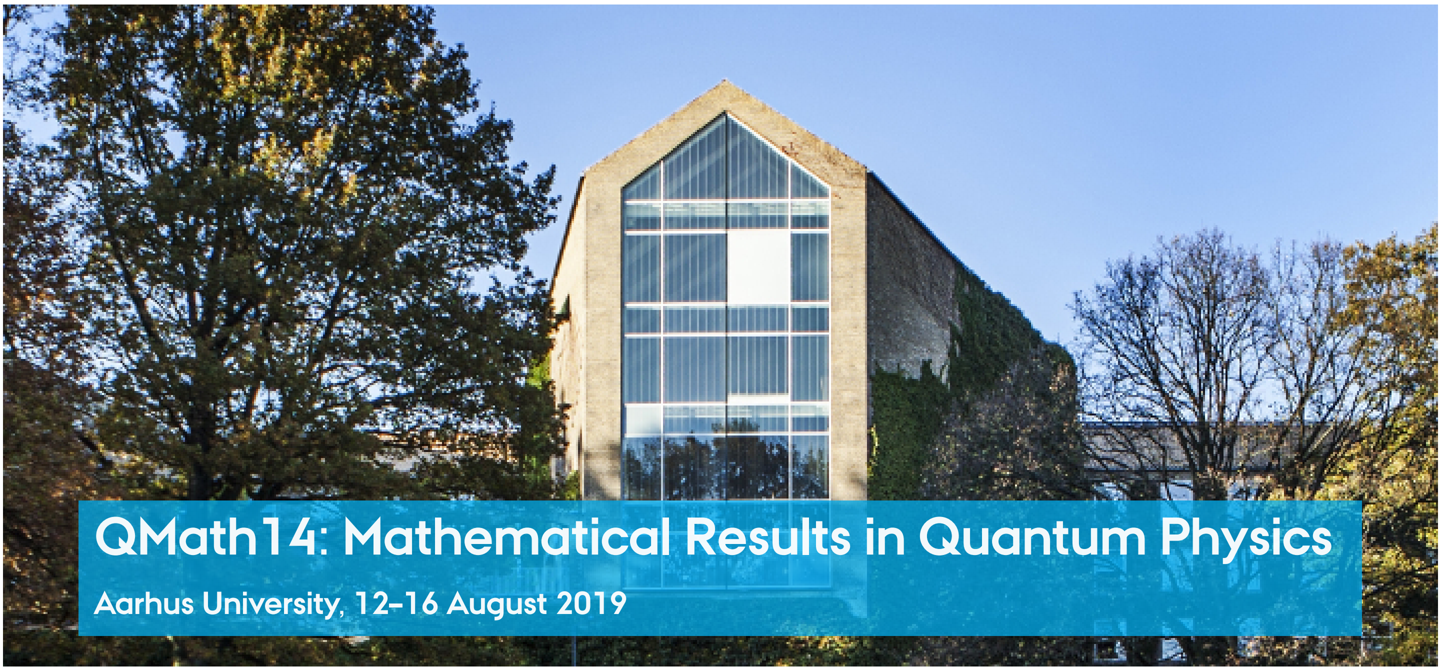

Programme and abstracts – including posters

http://conferences.au.dk/qmath14/

Last update: 2019-08-13 09:53:41
Foto: Anders Trærum, AU Communication

Programme

Monday, 12 August

09:00–12:00 **Mini course**

A quantum information travel guide for mathematicians

Lecturer: David Pérez García

Location: Aud E (1533.103)

12:00–14:00 **Lunch**
Location: MATH Canteen (1536, ground floor)

14:00–15:00 **Plenary talk**

Zeno and the bomb

Michael Wolf

Chair: Pavel Exner
Location: Aud E (1533.103)

15:00–15:30 **Coffee break**

15:30–16:30 **Plenary talk**

An update on Many-Body Localization

Wojciech De Roeck

Chair: Pavel Exner
Location: Aud E (1533.103)

16:30–17:00 **Break**

17:00– **Welcome reception**

Tuesday, 13 August

09:30–10:30 **Plenary talk**

Quantized quantum transport in interacting systems

Sven Bachmann

Chair: Simone Warzel
Location: Aud E (1533.103)

10:30–11:00 **Break**

11:00–12:00 **Plenary talk**

Universal Singularities of Random Matrices

Torben Krüger

Chair: Simone Warzel
Location: Aud E (1533.103)

12:00–14:00 **Lunch**
Location: MATH Canteen (1536, ground floor)

14:00–15:30 **Parallel sessions – Main speakers**

Spectral Theory in Aud F (1534.125) see page 8

Quantum Information in Aud G1 (1532.116) see page 9

Many-Body Systems in Aud G2 (1532.122) see page 10

Random Systems in Koll G3 (1532.218) see page 11

Condensed Matter in Koll G4 (1532.222) see page 12

15:30–16:00 **Coffee break**

16:00–17:55 **Parallel sessions – Contributed speakers**

Spectral Theory in Aud F (1534.125)	see page 8
Quantum Information in Aud G1 (1532.116)	see page 9
Many-Body Systems in Aud G2 (1532.122)	see page 10
Random Systems in Koll G3 (1532.218)	see page 11
Condensed Matter in Koll G4 (1532.222)	see page 12

18:00–19:00 **Poster session**

Wednesday, 14 August

09:00–10:00 **Plenary talk**

Entanglement subvolume law in 2D frustration-free spin systems

David Gosset

Chair: Jan Philip Solovej
Location: Aud E (1533.103)

10:00–10:30 **Coffee break**

10:30–11:30 **Plenary talk**

Breakup of degeneracies in disordered quantum systems

John Z. Imbrie

Chair: Jan Philip Solovej
Location: Aud E (1533.103)

11:30–12:30 **Plenary talk**

Linear response for gapped extended quantum systems

Stefan Teufel

Chair: Jan Philip Solovej
Location: Aud E (1533.103)

12:30–14:00 **Lunch**
Location: MATH Canteen (1536, ground floor)

15:00–16:00 **Reception – Aarhus City Hall**
Address: Aarhus City Hall, Rådhuspladsen 2, 8000 Aarhus

16:00– **ARoS Art MUSEUM**
Address: Aros Allé 2, 8000 Aarhus C

Thursday, 15 August

09:30–10:30 **Plenary talk**

Control of eigenfunctions on negatively curved surfaces

Semyon Dyatlov

Chair: Shu Nakamura
Location: Aud E (1533.103)

10:30–11:00 **Break**

11:00–12:00 **Plenary talk**

The polaron at strong coupling

Robert Seiringer

Chair: Shu Nakamura
Location: Aud E (1533.103)

12:00–14:00 **Lunch**
Location: MATH Canteen (1536, ground floor)

14:00–15:30 **Parallel sessions – Main speakers**

Spectral Theory in Aud F (1534.125) see page 13

Quantum Information in Aud G1 (1532.116) see page 14

Many-Body Systems in Aud G2 (1532.122) see page 15

Random Systems in Koll G3 (1532.218) see page 16

Condensed Matter in Koll G4 (1532.222) see page 17

15:30–16:00 **Coffee break**

16:00–17:55 **Parallel sessions – Contributed speakers**

Spectral Theory in Aud F (1534.125) see page 13

Quantum Information in Aud G1 (1532.116) see page 14

Many-Body Systems in Aud G2 (1532.122) see page 15

Random Systems in Koll G3 (1532.218) see page 16

Condensed Matter in Koll G4 (1532.222) see page 17

18:30 **Bus transport to conference dinner. Departure at 18:30**

Location: MATH parking space

19:00– **Conference dinner**

Address: Varna Palæet , Ørneredevej 3, 8000 Aarhus C

Friday, 16 August

09:30–10:30 **Plenary talk**

Dissipative quantum systems: scattering theory and spectral singularities

Jeremy Faupin

Chair: Arne Jensen
Location: Aud E (1533.103)

10:30–11:00 **Break**

11:00–12:00 **Plenary talk**

Unitary propagator for N-particle Schrödinger equations in an external field. Existence, uniqueness and regularity

Kenji Yajima

Chair: Arne Jensen
Location: Aud E (1533.103)

Tuesday, 13 August

Parallel session: Spectral Theory

Organizers: Jussi Behrndt and Bernard Helffer
Location: Aud F (1534.125)

14:00–14:40	**Spectral bounds for damped systems** *Christiane Tretter*
14:50–14:50	**Short break**
14:50–15:30	**Spectral optimization for singular Schrödinger operators** *Pavel Exner*
15:30–16:00	**Coffee break**
16:00–16:25	**Threshold Singularities of the Spectral Shift Function for Geometric Perturbations of Magnetic Hamiltonians** *Georgi Raikov*
16:25–16:30	**Short break**
16:30–16:55	**On homogenization of periodic hyperbolic systems** *Yulia Meshkova*
16:55–17:00	**Short break**
17:00–17:25	**Commutator method for the Stark Hamiltonian** *Kenichi Ito*
17:25–17:30	**Short break**
17:30–17:55	**Sharp spectral transition for eigenvalues embedded into the spectral bands of perturbed periodic operators** *Darren C. Ong*

Tuesday, 13 August

Parallel session: Quantum Information

Organizers: Laura Mancinska and David Pérez García
Location: Aud G1 (1532.116)

14:00–14:40	**Quantum advantage with noisy shallow circuits in 3D** *Robert König*
14:50–14:50	**Short break**
14:50–15:30	**Correlation length in random MPS and PEPS** *Cécilia Lancien*
15:30–16:00	**Coffee break**
16:00–16:25	**Beyond Noether's theorem: on robustness of conservation laws** *Cristina Cîrstoiu*
16:25–16:30	**Short break**
16:30–16:55	**New lower bounds to the output entropy of multi-mode quantum Gaussian channels** *Giacomo de Palma*
16:55–17:00	**Short break**
17:00–17:25	**Correlation length, mutual information, and entanglement area law in strongly-correlated systems** *Jaeyoon Cho*
17:25–17:30	**Short break**
17:30–17:55	**The Quantum Information Bottleneck: Properties and Applications** *Christoph Hirche*

Tuesday, 13 August

Parallel session: Many-Body Systems

Organizers: Mathieu Lewin and Jakob Yngvason
Location: Aud G2 (1532.122)

14:00–14:40	**Some exact results of strongly interacting one-dimensional bosons and fermions under external confinement** *Anna Minguzzi*
14:50–14:50	**Short break**
14:50–15:30	**On a kinematical algebra for interacting Bosons in infinite space: making a case for the Heisenberg picture** *Detlev Buchholz*
15:30–16:00	**Coffee break**
16:00–16:25	**Gross-Pitaevskii Limit of a Homogeneous Bose Gas at Positive Temperature** *Andreas Deuchert*
16:25–16:30	**Short break**
16:30–16:55	**Large-scale behavior of the local ground-state entropy of the ideal Fermi gas in a constant magnetic field** *Wolfgang Spitzer*
16:55–17:00	**Short break**
17:00–17:25	**Derivation of 1d and 2d Gross–Pitaevskii equations for strongly confined 3d bosons** *Lea Boßmann*
17:25–17:30	**Short break**
17:30–17:55	**Dirac Particles Interacting Directly in 1+3 Dimensions** *Markus Nöth*

Tuesday, 13 August

Parallel session: Random Systems

Organizer: Peter Müller
Location: Koll G3 (1532.218)

14:00–14:40	**Dynamics of Qubits in Random Matrix Environment** *Leonid Pastur*
14:50–14:50	**Short break**
14:50–15:30	**Some random operator dynamics** *Xiaolin Zeng*
15:30–16:00	**Coffee break**
16:00–16:25	**Pseudo-gaps for random hopping models** *Florian Dorsch*
16:25–16:30	**Short break**
16:30–16:55	**Quantitative continuity of the density of states in the probability distribution for continuum random Schrödinger operators** *Christoph Marx*
16:55–17:00	**Short break**
17:00–17:25	**Edge Universality for non-Hermitian Random Matrices** *Dominik Schröder*

Tuesday, 13 August

Parallel session: Condensed Matter

Organizers: Gianluca Panati and Marcello Porta
Location: Koll G4 (1532.222)

14:00–14:40	**The Quantum Random Energy Model** *Simone Warzel*
14:50–14:50	**Short break**
14:50–15:30	**Violation of bulk-edge correspondence in a hydrodynamic model** *Gian Michele Graf*
15:30–16:00	**Coffee break**
16:00–16:25	**Stability of the Laughlin phase in presence of interactions** *Alessandro Olgiati*
16:25–16:30	**Short break**
16:30–16:55	**Non-equilibrium almost-stationary states and linear response for gapped non-interacting quantum systems** *Giovanna Marcelli*
16:55–17:00	**Short break**
17:00–17:25	**Magnetic pseudodifferential operators represented as generalized Hofstadter-like matrices** *Benjamin Støttrup*
17:25–17:30	**Short break**
17:30–17:55	**Beyond Diophantine Wannier diagrams: gap labelling for Bloch-Landau Hamiltonians** *Massimo Moscolari*

Thursday, 15 August

Parallel session: Spectral Theory

Organizers: Jussi Behrndt and Bernard Helffer
Location: Aud F (1534.125)

14:00–14:40 **Quantum footprints of Liouville integrable systems**
San Vu Ngoc

14:40–14:50 **Short break**

14:50–15:30 **Spectral asymptotics on stationary spacetimes**
Steven Morris Zelditch

