dipolar Gases

C. Yüce
Anadolu University

The basic physics of rotating ultracold dilute trapped atomic gases, with emphasis on Bose-Einstein condensation is briefly reviewed. The solution to the nonlinear Schrodinger equation in the rotating frame is presented. The effect of dipole-dipole interaction on an off-axis straight vortex in a rotating ultracold gas is studied and vortex nucleation with many observable consequences is discussed.

MBQS8 On the Discrete Spectrum of Many Particle Hamiltonians of Some Nuclear Models

G. Zhislin
Nizhni Novgorod, Russia

Let $H(Z)$ be nonrelativistic hamiltonian of the relative motion of quantum system Z, consisting of the set N of n neutron type identical particles and of the set P of p proton type identical particles. Let $W(i,j)$ be the interaction potential for the particles number i and j. We assume 1) that $W(i,j)$ is short-range for i,j from N, 2)that $W(i,j) = bV(i,j)$, $b > 0$, $V(i,j) > 0$,is long-range for i,j from P and 3) that $W(i,j) = qV(i,j)$, $q < 0$, for i from N, j from P.
Theorem 1. Let $(p-1)+qn < 0$. Then the discrete spectrum of the operator $H(Z)$ is infinite. Let $H(Z,A)$ be the restriction of the operator $H(Z)$ to the subspace of functions, having the type A of permutation symmetry according to permutations of identical particles from Z.
Theorem 2. Under condition of Theorem 1 the discrete spectrum of the operator $H(Z,A)$ is infinite for any A.

3 Quantum chaos

Invited speakers

QC1 Onset of quantum chaos in one-dimensional many-body systems and its relation to thermalization

L. Santos
Yeshiva University

By means of exact diagonalization, we study level statistics, the structure of the eigenvectors, and few-body observables of one-dimensional bosonic and fermionic systems across the transition from integrability to quantum chaos. These systems are integrable in the presence of only nearest-neighbor terms, whereas the addition of next-nearest interaction may lead to the onset of chaos. We show that the eigenstate thermalization hypothesis, which is accompanied by the thermalization of the system, is valid whenever quantum chaos develops and even if the system is in the gapped phase. We discuss the dependence of signatures of nonintegrability on system size and particle statistics, and the use of delocalization measures as main indicators for the crossover from integrability to chaos.

QC2 Quantized open chaotic systems

S. Nonnenmacher
IPhT, CEA-Saclay

I will review some results in the spectral theory of "open quantum chaos", applicable in the following situations:

- scattering wave systems with a fractal hyperbolic repeller
- damped waves on a surface of negative curvature.

In both situations, the "spectrum" is made of complex eigenvalues, some properties of which (spectral gap, density of states) can be connected with classical invariants of the chaotic motion.

QC3 Classical orbit correlations: the key for understanding universality in quantum chaotic systems

K. Richter
University of Regensburg

A chaotic classical system is characterized by apparently random, ergodic phase space flow. However, a closer inspection shows that (periodic) orbits in chaotic systems are not independent but appear in bundles exhibiting strong classical correlations. While hidden in classical dynamics, these correlations are revealed through constructive interference in the corresponding quantum system.

I will introduce an advanced semiclassical path integral approach to demonstrate that such correlations are responsible for the universal behavior exhibited by quantum systems with a chaotic classical limit. Thereby I will provide a microscopic understanding of random matrix theory predictions for this universal behavior. This is relevant for spectral statistics but moreover in particular for chaotic scattering and for transport processes. I will address recent applications of this semiclassical theory to quantum transport of electrons on mesoscopic scales [1].

[1] J. Kuipers, D. Waltner, C. Petitjean, G. Berkolaiko and K. Richter, *Phys. Rev. Lett.* **104**, 027001 (2010).

Contributed talks

QC4 Many-particle systems on quantum graphs with singular interactions

J. Bolte
Royal Holloway, University of London

Single quantum particles on graphs have proven to provide interesting models of complex quantum systems; their spectral properties have been studied in great detail. In this talk we discuss extensions to quantum many-particle systems on graphs with singular interactions. We focus on two-particle interactions that are either localised at the vertices, or are of Dirac-delta type on the edges. In both cases the interactions are realised in terms of self-adjoint extensions of suitable Laplacians in two variables. These extensions can be characterised in terms of boundary conditions, and given particular boundary conditions the type of interactions can be identified. (This talk is based on joint work with Joachim Kerner.)

