QMATH 15

Schedule and Abstracts

Y Dynamical Systems   M Many-Body   P Plenary Talk

SEPTEMBER 12 • MONDAY

9:00am – 9:30am		**Registration**	
9:30am – 10:30am	P	**Nodal deficiency, spectral minimal partitions and the Dirichlet-to-Neumann map** *Speakers: Gregory Berkolaiko*	Giedt 1001
10:30am – 11:00am		**Coffee Break**	
11:00am – 12:00pm	P	**Correlation energy of weakly interacting Fermi gases** *Speakers: Benjamin Schlein*	Giedt 1001
12:00pm – 2:00pm		**Lunch Break**	
2:00pm – 2:40pm	Y	**Counting closed geodesics and improving Weyl's law for predominant sets of metrics** *Speakers: Yaiza Canzani*	Giedt 1007
2:00pm – 2:40pm	M	**A bulk gap in the presence of edge states for a truncated Haldane pseudopotential** *Speakers: Amanda Young*	Giedt 1003
2:40pm – 3:05pm	Y	**Weyl laws for open quantum maps** *Speakers: Zhenhao Li*	Giedt 1007
2:45pm – 3:25pm	M	**Non-abelian Hall conductance as a homotopy invariant of gapped lattice systems** *Speakers: Anton Kapustin*	Giedt 1003
3:05pm – 3:30pm	Y	**Quantitative Convergence of Semiclassical Particle Trajectories** *Speakers: Yonah Borns-Weil*	Giedt 1007
3:30pm – 4:00pm		**Coffee Break**	
4:00pm – 4:15pm	M	**Propagation bounds for the Bose-Hubbard model** *Speakers: Marius Lemm*	Giedt 1003
4:00pm – 4:40pm	Y	**Wave propagation on rotating cosmic string backgrounds** *Speakers: Jared Wunsch*	Giedt 1007
4:15pm – 4:30pm	M	**"Dynamic" Abelian Quantum Double Models** *Speakers: Siddharth Vadnerkar*	Giedt 1003
4:30pm – 4:45pm	M	**Continuous families of GNS constructions** *Speakers: Markus J. Pflaum*	Giedt 1003
4:40pm – 5:05pm	Y	**Diffraction and Scattering of the Aharonov--Bohm Hamiltonian** *Speakers: Mengxuan Yang*	Giedt 1007
4:45pm – 5:00pm	M	**The Projective Hilbert Bundle of a 1d Parametrized System** *Speakers: Daniel Spiegel*	Giedt 1003
5:00pm – 5:15pm	M	**Many-body localization transition** *Speakers: John Imbrie*	Giedt 1003
5:05pm – 5:30pm	Y	**Mathematics of internal waves in a 2D aquarium** *Speakers: Jian Wang*	Giedt 1007
5:15pm – 5:30pm	M	**Gaussian Matrix Product States cannot efficiently approximate critical systems** *Speakers: Adrián Franco-Rubio*	Giedt 1003

QMATH 15

Y Dynamical Systems **N** New Topics **P** Plenary Talk **Q** QI

SEPTEMBER 13 • TUESDAY

9:30am – 10:30am	P	**Uniform entropic continuity bounds via majorization flow** *Speakers: Nilanjana Datta*	Giedt 1001
10:30am – 11:00am		**Coffee Break**	
11:00am – 12:00pm	P	**The low-density limit of the Lorenz gas: random vs periodic, classical vs quantum** *Speakers: Jens Marklof*	Giedt 1001
12:00pm – 2:00pm		**Lunch Break**	
2:00pm – 2:25pm	Q	**Quantum Algorithms for Testing Hamiltonian Symmetry** *Speakers: Mark Wilde*	Giedt 1003
2:00pm – 2:40pm	Y	**On the ergodicity of the frame flow** *Speakers: Thibault Lefeuvre*	Giedt 1007
2:00pm – 2:40pm	N	**Quantization of Edge Transport in Interacting Hall Systems** *Speakers: Marcello Porta*	Math 1147
2:30pm – 2:55pm	Q	**Quantum f-divergences via Nussbaum-Szkoła Distributions: Applications to Petz-Rényi and von Neumann Relative Entropy, and Gaussian states** *Speakers: Tiju Cherian John*	Giedt 1003
2:40pm – 3:05pm	Y	**Periodic orbit evaluation of a spectral statistic of quantum graphs without the semiclassical limit** *Speakers: Jon Harrison*	Giedt 1007
2:40pm – 3:20pm	N	**Advanced QMath Ready for Difficult Problems** *Speakers: John Klauder*	Math 1147
3:00pm – 3:25pm	Q	**Quantum mean states are nicer than you think: fast algorithms to compute states maximizing average fidelity** *Speakers: Afham*	Giedt 1003
3:05pm – 3:30pm	Y	**Semiclassical Analysis of discrete Witten Laplacians** *Speakers: Giacomo Di Gesù*	Giedt 1007
3:30pm – 4:00pm		**Coffee Break**	
4:00pm – 4:25pm	Q	**Multi-mode Gaussian State Analysis with Total Photon Counting** *Speakers: Arik Avagyan*	Giedt 1003
4:00pm – 4:40pm	Y	**Topological insulators in semiclassical regime** *Speakers: Alexis Drouot*	Giedt 1007
4:00pm – 4:40pm	N	**Ultraviolet Stability for Quantum Electrodynamics in d=3** *Speakers: Jon Dimock*	Math 1147
4:30pm – 4:55pm	Q	**Transcendental properties of entropy-constrained sets** *Speakers: Vjosa Blakaj*	Giedt 1003
4:40pm – 5:05pm	Y	**Resonances for Axiom A flows** *Speakers: Zhongkai Tao*	Giedt 1007
4:40pm – 5:05pm	N	**Interacting Quantum Field Theory in a Non-Commutative Space-Time** *Speakers: Juan Felipe Lopez*	Math 1147
5:05pm – 5:30pm	N	**Pointwise asymptotics for wave equations** *Speakers: Shi-zhuo Looi*	Math 1147