15:30–16:00 **Coffee break**

16:00–16:25 **Long-range scattering matrix for Schrödinger-type operators**
Shu Nakamura

16:25–16:30 **Short break**

16:30–16:55 **Magnetic Agmon estimates**
Nicolas Raymond

16:55–17:00 **Short break**

17:00–17:25 **Neumann Domains**
Ram Band

17:25–17:30 **Short break**

17:30–17:55 **Self-adjoint extensions of Dirac–Coulomb operators and Dirac operators on manifolds with boundary**
Lukas Schimmer

Thursday, 15 August

Parallel session: Quantum Information

Organizers: Laura Mancinska and David Pérez García
Location: Aud G1 (1532.116)

14:00–14:40 **Universal quantum Hamiltonians**
Ashley Montanaro

14:40–14:50 **Short break**

14:50–15:30 **Dynamics and fields for holographic codes**
Tobias J. Osborne

15:30–16:00 **Coffee break**

16:00–16:25 **Optimal non-signalling violations via tensor norms**
Abderraman Amr Rey

16:25–16:30 **Short break**

16:30–16:55 **Tensor network representations from the geometry of entangled states**
Albert H. Werner

16:55–17:00 **Short break**

17:00–17:25 **Revisiting the simulation of quantum Turing machines by quantum circuits through the study of causal unitary evolutions**
Abel Molina

Thursday, 15 August

Parallel session: Many-Body Systems

Organizers: Mathieu Lewin and Jakob Yngvason
Location: Aud G2 (1532.122)

14:00–14:40	**Anomaly non-renormalization in interacting Weyl semimetals** *Marcello Porta*
14:40–14:50	**Short break**
14:50–15:30	**The excitation spectrum of the Bose gas in the Gross-Pitaevskii regime** *Chiara Boccato*
15:30–16:00	**Coffee break**
16:00–16:25	**Asymptotic Completeness in Wedge-local Quantum Field Theory** *Maximilian Duell*
16:25–16:30	**Short break**
16:30–16:55	**Subexponential decay rates of atomic eigenfunctions at critical threshold** *Michal Jex*
16:55–17:00	**Short break**
17:00–17:25	**Stability of anyonic superselection sectors** *Pieter Naaijkens*
17:25–17:30	**Short break**
17:30–17:55	**Equilibration towards generalized Gibbs ensembles in non-interacting theories** *Marek Gluza*

Thursday, 15 August

Parallel session: Random Systems

Organizer: Peter Müller
Location: Koll G3 (1532.218)

14:00–14:40 **Fractal properties of the Hofstadter's butterfly and singular continuous spectrum of the critical almost Mathieu operator**
Svetlana Jitomirskaya

14:40–14:50 **Short break**

14:50–15:30 **Dynamical localization in aperiodic media**
Constanza Rojas-Molina

15:30–16:00 **Coffee break**

16:00–16:25 **Non-ergodic delocalization in the Rosenzweig-Porter model**
Per von Soosten

16:25–16:30 **Short break**

16:30–16:55 **Gaussian Approximation of the Distribution of Strongly Repelling Particles on the Unit Circle**
Yuanyuan Xu

16:55–17:00 **Short break**

17:00–17:25 **Extremal eigenvalues of critical Erdos-Renyi graphs**
Raphaël Ducatez

17:25–17:30 **Short break**

17:30–17:55 **Bounds on the spectral shift function and a lower Wegner estimate for continuum random Schrödinger**
Martin Gebert

Thursday, 15 August

Parallel session: Condensed Matter

Organizers: Gianluca Panati and Marcello Porta
Location: Koll G4 (1532.222)

14:00–14:40	**(De)localized Wannier functions for Chern and quantum Hall insulators** *Domenico Monaco*
14:40–14:50	**Short break**
14:50–15:30	**Correlation Energy of the Mean-Field Fermi Gas by the Method of Collective Bosonization** *Niels Benedikter*
15:30–16:00	**Coffee break**
16:00–16:25	**The Topology of Mobility-Gapped Insulators** *Jacob Shapiro*
16:25–16:30	**Short break**
16:30–16:55	**A hierarchical supersymmetric model for weakly disordered three-dimensional semimetals** *Luca Fresta*
16:55–17:00	**Short break**
17:00–17:25	**Topological index for fermion systems in disordered media** *N. Javier Buitrago Aza*
17:25–17:30	**Short break**
17:30–17:55	**The Landau-Pekar equations: Adiabatic theorem and accuracy** *Nikolai Leopold*

List of abstracts

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Spectral Theory

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Plenary talks

Sven Bachmann (University of British Columbia)

Quantized quantum transport in interacting systems

Joint with Alex Bols, Wojciech De Roeck and Martin Fraas

For non-interacting fermions at zero temperature, it is well established that charge transport is quantized whenever the chemical potential lies in a gap of the single-body Hamiltonian. In the last decade, new tools originally developed in the context of the classification of exotic phases of matter have been successfully applied to understand this quantization even in the presence of interactions. As I shall explain, transport is in general fractional.

Semyon Dyatlov (UC Berkeley/MIT)

Control of eigenfunctions on negatively curved surfaces

Joint with Long Jin and Stéphane Nonnenmacher

Given an L^2-normalized eigenfunction with eigenvalue λ^2 on a compact Riemannian manifold (M,g) and a nonempty open set $\Omega \subset M$, what lower bound can we prove on the L^2-mass of the eigenfunction on Ω? The unique continuation principle gives a bound for any Ω which is exponentially small as $\lambda \to \infty$. On the other hand, microlocal analysis gives a λ-independent lower bound if Ω is large enough, i.e. it satisfies the geometric control condition.

This talk presents a λ-independent lower bound for any set Ω in the case when M is a negatively curved surface, or more generally a surface with Anosov geodesic flow. The proof uses microlocal analysis, the chaotic behavior of the geodesic flow, and a new ingredient from harmonic analysis called the Fractal Uncertainty Principle. Applications include control for Schrödinger equation and exponential decay of damped waves.

Jérémy Faupin (Université de Lorraine)

Dissipative quantum systems: scattering theory and spectral singularities

Based on two articles. The first one is joint work with Jürg Fröhlich and the second one is joint work with François Nicoleau.

In this talk, we will consider an abstract pseudo-hamiltonian given by a dissipative operator of the form $H = H_V - iC^*C$, where $H_V = H_0 + V$ is self-adjoint and C is a bounded operator. Such operators are frequently used to study scattering theory for dissipative quantum systems. We will recall conditions implying the existence of the wave operators associated to H and H_0, and we will see that they are asymptotically complete if and only if H has no spectral singularities embedded in its essential spectrum. In mathematical physics, spectral singularities have been considered in many different contexts. We will review several possible equivalent definitions of a spectral singularity. For dissipative Schrödinger operators, a spectral singularity corresponds to a real resonance, or, equivalently, to a point of the positive real axis where the scattering matrix is not invertible.

David Gosset (University of Waterloo)

Entanglement subvolume law in 2D frustration-free spin systems

Joint with Anurag Anshu and Itai Arad

The area law conjecture asserts a bound on the entanglement of the ground state of a quantum spin systems with local interactions on a d-dimensional lattice and a nonvanishing spectral gap. It states that the entanglement entropy of the ground state between any region A and its complement should be proportional to $|\partial A|$, the area of the boundary of the region. This contrasts with the naive upper bound which is proportional to the volume $|A|$. Hastings proved the area law conjecture for the special case of 1D spin systems, but the 2D case remains open. In this talk I will consider the case of frustration-free 2D systems, and describe the first *subvolume* bound on entanglement entropy of the ground state. In particular, for any bipartition of the grid into a rectangular region A and its complement, we show that the entanglement entropy is upper bounded as $\tilde{O}(|\partial A|^{5/3})$. In contrast with previous work, our bounds rely on the presence of a nonvanishing local (rather than global) spectral gap of the Hamiltonian. We prove our results using a known method which bounds the entanglement entropy of the ground state in terms of certain properties of an approximate ground state projector (AGSP).

To this end, we construct a new AGSP which is based on a robust polynomial approximation of the AND function and we show that it achieves an improved trade-off between approximation error and entanglement.

John Z. Imbrie (University of Virginia)

Breakup of degeneracies in disordered quantum systems

For disordered quantum systems such as the Anderson model, degeneracies provide avenues for long-range tunneling, and hence are a barrier to localization. In order to control the likelihood of degeneracies or near-degeneracies, one needs to understand in detail the way eigenvalues and eigenvalue gaps depend on the disorder. Using multiscale analysis, one can build up smoothness of eigenvalue distributions even in the case of discrete disorder distributions.

Torben Krüger (Universität Bonn)

Universal Singularities of Random Matrices

Joint with J. Alt, G. Cipolloni, L. Erdős and D. Schröder

As the dimension of a self-adjoint random matrix tends to infinity, its eigenvalue distribution is well approximated by a deterministic density function. For a broad class of random matrix models with decaying correlations among the entries, determining this function requires solving the *Dyson equation*. Via a detailed analysis of this non-linear matrix equation in asymptotically infinite dimensions down to the scale of the eigenvalue spacing we expose a universal behavior of the eigenvalue density for the underlying random matrix model. The spectrum separates into distinct *bands*. The density of states is positive and analytic inside the bands and exhibits square root growth at the edges. Whenever the gap between two bands closes a cusp singularity forms, showing cubic root growth on either side. Due to a strong *topological rigidity* the number of eigenvalues within each band does not fluctuate and no eigenvalues can be found inside the gaps between the bands with very high probability. Furthermore, the local eigenvalue statistics is universal at all singularities, i.e. independently of the distribution of the entries each edge eigenvalue follows the Tracy-Widom distribution, while at all cusp points the eigenvalues locally form a Pearcey process.

Wojciech De Roeck (KU Leuven)

An update on Many-Body Localization

I will discuss advances on many-body localization (MBL) from two points of view.

For the sake of this talk, MBL is defined as a robust absence of transport in many-body systems at thermodynamic parameters corresponding tot non-zero entropy density, ie. for example, excluding systems near the ground state.

The first point of view is numerical, and will serve to delineate the extent to which we should expect MBL to occur. Our numerics points to the conclusion that MBL is a rather marginal phenomenon: it is restricted to strongly disordered one-dimensional systems with finite on-site space. This finding is still a topic of ongoing debate.

The second point o view is mathematical and less ambititious: we give up on strict absence of transport and we investigate occurence of slow transport and thermalization. Here slow means 'non-perturbative in some parameter', i.e. due to instanton effects. This phenomenon, that is sometimes also called 'asymptotic localization' or 'quasi-localization' or simply also 'MBL' occurs in much greater generality and it is easily amenable to mathematical analysis.

Robert Seiringer (IST Austria)

The polaron at strong coupling

We review old and new results on the Fröhlich polaron model. The discussion includes the validity of the (classical) Pekar approximation in the strong coupling limit, quantum corrections to this limit, as well as the divergence of the effective polaron mass.

Stefan Teufel (Universität Tübingen)

Linear response for gapped extended quantum systems

Joint with Giovanna Marcelli

I will first review the problem of justifying linear response theory for gapped extended quantum systems, where typical perturbations close the spectral gap and drive the initial ground state into an almost-stationary state that is no longer even close to an eigenstate of the perturbed Hamiltonian. Then I present a recent approach to the rigorous justification of linear (and higher order) response based on an explicit construction of such almost-stationary states and a generalisation of the adiabatic theorem of quantum mechanics. The latter shows that even though the spectral gap closes, the evolution still adiabatically follows these almost-stationary states on appropriate time-scales.

My talk is based on [ArXiv:1708.03581, CMP Online First] and an ongoing joint project with Giovanna Marcelli.

Michael Wolf (Technische Universität München)

Zeno and the bomb

We will revisit the Quantum Zeno effect and its application for interaction-free channel discrimination. The first part of the talk discusses a generalization of the Quantum Zeno effect to time-dependent open-system dynamics interrupted by general quantum operations. The second part addresses the question when the Quantum Zeno effect of a general quantum channel enables interaction-free channel discrimination in the spirit of the Elitzur-Vaidman 'bomb tester'.

Kenji Yajima (Gakushuin University)

Unitary propagator for N-particle Schrödinger equations in an external field. Existence, uniqueness and regularity

We report two sets of sufficient conditions for a unique existence of unitary propagator which possesses a "nice convenient" dense invariant subspace for time-depenent Schrödinger equations for N non-relativistic quantum particles in a (classical) electro-magnetic field.

The first is a time dependent perturbation of classical results of Leinfelder-Simader or Iwatsuka on the selfadjointness and assumes that every time freezed Hamiltonian $H(t)$ is as in their theorems however, that time derivative of the Hamiltonian $\partial_t H(t)$ is bounded by $H(t)$ in the sense of operator or of quadractic form, which implies that $H(s)$ is a perturbation of $H(t)$.

The second assumes that an external field is smooth and grows moderately at spatial infinity so that instantanenous recurrence of singularities cannot happen. This allows time derivatives of inter-paticle potentials to have stronger singularities which may not be form-bounded by the Hamiltonian.

First result is proved via the abstract theory of temporally inhomogenous semi-groups and the second via more harmonic analysis type argument, Strichartz estimates for vector valued functions, in particular.

Mini-course

David Pérez García (UCM)

A quantum information travel guide for mathematicians

The aim of this mini-course is to present some of the main directions of research in quantum information theory, with a focus on the mathematical techniques.