QC5 Parameter-dependent spectral statistics of quantum graphs

O. Hul
Institute of Physics, Polish Academy of Sciences

Parameter-dependent spectral statistics of totally connected quantum graphs are studied. We consider two different types of spectra of quantum graphs. The first one is the spectrum of the Laplacian on a metric graph, and the second one is the spectrum (eigenphases) of the scattering matrix of a quantum graph. We found out that in both cases the parameter-dependent spectral statistics are very similar to each other.

This work was partially supported by the Ministry of Science and Higher Education.

QC6 Integrable theory of quantum transport in chaotic cavities

E. Kanzieper
Holon Institute of Technology & Weizmann Institute of Science

In this talk, I will show that the paradigmatic problem of conductance fluctuations in chaotic cavities with broken time-reversal symmetry is completely integrable in the universal transport regime. This observation will be utilised to prove that the cumulant generating function of the Landauer conductance in the cavities probed via ballistic point contacts is given by the fifth Painlev transcendent. If time permits, a closely related integrable theory of the noise power fluctuations in the crossover regime between thermal and shot noise will also be outlined.

4 Quantum field theory

Invited speakers

QFT1 Renormalization and resolution of singularities

C. Bergbauer
Universität Mainz, SFB 45

I will describe the combinatorial features of perturbative renormalization of Feynman integrals using resolutions of singularities in the sense of algebraic geometry, for example the Fulton-MacPherson compactification of configuration spaces. I will also sketch the relation to the Connes-Kreimer Hopf algebras and to other recent advances in the area. This is based on joint work with R. Brunetti and D. Kreimer.

QFT2 Renormalization Hopf algebras for gauge theories and BRST symmetries

V. van Suijlekom
Radboud University Nijmegen

The structure of the Connes–Kreimer renormalization Hopf algebra is studied for Yang-Mills gauge theories, with particular emphasis on the BRST-formalism. A coaction of the renormalization Hopf algebra is defined on the coupling constants and the fields. In this context, BRST-invariance of the action implies the existence of certain Hopf ideals in the renormalization Hopf algebra, encoding the (physical) Slavnov-Taylor identities for the coupling constants.

Contributed talks

QFT3 Topological charges for finite energy fields in a sigma-model

J. Dittrich
Nuclear Physics Institute ASCR

In the (2+1)-dimensional classical O(3) sigma-model, all finite energy fields have integer topological charges regardless of their asymptotic behavior at infinity. Topological charge is conserved for the fields with finite Euclidean action, without further assumptions on the field equations or asymptotics. The fields with continuous first derivatives as well as fields in Sobolev-like spaces analogical to $W^{1,2}$ are considered.

QFT4 Asymptotic completeness in wedge-local QFT

W. Dybalski
TU Muenchen

A novel deformation procedure has recently been proposed by Grosse and Lechner as a tool for construction of interacting quantum field theories with observables localized in spacelike wedges. In this talk this procedure is applied to two-dimensional theories of massless particles. The behavior of the scattering matrix under the deformation is obtained explicitly. It is shown that the deformation procedure not only introduces interaction but also preserves the property of asymptotic completeness. In particular, the deformations of chiral conformal quantum field theories give rise to interacting, wedge-local models which are asymptotically complete.

QFT5 Exact solution of a 2+1 dimensional interacting fermion model

E. Langmann
KTH Stockholm

We present a quantum field theory model describing interacting fermions in 2+1 dimensions that can be solved exactly using bosonization (to our knowledge, this model was first proposed by Mattis). This model gives an effective description of spinless fermions on a square lattice with local hopping and density-density interactions if, close to half filling, the system develops a partial energy gap. We present arguments that, after appropriate renormalizations, all short- and long distance cutoffs in this model can be removed.

If time permits we also present an exactly solvable 2+1 dimensional analogue of the Schwinger model.

(Based on common work with Jonas de Woul and, in particular, the following paper:
arXiv:math-ph/0606041v3 (to appear in Lett. Math. Phys.)
arXiv:0907.1277v2 [math-ph] (to appear in J. Stat. Phys.)
arXiv:0903.0055v3 [math-ph])

QFT6 Ground states of supersymmetric matrix models

D. Lundholm
Royal Institute of Technology (KTH) / Copenhagen University

We review recent progress concerning the problem of determining existence, uniqueness, and structure of zero-energy ground states in supersymmetric matrix models, which arise from a quantum mechanical description of relativistic membranes, reduced Yang-Mills gauge theory, and of nonperturbative features of string theory, respectively M-theory. One of the recent approaches involves introducing a weighted Hilbert space, and counting the number of negative eigenvalues of a certain perturbation of the associated matrix-valued Schrödinger operator.