M Many-Body **P** Plenary Talk **Q** QI **S** Spectral Theory

SEPTEMBER 14 • WEDNESDAY

9:30am – 10:30am	P	**TBA** *Speakers: Andreas Winter*	Giedt 1001
10:30am – 11:00am		**Coffee Break**	
11:00am – 12:00pm	P	**Supersymmetric approach to the deformed Ginibre ensemble** *Speakers: Tatyana Shcherbina*	Giedt 1001
12:00pm – 2:00pm		**Lunch Break**	
2:00pm – 2:25pm	S	**Geometrically induced spectral properties of soft quantum waveguides** *Speakers: Pavel Exner*	Math 2112
2:00pm – 2:40pm	M	**Two modes approximation for bosons in a double well potential** *Speakers: Nicolas Rougerie*	Giedt 1003
2:00pm – 2:40pm	Q	**NLTS Hamiltonians from good quantum codes** *Speakers: Anurag Anshu*	Giedt 1006
2:30pm – 2:55pm	S	**Quantum Systems at The Brink: Critical Potentials and dimensionality** *Speakers: Michal Jex*	Math 2112
2:40pm – 3:05pm	Q	**Upper bounds on device-independent quantum key distribution rates in static and dynamic scenarios** *Speakers: Karol Horodecki*	Giedt 1006
2:45pm – 3:00pm	M	**Extensive long-range entanglement in a nonequilibrium steady state** *Speakers: Shachar Fraenkel*	Giedt 1003
3:00pm – 3:15pm	M	**The BCS energy gap at low and high density** *Speakers: Asbjørn Bækgaard Lauritsen*	Giedt 1003
3:00pm – 3:30pm	S	**Scattering for Schrödinger operators with potentials concentrated near a subspace** *Speakers: Adam Black, Tal Malinovitch*	Math 2112
3:05pm – 3:30pm	Q	**Haar random approximate t-designs and Gaussian Ensembles** *Speakers: Adam Sawicki*	Giedt 1006
3:15pm – 3:30pm	M	**BCS Theory at High Density** *Speakers: Joscha Henheik*	Giedt 1003
3:30pm – 4:00pm		**Coffee Break**	
4:00pm – 4:15pm	M	**The ground state energy of dilute 1D many-body quantum systems** *Speakers: Johannes Agerskov*	Giedt 1003
4:00pm – 4:25pm	S	**An approach to universality using Weyl m-functions** *Speakers: Milivoje Lukic*	Math 2112
4:00pm – 4:40pm	Q	**Limitations of Linear Cross-Entropy as a Measure for Quantum Advantage** *Speakers: Xun Gao*	Giedt 1006
4:15pm – 4:30pm	M	**Bogoliubov Theory for Trapped Bosons in the Gross-Pitaevskii Regime** *Speakers: Severin Schraven*	Giedt 1003
4:30pm – 4:45pm	M	**Characterizing dynamical quantum phase transitions in the transverse field Ising model: A complex network theory approach** *Speakers: Brandon Barton*	Giedt 1003
4:30pm – 5:00pm	S	**Critical Points of Discrete Periodic Operators** *Speakers: Matthew Faust*	Math 2112
4:40pm – 5:05pm	Q	**Optimal universal quantum circuits for unitary complex conjugation** *Speakers: Michal Studzinski*	Giedt 1006

4:45pm – 5:00pm	M	**The energy of the 2D dilute Bose gas: an upper bound** *Speakers: Lukas Junge*	Giedt 1003
5:00pm – 5:15pm	M	**The energy of the 2D dilute Bose gas: a lower bound** *Speakers: Marco Olivieri*	Giedt 1003
5:00pm – 5:25pm	S	**Complex absorbing potential method for calculating scattering resonances** *Speakers: Haoren Xiong*	Math 2112

QMATH 15

D Disordered Systems **N** New Topics **P** Plenary Talk **Q** QI **S** Spectral Theory

SEPTEMBER 15 • THURSDAY

9:30am – 10:30am	P	**The sum-of-squares for fermionic systems** *Speakers: Matthew Hastings*	Giedt 1001
10:30am – 11:00am		**Coffee Break**	
11:00am – 12:00pm	P	**Random Matrix Spectral Fluctuations in Quantum Lattice Systems** *Speakers: Tomaz Prosen*	Giedt 1001
12:00pm – 2:00pm		**Lunch Break**	
2:00pm – 2:25pm	S	**Thomas-Fermi profile of a fast rotating Bose-Einstein condensate** *Speakers: NGUYEN Dinh Thi*	Math 2112
2:00pm – 2:40pm	D	**The crossover from the Macroscopic Fluctuation Theory to the Kardar-Parisi-Zhang equation controls the large deviations of diffusive systems** *Speakers: Alexandre Krajenbrink*	Giedt 1006
2:00pm – 2:40pm	N	**Chiral Central Charge and Modular Commutator** *Speakers: Isaac Kim*	Math 1147
2:00pm – 2:40pm	Q	**Sheaf Codes** *Speakers: Pavel Panteleev*	Giedt 1003
2:30pm – 2:55pm	S	**Hydrogen-like Schrodinger Operators at Low Energies** *Speakers: Ethan Sussman*	Math 2112
2:40pm – 3:05pm	D	**Power Spectrum Analysis for the Circular Unitary Ensemble** *Speakers: Roman Riser*	Giedt 1006
2:40pm – 3:05pm	Q	**The vacuum provides quantum advantage to otherwise simulatable architectures** *Speakers: Cameron Calcluth*	Giedt 1003
2:40pm – 3:20pm	N	**Quantum Spin Glasses** *Speakers: Simone Warzel*	Math 1147
3:00pm – 3:25pm	S	**Ballistic Transport for Limit-periodic Schr\"odinger Operators in One Dimension** *Speakers: Giorgio Young*	Math 2112
3:05pm – 3:30pm	D	**The field Theory of Anderson-transition: the Spin Quantum Hall effect** *Speakers: Nick Nussbaum*	Giedt 1006
3:05pm – 3:30pm	Q	**The pretty good measurement of an ensemble of bosonic Gaussian states** *Speakers: Hemant Mishra*	Giedt 1003
4:00pm – 4:25pm	S	**Diffusion for a Quantum Particle in a Lindbladian Environment with a Periodic Hamiltonian** *Speakers: Jacob Gloe*	Math 2112
4:00pm – 4:40pm	D	**Large deviation estimates for CLTs in certain log-correlated fields** *Speakers: Emma Bailey*	Giedt 1006
4:00pm – 4:40pm	N	**TBA** *Speakers: Michael Levin*	Math 1147
4:30pm – 4:55pm	Q	**Quantum algorithms for Hamiltonian simulation with unbounded operators** *Speakers: Di Fang*	Giedt 1003
4:30pm – 4:55pm	S	**Optimal convergence rate in the quantum Zeno effect for open quantum systems in infinite dimensions** *Speakers: Tim Möbus*	Math 2112
4:40pm – 5:05pm	D	**Localization for Gaussian Random Band Matrices up to W** *Speakers: Jeff Schenker*	Giedt 1006

4:40pm – 5:05pm N **Inhomogeneous Tomonaga-Luttinger liquids out of equilibrium** Math 1147