Outline:

1. Introduction
2. Quantum cryptography and communication
   - **2.1.** Setup and main achievements
   - **2.2.** Mathematical toolbox
3. Quantum computation and simulation
   - **3.1.** Setup and main achievements
   - **3.2.** Mathematical toolbox
4. Connections to other areas of mathematical physics
5. A selection of open problems

Parallel Sessions

Tuesday and Thursday afternoons. Organized in 5 topical tracks.

Spectral Theory

Session organizers: Jussi Behrndt and Bernard Helffer

Ram Band (Technion)

Neumann Domains

Joint with Sebastian Egger, David Fajman and Alexander Taylor

The nodal set of a Laplacian eigenfunction forms a partition of the underlying manifold. An alternative partition, based on the gradient field of the eigenfunction, is via the so called Neumann domains. A Neumann domain of an eigenfunction is a connected component of the intersection between the stable manifold of a certain minimum and the unstable manifold of a certain maximum. We introduce this subject, discuss various properties of Neumann domains and point out the similarities and differences between nodal domains and Neumann domains.

Pavel Exner (Doppler Institute for Mathematical Physics and Applied Mathematics, Prague)

Spectral optimization for singular Schrödinger operators

Joint with Sylwia Kondej and Vladimir Lotoreichik

The talk is concerned with finding configurations of singular interactions which optimize the ground state of the corresponding Schrödinger operator. We consider finite of point interactions situated at a circle or a sphere as well attractive δ type interactions of supported by a manifold or complex of codimension one.

Kenichi Ito (The University of Tokyo)

Commutator method for the Stark Hamiltonian

Joint with Tadayoshi Adachi, Kyohei Itakura and Erik Skibsted

We discuss spectral theory for a perturbed Stark Hamiltonian. The main results are Rellich's theorem, the limiting absorption principle, the radiation condition bounds and Sommerfeld's uniqueness result. For their proofs we adopt a commutator scheme from Ito-Skibsted (2016), in which choice of an escape function plays a key role. Our escape function conforms well with classical mechanics of the Stark Hamiltonian, and generates the conjugate operator and the Besov-type spaces that appear in the statements of the main results.

Yulia Meshkova (St. Petersburg State University)

On homogenization of periodic hyperbolic systems

The talk is devoted to homogenization of periodic differential operators. Let $B_\varepsilon = B_\varepsilon^* > 0$ be a second order matrix strongly elliptic differential operator acting in $L_2(\mathbb{R}^d;\mathbb{C}^n)$. The coefficients of the operator B_ε depend on $\mathbf{x}/\varepsilon$, $0 < \varepsilon \leqslant 1$. Consider the hyperbolic system

$$\partial_t^2 \mathbf{u}_\varepsilon(\mathbf{x},t) = -B_\varepsilon \mathbf{u}_\varepsilon(\mathbf{x},t) + \mathbf{F}(\mathbf{x},t), \quad \mathbf{u}_\varepsilon(\mathbf{x},0) = 0, \quad (\partial_t \mathbf{u}_\varepsilon)(\mathbf{x},0) = \boldsymbol{\psi}(\mathbf{x}),$$

where $\boldsymbol{\psi} \in L_2(\mathbb{R}^d;\mathbb{C}^n)$ and $\mathbf{F} \in L_1((0,T);L_2(\mathbb{R}^d;\mathbb{C}^n))$ for some $0 < T \leqslant \infty$. Then

$$\mathbf{u}_\varepsilon(\cdot,t) = B_\varepsilon^{-1/2}\sin(tB_\varepsilon^{1/2})\boldsymbol{\psi} + \int_0^t B_\varepsilon^{-1/2}\sin((t-\tilde{t})B_\varepsilon^{1/2})\mathbf{F}(\cdot,\tilde{t})\,d\tilde{t}.$$

We are interested in the behaviour of the solution $\mathbf{u}_\varepsilon(\cdot,t)$ in the small period limit $\varepsilon \to 0$. It turns out that, for sufficiently smooth $\boldsymbol{\psi}$ and $\mathbf{F}$, the error estimates in approximations for the solution $\mathbf{u}_\varepsilon$ depend on suitable norms of $\boldsymbol{\psi}$ and $\mathbf{F}$ explicitly. In other words, we can approximate the operator $B_\varepsilon^{-1/2}\sin(tB_\varepsilon^{1/2})$ in a uniform operator topology:

$$\begin{aligned}
&\|B_\varepsilon^{-1/2}\sin(tB_\varepsilon^{1/2}) - (B^0)^{-1/2}\sin(t(B^0)^{1/2})\|_{H^1(\mathbb{R}^d;\mathbb{C}^n)\to L_2(\mathbb{R}^d;\mathbb{C}^n)} \\
&\qquad \leqslant C\varepsilon|t|,
\end{aligned} \tag{1}$$

$$\begin{aligned}
&\|B_\varepsilon^{-1/2}\sin(tB_\varepsilon^{1/2}) - (B^0)^{-1/2}\sin(t(B^0)^{1/2}) - \varepsilon K_1(\varepsilon;t)\|_{H^2(\mathbb{R}^d;\mathbb{C}^n)\to H^1(\mathbb{R}^d;\mathbb{C}^n)} \\
&\qquad \leqslant C\varepsilon(1+|t|),
\end{aligned} \tag{2}$$

$$\begin{aligned}
&\|B_\varepsilon^{-1/2}\sin(tB_\varepsilon^{1/2}) - (B^0)^{-1/2}\sin(t(B^0)^{1/2}) - \varepsilon K_2(\varepsilon;t)\|_{H^3(\mathbb{R}^d;\mathbb{C}^n)\to L_2(\mathbb{R}^d;\mathbb{C}^n)} \\
&\qquad \leqslant C\varepsilon^2(1+t^2).
\end{aligned} \tag{3}$$

Here B^0 is the so-called effective operator with constant coefficients, $K_1(\varepsilon;t)$ and $K_2(\varepsilon;t)$ are the correctors. The correctors contain rapidly oscillating factors and so depend on ε.

We derive estimates (1) and (2) from the corresponding approximations for the resolvent B_ε^{-1}, obtained by T. A. Suslina (2010) with the help of the spectral theory approach to homogenization problems. Our method is a modification of the classical proof of the Trotter-Kato theorem. The analogue of estimate (3) is also known (Suslina, 2014). But the author have no idea how to modify the Trotter-Kato theorem for this case. So, to prove estimate (3), we directly apply the spectral theory approach in a version developed by M. Sh. Birman and T. A. Suslina. The technique is based on the unitary scaling transformation, the Floquet-Bloch theory, and the analytic perturbation theory.

Shu Nakamura (Gakushuin University)

Long-range scattering matrix for Schrödinger-type operators

For Schrödinger operator-type pseudodifferential operators with long-range perturbations, it is shown that the modified scattering matrix is a Fourier integral operator, and it is a natural quantization of the scattering map for the corresponding modified classical scattering. The spectral properties of scattering matrices for several models are discussed, and it is shown that the scattering matrix can have absolutely continuous spectrum.

References

[1] S. Nakamura: Long-range scattering matrix for Schrödinger-type operators. Preprint 2018: https://arxiv.org/abs/1804.05488.

[2] S. Nakamura: Remarks on scattering matrices for Schrödinger operators with critically long-range perturbations. Preprint 2018: https://arxiv.org/abs/1804.05489.

San Vũ Ngọc (University of Rennes)

Quantum footprints of Liouville integrable systems

Joint with Monique Dauge and Mike Hall

Liouville integrable systems in classical mechanics have a rich geometric structure which gives rise to many interesting invariants: monodromy, rotation number, singularity types, twisting indices, etc. A natural quantum version of Liouville integrability is the data of commuting self-adjoint operators. I will report on various progress on the question “can you ‘hear’ the classical invariants from the joint spectrum of a quantum integrable system? (in the semiclassical limit)”. I will include a recent work with Dauge and Hall on the detection of the so-called “asymptotic lattices”, corresponding to Bohr-Sommerfeld tori.

Darren C. Ong (Xiamen University Malaysia)

Sharp spectral transition for eigenvalues embedded into the spectral bands of perturbed periodic operators

Joint with Wencai Liu

In this paper, we consider the Schrödinger equation,

$$Hu = -u'' + (V(x) + V_0(x))u = Eu,$$

where $V_0(x)$ is 1-periodic and $V(x)$ is a decaying perturbation. By Floquet theory, the spectrum of $H_0 = -\nabla^2 + V_0$ is purely absolutely continuous and consists of a union of closed intervals (often referred to as spectral bands). Given any finite set of points $\{E_j\}_{j=1}^N$ in any spectral band of H_0 obeying a mild non-resonance condition, we construct smooth functions $V(x) = \frac{O(1)}{1+|x|}$ such that $H = H_0 + V$ has eigenvalues $\{E_j\}_{j=1}^N$. Given any countable set of points $\{E_j\}$ in any spectral band of H_0 obeying the same non-resonance condition, and any function $h(x) > 0$ going to infinity arbitrarily slowly, we construct smooth functions $|V(x)| \leq \frac{h(x)}{1+|x|}$ such that $H = H_0 + V$ has eigenvalues $\{E_j\}$. On the other hand, we show that there is no eigenvalue of $H = H_0 + V$ embedded in the spectral bands if $V(x) = \frac{o(1)}{1+|x|}$ as x goes to infinity. We prove also an analogous result for Jacobi operators.

Georgi Raikov (Pontificia Universidad Católica de Chile)

Threshold Singularities of the Spectral Shift Function for Geometric Perturbations of Magnetic Hamiltonians

Joint with V. Bruneau

I will consider the 3D Schrödinger operator H_0 with constant magnetic field, and its perturbations H_+ (resp., H_-) obtained from H_0 by imposing Dirichlet (resp., Neumann) conditions on an appropriate surface in $\mathbb{R}^3$. I will introduce the Krein spectral shift function $\xi(E; H_\pm, H_0)$, $E \geq 0$, for the operator pairs $(H_\pm, H_0)$, and will discuss its singularities at the Landau levels which play the role of thresholds in the spectrum of the unperturbed operator H_0.

The partial support of the Chilean Science Foundation *Fondecyt* under Grant 1170816 is gratefully acknowledged.

Nicolas Raymond (Université d'Angers)

Magnetic Agmon estimates

Joint with Y. Bonthonneau and S. Vũ Ngọc

A new upper bound for the tunneling effect away from a non-degenerate bidimensional magnetic well will be given. In particular, it will be explained how we can establish an accurate Agmon estimate in a pure magnetic setting by using the Fourier-Bros-Iagolnitzer transform and microlocal exponential estimates.

Lukas Schimmer (University of Copenhagen)

Self-adjoint extensions of Dirac–Coulomb operators and Dirac operators on manifolds with boundary

Joint with Jan Philip Solovej and Sabiha Tokus

Semibounded symmetric operators have a distinguished self-adjoint extension, the Friedrichs extension. Its eigenvalues are given by a variational principle that involves only the domain of the symmetric operator. Although Dirac operators are not semibounded, the Dirac operator with Coulomb potential is known to have a distinguished self-adjoint extension. Similarly, for Dirac-type operators on manifolds with boundary a distinguished self-adjoint extension is characterised by the Atiyah–Patodi–Singer boundary condition.

I will relate both of these extensions to a generalisation of the Friedrichs extension to the setting of symmetric operators satisfying a gap condition and will in particular explain how the Atiyah–Patodi–Singer boundary condition arises in this context. I will establish, in the general setting, that the eigenvalues of this extension are also given by a variational principle that involves only the domain of the symmetric operator.

Christiane Tretter (University of Bern)

Spectral bounds for damped systems

Joint with Birgit Jacob, Carsten Trunk and Hendrik Vogt

In this talk we present enclosures for the spectra of operators associated with second order Cauchy problems for the case of non-selfadjoint damping. These new results yield much better bounds than the numerical range for both uniformly accretive and sectorial damping, and even in the case of selfadjoint damping.

Steven Morris Zelditch (Northwestern University)

Spectral asymptotics on stationary spacetimes

Spectral asymptotics refers to Weyl's law and the Gutzwiller trace formula for the Laplacian of a compact Riemannian manifold. They are corner-stone results in non-relativistic quantum mechanics. The purpose of my talk – joint work with Alex Strohmaier– is to give a relativistic generalization of these results for any globally hyperbolic stationary spacetime with a compact Cauchy hyper surface. I will also briefly allude to generalizations to cases where the Cauchy hypersurfaces are of infinite volume. Almost any result in spectral asymptotics has a relativistic generalization.

Quantum Information

Session organizers: Laura Mancinska and David Pérez García

Jaeyoon Cho (Asia Pacific Center for Theoretical Physics)

Correlation length, mutual information, and entanglement area law in strongly-correlated systems

Proving or disproving the entanglement area law in high dimension is one of the central open problems in quantum many-body theories. In this talk, I introduce a certain structure of mutual information in many-body states as a sufficient condition for the state to obey the entanglement area law in arbitrary dimension. I then argue that in one dimension, such a structure follows from a finite correlation length, which proves that in one dimension, a finite correlation length alone implies the entanglement area law.