QFT7 Foundation of Quantum Potential based on Generalized Quantum Hamilton-Jacobi Equation

M. Mollai
Islamic Azad University of Mashhad

Canonical transformations play a central role in classical mechanics. Based on their classical analogues, one would expect them to provide a powerful quantum tool. We sketch and emphasize here the automatic emergence of a quantum potential Q in e.g. quantum Hamilton-Jacobi equation without inserting a (Bohmian) polar complex wave function $\psi = \exp(iS/h)$. The interpretation of Q in terms of independent entity is discussed along with the discussion about $R2$ as a probability density.

QFT8 Factorization Method and Special Orthogonal Functions

H. Motavalli
Tabriz university

We present a general construction for ladder operators for the special orthogonal functions based on Nikiforov-Uvarov mathematical formalism. A list of creation and annihilation operators are provided for the well known special functions. Furthermore, we establish the dynamic group associated with these operators.

QFT9 Infrared aspects of a model of QFT on a static space time

A. Panati
Centre de Physique Théorique, Luminy

We consider the Nelson model with variable coefficients, which can be seen as a model describing a particle interacting with a scalar field on a static space time. We consider the problem of the existence of the ground state, showing that it depends on the decay rate of the coefficients at infinity. We also show that it is possible to remove the ultraviolet cutoff, as it is in the flat case (joint work with C.Grard, F.Hiroshima, A.Suzuki)

QFT10 Asymptotic Completeness Below the Two-Boson Threshold of the Translation Invariant Nelson and Polaron Models

M. G. Rasmussen
Aarhus University

We present some recent results on a class of models including the massive translation invariant Nelson model and the Polaron model of H. Fröhlich. The results are valid for arbitrary values of the coupling constant, and include absence of singular continuous spectrum below the two-boson threshold as well as a partial asymptotic completeness result, valid for the model restricted to the associated subspace. As a by-product, we get a so-called geometric asymptotic completeness result, which holds for the full model. The talk is based on joint work with Jacob Schach Møller.

QFT11 Causal Interpretation of Klein Paradox for Downward Step

S. Razavi Govareshk
Islamic Azad University of Mashhad

The Bohmian trajectories of the incoming scattering plane waves for Kleins potential step in explicit form have been done. In this work the Bohmian trajectories are discussed in downward step. For finite norm incoming scattering solutions we derive their asymptotic space-time localization and we compute some Bohmian trajectories analytically.

QFT12 Krein Spaces in de Sitter Quantum Theories

P. Siegl
FNSPE CTU in Prague & NPI AS CR & APC Universite Paris 7

Experimental evidences and theoretical motivations lead to consider the curved space-time relativity based on the de Sitter group SO(1,4) or Sp(2,2) as an appealing substitute to the flat space-time Poincare relativity. Quantum elementary systems are then associated to unitary irreducible representations of that simple Lie group. At the lowest limit of the discrete series lies a remarkable family of scalar representations involving Krein structures and related indecomposable representation cohomology which deserves to be thoroughly studied in view of quantization of the corresponding carrier fields. The purpose of this presentation is to indicate possible extensions of an exemplary case, namely the so-called de Sitterian massless minimally coupled field.
This is a joint work with J.-P.Gazeau and A. Youssef.

5 Quantum information

Invited speakers

QC1 The quantum and classical embedding problems

T. Cubitt
University of Bristol

The embedding problem is a long-standing open problem in probability theory, dating at least as far back as 1937. The problem is to characterise of the stochastic maps that can be generated by a continuous-time Markov process. A very similar question can be asked in the quantum setting, where the problem becomes one of characterising the completely-positive maps that can be generated by a master equation.

From the literature, these may appear to be very abstract mathematical problems. Far from it! The embedding problem (and its quantum generalisation) is closely related to a very practical task in experimental physics. Imagine that you have gathered a large amount of measurement data for some physical system, whose behaviour you would like to understand. The embedding problem is essentially the problem of using that experimental data to reconstruct the dynamical equations of the system.

In recent work, we [1,2] finally layed both the classical and quantum embedding problems to rest, by proving that they are NP-hard. I will explain the embedding problems and their relation to physics, outline their recent resolution, and discuss their implications.

[1] T. S. Cubitt, J. Eisert, M. M. Wolf, arXiv:0908.2128[math-ph]
[2] T. S. Cubitt, J. Eisert, M. M. Wolf, arXiv:1005.0005[quant-ph]

QC2 Holographic quantum states

T. Osborne
Royal Holloway

In this talk I'll describe how continuous matrix product states of quantum field theories can be described in terms of the dissipative non-equilibrium dynamics of a lower-dimensional auxiliary boundary field theory. This equivalence illustrates an intimate connection between the theory of continuous quantum measurement and quantum field theory and gives an explicit construction of the boundary field theory allowing the extension of real-space renormalization group methods to arbitrary dimensional quantum field theories without the introduction of a lattice parameter.