Speakers: Per Moosavi

D Disordered Systems **S** Spectral Theory

SEPTEMBER 16 • FRIDAY

9:00am – 9:40am	D	**Random determinants, the elastic manifold, and landscape complexity beyond invariance** *Speakers: Ben McKenna*	Giedt 1006
9:00am – 9:40am	S	**Polya Conjecture for the Dirichlet problem in a multi-dimensional ball** *Speakers: Nikolay Filonov*	Math 2112
9:40am – 10:20am	S	**TBA** *Speakers: Julien Sabin*	Math 2112
9:45am – 10:10am	D	**Localization and eigenvalue statistics within Hartree-Fock theory** *Speakers: Rodrigo Matos*	Giedt 1006
10:20am – 10:50am		**Coffee Break**	
10:50am – 11:30am	D	**Extreme eigenvalues of random graphs with growing degrees** *Speakers: Jiaoyang Huang*	Giedt 1006
10:50am – 11:30am	S	**Johnson-Schwartzman gap labelling and applications** *Speakers: David Damanik*	Math 2112
11:30am – 12:10pm	S	**TBA** *Speakers: Lingrui Ge*	Math 2112

Abstracts

Afham: *Quantum mean states are nicer than you think: fast algorithms to compute states maximizing average fidelity*

Fidelity is arguably the most popular figure of merit in quantum sciences. However, many of its properties are still unknown. In this work, we resolve the open problem of maximizing average fidelity over arbitrary finite ensembles of quantum states and derive new upper bounds. We first construct a semidefinite program whose optimal value is the maximum average fidelity and then derive fixed-point algorithms that converge to the optimal state. The fixed-point algorithms outperform the semidefinite program in terms of numerical runtime. We also derive expressions for near-optimal states that are easier to compute and upper and lower bounds for maximum average fidelity that are exact when all the states in the ensemble commute. Finally, we discuss how our results solve some open problems in Bayesian quantum tomography.

Johannes Agerskov: *The ground state energy of dilute 1D many-body quantum systems*

In this talk we consider a dilute gas of 1D bosons interacting through a general, repulsive two-body potential. We will show that the ground state energy admits a first order expansion in the 1D diluteness parameter, where the zeroth-order term coincides with the free Fermi ground state energy. This result covers the strong-coupling/low-density limit of the Lieb-Liniger model but applies to a much more general class of repulsive pair potentials, including potentials with a positive scattering length. A corresponding result follows straightforwardly for spinless fermions. Finally, we will conjecture an expansion of a similar structure for spin-1/2 fermions. The talk is based on joint work with Robin Reuvers and Jan Philip Solovej (arXiv:2203.17183)

Anurag Anshu: *NLTS Hamiltonians from good quantum codes*

The NLTS (No Low-Energy Trivial State) conjecture of Freedman and Hastings [2014] posits that there exist families of Hamiltonians with all low energy states of non-trivial complexity (with complexity measured by the quantum circuit depth preparing the state). We prove this conjecture by showing that the recently discovered families of constant-rate and linear-distance QLDPC codes correspond to NLTS local Hamiltonians. The central technique is a clustering property of approximate codewords of X and Z codes that arise in these QLDPC codes.

Arik Avagyan: *Multi-mode Gaussian State Analysis with Total Photon Counting*

The continuing improvement in the qualities of photon-number-resolving detectors opens new possibilities for measuring quantum states of light. In this work we consider the question of what properties of an arbitrary multimode Gaussian state are determined by a single photon-number-resolving detector that measures total photon number. We find an answer to this question in the ideal case where the exact photon-number probabilities are known. We show that the quantities determined by the total photon number distribution are the spectrum of the covariance matrix, the absolute displacement along each eigenspace of the covariance matrix, and nothing else. In the case of pure Gaussian states, the spectrum determines the squeezing parameters. For mixed states we investigate the set of admissible covariance matrices with a given spectrum.

Emma Bailey: *Large deviation estimates for CLTs in certain log-correlated fields*

TBA

Brandon Barton: *Characterizing dynamical quantum phase transitions in the transverse field Ising model: A complex network theory approach*

Following a quantum quench, dynamical quantum phase transitions occur in non-analytic kinks of the rate of return (Loschmidt echo) and the long-time dynamics of the order parameter. We investigate the dynamics of the transverse field Ising model following a sudden quench in the transverse magnetic field parameter. Specifically, we aim to characterize the complexity of dynamical quantum phase transitions with weighted generalizations of complex network measures on two-body correlations from quantum many-body states. Pairwise networks constructed from the reduced density matrix lend methods of calculating weighted network measures on the adjacency matrix of entropy and entanglement correlations. We propose that complex network metrics may unveil a novel method for describing dynamical quantum phase transitions.

Bjarne Bergh: *Parallelization of Sequential Quantum Channel Discrimination in the Non-Asymptotic Regime*

We investigate the performance of parallel and sequential quantum channel discrimination strategies for a finite number of channel uses. It has recently been shown that, in the asymmetric setting with asymptotically vanishing type I error probability, sequential strategies are asymptotically not more powerful than parallel ones. We extend this result to the non-asymptotic regime with finitely many channel uses, by explicitly constructing a parallel strategy for any given sequential strategy, and bounding the difference in their performances, measured in terms of the decay rate of the type II error probability per channel use.

Gregory Berkolaiko: *Nodal deficiency, spectral minimal partitions and the Dirichlet-to-Neumann map*

In this overview talk we will explore connections between the subjects mentioned in the title as well as some other notions such as the spectral shift and the lateral variation principle. For an eigenfunction of the Dirichlet Laplacian, the nodal deficiency is the difference between the label of an eigenfunction (starting with 1 for the ground state) and the number of its nodal domains. It is known to be equal to the Morse index of a critical point of a certain spectral functional defined on the space of partitions of the manifold. The connection between the two is easier understood via the introduction of a two-sided Dirichlet-to-Neumann map. On one hand, the number of its negative eigenvalues is related to the spectral shift (which is a natural interpretation of the nodal deficiency). On the other hand, the DtN map is unitarily equivalent to the Hessian of the spectral functional at the critical point. The talk is based on several papers of Yaiza Canzani, Graham Cox, Bernard Helffer, Peter Kuchment, Jeremy Marzuola, Uzy Smilansky and Mikael Sundqvist, with and without the speaker.