Cristina Cîrstoiu (Oxford University)

Beyond Noether's theorem: on robustness of conservation laws

Joint with Kamil Korzekwa and David Jennings

Symmetries of closed systems lead to conservation laws. Under a unitary symmetric dynamics, expectation values of Noether's conserved charges remain constant. However, for open quantum systems this is usually no longer the case. *How robust are conservation laws under a dynamics described by a symmetric (covariant) quantum channel?* We quantify the trade-off relations between decoherence and violations of conservation laws for systems that undergo a symmetric general quantum process. The analysis leads to bounds on unitarity in terms of the average deviation from the conservation laws. We show that if a symmetric quantum channel approximates a symmetric unitary dynamics then the corresponding conservation law holds approximately. The converse holds only for particular cases such as spin systems carrying an irreducible representation of $SU(2)$, and more generally whenever the input and output operator spaces have a multiplicity-free decomposition into irreducible components. Therefore for these particular types of symmetries we show robustness of conservation laws under symmetric interaction with an environment. We also investigate *what are the maximal expected deviations from a conservation law*? These give fundamental limits imposed by quantum mechanics and for spin j systems the question is directly related to the maximal allowed spin inversion which in the particular case of 1/2-spin system is achieved by the Universal-NOT operation.

Christoph Hirche (University of Copenhagen)

The Quantum Information Bottleneck: Properties and Applications

Joint with Nilanjana Datta and Andreas Winter

In classical information theory, the information bottleneck method (IBM) can be regarded as a method of lossy data compression which focuses on preserving meaningful (or relevant) information. As such it has of late gained a lot of attention, primarily for its applications in machine learning and neural networks. A quantum analogue of the IBM has recently been defined, and an attempt at providing an operational interpretation of the so-called quantum IB function as an optimal rate of an information-theoretic task, has recently been made by Salek et al. The interpretation given by these authors is however incomplete, as its proof is based on the conjecture that the quantum IB function is convex. Our first contribution is the proof of this conjecture. Secondly, the expression for the rate function involves certain entropic quantities which occur explicitly in the very definition of the underlying information-theoretic task, thus making the latter somewhat contrived. We overcome this drawback by pointing out an alternative operational interpretation of it as the optimal rate of a bona fide information-theoretic task, namely that of quantum source coding with quantum side information at the decoder, which has recently been solved by Hsieh and Watanabe. We show that the quantum IB function characterizes the rate region of this task, Finally, we discuss some further properties, applications and the related privacy funnel function.

Robert König (TU Munich)

Quantum advantage with noisy shallow circuits in 3D

Joint work with Sergey Bravyi, David Gosset and Marco Tomamichel

Prior work has shown that there exists a relation problem which can be solved with certainty by a constant-depth quantum circuit composed of geometrically local gates in two dimensions, but cannot be solved with high probability by any classical constant depth circuit composed of bounded fan-in gates. Here we provide two extensions of this result. Firstly, we show that a separation in computational power persists even when the constant-depth quantum circuit is restricted to geometrically local gates in one dimension. The corresponding quantum algorithm is the simplest we know of which achieves a quantum advantage of this type. It may also be more practical for future implementations. Our second, main result, is that a separation persists even if the shallow quantum circuit is corrupted by noise. We construct a relation problem which can be solved with near certainty using a noisy constant-depth quantum circuit composed of geometrically local gates in three dimensions, provided the noise rate is below a certain constant threshold value. On the other hand, the problem cannot be solved with high probability by a noise-free classical circuit of constant depth. A key component of the proof is a quantum error-correcting code which admits constant-depth logical Clifford gates and single-shot logical state preparation. We show that the surface code meets these criteria. To this end, we provide a protocol for single-shot logical state preparation in the surface code which may be of independent interest.

Cécilia Lancien (Institut de Mathématiques de Toulouse & CNRS)

Correlation length in random MPS and PEPS

With David Pérez-García

Tensor network states are used extensively as a mathematically convenient description of physically relevant states of many-body quantum systems. Those built on regular lattices, i.e. matrix product states (MPS) in dimension 1 and projected entangled pair states (PEPS) in dimension 2 or higher, are of particular interest in condensed matter physics. The general goal of the work that I will present in this talk is to characterize which features of MPS and PEPS are generic and which are, on the contrary, exceptional. This problem can be rephrased as follows: given an MPS or PEPS sampled at random, what are the features that it displays with either high or low probability? One property which we will focus on is that of having either rapidly decaying or long-range correlations. In a nutshell, the main result I will state is that translation-invariant MPS and PEPS typically exhibit exponential decay of correlations at a high rate. I will show two distinct ways of getting to this conclusion, depending on the dimensional regime under consideration. Both yield intermediate results which are of independent interest, namely: the parent Hamiltonian and the transfer operator of such MPS and PEPS typically have a large spectral gap.

Abel Molina (University of Waterloo)

Revisiting the simulation of quantum Turing machines by quantum circuits through the study of causal unitary evolutions.

Joint with John Watrous

Yao [1] proved that $t \geq n$ steps of a quantum Turing machine running on an input of length n can be simulated by a uniformly generated family of quantum circuits with size quadratic in t. We revisit the simulation of quantum Turing machines with uniformly generated quantum circuits, and present a new variant of the simulation method employed by Yao, together with an analysis of it. This analysis reveals that the simulation of quantum Turing machines can be performed by quantum circuits having depth linear in t, rather than quadratic depth, and can be extended to variants of quantum Turing machines, such as ones having multi-dimensional tapes.

Our analysis is based on extending a method of Arrighi, Nesme, and Werner [2] that allows for the localization of causal unitary evolutions. Our extension proves that such localization can still be performed when the causality assumptions are weakened. More specifically, it considers unitary evolutions that do not necessarily act causally on all elements of the space $\mathcal{H}$ they act upon. Instead, the unitary evolutions we consider are only causal when restricted to a subspace that satisfies certain constraints in its relation to the local spaces that together (i.e. through their tensor product) constitute the space $\mathcal{H}$.

References

[1] A. C. Yao, Quantum circuit complexity. *Proc. 34th Annual Symposium on Foundations of Computer Science* (1993): 352-361.

[2] Arrighi, Pablo, Vincent Nesme, and Reinhard Werner. Unitarity plus causality implies localizability. *Journal of Computer and System Sciences* 77.2 (2011): 372-378.

Ashley Montanaro (University of Bristol)

Universal quantum Hamiltonians

Joint with Toby Cubitt and Stephen Piddock

In this talk, I will discuss a particular notion of universality for quantum Hamiltonians. A family of quantum Hamiltonians is said to be "universal" if any other finite-dimensional Hamiltonian can be approximately encoded within the low-energy space of a Hamiltonian from that family. Universal quantum Hamiltonians can be used to construct universal analogue quantum simulators and universal quantum computers. Over the last few years, based on techniques from the field of quantum Hamiltonian complexity, many universal families of Hamiltonians have been found. I will summarise the results obtained in this classification programme, and the mathematical ingredients behind them.

Tobias J. Osborne (Leibniz Universität Hannover)

Dynamics and fields for holographic codes

Joint with Deniz Stiegemann

I describe how to introduce dynamics for the holographic states and codes introduced by Pastawski, Yoshida, Harlow and Preskill as quantum-information inspired toy models of the AdS/CFT correspondence. This task requires the definition of a continuous limit of the kinematical Hilbert space of a finite which may be achieved via the semicontinuous limit of Jones. Dynamics is then introduced by building a unitary representation of a group known as Thompson's group T, which is a discretised analogy of the conformal group conf($\mathbb{R}^{1,1}$). Field operators may be defined for the boundary theory yielding a theory with discrete scaling symmetry.

Giacomo De Palma (QMATH, University of Copenhagen)

New lower bounds to the output entropy of multi-mode quantum Gaussian channels

We prove that quantum thermal Gaussian input states minimize the output entropy of the multi-mode quantum Gaussian attenuators and amplifiers that are entanglement breaking and of the multi-mode quantum Gaussian phase contravariant channels among all the input states with a given entropy. This is the first time that this property is proven for a multi-mode channel without restrictions on the input states. A striking consequence of this result is a new lower bound on the output entropy of all the multi-mode quantum Gaussian attenuators and amplifiers in terms of the input entropy. We apply this bound to determine new upper bounds to the communication rates in two different scenarios. The first is classical communication to two receivers with the quantum degraded Gaussian broadcast channel. The second is the simultaneous classical communication, quantum communication and entanglement generation or the simultaneous public classical communication, private classical communication and quantum key distribution with the Gaussian quantum-limited attenuator.

Abderraman Amr Rey (Complutense University of Madrid)

Optimal non-signalling violations via tensor norms

Joint with Carlos Palazuelos and Ignacio Villanueva

During this talk we will characterize the set of bipartite non-signalling probability distributions in terms of tensor norms. Using this characterization we will give optimal upper and lower bounds on Bell inequality violations when non-signalling distributions are considered.

More specifically, in the Bell scenario, the tensor $(P(a,b|x,y))_{xyab}$ denotes the probability distribution of two spacially separated parties (Alice and Bob) who perform two different measurements x and y to obtain outputs a and b, respectively. The use of classical resources makes this tensor to lie in $\mathcal{L}$, the set of classical probability distributions; while if they share a quantum state and perform quantum measurements on it, the tensor lies in $\mathcal{Q}$, the set of quantum probability distributions; finally, we can include both of them in a more general set, $\mathcal{NS}$, known as the non-signalling set, in which marginal probability distributions $Q_1(a|x) = \sum_b P(a,b|x,y)$ and $Q_2(b|y) = \sum_a P(a,b|x,y)$ are well defined.

A natural quantification of how different the sets of $\mathcal{L}$, $\mathcal{Q}$ and $\mathcal{NS}$ are can be done by means of the so called Bell inequality violations. More precisely, if $\mathcal{A},\mathcal{B} \in \{\mathcal{L},\mathcal{Q},\mathcal{NS}\}$ and $M \in \mathbb{R}^{N^2K^2}$ is any tensor, let us denote

$$\omega_{\mathcal{A}}(M) = \sup_{P\in\mathcal{A}} |\langle M,P\rangle|,$$

where the dual action is given by $\langle M,P\rangle = \sum_{x,y;a,b=1}^{N,K} M_{x,y}^{a,b} P(a,b|x,y)$. Then, there is an $\mathcal{B}-\mathcal{A}$ *Bell violation* for M if $\omega_{\mathcal{A}}(M)/\omega_{\mathcal{B}}(M) > 1$.

Although during the talk some other results will be shown, the main theorems are:

Theorem 1: Given a general tensor $M \in \mathbb{R}^{N^2K^2}$. Then,

$$\frac{\omega_{\mathcal{NS}}(M)}{\omega_{\mathcal{L}}(M)} \leq O(\min\{N, \sqrt{NK}\}).$$

Theorem 2: For every natural number n there exists a pointwise non-negative tensor $G_n \in \mathbb{R}^{N^2K^2}$, $N{=}K{=}n$, such that

$$\frac{\omega_{\mathcal{NS}}(G)}{\omega_{\mathcal{L}}(G)} \geq D\frac{n}{\log n},$$

where D is a universal constant.

The aim of studying this ratio, the classical-non-signalling Bell violation, should be seen as a way to study the ultimate limitations of any *meaningful* physical theory. During the talk we will compare these upper and lower bounds with the existing ones for the quantum-classical Bell violation. Then, a remarkable results follows: although we can not say yet that the largest quantum Bell violation is comparable to the largest non-signalling Bell violation, our bounds show that this result is indeed very plausible. This emphasizes the idea that, in some sense, the theory of quantum mechanic is as non-local as any other physical theory can be.

Albert H. Werner (QMATH, University of Copenhagen)

Tensor network representations from the geometry of entangled states

Joined work with Matthias Christandl, Angelo Lucia and Péter Vrana

Tensor network states provide successful descriptions of strongly correlated quantum systems with applications ranging from condensed matter physics to cosmology. Any family of tensor network states possesses an underlying entanglement structure given by a graph of maximally entangled states along the edges that identify the indices of the tensors to be contracted. Recently, more general tensor networks have been considered, where the maximally entangled states on edges are replaced by multipartite entangled states on plaquettes. Both the structure of the underlying graph and the dimensionality of the entangled states, i.e. the bond dimension, influence the computational cost of contracting these networks. Using the geometrical properties of entangled states, we provide a method to construct tensor network representations with smaller effective bond dimension. We illustrate our method with the resonating valence bond state on the kagome lattice.

Many-Body Systems

Session organizers: Mathieu Lewin and Jakob Yngvason

Chiara Boccato (IST Austria)

The excitation spectrum of the Bose gas in the Gross-Pitaevskii regime

Joint work with C. Brennecke, S. Cenatiempo and B. Schlein.

We consider a gas of interacting bosons trapped in a box of side length one in the Gross-Pitaevskii limit. We establish the validity of Bogoliubov's prediction for the ground state energy and the low-energy excitation spectrum.

Lea Boßmann (University of Tübingen)

Derivation of 1d and 2d Gross–Pitaevskii equations for strongly confined 3d bosons

Joint with Stefan Teufel

We study the dynamics of a system of N interacting bosons in a cigar- or disc-shaped trap, which initially exhibit Bose–Einstein condensation and interact via a non-negative interaction potential in the Gross–Pitaevskii scaling regime. The trap is realized by an external potential, which confines the bosons in two/one spatial dimensions to a region of order ε. We study the simultaneous limit $(N,\varepsilon) \to (\infty, 0)$ and show that the N-body dynamics preserve condensation. The time-evolved condensate wave function is the solution of a one/two-dimensional Gross–Pitaevskii equation.