QC3 Mixing times of quantum Markov processes

F. Verstraete
Univerity of Vienna

We will talk about mixing times of quantum stochastic processes, and discuss applications to quantum spin systems, quantum field theories and the construction of novel quantum algorithms.

Contributed talks

QC4 Perfect state transfer within networks of arbitrary topology

T. Brougham
CTU in Prague (Doppler Institute)

The task of constructing a quantum computer has many technical challenges associated with it. One such example is transferring the state of a quantum system between different components of a quantum computer [1]. A common approach to this problem is the use of a quantum wire, i.e. a chain or network of coupled quantum systems where the interactions are such that the quantum state is transferred through the wire. Many different realizations of such perfect state transfer (PST), using quantum wires, have been proposed [2-4]. The approach that is often taken to the problem of PST is to construct a Hamiltonian and show that this allows the state to be perfectly transferred. An alternative approach has been proposed that enables a broad class of Hamiltonians to be constructed [5]. This approach does not make any assumptions about the coupling or the topology of the network. Instead, a class of Hamiltonians that lead to a particular permutation are derived. This work was developed for the task of transferring a state between two points in a network. We will show how one can use the formalism outlined in [5] to control quantum information in a more general manner. For example, we may wish to transfer a state to several different nodes within a network, at different times. This would enable us to generalize the problem of PST to networks with a nontrivial logical bus topology. The formalism can also be used to find Hamiltonians that enable PST when we have multiple interacting excitations.

[1] D. P. DiVincenzo, Fortschr. Phys. 48, 771 (2000).
[2] S. Bose, Phys. Rev. Lett. 91, 207901 (2003).
[3] G. M. Nikolopoulos, D. Petrosyan and P. Lambropoulos, Europhys. Lett. 65, 297 (2004).
[4] M. Christandl, N. Datta, A. Ekert, A. Kay and A. J. Landahl, Phys. Rev. Lett. 92, 187902 (2004).
[5] V. Kostak, G. M. Nikolopoulos, and I. Jex, Phys. Rev. A 75, 042319 (2007).

QC5 Controllability of quantum walks on graphs

D. D'Alessandro
Iowa State University

In recent years, quantum walks on graphs have emerged as one of the most useful protocols to design quantum algorithms. The study of the controllability of these systems refer to the analysis of the set of states the system can be in. In this talk, I will consider discrete time quantum walks on graphs with coin. These systems consist of two coupled quantum systems: a walker system whose states are in correspondence with the nodes of the underlying graph and a coin system whose states indicate the directions for the motion on the graph. The evolution consists of two operations at each step: a coin tossing operation which is a unitary operation on the space of the coin only and a conditional shift operation which changes the state of the walker system according to the current value of the coin. The talk deals with the case where the coin operation can be changed at every time step and presents a study of the set of possible evolutions and states. The first result discussed says that the set of available unitary transformations is a Lie group whose Lie algebra can be described explicitly in every case. The system is called completely controllable if the set of available evolutions is the full unitary group. I give both Lie algebraic and combinatorial tests to check complete controllability. In particular, the combinatorial tests are based on the construction of an auxiliary graph whose connectedness is equivalent to the controllability of the given system. This test avoids Lie algebraic calculations which typically involve commutators of very large matrices. I prove that controllability only depends on the underlying graph and not on the specific quantum walk considered on it. It is in particular always verified for complete graphs and product graphs of controllable systems. In view of this dynamical and control theoretic analysis, in the second part of the talk, I take a different look at two issues of current interest in quantum information: quantum algorithms and approximation of continuous dynamics by discrete time quantum walks. A quantum algorithm is a sequence of unitary operations to transfer the state of a quantum system from an initial value to a desired final value. As such, it can be seen as a control algorithm. I provide general constructive algorithms to transfer between two arbitrary states for a quantum walk. These consist of appropriate sequences of coin tossing operations and conditional shifts. I give an upper bound on the number of steps needed for an arbitrary transfer which depends on the features of the underlying graph. Furthermore, I discuss the interplay of these results with two types of algorithms of current interest in quantum information: search algorithms on a graph and algorithms to generate certain outputs with a prescribed probability distribution which are at the heart of classical randomized algorithms. As for the approximation of continuous time dynamics by discrete time quantum walks, the controllability analysis leads to the study of a special Lie algebra of skew-Hermitian operators on the full space for the coin and walker systems. The continuous time evolutions corresponding to Hamiltonians in this Lie algebra (modulo multiplication by the imaginary unit) can be reproduced using the discrete time quantum walk. This can be achieved both exactly and approximately with various constructive methods. I illustrate this using an example: a quantum walk on a 2-dimensional periodic lattice. Of particular interest are dynamics that correspond to continuous time quantum walks on the same graph. The described results give a general method to obtain the continuous time quantum walk as a limit of the discrete time quantum walk and, in that, answer an open question in quantum information theory. Moreover they offer tools to compare the performance of the discrete and continuous quantum walks in several cases. [In collaboration with Dr. F. Albertini at the University of Padova, Italy]