Adam Black & Tal Malinovitch: *Scattering for Schrödinger operators with potentials concentrated near a subspace*

We consider the scattering properties of Schrödinger operators with potentials concentrated near a subspace of Euclidean space. This is one of many models of a quantum particle interacting with a surface. For such operators, we show the existence of scattering states and characterize their orthogonal complement as a set of "surface states," which consists of states that are confined to the subspace (such as pure point states) and states that escape it at a sublinear rate, in a suitable sense. Our proof uses a novel interpretation of the Enss method in order to obtain a dynamical characterization of the orthogonal complement of the scattering states. In this talk we will state our results and sketch some of the main ideas of the proof.

Vjosa Blakaj: *Transcendental properties of entropy-constrained sets*

For information-theoretic quantities with an asymptotic operational characterization, the question arises whether an alternative single-shot characterization exists, possibly including an optimization over an ancilla system. If the expressions are algebraic and the ancilla is finite, this leads to semialgebraic level sets. In this work, we provide a criterion for disproving that a set is semialgebraic based on an analytic continuation of the Gauss map. Applied to the von Neumann entropy, this shows that its level sets are nowhere semialgebraic in dimension $d > 2$, ruling out algebraic single-shot characterizations with finite ancilla (e.g., via catalytic transformations). We show similar results for related quantities, including the relative entropy, and discuss under which conditions entropy values are transcendental, algebraic, or rational

Yonah Borns-Weil: *Quantitative Convergence of Semiclassical Particle Trajectories*

We study the trajectories of a quantum particle in a detector under repeated indirect measurement, in the semiclassical regime. We extend the results of Benoist, Fraas, and Fröhlich to discrete-time quantum maps on the quantized torus, and provide the first numerics illustrating the results. In addition, we derive quantitative bounds on the convergence to a classical trajectory based on classical dynamical measures of chaos of the system. This is joint work with Izak Oltman.

Cameron Calcluth: *The vacuum provides quantum advantage to otherwise simulat-*

able architectures

We consider a computational model composed of ideal Gottesman-Kitaev-Preskill stabilizer states, Gaussian operations - including all rational symplectic operations and all real displacements -, and homodyne measurement. We prove that such architecture is classically efficiently simulatable, by explicitly providing an algorithm to calculate the probability density function of the measurement outcomes of the computation. We also provide a method to sample when the circuits contain conditional operations. This result is based on an extension of the celebrated Gottesman-Knill theorem, via introducing proper stabilizer operators for the code at hand. We conclude that the resource enabling quantum advantage in the universal computational model considered by B.Q. Baragiola et al [Phys. Rev. Lett. 123, 200502 (2019)], composed of a subset of the elements given above augmented with a provision of vacuum states, is indeed the vacuum state.

Yaiza Canzani: *Counting closed geodesics and improving Weyl's law for predominant sets of metrics*

We discuss the typical behavior of two important quantities on compact manifolds with a Riemannian metric g: the number, $c(T, g)$, of primitive closed geodesics of length smaller than T, and the error, $E(L, g)$, in the Weyl law for counting the number of Laplace eigenvalues that are smaller than L. For Baire generic metrics, the qualitative behavior of both of these quantities has been understood since the 1970's and 1980's. In terms of quantitative behavior, the only available result is due to Contreras and it says that an exponential lower bound on $c(T, g)$ holds for g in a Baire-generic set. Until now, no upper bounds on $c(T, g)$ or quantitative improvements on $E(L, g)$ were known to hold for most metrics, not even for a dense set of metrics. In this talk, we will introduce the concept of predominance in the space of Riemannian metrics. This is a notion that is analogous to having full Lebesgue measure in finite dimensions, and which, in particular, implies density. We will then give stretched exponential upper bounds for $c(T, g)$ and logarithmic improvements for $E(L, g)$ that hold for a predominant set of metrics. This is based on joint work with J. Galkowski.

Tiju Cherian John: *Quantum f-divergences via Nussbaum-Szkoła Distributions: Applications to Petz-Rényi and von Neumann Relative Entropy, and Gaussian states*

We prove that the quantum f-divergence of two states (density operators on a Hilbert space of finite or infinite dimensions) is same as the classical f-divergence of the corresponding Nussbaum-Szkoła distributions. This provides a general framework to study most of the known quantum entropic quantities using the corresponding classical entities. In this spirit, we study the Petz-Rényi and von Neumann relative entropy and prove that these quantum entropies are equal to the corresponding classical counterparts of the Nussbaum-Szkoła distributions. This is a generalization of a finite dimensional result that was proved by Nussbaum and Szkoła [Ann. Statist. 37, 2009, 2] to the infinite dimensions. We apply classical results about Rényi and Kullback-Leibler divergences to obtain new results and new proofs for some known results about the quantum relative entropies. Most important among these are (i) a quantum Pinsker type inequality in the infinite dimensions, and (ii) necessary and sufficient conditions for the finiteness of the Petz-Rényi α-relative entropy for any order $\alpha \in [0, \infty]$. Furthermore, we construct an example to show that the information theoretic definition of the von Neumann relative entropy is different from Araki's definition of relative entropy when the dimension of the Hilbert space is infinite. This discrepancy can be bridged using the notion of the distribution of an unbounded positive selfadjoint operator with respect to a positive compact operator and Haagerup's extension of the trace. Our results are valid in both finite and infinite dimensions and hence can be applied to continuous variable systems as well. To illustrate the point, we study the Petz-Rényi relative entropy of Gaussian states using our results.

David Damanik: *Johnson-Schwartzman gap labelling and applications*

We give an introduction to Johnson's gap labelling based on the Schwartzman homomorphism and describe several recent applications of this theory, including a positive answer to a question of Bellissard about the structure of the almost sure spectra of random Schrödinger operators.

Nilanjana Datta: *Uniform entropic continuity bounds via majorization flow*

We employ majorization theory to obtain a powerful tool for deriving simple and universal proofs of continuity bounds for various entropies which are relevant in information theory. In obtaining this, we first derive a more general result which may be of independent interest: a necessary and sufficient condition under which a state maximizes a concave, continuous, Gateaux-differentiable function in an epsilon-ball in trace distance. Examples of such a function include the von Neumann entropy, Renyi entropies, and the conditional entropy. In particular, by introducing a notion of majorization flow, we prove that the α-Rényi entropy is Lipschitz continuous, for $\alpha > 1$, thus resolving an open problem and providing a substantial improvement over previously known bounds. We also discuss some challenging open questions. This is joint work with Eric Hanson.