Detlev Buchholz (Universität Göttingen)

On a kinematical algebra for interacting Bosons in infinite space: making a case for the Heisenberg picture

The long-standing quest for a kinematical algebra of interacting Bosons is recalled and the steps towards its resolution are outlined. The result is a descendant of the resolvent algebra of canonical quantum systems which can be desribed in simple algebraic terms. It provides a natural framework for the study of bosonic matter in infinite space.

Andreas Deuchert (IST Austria)

Gross-Pitaevskii Limit of a Homogeneous Bose Gas at Positive Temperature

Joint with Robert Seiringer

We consider a dilute, homogeneous Bose gas at positive temperature. The system is investigated in the Gross-Pitaevskii (GP) limit, where the scattering length a is so small that the interaction energy is of the same order of magnitude as the spectral gap of the Laplacian, and for temperatures that are comparable to the critical temperature of the ideal gas. We show that the difference between the specific free energy of the interacting system and the one of the ideal gas is to leading order given by $4\pi a(2\rho^2 - \rho_0^2)$. Here ρ denotes the density of the system and ρ_0 is the expected condensate density of the ideal gas. Additionally, we show that the one-particle density matrix of any approximate minimizer of the Gibbs free energy functional is to leading order given by the one of the ideal gas. This in particular proves Bose-Einstein condensation with critical temperature given by the one of the ideal gas to leading order. One key ingredient of our proof is a novel use of the Gibbs variational principle that goes hand in hand with the c-number substitution.

Maximilian Duell (TU München)

Asymptotic Completeness in Wedge-local Quantum Field Theory

Joint with Wojciech Dybalski (PhD Advisor)

I will present N-particle scattering theory for wedge-local QFTs, as developed in my PhD project. The construction relies on the wedge duality property, which is very natural and thoroughly studied in the local and wedge-local contexts and leads to a wedge swapping symmetry of one particle states. On these grounds I can avoid a geometric pitfall in the conventional Haag-Ruelle method requiring impossible assignments of space-like separated localizing wedges to $N > 2$ particles, which has blocked progress on this topic until now.

With the new results at hand, I can pose and positively answer the question of complete particle interpretation of massive Grosse-Lechner type models. Thereby first examples of relativistic (wedge-local) QFT in four-dimensional spacetime are exhibited which are interacting and asymptotically complete. If time permits I will also discuss a mechanism for the breakdown of asymptotic completeness in models constructed recently by Longo, Tanimoto and Ueda.

(partially based on CMP 364 (2018) pp.203–232)

Marek Gluza (FU Berlin)

Equilibration towards generalized Gibbs ensembles in non-interacting theories

Joint with J. Eisert and T. Farelly

Even after almost a century, the foundations of quantum statistical mechanics are still not completely understood. In this work, we provide a precise account on these foundations for a class of systems of paradigmatic importance that appear frequently as mean-field models in condensed matter physics, namely non-interacting lattice models of fermions (with straightforward extension to bosons). We demonstrate that already the translation invariance of the Hamiltonian governing the dynamics and a finite correlation length of the possibly non-Gaussian initial state provide sufficient structure to make mathematically precise statements about the equilibration of the system towards a generalized Gibbs ensemble, even for highly non-translation invariant initial states far from ground states of non-interacting models. Whenever these are given, the system will equilibrate rapidly according to a power-law in time as long as there are no long-wavelength dislocations in the initial second moments that would render the system resilient to relaxation. Our proof technique is rooted in the machinery of Kusmin-Landau bounds. Subsequently, we numerically illustrate our analytical findings through a quench scenario with an initial state corresponding to an Anderson insulator observing power-law equilibration. We consider some possibilities for realizing distinct instances of generalized Gibbs ensembles in optical lattice-based quantum simulators and studying their stability in the presence of interactions.

Michal Jex (Karlsruhe Institute of Technology)

Subexponential decay rates of atomic eigenfunctions at critical threshold

Joint with Dirk Hundertmark and Markus Lange

In the talk we present a new method for calculating the decay rates of eigenfunctions for eigenvalues below the threshold of the essential spectrum. Our method is applicable also for eigenvalues at the threshold provided that the eigenfunction exists. We apply our result to the ground states of N electron atoms. We show that the decay rate of an eigenfunction at the threshold of the essential spectrum behaves as $\exp(-C\sqrt{|x|_\infty})$, where $|x|_\infty = \max_j(\|x_j\|)$ is the maximal distance of electron coordinates at the given point. We also show the existence of the eigenstate at the threshold where it turns out that our uniform estimates play a crutial role.

Anna Minguzzi (LPMMC, CNRS and University Grenoble-Alpes)

Some exact results of strongly interacting one-dimensional bosons and fermions under external confinement

We consider a one-dimensional gas of delta-interacting quantum particles under external confinement, choosing for specificity a harmonic confinement. This is an extension of the Lieb-Liniger model for bosons and of the Yang-Gaudin model for two-component fermions. Due to the presence of the external confinement, no Bethe Ansatz solution is available. Focusing on the limit of infinitely strong interactions, we develop and use an exact solution to obtain various physical properties of both bosons and multi-component fermions, both for static and dynamical properties.

Pieter Naaijkens (Universidad Complutense de Madrid)

Stability of anyonic superselection sectors

Joint with Matthew Cha and Bruno Nachtergaele

Two states are said to be in the same gapped phase if they are the ground states of a pair of gapped local Hamiltonians that can be connected by a continuous path of local Hamiltonians with a uniform spectral gap. Topologically ordered states have the interesting property that they give rise to excititations with braided statistics, called anyons. Their properties are encoded by a (typically modular) braided tensor category, describing the superselection sector theory of the model. This is believed to be an invariant of the gapped quantum phase. In our work we prove that this is true for an interesting class of quantum spin systems, using only a few physically transparant assumptions. To do this, we generalise earlier results on Doplicher-Haag-Roberts theory for quantum spin systems, to allow for excitations that can only be approximately localised. Two ingredients in our analysis are the (bi-)asymptopias introduced by Buchholz et al., and a Lieb-Robinson bound for quasi-local observables localised in infinite cone-like regions. These bounds allow us to show that the structure remains invariant after applying an automorphism with sufficient decay properties, such as obtained from the spectral flow (also called quasi-adiabatic continuation). With these results we then prove that the sector structure of abelian quantum double models is invariant under sufficiently small perturbations of the dynamics.

Markus Nöth (LMU Munich)

Dirac Particles Interacting Directly in 1+3 Dimensions

Joint with Matthias Lienert

We investigate existence and uniqueness of a class of integral equations that implement direct interaction, rather than interaction via potentials or a mediating field, between two Dirac particles. This class of equations arises naturally as a relativistic generalisation of the two particle Schödinger equation. In implementing a delayed interaction these integral equations rely crucially on using a multi-time wavefunction. While introducing interaction we avoid ultraviolet divergences as well as breaking Lorentz symmetry.

Marcello Porta (Eberhard Karls Universität Tübingen)

Anomaly non-renormalization in interacting Weyl semimetals

Joint with A. Giuliani and V. Mastropietro

Weyl semimetals are a recently discovered class of materials, whose band structure at the Fermi level mimics massless relativistic fermions in $3+1$ dimensions. As predicted by Nielsen and Ninomiya three decades before their discovery, when exposed to external electromagnetic fields these materials display the analogue of the chiral anomaly of QED, arising as a net quasi-particle flow between different Fermi points. In this talk I will discuss a rigorous generalization of Nielsen-Ninomiya's prediction to the case of interacting lattice Weyl semimetals. Our result extends the Adler-Bardeen anomaly non-renormalization property of QED to an interacting condensed matter system.

Wolfgang Spitzer (FernUniversität in Hagen)

Large-scale behavior of the local ground-state entropy of the ideal Fermi gas in a constant magnetic field

With Hajo Leschke and Alexander V. Sobolev

We consider the ground state of an ideal Fermi gas confined to a plane perpendicular to a constant magnetic field. We determine the precise leading scaling behavior of its entropy localized to some bounded domain $\Lambda \subset \mathbb{R}^2$. This local entropy satisfies a so-called area law in the sense that it scales with the length of the boundary curve $\partial\Lambda$ as Λ becomes large.

Random Systems

Session organizer: Peter Müller

Florian Dorsch

Pseudo-gaps for random hopping models

For one-dimensional random Schrödinger operators, the integrated density of states is known to be given in terms of the (averaged) rotation number of the Prüfer phase dynamics. We develop a controlled perturbation theory for the rotation number around an energy, at which all the transfer matrices commute and are hyperbolic. Such a hyperbolic critical energy appears in random hopping models. The main result is a Hölder continuity of the rotation number at the critical energy that, under certain conditions on the randomness, implies the existence of a pseudo-gap. This is illustrated by numerics.

Raphaël Ducatez (Université de Geneve)

Extremal eigenvalues of critical Erdos-Renyi graphs

Joint with Johannes Alt and Antti Knowles

We complete the analysis of the extremal eigenvalues of the the adjacency matrix A of the Erdős-Rényi graph $G(N,d/N)$ in the critical regime $d \asymp \log N$ of the transition previously uncovered, where the regimes $d \gg \log N$ and $d \ll \log N$ were studied. We establish a one-to-one correspondence between vertices of degree at least $2d$ and nontrivial (excluding the trivial top eigenvalue) eigenvalues of $A/\sqrt{d}$ outside of the asymptotic bulk $[-2,2]$. This correspondence implies that the transition characterized by the appearance of the eigenvalues outside of the asymptotic bulk takes place at the critical value $d = d_* = \frac{1}{\log 4-1}\log N$. For $d < d_*$ we obtain rigidity bounds on the locations of all eigenvalues outside the interval $[-2,2]$, and for $d > d_*$ we show that no such eigenvalues exist. All of our estimates are quantitative with polynomial error probabilities.

Our proof is based on a tridiagonal representation of the adjacency matrix and on a detailed analysis of the geometry of the neighbourhood of the large degree vertices. An important ingredient in our estimates is a matrix inequality obtained via the associated nonbacktracking matrix and an Ihara-Bass formula. Our argument also applies to sparse Wigner matrices, defined as the Hadamard product of A and a Wigner matrix, in which case the role of the degrees is replaced by the squares of the ℓ^2-norms of the rows.

Martin Gebert (University of California, Davis)

Bounds on the spectral shift function and a lower Wegner estimate for continuum random Schrödinger

We consider continuum random Schrödinger operators with iid random variables and an absolutely continuous single-site distribution with bounded density. We show pointwise-in-energy bounds on the expectation of the spectral shift function at *all* energies for such operators and perturbations corresponding to additional Dirichlet or Neumann boundary conditions along the boundary of a cube, i.e. perturbation by a delta-function on a hypersurface. We show that the bound scales with the area of the hypersurface where the boundary conditions are changed. We use these bounds to show a lower Wegner estimate. This implies a strictly positive, locally uniform lower bound on the density of states (DOS) of continuum random Schrödinger operators on the *entire spectrum*, i.e. the DOS does not have a zero within the spectrum.

Svetlana Jitomirskaya (University of California)

Fractal properties of the Hofstadter's butterfly and singular continuous spectrum of the critical almost Mathieu operator

Harper's operator – the 2D discrete magnetic Laplacian – is the model behind the Hofstadter's butterfly. It reduces to the critical almost Mathieu family, indexed by phase. We discuss the proof of singular continuous spectrum for this family, for all phases, finishing a program with a long history. We also present a result (with I. Krasovsky) that proves one half of the Thouless' one half conjecture from the early 80s: that Hausdorff dimension of the spectrum of Harper's operator is bounded by 1/2 for all irrational fluxes.

Christoph Marx (Oberlin College)

Quantitative continuity of the density of states in the probability distribution for continuum random Schrödinger operators

With Peter Hislop

We show that the density of states measure for random Schrödinger operators on $\mathbb{R}^d$ is Hölder continuous, with respect to the weak topology, in the underlying probability distribution. This extends our earlier result obtained for discrete random Schrödinger operators on $\mathbb{Z}^d$ and on graphs.

Leonid Pastur (B.I.Verkin Institute for Low Temperature Physics and Engineering)

Dynamics of Qubits in Random Matrix Environment

Joint with with E. Bratus

We consider models of dissipative and decoherent evolution of two qubits embedded in a disordered environment. Unlike the well known spin-boson model, which describes the translation invariant and macroscopic environment, we model both the environment and its interaction with qubits by random matrices of large size, which are widely used to describe multi-connected disordered media of mesoscopic and even nanoscopic size. An important property of our model is that it incorporates the so called non-Markovian dynamics, which allows for the backflow of energy and information from the environment to qubits and has been actively studied recently in various settings.

We obtain asymptotically exact in the size of environment expressions for the reduced density matrix of qubits valid for all typical realizations of the environment. The expressions, however, are rather complex and we employ the Bogolyubov-van Hove regime (long evolution time and weak qubit-environment interaction) to carry out their detailed analysis both analytical and numerical.

We find several interesting regimes of the entanglement evolution of two qubits, including vanishing their entanglement at a finite moment and, especially, the subsequent entanglement revival. These cases of entanglement dynamics are known in quantum information theory as the entanglement sudden death and entanglement sudden birth and are pertinent to the non-Markovian evolution. They have been found before in special versions of the macroscopic and translation invariant spin-boson model. Our results, obtained for non-macroscopic and disordered environment, demonstrate the robustness and universality of the above and other essential properties of entanglement evolution. Being combined with other processes of quantum information technology (e.g. entanglement distillation), they can lead to a considerably slower decay of entanglement up to its asymptotic persistence.