QC6 Phase transitions and metastability in the distribution of the bipartite entanglement of a large quantum system

A. De Pasquale
Physics department, University of Bari

We study the distribution of the Schmidt coefficients of the reduced density matrix of a quantum system in a pure state. By applying general methods of statistical mechanics, we introduce a fictitious temperature and a partition function and translate the problem in terms of the distribution of the eigenvalues of random matrices.We investigate the appearance of two phase transitions, one at a positive temperature, associated with very entangled states, and one at a negative temperature, signaling the appearance of a significant factorization in the many-body wave function. We also focus on the presence of metastable states (related to two-dimensional quantum gravity) and study the finite size corrections to the saddle point solution.

QC7 Classical Statistical Mechanics Approach to Multipartite Entanglement

G. Florio
University of Bari

We characterize the multipartite entanglement of a system of n qubits in terms of the distribution function of the bipartite purity over balanced bipartitions. We search for maximally multipartite entangled states, whose average purity is minimal, and recast this optimization problem into a problem of statistical mechanics, by introducing a cost function, a fictitious temperature and a partition function. By investigating the high-temperature expansion, we obtain the first three moments of the distribution [1]. On the other hand, when many bipartitions are considered, the requirement that purity be minimal for all bipartitions can engender conflicts and frustration arises. This unearths an interesting link between frustration and multipartite entanglement [2].

[1] J. Phys. A: Math. Theor. 43, 225303 (2010)
[2] New Journal of Physics 12, 025015 (2010)

QC8 Optimal parametrizations of adiabatic paths

M. Fraas
Technion Haifa

The parametrization of adiabatic paths is optimal when tunneling is minimized. Hamiltonian evolutions do not have unique optimizers. However, dephasing Lindblad evolutions do. The optimizers are simply characterized by an Euler-Lagrange equation and have a constant tunneling rate along the path irrespective of the gap. Application to quantum search algorithms recovers the Grover result for appropriate scaling of the dephasing. Dephasing rates that beat Grover imply hidden resources in Lindblad operators.

QC9 Entanglement and functions of nilpotent variables

A. Frydryszak
University of Wroclaw

Within supersymmetric theories fermions are described with use of the grassmannian variables - anticommuting, hence, nilpotent. Recently proposed formalism based on nilpotent, but commuting variables, turns out to be suitable to describe qubit systems. Separability of multiqubit states can be examined in terms of factorability of functions of such nilpotent variables. Relevant functional determinants are naturally linked to the invariants known from the Classical Invariant Theory, and used for characterization of multiqubit pure state entanglement. I will present the "nilpotent" analog of the Schroedinger representation and formalism for description multiqubit systems and entanglement. It turns out that some of interesting multiqubit entangled states proposed in quantum optics context, are represented by elementary functions of nilpotent variables.

QC10 Single photon quantum walk with adjustable coin operations

A. Gábris
Czech Technical University in Prague

We present a robust implementation of a coined quantum walk over 14 steps using only passive optical elements. At the core of our realization is a fiber optical network loop which allowed to keep the amount of required resources constant as the walkers position Hilbert space is increased. We have observed a non-Gaussian distribution of the walkers final position, thus characterizing a faster spread of the photon wave packet in comparison to the classical random walk. The walk is realized for many different coin settings and initial states, necessary for future implementation of quantum-walk-based search algorithms.

QC11 Asymptotic dynamics of quantum systems under random unitary uvolution

J. Novotný
TU Darmstadt, CTU Prague

We investigate the asymptotic dynamics of quantum systems resulting from large numbers of iterations of randomly aplied unitary quantum operations. Despite the fact that in general the evolution superoperator of such random unitary operations cannot be diagolanlized it is shown that the resulting iterated asymptotic dynamics is discribed by a diagonalizable superoperator. As a consequence it turns out that tipically the resulting iterated asymptotic dynamics is governed by a low dimensional attractor space which is determined completely by the unitary transformations involved and which is independent of the probability distributions with which these unitary transformations are selected. Based on this general approach analytical results are presented for the asymptotic dynamics of large qubit networks whose nodes are coupled by randomly applied unitary operations. These networks appear to be a good tool for studying phenomens like decoherence, thermalization or quantum homogenization.