Giacomo Di Gesù : *Semiclassical Analysis of discrete Witten Laplacians*

We consider a discrete Schrödinger operator $H_\epsilon = -\epsilon^2\Delta + V_\epsilon$ on $l^2(\epsilon Z^d)$, where V_ϵ is defined in terms of a general multiwell energy landscape f. This operator can be seen as a discrete analog of the semiclassical Witten Laplacian in Euclidean space. Moreover it is unitarily equivalent to a type of discrete diffusion arising in the context of disordered mean field models in Statistical Mechanics, as e.g. the Curie-Weiss model. In this talk I will present results on the bottom of the spectrum of H_ϵ in the semiclassical regime $\epsilon << 1$, including the fine asymptotics of the tunnel effect between wells. These results require minimal regularity assumptions on f, are based on microlocalization techniques and permit to recover the Eyring-Kramers formula for the metastable tunneling time of the underlying stochastic process.

Jon Dimock: *Ultraviolet Stability for Quantum Electrodynamics in d=3*

We report on results for quantum electrodynamics on a finite volume Euclidean spacetime in dimension $d = 3$. The theory is formulated as a functional integral on a fine toroidal lattice involving both fermion fields and abelian gauge fields. The main result is that, after renormalization, the partition function is bounded uniformly in the lattice spacing. This is a first step toward the construction of the model. The result is obtained by renormalization group analysis pioneered by Balaban. A single renormalization group transformation involves block averaging, a split into large and small field regions, and an identification of effective actions in the small field regions via cluster expansions. This leads to flow equations for the parameters of the theory. Renormalization is accomplished by fine-tuning the initial conditions for these equations. Large field regions need no renormalization, but are shown to give a tiny contribution.

Alexis Drouot: *Topological insulators in semiclassical regime*

We will study the dynamics of waves propagating along interfaces between topologically distinct insulators. I will show that they split in two parts: one that propagates coherently at a predetermined speed and direction, and one that immediately collapses. This relies on the analysis of semiclassical systems whose symbols admit conically degenerate eigenvalues.

Pavel Exner: *Geometrically induced spectral properties of soft quantum waveguides*

We discuss Schrödinger operators with an attractive potential in the form of a 'ditch' of a fixed profile built along a smooth curve in $\mathbb{R}^\nu$. If $\nu = 2$ and the curve is infinite and not straight, but asymptotically straight in a suitable sense, we derive a sufficient condition for the discrete spectrum of such an operator to be nonempty, for $\nu = 3$ we get a similar result under an additional restriction on the curve torsion. We also address the questions about weak coupling asymptotics and of ground state optimization in the situation when the generating curve in $\mathbb{R}^2$ has the shape of a loop without self-intersections.

Di Fang: *Quantum algorithms for Hamiltonian simulation with unbounded operators*

Recent years have witnessed tremendous progress in developing and analyzing quantum algorithms for quantum dynamics simulation of bounded operators (Hamiltonian simulation). However, many scientific and engineering problems require the efficient treatment of unbounded operators, which frequently arise due to the discretization of differential operators. Such applications include molecular dynamics, electronic structure theory, quantum control and quantum differential equations solver. We will introduce some recent advances in quantum algorithms for efficient unbounded Hamiltonian simulation, including Trotter type splitting and the quantum highly oscillatory protocol (qHOP) in the interaction picture.

Matthew Faust: *Critical Points of Discrete Periodic Operators*

The spectral gap conjecture is a well known and widely believed conjecture in mathematical physics concerning the structure of the Bloch variety (dispersion relation) of periodic operators. The Bloch variety of a discrete operator is algebraic, inviting methods from algebraic geometry to their study. Motivated by this conjecture, this talk will introduce a bound on the number of critical points of the dispersion relation for discrete periodic operators, and provide a general criterion for when this bound is achieved. We also present a class of periodic graphs for when this criteria is satisfied for Schrödinger operators. This is joint work with Frank Sottile.

Nikolay Filonov: *Polya Conjecture for the Dirichlet problem in a multi-dimensional ball*

TBA

Shachar Fraenkel: *Extensive long-range entanglement in a nonequilibrium steady state*

Entanglement measures constitute powerful tools in the quantitative description of quantum many-body systems out of equilibrium. We study entanglement in the current-carrying steady state of a paradigmatic one-dimensional model of noninteracting fermions at zero temperature in the presence of a scatterer. In our previous work [1] we found an unusual scaling law for the entanglement entropy of a subsystem that is far away from the scatterer. Our exact results showed that the entanglement entropy of such a subsystem obeys an extensive (volume-law) scaling along with an additive logarithmic correction. In this new work [2], we show that disjoint intervals located on opposite sides of the scatterer and within similar distances from it display volume-law entanglement regardless of their separation, as measured by their fermionic negativity [3] and coherent information [4]. We analytically derive exact expressions for the extensive terms of these quantities and, given a large separation, also for the subleading logarithmic terms. Remarkably, our results imply in particular that far-apart intervals that are positioned symmetrically relative to the scatterer are more strongly entangled than if we had reduced the distance between them by choosing one of these intervals to be closer to the scatterer. The strong long-range entanglement is generated by the coherence between the transmitted and reflected parts of propagating particles within the bias-voltage window, despite the fact that only single particles are scattered independently. The generality and simplicity of the model suggest that this behavior should characterize a large class of nonequilibrium steady states. [1] S. Fraenkel and M. Goldstein, Entanglement measures in a nonequilibrium steady state: Exact results in one dimension, SciPost Phys. 11, 85 (2021). [2] S. Fraenkel and M. Goldstein, Extensive long-range entanglement in a nonequilibrium steady state, arXiv:2205.12991 (2022). [3] H. Shapourian, K. Shiozaki, and S. Ryu, Partial time-reversal transformation and entanglement negativity in fermionic systems, Phys. Rev. B 95, 165101 (2017). [4] M. Horodecki, J. Oppenheim, and A. Winter, Partial quantum information, Nature 436, 673 (2005).

Adrián Franco-Rubio: *Gaussian Matrix Product States cannot efficiently approximate critical systems*

Gaussian fermionic matrix product states (GfMPS) form a class of ansatz quantum states for 1d systems of noninteracting fermions. We prove, for a simple critical model of free hopping fermions, that any GfMPS approximation to its ground state must have bond dimension scaling superpolynomially with the system size, whereas there exists a non-Gaussian MPS approximation with polynomial bond dimension. This proves that, in general, imposing Gaussianity at the level of the tensor network may significantly alter its capability to efficiently approximate critical Gaussian states. The proof is based on a lower bound on the approximation error derived from the entanglement spectrum of the chain, which itself is constrained by arguments from asymptotic Toeplitz determinant theory. We also provide numerical evidence that the required bond dimension is still subexponential, and comment on how, for this computation, large system sizes can be reached more easily by exploting a connection between symmetric GfMPS and transfer functions of linear, time-invariant systems. Based on joint work with Ignacio Cirac (arXiv:2204.02478).