Constanza Rojas-Molina (Heinrich Heine Universiät Düsseldorf)

Dynamical localization in aperiodic media

In this talk we review old and new results on the phenomenon of dynamical localization arising in aperiodic media, as for example, in quasicrystals. We discuss how random Schrödinger operators appear naturally as auxiliary models in the study of wave propagation in purely aperiodic systems, and its consequences on the transport and spectral properties of such materials.

Dominik Schröder (IST Austria)

Edge Universality for non-Hermitian Random Matrices

We consider large non-Hermitian real or complex random matrices X with independent, identically distributed centred entries. We prove that their local eigenvalue statistics near the spectral edge, the unit circle, coincide with those of the Ginibre ensemble, i.e. when the matrix elements of X are Gaussian. Previously non-Hermitian edge universality had only been established under the condition of four matching moments [Tao, Vu (2015)]. The proof relies on the recently obtained optimal local law in the cusp regime of Hermitian random matrices, and a supersymmetric estimate on the least singular value of shifted Ginibre ensembles. This estimate on the least singular value improves the classical smoothing bound from [Sankar, Spielman, Teng (2006)] in the transitional edge regime.

Per von Soosten (Technische Universität München)

Non-ergodic delocalization in the Rosenzweig-Porter model

Joint with Simone Warzel

The Rosenzweig-Porter model, which linearly interpolates a random diagonal matrix and the Gaussian Orthogonal Ensemble, has recently received a renewed surge of interest related to the many-body localization transition. In this context, the model provides a very basic example of a non-ergodic delocalized phase, in which eigenfunctions spread to a large number of sites but not uniformly over the entire volume. We prove this phenomenon using martingale estimates along the characteristic curves of a stochastic advection equation satisfied by resolvent.

Yuanyuan Xu (KTH)

Gaussian Approximation of the Distribution of Strongly Repelling Particles on the Unit Circle

Joint with Alexander Soshnikov

In this talk, we consider an interacting system of n particles randomly distributed on the unit circle with stronger repelling than that of the Circular beta Ensemble. I will prove the Gaussian approximation of the distribution of the particles in this model.

Xiaolin Zeng (Université de Strasbourg)

Some random operator dynamics

Joint with Thomas Gérard and Christophe Sabot

Matsumoto and Yor studied the dynamics of exponential of drifted Brownian motions, in particular, they discovered an opposite drift phenomenon: when conditioned on some element of the tail sigma algebra of the process, the drift sign is flipped. We start by recalling this theorem, then we present a random matrix version discussed in a paper of Rider and Vlako, then a similar theorem in terms of random Schrödinger operator, which is related to the susy hyperbolic sigma model.

Condensed Matter

Session organizers: Gianluca Panati and Marcello Porta

N. Javier Buitrago Aza (Universidad de los Andes)

Topological index for fermion systems in disordered media

With A. F. Reyes–Lega and L. Sequera, based on Joint Works with J.–B. Bru and W. de Siqueira Pedra

A considerable number of mathematical results regarding gapped Hamiltonians of fermions were achieved in recent years. Among the most important are topological protection under small perturbations and the persistence of the spectral gap for interacting fermions. However, information on the classification of the underlying systems in terms of topological indices is lacking. We show the first step towards the relation between a sort of topological index σ, introduced at the 80's by Araki and Evans for gapped Hamiltonians of interacting fermion systems on the lattice. Our mathematical framework are Self–dual CAR Algebras (sCAR), whose structure contains the information on the symmetries of free fermions embedded in disordered systems, and are also useful to study interacting fermion systems even with supperconductors terms. Last but not least, sCAR are closely related to the Shale–Stinespring Theorem. The latter plays an important role in the study of Fredholm modules in the context of Clifford and CAR algebras. In this way a new approach encompassing examples of both topological as well as more traditional types of phase transitions of simple models, and which is close in spirit to noncommutative geometry, is proposed. Finally, I will comment how to tackle the problem of classification of Gapped Hamiltonians in terms of σ for the interparticle case.

Niels Benedikter (IST Austria)

Correlation Energy of the Mean-Field Fermi Gas by the Method of Collective Bosonization

Joint with Phan Thành Nam, Marcello Porta, Benjamin Schlein and Robert Seiringer

Quantum correlations play an important role in interacting systems; however, their mathematical description is a highly non-trivial task. I explain how correlations in fermionic systems can be described by bosonizing collective pair excitations. This leads us to an effective quadratic bosonic Hamiltonian. We then establish a theory of approximately bosonic Bogoliubov transformations. Using this theory we derive a Gell-Mann–Brueckner–type formula as an upper bound for the fermionic ground state energy.

Luca Fresta (University of Zurich)

A hierarchical supersymmetric model for weakly disordered three-dimensional semimetals

Joint with G. Antinucci and M. Porta

An important open problem in quantum mechanics is to prove that three-dimensional lattice Schrödinger operators with extensive disorder exhibit a localization/delocalization transition as a function of the disorder strengh. We studied a hierarchical supersymmetric lattice model for Weyl semimetals with weak Anderson-type disorder. In the talk I will present a theorem about the algebraic decay of the disorder-averaged two-point correlation function, compatible with delocalization. Our method is based on a rigorous implementation of the renormalization group, reminiscent of the Gawędzki-Kupiainen block spin transformations. The main technical novelty is the multi-scale analysis of massless Gaussian convolutions with purely imaginary covariances via stationary phase expansions.

Gian Michele Graf (ETH Zurich)

Violation of bulk-edge correspondence in a hydrodynamic model

Joint with H. Jud and C. Tauber

Shallow water models are known to exhibit topological properties in presence of Coriolis forces. Such models can be considered from a bulk perspective, and thus in terms of waves on an unbounded expanse of water, or from an edge perspective, in terms of waves coming to shore or propagating along it. Some form of bulk-edge correspondence would be expected, if not taken for granted. It however turns out that the correspondence is anomalous, as found by Tauber et al. or, by considering more boundary conditions, simply violated. The reasons are linked to Levinson's theorem from scattering theory.

Nikolai Leopold (IST Austria)

The Landau-Pekar equations: Adiabatic theorem and accuracy

Joint with Simone Rademacher, Benjamin Schlein and Robert Seiringer

We prove an adiabatic theorem for the Landau-Pekar equations. This allows us to derive new results on the accuracy of their use as effective equations for the time evolution generated by the Fröhlich Hamiltonian with large coupling constant α. In particular, we show that the time evolution of Pekar product states with coherent phonon field and the electron being trapped by the phonons is well approximated by the Landau-Pekar equations until times short compared to α^2.

Giovanna Marcelli (Universität Tübingen)

Non-equilibrium almost-stationary states and linear response for gapped non-interacting quantum systems

Joint with Stefan Teufel (Universität Tübingen)

We prove the validity of linear response theory at zero temperature for gapped infinitely extended quantum systems within the one-particle approximation. A gapped Hamiltonian, which is not necessarily periodic, is perturbed by switching on adiabatically in time a constant electric field of intensity $\varepsilon \ll 1$, modelled by a linear potential. It is shown that the initial Fermi projection evolves adiabatically into *non-equilibrium almost-stationary state* (NEASS), once the perturbation, which closes immediately the spectral gap of the unpertubed Hamiltonian, is turned on. We prove formulas for linear and higher order response coefficients, including the conductivity tensor.

We follow the strategy implemented in [2], but for both discrete and continuum models. Two new technical difficulties occur: to establish the trace class property and to deal with domain issues of some relevant unbounded operators (e.g. the domain of the perturbed Hamiltonian does depend on time). Finally, we provide a rigorous comparison between our approach, in which a uniform electric field is modelled by a linear (unbounded) potential, and the more traditional one where a time-dependent gauge transformation is performed (e.g. [1]).

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Domenico Monaco (Università Roma Tre)

(De)localized Wannier functions for Chern and quantum Hall insulators

Joint with H. Cornean, M. Moscolari, G. Panati, A. Pisante and S. Teufel

We consider gapped periodic quantum systems in 2- and 3-dimensions, like quantum Hall or Chern insulators, and we investigate the possibility to span the space of energy states below the spectral gap with localized Wannier functions. We show that, in presence of a non-zero Chern number, the optimal rate of decay for orthonormal Wannier functions is such that all moments of the position operators up to but not including the second are finite, and the second moment diverges. If one gives up the linear independence of Wannier functions, then we show how one can construct a Parsevel frame of exponentially localized Wannier functions also in the topological phases.

Massimo Moscolari (Aalborg University)

Beyond Diophantine Wannier diagrams: gap labelling for Bloch-Landau Hamiltonians

Joint work with H. Cornean and D. Monaco

In 1978 Wannier discovered a Diophantine relation expressing the integrated density of states of a gapped group of bands of the Hofstadter Hamiltonian as a linear function of the magnetic field flux with integer slope. I will show how to extend this relation to a gap labelling theorem for any 2D Bloch-Landau Hamiltonian operator and to certain non-covariant systems having slowly varying magnetic fields. The integer slope will be interpreted as the Chern character of the projection onto the space of occupied states.

Alessandro Olgiati (CNRS Grenoble)

Stability of the Laughlin phase in presence of interactions

Joint with Nicolas Rougerie

The Laughlin wave function is at the basis of the description of the fractional quantum Hall effect, nevertheless, many of its fundamental properties are yet to be understood. I will present a model for its response, within Laughlin's ansatz, to variations of the external potential and of the interaction among particles.

Our main result is that the energy is asymptotically captured by the minimum of an effective functional with variational constraints fixed by the incompressibility of the Laughlin phase. Moreover, as was already known for the Laughlin wave-function, the one-body density converges to the characteristic function of a set.

Jacob Shapiro (Columbia University)

The Topology of Mobility-Gapped Insulators

Studying deterministic operators, we define an appropriate topology on the space of mobility-gapped insulators such that topological invariants are continuous maps into discrete spaces, and we prove that this is indeed the case for the integer quantum Hall effect. That is, we show the Chern number is continuous w.r.t. deterministic deformations of the Hamiltonian, in strong localization that closes the spectral gap. Lastly we show why our "insulator" condition makes sense from the point of view of the localization theory using the fractional moments method.

Benjamin Støttrup (Aalborg University)

Magnetic pseudodifferential operators represented as generalized Hofstadter-like matrices

Joint with Horia D. Cornean, Henrik Garde and Kasper S. Sørensen

First, we reconsider the magnetic pseudodifferential calculus and show that for a large class of non-decaying symbols, their corresponding magnetic pseudodifferential operators can be represented, up to a global gauge transform, as generalized Hofstadter-like, bounded matrices. As a by-product, we prove a Calderón–Vaillancourt type result. Second, we make use of this matrix representation and prove sharp results on the spectrum location when the magnetic field strength b

varies. Namely, when the operators are self-adjoint, we show that their spectrum (as a set) is at least 1/2-Hölder continuous with respect to b in the Hausdorff distance.

Simone Warzel (TU Munich)

The Quantum Random Energy Model

The quantum random energy model serves as a simple cornerstone and testing ground in a variety of fields. It is the simplest of all mean-field spin glass models in which quantum effects due to the presence of a transversal field are studied. More recently, renewed interest in its spectral properties arose in connection with many-body localisation. In this talk, I will review some of the conjectures related to this model and present a recent proof of the predicted thermal phase diagram.

Posters

Spectral Theory

Lior Alon (Technion)

Nodal statistics of quantum graphs

Joint with Ram Band and Gregory Berkolaiko

The nodal surplus is the suitably normalized number of zeros of a Laplacian eigenfunction. Berkolaikos remarkable nodal-magnetic connection implies that the nodal surplus of a metric graph eigenfunction is equal to the stability index of its eigenvalue under magnetic perturbations. It has been suggested that the distribution of the nodal surplus contains information about the geometry of the underlying domain. We study the nodal surplus distribution for metric graphs. The existence of the distribution is established, along with its symmetry. One consequence of the symmetry is that a topological quantity – the Euler characteristic of the graph can be recovered as twice the average nodal surplus of its eigenfunctions. Furthermore, for graphs with disjoint cycles it is proven that the distribution has a universal form – it is binomial over the allowed range of values of the surplus.

Irina Blinova (ITMO University)

Resonance states completeness for quantum graph with Rashba Hamiltonian

Joint with Igor Popov and Maria Smolkina

A quantum graph Γ consisting of a ring Γ_0 and coupled infinite wires with is considered. The Rashba Hamiltonian with spin-orbit interaction on edges and the Kirchhoff coupling condition at the vertices are assumed. The scattering matrix is obtained. Completeness of the system of resonance states on the ring is studied. The proof technique is based on the factorization theorems for the characteristic function in the Sz-Nagy functional model [1] related to the scattering matrix for the quantum graph. Namely, the criterion of the absence of a singular inner factor is used.

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Anton Boitsev (ITMO University)

Model of electron in quantum graph interacting with two-level system

Joint with Igor Popov

We consider a model of an electron in a quantum graph interacting with two-level system. The operator has the form of sum of tensor products. We use boundary triplets approach to construct the scattering matrix. Numerical analysis of the movement of the resonances is considered.