QC12 Quantum Levy walks

V. Potoček
FNSPE, Czech Technical University in Prague

Quantum walks form an interesting paradigm for quantum computing, which has been appreciated mainly for the faster spreading than classical random walks allow. On the other hand, in the classical theory one can meet so-called Levy random walks, which, by relaxing the condition on the locality of the steps, also have interesting spreading and hitting properties. Recently, Levy walks have been shown to be optimal for searching for sparse samples in 2D, and they have been observed to be used for this purpose in real natural processes. In this talk, we propose a novel concept of Quantum Levy Walks, obtained by combining of the two above enhancements of a random walk. We define a quantum Levy walk on an infinite line and on a circle and discuss their basic properties. We briefly address the potential uses of this theory.

QC13 Molecular solution for the subset-sum problem on DNA -based quantum computing

M. Rezaei Karamati
University of Tabriz

Molecular computation was proposed by Feynman in 1961 and it was showed that computing devices based on quantum theory are able to finish computations faster than the standard Turing machines. In 1994, Adleman succeeded to solve an instance of the Hamiltonian path problem in a test tube, just by handling DNA strands. Lipton investigated a special case of more general methods that could solve NP-complete problems using DNA experiments. Deutsch presented a general model of quantum computation i.e., the quantum Turing machine. Molecular solution for the subset-sum problem on DNA-based supercomputing has been offered by Chang in 2003. It has been proved, the subset-sum problem is the NP-complete problem (Cormen et al., 2003; Garey and Johnson, 1979; Cook, 1971; Karp, 1972).

Here, a finite set $S = \{s_1, ..., s_q\}$ is defined for solving subset-sum problem using DNA-based algorithm and it is supposed that every elements in S are positive integer. Now the aim is finding possible subsets S_i as a subset of S such that the sum of all elements in S_i be exactly equal to b, where b is a positive integer and can implement by Hadamard gates, NOT gates, CNOT gates, CCNOT gates, Grover's operators, and quantum measurements on a quantum computer. In order to achieve this, first we use q number Hadamard gates to construct 2^q possible subsets of a q-element set S, then we apply NOT gates, CCNOT gates and Grover's operators to construct solution space. It is demonstrated, the DNA-based quantum algorithm of an n-qubit parallel adder and a DNA based quantum algorithm of an n-qubit parallel comparator can implement using quantum gates and Grover's operators to formally verify our designed molecular solutions for the subset-sum problem. For this propose, we introduce some quantum registers again and compute solutions spaces, in each step by using 19-CCNOT gates , and NOT gates. Last algorithm is parallel comparator for comparing the sum of elements for subsets of a finite set with any given positive integer by using quantum gates and Grover's operators.

QC14 Optimal replication of von Neuman measurements

M. Sedlák
Dipartimento di Fisica A. Volta, Universita degli studi di Pavia

Suitable mathematical representation of objects emerging in quantum mechanics is crucial for solving most of the optimization problems. Introduction of Process Positive Operator Valued Measures (PPOVM) and Quantum Combs allowed to solve several problems in which the most general (thought) experiments involving N uses of a tested quantum channel (completely positive trace preserving maps) have to be optimized. In this contribution, we apply quantum combs to optimize quantum circuits achieving transformations of measurements. More precisely, such a circuit has to work as one big POVM after N measurements are inserted into the open slots of the circuit. The aim of the circuit is to create M replicas of the inserted measurements, which are assumed to be unknown POVMs of the Von Neuman type (i.e. non-degenerate projective measurements). We show that for arbitrary figure of merit the presence of measurements in the circuit allow us to restrict the optimization to a subclass of quantum combs, which are called diagonal. Using diagonal quantum combs we solve the following tasks: N→ 1, 1→2 Learning of a qudit POVM (N=1,2,3) and 1→2 Cloning of a qudit POVM. The goal of N→M Learning of a POVM is to use the unknown measurement N times, store what was learned about it in a quantum memory and later retrieve M uses of the original measurement on a state that is not available in the learning phase. In contrast in N→M Cloning of a POVM the state to be measured is available from the very beginning, but we have to mimic M>N uses of the unknown measurement by using it just N times. We compare the performance of the optimal 1→2 Learning with 1→2 Cloning of a POVM. Similarly, to the analogous tasks for unitary channels the performance of cloning is much better than that of learning. We discovered that the uses of the unknown measurements in the optimal circuit cannot be parallelized for 3→1 Learning of a qudit POVM. Thus, N→1 Learning of a qudit POVM represents a task, where the optimal strategy is necessarily sequential. This feature of non-parallelizability is present also in Grover algorithm, where the calls to the oracle cannot be parallelized as was shown by Zalka. Indirectly, our findings can help to understand how to search for optimal quantum circuits i.e. optimal quantum algorithms with oracle callings, which cannot be parallelized.