Xun Gao: *Limitations of Linear Cross-Entropy as a Measure for Quantum Advantage*

In recent experiments, Google and USTC claimed to achieve quantum advantage based on sampling from random quantum circuits. To certify the correctness of the sampling task, they developed a linear cross-entropy benchmark (XEB) and made their claim based on achieving a high value of XEB. The implicit assumption is that XEB approximates the fidelity well and hence could serve as a proxy in practice. However, it turns out that XEB can often deviate from fidelity, so it is crucial to understand how XEB and fidelity are related. I introduce a novel approach to analyze XEB through a mapping of random quantum circuits to a discrete classical statistical-physics models. By analyzing this model by a combination of qualitative analysis, numerical computation, and analycal methods, we show that XEB could drastically overestimates fidelity under certain conditions. Based on this observation, we design a classical spoofing algorithm which achieves comparable XEB values to those obtained in the state-of-the-art experiments by using 1 GPU within 1 second. Furthermore, we show that this algorithm performs better than noisy quantum circuits in the limit of large system size and depth in many cases. These results indicate that XEB on its own is not a good benchmark to certify quantum advantage.

Jacob Gloe: *Diffusion for a Quantum Particle in a Lindbladian Environment with a Periodic Hamiltonian*

A quantum particle restricted to a lattice of points has been well studied in many different contexts. In the absence of considering the interaction with its environment, the particle simply undergoes ballistic transport for many suitable Hamiltonian operators. Recently, progress has been made on introducing a Lindbladian interaction term to the model, which drastically changes the dynamics in the large time limit. We prove that indeed diffusion is present in this context for an arbitrary periodic Hamiltonian. Additionally, we show that the diffusion constant is inversely proportional to the particles' coupling strength with its environment.

Jon Harrison: *Periodic orbit evaluation of a spectral statistic of quantum graphs without the semiclassical limit*

Energy level statistics of quantized chaotic systems are often evaluated in the semiclassical limit via their periodic orbits using the Gutzwiller or related trace formulae. Here, we evaluate a spectral statistic of 4-regular quantum graphs from their periodic orbits without the semiclassical limit. The variance of the n-th coefficient of the characteristic polynomial is determined by the sizes of the sets of distinct primitive periodic orbits with n bonds which have no self-intersections, and the sizes of the sets with a given number of self-intersections which all consist of two sections crossing at a single vertex. Using this we observe the mechanism that connects semiclassical results to the total number of orbits regardless of their structure.

Matthew Hastings: *The sum-of-squares for fermionic systems*

I will discuss some recent results using the sum-of-squares method to prove bounds on the ground state energy of interacting fermionic systems.

Joscha Henheik: *BCS Theory at High Density*

After a brief introduction to the mathematical formulation of the Bardeen-Cooper-Schrieffer (BCS) theory of superconductivity, we will present and explain an asymptotic formula for the critical temperature T_c in the limit of high densities, $\mu \to \infty$. This formula strongly depends on the strength of the interaction potential V on the Fermi surface. Since $T_c \sim \mu A \exp(-B/\sqrt{\mu})$ in the limit of low density, $\mu \to 0$ (C. Hainzl, R. Seiringer, Lett. Math. Phys. 84, 2008), the high-density limit is in particular relevant for explaining superconducting domes, i.e. a non-monotonic behavior of $T_c(\mu)$, exhibiting a maximum value at finite μ and going to zero for large μ. If time permits, we will discuss a similar asymptotic formula for the energy gap Ξ, which, together with the previous formula for T_c, proves the universality of the ratio Ξ/T_c in the high-density limit, independent of the interaction potential V. This is joint work with Asbjørn Bækgaard Lauritsen.

Karol Horodecki: *Upper bounds on device-independent quantum key distribution rates in static and dynamic scenarios*

In this work, we develop upper bounds for key rates for device-independent quantum key distribution (DI-QKD) protocols and devices. We study the reduced cc-squashed entanglement and show that it is a convex functional. As a result, we show that the convex hull of the currently known bounds is a tighter upper bound on the device-independent key rates of standard Clauser-Horne-Shimony-Holt (CHSH)-based protocol. We further provide tighter bounds for DI-QKD key rates achievable by any protocol applied to the CHSH-based device. This bound is based on reduced relative entropy of entanglement optimized over decompositions into local and non-local parts. In the dynamical scenario of quantum channels, we obtain upper bounds for device-independent private capacity for the CHSH based protocols. We show that the device-independent private capacity for the CHSH based protocols on depolarizing and erasure channels is limited by the secret key capacity of dephasing channels.

Jiaoyang Huang: *Extreme eigenvalues of random graphs with growing degrees*

I will discuss some results on extreme eigenvalue distributions of adjacency matrices of Erdös-Rényi graphs $G(N, p)$ and random d-regular graphs , when the degree grows with the size N of the graph. On the regime $N^{\epsilon} \leq pN << N$ for Erdös-Rényi graphs and $N^{\epsilon} \leq d << N^{1/3}$ for random d-regular graphs, we prove after proper normalization, the fluctuation of their extremal eigenvalues converges to the Tracy-Widom distribution. As a consequence, in the same regime of d, about 69% of all d-regular graphs have the second-largest eigenvalue strictly less than $2\sqrt{d-1}$. Our proof is based on constructing a higher order self-consistent equation for the Stieltjes transform of the empirical eigenvalue distributions. This is based on joint works with Horng-Tzer Yau.

John Imbrie: *Many-body localization transition*

A quantum system is said to be many-body localized (MBL) if it remains close to its initial state, i.e., it fails to thermalize. In 2016, I published a proof that certain one-dimensional spin chains have an MBL phase (the proof depended on a certain assumption on level statistics). Some recent numerical studies have raised questions about whether there is a true MBL phase. I will attempt to summarize the issues raised, but the fact remains that the mechanisms for the breakdown of MBL are well understood theoretically. In recent work with Morningstar and Huse (PRB, 2020), we develop specific RG flow equations. These are similar to the Kosterlitz-Thouless (KT) flow as previously shown, but there are important differences that place the MBL transition in a new universality class.

Michal Jex: *Quantum Systems at The Brink: Critical Potentials and dimensionality*

One of the crucial properties of a quantum system is the existence of bound states. While the existence of eigenvalues below zero, i.e., below the essential spectrum, is well understood, the situation of zero energy bound states at the edge of the essential spectrum is far less understood. We present necessary and sufficient conditions for Schrödinger operators to have a zero energy bound state. Our sharp criteria show that the existence and non-existence of zero energy ground states depends strongly on the dimension and the asymptotic behavior of the potential. There is a spectral phase transition with dimension four being critical.