Sebastian Egger (Technion)

Spectral-geometric properties of Neumann domains

Joint with Ram Band, Michael Bersudsky, Lior Alon and Alexander Taylor

A Laplacian eigenfunction on a manifold imposes a natural partition of a Riemannian manifold. This partition is determined by the gradient vector field of the Laplacian eigenfunction. The submanifolds of that partition are called Neumann domains. Their counterparts are the well-known nodal domains and various analogous question may be raised for Neumann domains as for nodal domains. For examples, it is well-known that the restriction of an eigenfunction to nodal domains yields always the ground state eigenfunction for the Dirichlet Laplacian of that nodal domain. Recently, it was conjectured by S. Zelditch that for 'most' Neumann domains an analogous statement holds. In this talk I present recent results on spectral-geometric properties of Neumann domains and compare them with analogous results for nodal domains.

Dario Feliciangeli (IST Austria)

Uniqueness and Non-Degeneracy of Minimizers of the Pekar Functional on a Ball

Joint with Robert Seiringer

We review some properties of the Pekar functional confined to balls. In particular, some recent results concerning existence, uniqueness and non-degeneracy of minimizers, are presented. These properties were already known to hold on the full space (thanks to works of Lieb and Lenzmann). The study of the confined case is motivated by a recent paper by Rupert Frank and Robert Seiringer, in which the validity of the aforementioned results is conjectured and taken as a working assumption.

Gyorgy Pal Geher (University of Reading)

Coexistence of quantum unsharp events

Joint with Peter Šemrl

In the classical formulation of quantum mechanics (sharp) quantum events are represented by projections, i.e. self-adjoint operators whose spectrum is contained in the two-point set $\{0, 1\}$. If P and Q are two projections, then

- they are each other's negation if $P + Q = I$,
- the occurrence of P implies the occurrence of Q if $P \leq Q$, and
- they are coexistent (i.e. can be measured together by applying a suitable apparatus) if they commute: $PQ = QP$.

In the theory of unsharp quantum measurement quantum events are represented by so-called effects, i.e. self-adjoint operators whose spectrum is contained in the interval $[0, 1]$. The set of all effects is called the effect algebra (or the $[0, I]$ operator interval) which is usually denoted by $\mathcal{E}(H)$, where H is a complex Hilbert space. If A and B are two effects, then

- they are each other's negation if $A + B = I$, and
- the occurrence of A implies the occurrence of B if $A \leq B$.

However, according to a theorem of Ludwig, the relation of coexistence (i.e. the relation that the two quantum unsharp events can be measured together by applying a suitable apparatus) translates into the following mathematical definition:

- A and $B \in \mathcal{E}(H)$ are coexistent if and only if there exist $E, F, G \in \mathcal{E}(H)$ such that
$$A = E + G, \quad B = F + G, \quad \text{and} \quad E + F + G \in \mathcal{E}(H).$$

Note that it can be easily shown that if A and B are projections, then they are coexistent in this sense if and only if they commute (which corresponds to the classical formulation).

The semi-definite order $\leq$ on the effect algebra is fairly well-understood. However, the relation of coexistence is very poorly understood, even for qubit effects. The aim of my talk is to present some new results about this interesting relation. First, I will answer a very natural question, namely, when two effects A and B are coexistent with exactly the same effects. Then I will present some classical results on the automorphisms of $\mathcal{E}(H)$, in particular, Ludwig's theorem and Molnar's theorem. Finally, I will present our most recent result on automorphisms of $\mathcal{E}(H)$ with respect to the relation of coexistence.

Benjamin Hinrichs (FSU Jena)

Absence of Ground States in the Renormalized Nelson Model

Joint with Thomas Norman Dam

We consider a model describing a non-relativistic massive boson interacting with a bosonic field, widely known as the Nelson model. Introducing an ultraviolet cutoff Λ, the model is described by the Hamilton operator H_Λ. Its renormalizability goes back to Nelson. Explicitly, setting $E_\Lambda = \inf \sigma(H_\Lambda)$, the operator $H_\Lambda - E_\Lambda$ converges to a self-adjoint operator H in norm resolvent sense as Λ tends to ∞. Due to translation invariance, the operator decomposes into fiber operators $H(\xi)$, with ξ being the total momentum of particle and field. We discuss that, under certain infrared criticality conditions, the fiber operators do not exhibit a ground state for arbitrary choice of ξ. Especially, this implies the absence of ground states for the physical model of a spinless particle interacting with a massless photon field in three dimensions.

Hideki Inoue (Nagoya University)

Wave operators on the half-line: continuous and discrete cases

Joint work with Naohiro Tsuzu

In this poster we report explicit formulas for the wave operators for Schrödinger operators on continuous and discrete half-lines. The computation for both cases is based on the stationary approach of scattering theory. Our main contribution to the continuous case is that we establish those formulas under an optimal assumption on the potential. Such an explicit formula in the discrete case has never been established so far up to our knowledge. As an application we give a topological interpretation for the so-called Levinson's theorem, which is a relation between the scattering phase shift and the number of bound states of a suitable quantum system.

Atsuhide Ishida (Tokyo University of Science)

Propagation property and inverse scattering for fractional powers of negative Laplacian

Enss (1983) proved a propagation estimate for the usual free Schrödinger operator that turned out to be very useful for inverse scattering by Enss-Weder (1995). Since then, this method has been called the Enss-Weder time-dependent method. In this talk, first, we introduce the same type propagation estimate for the fractional powers of negative Laplacian. Second, we report about the inverse scattering by applying the Enss-Weder time-dependent method. We find that the high velocity limit of the scattering operator uniquely determines the short-range interactions.

Jalaledin Yousefi Koupaei (Institutes for Theoretical Physics and Mathematics (IPM))

From the Classical Hamilton-Jacobi Theory to the Quantum Theory of Motion on a Curved Surface

Joint with Mehdi Golshani

We extend the classical motion of a constrained particle to the quantum domain, using Bohm's view of quantum mechanics. We introduce an effective geometrical model for the motion of a particle on an orientable connected surface, embedded in $\mathbb{R}^3$. This model is obtained from a generalization of the classical HamiltonJacobi theory and its ensemble description. The generalization is based on an action principle.

Finally, by some mathematical considerations, we show how the geometrical properties of the surfaces as a curved space, affect the motion of a particle in the domain of quantum mechanics. Also we show that, in addition to intrinsic geometrical properties, non-intrinsic properties of the surface appear in the dynamical equations.

Simon Larson (KTH)

Two-term spectral asymptotics for the Dirichlet Laplacian in a Lipschitz domain

Joint with Rupert Frank

In this talk I will discuss recent work on two-term spectral asymptotics for sums of eigenvalues of the Dirichlet Laplacian in a bounded open set with Lipschitz boundary. If time permits we shall also discuss applications to an asymptotic problem in spectral shape optimization and how the methods developed can be used to obtain universal, i.e. non-asymptotic, bounds.

Søren Mikkelsen (Aarhus University)

A semiclassical bound on certain commutators

Joint with Søren Fournais

In this talk we will for a Schrödinger operator $H_\hbar = -\hbar^2\Delta + V$ discuss semiclassical commutator bounds of the type:

$$\|[A, \mathbf{1}_{(-\infty,0]}(H_\hbar)]\|_1 \leq C\hbar^{1-d},$$

where A is either the position operator x or the momentum operator $-i\hbar\nabla$. Here C is a positive constant and $\|\cdot\|_1$ denotes the trace norm. This corresponds to a mean-field version of bounds introduced as an assumption by Benedikter, Porta and Schlein in a study of the mean-field evolution of a fermionic system.

Léo Morin (Rennes University)

A Birkhoff normal form for the semiclassical magnetic Laplacian

Joint with Nicolas Raymond and San Vũ Ngọc

For $A \in \mathcal{C}^\infty(\mathbf{R}^d, \mathbf{R}^d)$, we consider the semiclassical magnetic Schrodinger operator $\mathcal{H}_\hbar = (i\hbar\nabla + A)^2$ acting on $\mathsf{L}^2(\mathbf{R}^d)$, with d even. We assume that the magnetic matrix $B = (\partial_j A_i - \partial_i A_j)$ is invertible, and that the magnetic intensity $b = \mathrm{Tr}^+ B$ admits a unique and non-degenerate minimum. Under non-resonance assumptions on the eigenvalues of B, we can use the microlocalization properties of the pseudodifferential operator $\mathcal{H}_\hbar$ to construct a normal form. $\mathcal{H}_\hbar$ is reduced to a pseudodifferential operator of the form

$$\mathcal{N}_\hbar = \sum_{j=1}^{d/2} \mathsf{Op}\Big(\beta_j(w)\Big)\mathcal{I}_\hbar^{(j)} + \mathsf{Op} f\Big(\hbar, w, \mathcal{I}_\hbar^{(1)}, \ldots, \mathcal{I}_\hbar^{(d/2)}\Big),$$

where $\mathcal{I}_\hbar^{(j)}$ are harmonic oscillators. We deduce an expansion of the N first eigenvalues of $\mathcal{H}_\hbar$ in powers of $\hbar^{1/2}$. This also works on compact Riemannian manifolds with boundary, and Dirichlet boundary conditions.

Hiroaki Niikuni (Maebashi Institute of Technology)

On the eigenvalues embedded in the spectral bands for carbon nanotubes with impurities

In this talk, we discuss the spectra of Schrödinger operators on carbon nanotubes with impurities from the point of view of the theory of quantum graphs. In the case of periodic Schrödinger operators on carbon nanotubes without impurities, it is known that the spectrum the spectrum consists of infinitely many spectral bands and the set of eigenvalues with infinite multiplicities. In this talk, we give a finite number of impurities expressed as the δ vertex conditions to the operator. As a result, we obtain additional eigenvalues embedded in the spectral bands. Furthermore, we have an estimate from below of the number of embedded eigenvalues in each spectral bands for a suitable strength of δ vertex conditions.

In this talk, we deal with symmetric impurities with respect to xy-plane and rotation. Due to the rotational symmetry, we obtain a unitary equivalence between our operator and the direct sum of a finite number of Schrödinger operators on the degenerate carbon nanotube. Furthermore, we utilize the space-symmetry on xy-plane and decompose those operators as the direct sum of the reduced operators on half size degenerate carbon nanotube with the Dirichlet and Newmann boundary condition. After those decomposition, we examine the estimate from below of the number of eigenvalues in the spectral gaps of each reduced operator. Finally, we show that those eigenvalues are embedded in the spectral bands of other reduced operators.

Oliver Siebert (FSU Jena)

On ionization of atoms in a thermal field

Joint with David Hasler

We consider a model of an atom coupled to black body radiation at positive temperature. This will be implemented as a Schrödinger operator with finitely many eigenvalues, and a bosonic field with a linear QED coupling term where we have to impose a spatial cutoff. One expects that the atom will end up being ionized, eventually. Mathematically, one has to show that there are no time-translation invariant states corresponding to the coupled system, which reduces to the fact that the Liouville operator does not have any eigenvalues. This will be shown with the method of positive commutators for small coupling constants.

Quantum Information

David Davalos (Instituto de Física UNAM)

Divisibility of qubit channels and dynamical maps

Joint with Mario Ziman, Carlos Pineda

The concept of divisibility of dynamical maps is used to introduce an analogous concept for quantum channels by analyzing the *simulability* of channels by means of dynamical maps. In particular, this question is addressed for Lindblad divisible, completely positive divisible and positive divisible dynamical maps. The corresponding L-divisible, CP-divisible and P-divisible subsets of channels are characterized (exploiting the results by Wolf et al., Comm. Math. Phys., 279(1):147–168, 2008) and visualized for the case of qubit channels. We discuss the general inclusions among divisibility sets and show some equivalences for qubit channels. To this end we study the conditions of L-divisibility for finite dimensional channels, especially the cases with negative eigenvalues, extending and completing the results of Phys. Rev. Lett., 101(15):150402, 2008. Furthermore we show that transitions among every two of the defined divisibility sets are allowed. We explore particular examples of dynamical maps to compare these concepts. Finally, we show that every divisible but not infinitesimal divisible qubit channel (in positive maps) is entanglement-breaking, and open the question if something similar occur for higher dimensions.

Rasim Dermez (University of Afyon Kocatepe)

Quantification of entangled qudits for an ionic-phononic system in the Lamb-Dick regime

The focus of this paper is the entangled states of atomic trapped ion interacting within two phonons in Lambda configuration forming a twelve-dimensional Hilbert space. The work carried out two complicated measurements which are negativity (N) and concurrence (C). They have important functions in current theoretical studies. Hence, we worked with three-dimensional reduced density matrix in calculating the developed measurements for pure qudit states in the ionic-phononic system. To demonstrate the benefits of two complicated measurements for the family, we have applied them to study different values of

Lamb-Dicke (LD) parameters, $\eta = 0.01, 0.3, 0.5$. Two measurements of family is equal to a group of quantum measurements. Finally, our pure qudit states are maximally entangled states: $C = 1.0$, $N = 0.6$.