QC15 Quantum walks with two particles

M. Štefaňák
Czech Technical University in Prague

We study the motion of two non-interacting particles performing a quantum walk on a line. We focus on the spatial correlations and the meeting problem. Influence of entanglement and indistinguishability of the particles are analyzed. Applications to experimental realizations of two-dimensional quantum walks are briefly discussed.

QC16 Decay of coherent states for damped harmonic oscillator

N. Unal
Akdeniz University

In this study, we discuss the effect of damping on the coherent states of the harmonic oscillator. The damping is represented by an exponentially increasing mass in time.

QC17 Uncertainty Relations and Entanglement in Fermion Systems

C. Zander
University of Pretoria

The entanglement-related features of systems of identical fermions are relevant to the study of diverse physical systems and also have implications for the development of quantum information technology. However, the concept of entanglement in fermion systems differs from the corresponding concept in systems consisting of distinguishable subsystems. In particular, the development of criteria for entanglement detection for mixed quantum states is much more difficult in the case of fermion systems and remains a largely unexplored problem. The aim of the present contribution is to investigate the violation of uncertainty relations as a signature of entanglement for both pure and mixed states of two identical fermions. In the case of fermions with a four dimensional single particle Hilbert space we obtain several different types of uncertainty-related entanglement criteria based on local uncertainty relations, on the sum of variances of projectors and on various entropic measures. Within the latter approach we consider either entropic uncertainty relations involving a single observable or relations based upon the sum of entropies associated with more than one observable. We extend the projector based entanglement criterion to the case of two-fermion and three-fermion systems with a six dimensional single particle Hilbert space.

6 Physics of social systems

Invited speakers

PSS1 Morphology of the land parcel mosaic: The key to understand the urbanization process

M. Fialkowski
Department of Physical Chemistry, Polish Academy of Sciences

Many structures both natural and artificial such as cities, arise as a result of continuous complex processes. These processes transform the environment and leave behind acharacteristic spatial structure a kind of their morphological fingerprint. In some cases it is possible to infer the nature of the process from the observed morphological structure. In my presentation I discuss the fragmentation of land accompanying the urbanization process. Here, the morphological fingerprint is the mosaic formed by the land parcels. The parcel pattern exhibits only three, well-defined morphological types. Each type is unambiguously determined by the shape of the distribution function of the parcel sizes. The following three types of the parcel size distribution are found: (1) power-law distribution with the exponent equal to 2, (2) power-law distribution with the exponent equal to 1, and (3) log-normal distribution. They correspond, respectively, to a highly urbanized core of a city, rural area, and suburban area. These regularities indicate that some universal mechanism underlies the process of land fragmentation by humans. I my presentation I present also a mechanism of the city formation within a two-dimensional bond percolation. Within this model, a city is formed from the collection of settlements when the density of urban street network reaches some critical value corresponding to the percolation threshold. The model reproduces faithfully all properties of the morphology of the parcel pattern observed in the city cores analysed.

PSS2 Reliability issues in the microscopic modelling of pedestrian movement

B. Steffen
Forschungszentrum Jülich GmbH

Microscopic models of pedestrian movement have been developed since 1990 mainly to gain insight into the mechanisms behind known pattern of movement or jamming, and to predict evacuation time and critical areas during evacuation in the planning and authorization process of large buildings and pedestrian facilities. This raises the question of reliability: Is the model capable of calculating the correct movement and to what detail, and are the parameters known well enough that they can be applied in routine practice of civil engineering. It is shown that used properly, the different models all can predict evacuation times fairly accurately and give further useful information; but the proper use requires expertise, and the models generally are not correct down to the degree of detail they provide. Modern overhead video equipment is capable of giving correct trajectories of persons even in high density situations, and so a detailed verification will be possible in the future, hopefully leading to much improved reliability of the models.

The talk reports joint work with Armin Seyfried and Maik Boltes (all Forschungszentrum Jülich GmbH)

PSS3 Urban structure analysis

D. Vašata
Czech Technical University

The built-up land represents an important type of overall landscape. We analyse the structure of built-up land mainly in urban areas of the Czech Republic using the framework of statistical physics. To do this, both the variance of the built-up area and the number variance of built-up landed plots in circles are calculated.