Lukas Junge: *The energy of the 2D dilute Bose gas: an upper bound*

We provide an upper bound for the ground state energy density of the dilute Bose gas in the thermodynamic regime in two dimensions. We prove an expansion analogous to the famous Lee-Huang-Yang formula in three dimensions. Our result holds for essentially all radial, positive potentials with finite scattering length, in particular including the special case of the hard-core potential. From a joint work with S. Fournais, T. Girardot, L. Morin and M. Olivieri.

Anton Kapustin: *Non-abelian Hall conductance as a homotopy invariant of gapped lattice systems*

I will explain how to define homotopy invariants of gapped lattice systems which are invariant under a Lie group G. These invariants are locally computable and take values in G-invariant polynomials on the Lie algebra of G. In the case when $G = U(1)$ and the lattice is two-dimensional, the invariant is equal to the Hall conductance at zero temperature.

Isaac Kim: *Chiral Central Charge and Modular Commutator*

We review a recently proposed formula for the chiral central charge of a two-dimensional gapped system with a chiral edge. We formalize this proposal as a mathematical conjecture and provide evidences supporting this conjecture.

John Klauder: *Advanced QMath Ready for Difficult Problems*

A new quantization procedure that can solve difficult problems, such as those with $q > 0$. It can also quantize nonrenormalizable field theories and gravity.

Alexandre Krajenbrink: *The crossover from the Macroscopic Fluctuation Theory to the Kardar-Parisi-Zhang equation controls the large deviations of diffusive systems*

In this talk, I will explore the problem of the crossover from the macroscopic fluctuation theory (MFT) which describes 1D stochastic diffusive systems at late times, to the weak noise theory (WNT) which describes the Kardar-Parisi-Zhang (KPZ) equation at early times. I will focus on the example of the diffusion in a time-dependent random field, observed in an atypical direction which induces an asymmetry and my goal will be to obtain the rate function which describes the large deviations of the cumulative distribution of the tracer position. This rate function exhibits a crossover as the asymmetry is varied, recovering both MFT and KPZ limits. To reach this aim, I will expand the program of the MFT and the WNT and unveil their complete solvability through a connection to the integrability of the derivative Nonlinear Schrodinger equation. I will solve this system using the inverse scattering method for mixed-time boundary conditions introduced by Pierre Le Doussal and myself to solve the WNT. This is based on the work arXiv:2204.04720 with P. Le Doussal.

Asbjørn Bækgaard Lauritsen: *The BCS energy gap at low and high density*

We study the energy gap Ξ of the Bardeen–Cooper–Schrieffer (BCS) theory of superconductivity in both the low- and high-density limits. In these limits we find asymptotic formulas for the energy gap, which in the low-density limit only depends on the interaction through the scattering length. Comparing the formulas for the energy gap with known formulas for the critical temperature T_c we verify a result from the physics literature, that the ratio Ξ/T_c is a universal constant, independent of the microscopic details of the interaction. Joint work with Joscha Henheik. Based on arXiv:2009.03701 and arXiv:2106.02028.

Thibault Lefeuvre: *On the ergodicity of the frame flow*

Negatively-curved Riemannian manifolds are typical examples of manifolds exhibiting a chaotic behaviour: for instance, their geodesic flow is ergodic and it is conjectured that their Laplace eigenfunctions equidistribute to the Liouville measure (Quantum Unique Ergodicity conjecture). In this talk, I will investigate the ergodicity of their frame flow, a natural isometric extension of the geodesic flow. While it has been known since Brin-Gromov in the 80s that this flow is ergodic on negatively-curved odd-dimensional manifolds, the even-dimensional case has long been open. The main result will be that even-dimensional manifolds have an ergodic frame flow whenever their pinching is close to 1/4. Joint work with Mihajlo Cekić, Andrei Moroianu, Uwe Semmelmann.

Marius Lemm: *Propagation bounds for the Bose-Hubbard model*

The celebrated Lieb-Robinson bound asserts the existence of a maximal propagation speed for the quantum dynamics of lattice spin systems. Analogous bounds are not generally available for bosonic lattice gases due to their unbounded local interactions. We consider the Bose-Hubbard model and prove a Lieb-Robinson type bound under a low-density assumption on the initial state and a novel general ballistic upper bound on macroscopic particle transport that is the first to cover initial states with positive density including Mott states. The proof rests on controlling the time evolution of a new kind of adiabatic spacetime localization observable via iterative differential inequalities. Joint work with J. Faupin and I.M. Sigal.

Michael Levin: *TBA*

TBA

Zhenhao Li: *Weyl laws for open quantum maps*

Open quantum maps provide simple finite-dimensional models of open quantum chaos. They are families of $N \times N$ matrices that quantize a symplectic relation on a compact phase space, and their eigenvalues model resonances of certain open quantum systems in the semiclassical limit. This makes them especially conducive to numerical experimentation and thus appealing in the study of scattering resonances. We consider a particular toy model that arises from quantizing the classical baker's map. We find a fractal Weyl upper bound in the semiclassical limit for the number of eigenvalues in a fixed annulus, as well as a dependence on the radius of the annulus for open quantum maps in the Gevrey class. These results are accompanied by numerical experiments.

Shi-zhuo Looi: *Pointwise asymptotics for wave equations*

In this talk, I will talk about some results on pointwise asymptotics for wave equations on dynamical and asymptotically flat spacetimes in even space dimensions obtained using microlocal analysis methods. This is joint work with S.-J. Oh.

Juan Felipe Lopez: *Interacting Quantum Field Theory in a Non-Commutative Space-Time*

It is well known that a continuous structure of space-time is inconsistent with General Relativity and Quantum Field Theory (QFT). Starting from phenomenological arguments; Doplicher, Fredenhagen, and Roberts (DFR) proposed a model for a quantum Minkowski space-time in the setting of non-commutative geometry. In this talk, the DFR space-time shall be presented as an algebra of operators over a Hilbert space. Also, it shall be introduced a couple of inequivalent implementations of an interacting scalar quantum field theory using the framework of perturbative Algebraic QFT (pAQFT). Modified Feynman diagrams are discussed with emphasis in the effects due to non-commutativity.