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Demosthenes Ellinas (Technical University of Crete)

Phase Space Operator Valued Probability Measures: Constructions via Quantum Channel Maps and Random Evolution via Quantum Master Equations

Operator valued measures (OVM) are introduced on symplectic phase plane (PP), by means of quasi-probability Wigner function. Employing the metaplectic group MSp(2), constructions of such OVM for various PP regions (a.k.a region operators RO), are carried out. Creating RO for extended regions is shown to require the action of positive trace increasing maps (pti maps), which in their operator sum representation have generators identified with (sub)group elements of the quantum symplectic in-homogeneous group ISp(2). Examples of phase space regiond with constructed RO include sets of points on axes, line segments and rotated line segments, circles and disks, straight and rotated lines, canonical polygons, and squeezed line segments, as well as lines related to Radon transform reconstruction problem in phase space. The symplectic group unifies the construction technique of all those cases and employs the group ISp(2) as the appropriate kinematical group for all region operator (generalized observable) constructions on the phase plane. Stochastic increments, operating at the level of Wigner function/region operator, are then introduced algebraically via a commutative/co-commutative

Hopf algebra of PP functions, together with a shift invariant algebraic functional. The functional gives rise to a a Markov operator which generates completely positive trace preserving maps, operating at the level of PP state-density operator or dually on OVMs. In this way an algebraic random walk (ARW) is derived. The so constructed ARW in its asymptotic limit leads to a quantum master equation Lindblad type for the density operator or dually to a generalized diffusion equation for Wigner function. The construction extends to systems of covariance formed by translation operator and its associated positive OVM (POVM) on e.g. the circle and derives an algebraic quantum random walk by means of completely positive trace preserving maps. Asymptotic limit of the action of such maps is shown to lead to ISO(2) algebra valued quantum master equations of Lindblad type.

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Daniel Stilck França (University of Copenhagen)

Poincare inequalities for quantum channels with applications to entanglement breaking times

Joint with Cambyse Rouzé and Eric P. Hanson

We investigate entanglement breaking times of Markovian evolutions in discrete and continuous time. In continuous time, we characterize which Markovian evolutions areeventually entanglement breaking, that is, evolutions for which there is a finite time afterwhich any entanglement initially has been destroyed by the noisy evolution. In the discretetime framework, we consider the entanglement breaking index, that is, the number oftimes a quantum channel has to be composed with itself beforeit becomes entanglementbreaking. To obtain these estimates, we introduce a notion of robustness of separabilitywhich we use to obtain bounds on the radius ofthe largest separable ball around faithful product states. We also extend the framework of Poincaré inequalities for nonprimitive semigroups to the discrete setting to quantify the convergence of quantum semigroups in discrete time, which might be of independent interest.

Pascal Fries (JMU Würzburg)

The entanglement Hamiltonian of chiral fermions on the torus

Joint with Ignacio Reyes, Guillem Perez-Nadal and David Blanco

We show that the entanglement Hamiltonian of chiral fermions on a general Riemann surface can be obtained by solving a singular integral equation. We solve this equation analytically on the torus, yielding explicit formulae for the entanglement Hamiltonian and entropy. Our result has a natural low temperature expansion and recovers literature results for the plane and cylinder as a limit.

Kabgyun Jeong (Seoul National University)

New upper bounds on the quantum capacity for general attenuator and amplifier

Joint with Youngrong Lim, Soojoon Lee and Jaewan Kim

There have been several upper bounds on the quantum capacity of the single-mode Gaussian channels with thermal noise, such as thermal attenuator and amplifier. We consider a class of attenuator and amplifier with more general noises, including squeezing or even non-Gaussian one. We derive new upper bounds on the energy-constrained quantum capacity of those channels by using the quantum conditional entropy power inequality (cQEPI). Also, we obtain lower bounds for the same channels by means of Gaussian optimizer with fixed input entropy. They give narrow bounds when the transmissivity is near unity and the energy of input state is low.

Igor Popov (ITMO University)

On entanglement transmission through atmosphere

Joint with Maria Faleeva and Bogdan Timchenko

We consider transmission of entangled qubits through turbulent atmosphere. Qubits are coded by means of modes of the Gaussian beam. The change of the density matrix of the input photons due to travelling through a stochastic medium and received by a device with aperture of finite size is described using the approach suggested in [1]. The quality of the entanglement transmission is estimated using the distance the transmission matrix and the subspace of matrices being tensor products. The possibility of the dense coding quantum algorithm implementation through the turbulent atmosphere is analyzed.

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Henrik Wilming (ETH Zürich)

Single-shot interpretations of von Neumann entropy

Joint work with Paul Boes, Rodrigo Gallego, Jens Eisert and Markus P. Müller

It is common wisdom in quantum information theory that, due to typicality, *i.i.d* settings are controlled by von Neumann entropy and its cousins like the quantum relative entropy, while single-shot settings are characterized by (smoothed) Rényi entropies and their relatives. In this talk, I present results that show that, under appropriate circumstances, the von Neumann entropy also characterizes single-shot settings. The presentation is based on the pre-prints ArXiv:1807.08773 and ArXiv:1809.10156. Depending on the length of the talks, the presentation may be split up or be reduced to either of the two parts.

First, I present (and discuss evidence for) the *catalytic entropy conjecture*, which, if true, provides an operational characterization of the von Neumann (and Shannon) entropy that does not rely on any *i.i.d* limits or typicality. Instead it works in the single-shot by making use of *catalysts* – auxiliary systems that return to their initial state after a physical process, but may become correlated with the system of interest. More precisely, consider two density matrices ρ and ρ'. Write $\rho \to \rho'$ if there exists a density matrix σ and a unitary U such that

$$\rho' = \mathrm{Tr}_2(U\rho \otimes \sigma U^\dagger), \quad \sigma = \mathrm{Tr}_1(U\rho \otimes \sigma U^\dagger). \tag{4}$$

Then the catalytic entropy conjecture states that if ρ and ρ' have different spectra, then

$$\rho \to \rho' \quad \Leftrightarrow \quad S(\rho) < S(\rho') \qquad \text{and} \qquad \mathrm{rank}(\rho) \leq \mathrm{rank}(\rho'). \tag{5}$$

This means that such catalytic transitions essentially completely characterize the von Neumann entropy and vice-versa (up to the rank-condition, which is not physically relevant since any state may be approximated by one with full rank with arbitrary small error while the von Neumann entropy is continuous). As part of the evidence for the conjecture, I show that i) it holds true in a large subset of transitions, namely those of the form $\rho \otimes \mathbf{1}/d \to \rho' \otimes \mathbf{1}/d$ for sufficiently large d and ii) the conjecture can be proven if one allows the catalyst to build up coherences in its initial eigenbasis, but remain invariant on the diagonal. In case ii) it is therefore sufficient to have access to a decohering environment in addition to access to catalysts and the ability to implement unitaries. Since decohering environments are ubiquitous, this result already provides an interesting single-shot characterization of von Neumann entropy. Time permitting, I also discuss applications to thermodynamics, such as single-shot algorithmic cooling and circumventing fluctuation theorems.

Second, I show that the Area Law in quantum many-body theory, which is formulated in terms of the von Neumann entanglement entropy, admits an operational single-shot interpretation: If a pure state on a lattice fulfills an Area Law, then the quantum information contained in a subregion of the lattice may be compressed, by a local unitary, onto the surface of the region. More precisely, consider a pure state $|\Psi\rangle$ on a regular lattice Λ of identical, finite-dimensional Hibert-spaces and assume that for any region A on the lattice,

$$S(\rho_A) \leq k|\partial A|, \tag{6}$$

where $|\partial A|$ denotes the surface area of A. Denote by $\mathrm{Ann}(A, l)$ an annulus of width l inside of A:

$$\mathrm{Ann}(A, l) := \{x \in A : d(x, A^c) \leq l\}, \tag{7}$$

where d is the lattice distance. Then we show that for any $\epsilon > 0$ and any region A there exists a unitary operation, acting only on A, such that

$$U_A|\Psi\rangle \approx_\epsilon |\chi\rangle_{\mathrm{Ann}(A,k/\epsilon)\cup A^c} \otimes |\emptyset\rangle_{A\setminus\mathrm{Ann}(A,k/\epsilon)}, \tag{8}$$

where $|\emptyset\rangle$ is a reference-state that may be chosen arbitrarily and the error is measured in terms of fidelity. In other words: by acting with U_A, one can effectively compress all the information contained in A into a thickened boundary of A of width $\sim k/\epsilon$. For a fixed $\epsilon > 0$ and in the limit of a large region A, this thickened boundary has a volume arbitrarily small compared to that of A. For any $\epsilon > 0$, the proof of this result also gives rise to an algebra of operators whose correlation functions can be computed (up to an error ϵ) in the representation on the boundary. This bears some similarity with toy-models of the holographic duality in terms of quantum error correcting codes and I discuss some open problems in this direction as well as results that show how the error-scaling can be improved when one takes into account more information about $|\Psi\rangle$ – for example, that it is a ground-state of a certain local Hamiltonian.

Many-Body Systems

Birger Brietzke (Heidelberg University)

A simple 2nd order lower bound to the energy of dilute Bose gases

Joint work with Jan Philip Solovej and Søren Fournais

For a dilute system of non-relativistic bosons interacting through a regular, positive potential v with scattering length a we prove that the ground state energy density satisfies the bound $e(\rho) \geq 4\pi a\rho^2(1 - C\sqrt{\rho a^3})$.

Based on ArXiv:1901.00539.

Thomas Forrest Kieffer (Georgia Institute of Technology)

Time Global Finite-Energy Weak Solutions to the Many-Body Maxwell-Pauli Equations

We study the quantum mechanical many-body problem of N nonrelativistic electrons interacting with their self-generated classical electromagnetic field and K static nuclei. The system of coupled equations governing the dynamics of the electrons and their self-generated electromagnetic field is referred to as the many-body Maxwell-Pauli equations. Here we construct time global, finite-energy, weak solutions to the many-body Maxwell-Pauli equations under the assumption that the fine structure constant α and the atomic numbers are not too large. The particular assumptions on the size of α and the atomic numbers ensure that we have energetic stability of the many-body Pauli Hamiltonian, i.e., the ground state energy is finite and uniformly bounded below with lower bound independent of the magnetic field and the positions of the nuclei. This work serves as an initial step towards understanding the connection between the energetic stability of matter and the wellposedness of the corresponding dynamical equations.

Markus Lange (Karlsruhe Institute of Technology)

Ground state properties of momentum transformed Fröhlich Bipolaron

Joint with Dirk Hundertmark and Michal Jex

The Fröhlich Bipolaron model describes two non-relativistic particles with Coulomb repulsion U that interact with a quantized scalar field. Using a new method we show in this talk that in the center of mass coordinates the Fröhlich Bipolaron has a ground state ψ below the ciritical value of U with the following decay property

$$\left|\langle \psi, e^{C\sqrt{|x_r|}}\psi\rangle\right| < \infty,$$

where x_r is the distance between the electrons and C is uniform in U up to the critical value. Our bound then can be used in a proof that the Bipolaron has a ground state at total momentum zero at the critical coupling.

Peter S. Madsen (Aarhus University)

Semi-classical limit of large fermionic systems at positive temperature

Joint with M. Lewin and A. Triay

We consider a system of N interacting fermions in $\mathbb{R}^d$ confined by an external potential in a regime where the strength of the interaction scales like $1/N$. At fixed positive temperature and with an effective semi-classical parameter $\hbar = N^{-1/d}$, we prove the convergence of the free energy of the system to the corresponding Thomas-Fermi energy. Furthermore, we obtain results on the convergence of approximate Gibbs states, and we are also able to treat the dilute case, where the interaction potential has the form $w_N(x) = N^{d\eta} w(N^\eta x)$.

Dinh-Thi Nguyen (Mathematisches Institut der LMU München)

Blow-up of neutron stars in the Hartree–Fock–Bogoliubov theory

It is a fundamental fact that neutron stars collapse when their masses are bigger than a critical number (Chandrasekhar limit). We will study the detail of the collapse phenomenon in the Hartree–Fock–Bogoliubov theory and prove that in the mass critical limit the HFB minimizers develop a universal blow-up profile given by the Lane–Emden solution.

Marco Olivieri (Sapienza University of Rome)

Quasi-Classical Dynamics of the Nelson Model

with Michele Correggi and Marco Falconi

The quasi-classical limit is a mathematical procedure which allows to derive effective models for microscopic systems composed by quantum particles interacting with a bosonic field, in regimes where the latter can be approximated by its classical counterpart. We show that, under suitable assumptions, any state of the whole system admits a limit given by a classical measure with values on trace class operators on the particle Hilbert space (state-valued measures). We then apply this framework to the Nelson model and derive an effective dynamics for the particles in the quasi-classical limit.

Condensed Matter

Daniele Dimonte (SISSA (International School for Advanced Studies))

Dynamics of Bose-Einstein Condensates in the Thomas-Fermi Regime

Joint work in progress with M. Correggi, D. Mitrouskas and P. Pickl

We discuss the time evolution for a many-body system of interacting bosons in the mean-field regime with scaled potential with shrinking support. Under appropriate assumptions the many-body Schrödinger dynamics for N particles is expected to be approximated by a one-particle nonlinear Schrödinger equation. The pure mean-field or GP limits have already been studied in detail, and the approximation proven to be correct on suitable time scales. On the opposite, in spite of its relevance in experimental physics, the Thomas-Fermi (TF) regime has not been fully investigated: in this regime the support of the interaction potential shrinks as the scattering length diverges with N. We show that the dynamic approximation is more subtle in this case, in particular at large time scales, but the effective description is still correct.

Kasper Studsgaard Sørensen (Aalborg University)

Some Spectral Properties of Magnetic Pseudodifferential Operators Represented as Generalized Hofstadter-Like Matrices

Joint with Horia Cornean, Henrik Garde and Benjamin Støttrup

We first show that the minimum and maximum values of the spectrum of a large class of bounded magnetic pseudodifferential operators with non-decaying symbols are Lipschitz continuous when the magnetic perturbation comes from a constant magnetic field. We then use this to show that gap edges of such operators also are Lipschitz continuous, as long as the gap does not close.