In both cases the variance as a function of a circle radius follows a power law. The obtained value of the exponents are comparable to exponents typical for critical systems.

The scale invariance as a most fundamental property of critical systems is discussed. The study is based on cadastral data from the Czech Republic.

This is joint work with Petr Šeba and Pavel Exner.

Contributed talks

PSS4 The totally asymmetric simple exclusion process in two–dimensional finite lattice, comparison of density profiles

P. Hrabák
Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University

A two–dimensional model based on the totally asymmetric exclusion process is introduced. It's dynamics is inspired by pedestrian movement. We come out of the one–dimensional TASEP with open boundaries defined on a finite lattice of N sites. This model is solvable by means of the Matrix Product Ansatz method, which gives exact formulas for density profiles and phase diagram containing three phases, maximal current, low- and high–density phase; for both time continuous dynamics and discrete parallel updates. We define similar dynamics on a rectangle lattice of

MxN sites with open boundaries. Several update procedures are discussed, and the permutation–parallel update is introduced. Via computer simulations the average density in steady state has been studied, and similar behavior to the one dimensional model has been observed. We have identified the same three phases and the same shape of the transition line between the low- and high–density phase. Finally, an idea of generalization for two particle species model is presented.

PSS5 Elliptical Volume Exclusion of Pedestrian Crowd

M. Chraibi
Forschungszentrum Jülich

This paper introduces a spatially continuous force-based model for simulating pedestrian dynamics. By means of repulsive forces collision-avoidance is performed by moving pedestrians. A driving force models the intention of pedestrians to reach some destination. The main intention of the developed model is the quantitative description of pedestrian movement in several geometries. Measurements of the fundamental diagram in narrow and wide corridors are performed. The results of the proposed model show a good agreement with empirical data. Having the ambition to describe with the same set of parameters the dynamics in one and two dimensional space we extend our model by introducing an elliptical volume exclusion. Given a pedestrian i we define an ellipse with velocity-dependent major semi-axis a and minor semi-axis b. The space requirement of pedestrian i is given by a, and b reflects the swaying of pedestrians while moving. To guarantee robust numerical integration of the equation of motion and to restrict the range of the repulsive force to those between adjacent pedestrians, a two-sided Hermite-interpolation of the repulsive force is implemented.

PSS6 Employment, Production and Consumption Model: Patterns of Phase Transitions

H. Lavička
FNSPE, Czech Technical University

We have simulated the model of Employment, Production and Consumption (EPC) using Monte Carlo. The EPC model is an agent-based model that mimics very basic rules of industrial economy. From perspective of physics, the nature of the interactions in the EPC model represents multi-agent interactions where the relations among agents follow the key laws for circulation of capital and money. Monte Carlo simulations of the stochastic model reveal phase transition in the model economy. The two phases are the phase with full unemployment and the phase with nearly full employment. The economy switches between these two states suddenly as a reaction to a slight variation in the exogenous parameter, thus the system exhibits strong non-linear behavior as a response to the change of the exogenous parameters.

Social programme

Concert

The concert will take place on *Tuesday, September 7* at 8 pm in the *Church of the Assumption of the Blessed Virgin Mary* in the historical city centre. The programme:

- A. Corelli: Concerto groso No. 8
- W. A. Mozart: A selection of opera arias
- J. Suk: A meditation on the Old Czech Chorale "Saint Wenceslas"
- L. Janáček: Suita for strings

The performance will be given by the UHK Chamber Orchestra, the price is included in the registration fee.

Excursion

The conference trip will be arranged on *Wednesday, September 8* to *Adršpach Rock Town and Náchod Brewery*. The latter is a national natural protected area covering an area of 17 squared kilometers, where Sandstone fins eroded into many interesting rock formations by water, wind and frost. It offers many marked tourist trails. Beside romantic walks among bizarre rock formations there are also lots of challenging climbing opportunities. Around the so-called Grand and Small Waterfall and a natural lake you can have a boat ride for an extra EUR 1.50.

Náchod Primátor is one of lesser known but high quality beers; its water comes from Adršpach, malt from South Moravia and the hops from Žatec region. We will visit the brewery, taste the beer and have a dinner there.

The charge for the trip is EUR 25.

Conference dinner

The conference dinner will be held on *Thursday, September 9* at *Nové Adalbertinum* in the historical city centre. The price is included in the conference fee.

Dinner organised in honour of Ari Laptev 60th birthday

The birthday dinner for Ari Laptev's colleagues and friends will be held on *Friday, September 10* at *Nové Adalbertinum*.

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