Milivoje Lukic: *An approach to universality using Weyl m-functions*

We present an approach to universality limits for orthogonal polynomials on the real line which is completely local and uses only the boundary behavior of the Weyl m-function at the point. We show that bulk universality of the Christoffel-Darboux kernel holds for any point where the imaginary part of the m-function has a positive finite nontangential limit. This approach is based on studying a matrix version of the Christoffel-Darboux kernel and the realization that bulk universality for this kernel at a point is equivalent to the fact that the corresponding m-function has normal limits at the same point. The proof uses de Branges canonical systems and applies to other systems with 2×2 transfer matrices. Joint work with Benjamin Eichinger and Brian Simanek

Jens Marklof: *The low-density limit of the Lorenz gas: random vs periodic, classical vs quantum*

Since the pioneering work of Maxwell and Boltzmann well over a century ago, a major challenge in mathematical physics has been the rigorous justifications of macroscopic transport equations, such as the laws of thermodynamics or the Navier-Stokes equations of fluid mechanics, from the underlying fundamental laws. In this lecture I will review recent progress in the case of the Lorentz gas, one of the most popular models of particle transport in low-density matter—both classical and quantum. We will examine when we can expect convergence to the linear Boltzmann equation (the expected limit) and when new transport processes may emerge due to subtle long-range correlations in the scatterer configuration.

Rodrigo Matos : *Title:Localization and eigenvalue statistics within Hartree-Fock theory*

This talk will consist of two parts. In the first part, I will provide background and present localization results for the disordered Hubbard model within Hartree-Fock theory which were obtained in joint work with Jeffrey Schenker (CMP21). In the second part, I will present recent progress on the eigenvalue statistics for the above model. In particular, under weak interactions and for energies in the localization regime which are also Lebesgue points of the density of states, it is shown that a suitable local eigenvalue process converges in distribution to a Poisson process with intensity given by the density of states times Lebesgue measure. Time allowing, I will also discuss possible extensions to other interacting Hamiltonians and proof ideas.

Ben McKenna: *Extremal statistics of quadratic forms of GOE/GUE eigenvectors*

We consider quadratic forms evaluated at GOE/GUE eigenvectors, like those studied in the context of quantum unique ergodicity. Under a rank assumption, we show that, to compute their extremal statistics, it suffices to replace the eigenvectors with independent Gaussian vectors. By carrying out some representative Gaussian computations, we thus find Gumbel and Weibull limiting distributions for the original problem. Joint work with László Erdős.

Hemant Mishra: *The pretty good measurement of an ensemble of bosonic Gaussian states*

The pretty good measurement is a fundamental analytical tool in quantum information theory, giving a method for inferring the classical label that identifies a quantum state chosen probabilistically from an ensemble. It is called "pretty good" because the error probability incurred in identifying the selected state is no more than twice that of the optimal measurement. Identifying/constructing the pretty good measurement for the class of bosonic Gaussian states is of immediate practical relevance in quantum information processing tasks. In our work, we consider the pretty good measurement of an ensemble of bosonic Gaussian states, and we prove that this measurement is a bosonic Gaussian measurement. Moreover, we provide an explicit and efficiently computable form for it. As such, this measurement is no longer merely an analytical tool for this case but can also be implemented experimentally in quantum optics laboratories.

Tim Möbus: *Optimal convergence rate in the quantum Zeno effect for open quantum systems in infinite dimensions*

In open quantum systems, the quantum Zeno effect consists in frequent applications of a given quantum operation, e.g. a measurement, used to restrict the time evolution (due e.g. to decoherence) to states that are invariant under the quantum operation. In an abstract setting, the Zeno sequence is an alternating concatenation of a contraction operator (quantum operation) and a strongly continuous contraction semigroup (time evolution) on a Banach space. In this paper, we prove the optimal convergence rate of the Zeno sequence under weak boundedness assumptions, which induce a Zeno dynamics generated by an unbounded generator. For that, we derive a new Chernoff-type lemma, which improves the convergence rate for vector-valued function converging linearly to the identity and which we believe to be of independent interest. We achieve the optimal Zeno convergence rate of order $1/n$.

Per Moosavi: *Inhomogeneous Tomonaga-Luttinger liquids out of equilibrium*

Conformal field theory (CFT) in one spatial dimension is successfully used to describe the low-energy properties of a large class of gapless quantum many-body systems called Tomonaga-Luttinger liquids (TLLs). Examples include quasi-one-dimensional condensates of ultra-cold atoms, gapless quantum spin chains, and electron flows in quantum wires. For inhomogeneous systems, such as ultra-cold atoms in a trap or spin chains with smoothly varying couplings, the standard CFT description of TLLs needs to be generalized so that the usual propagation velocity and Luttinger parameter depend on position. In this talk, I will show how such inhomogeneous TLLs can be studied by exact analytical means even out of equilibrium, based on applications of Sturm-Liouville theory and projective unitary representations of diffeomorphisms on the circle. Among the non-equilibrium results, I will show how the inhomogeneities can lead to a breaking of the Huygens-Fresnel principle and anomalous diffusion solely due to forward scattering when the inhomogeneities are random. Based on joint works with K. Gawedzki, M. Gluza, E. Langmann, and S. Sotiriadis.

Dinh Thi Nguyen: *Thomas-Fermi profile of a fast rotating Bose-Einstein condensate*

We study the minimizers of a magnetic 2D non-linear Schrödinger energy functional in a quadratic trapping potential, describing a rotating Bose-Einstein condensate. We derive an effective Thomas-Fermi-like model in the rapidly rotating limit where the centrifugal force compensates the confinement, and available states are restricted to the lowest Landau level. The coupling constant of the effective Thomas-Fermi functional is to linked the emergence of vortex lattices (the Abrikosov problem). We define it via a low density expansion of the energy of the corresponding homogeneous gas in the thermodynamic limit.

Nick Nussbaum: *The field Theory of Anderson-transition: the Spin Quantum Hall effect*

TBA

Marco Olivieri: *The energy of the 2D dilute Bose gas: a lower bound*

We provide a lower bound for the ground state energy density of dilute Bose gases in the thermodynamical regime in two dimensions. We prove an expansion analogous to the famous Lee-Huang-Yang formula in 3D. Our result holds for essentially all the radial, positive potentials with finite scattering length, in particular including the special case of the hard-core potential. From a joint work with S. Fournais, T. Girardot, L. Junge and L. Morin.

Pavel Panteleev: *Sheaf Codes*

Sipser-Spielman expander codes are the classical codes defined on expander graphs by placing the code bits on the edges and assigning a small linear code to each vertex, used as a local constraint for the bits on the edges connected to it. Expander codes are essential in coding theory since they provide explicit families of asymptotically good classical LDPC codes with very simple linear time decoding. Last year's constructions [DELLM21, PK21] of asymptotically good classical LTCs and qLDPC codes, as well as their more recent modifications [LZ22, DHLV], have motivated the study of generalizations of Sipser-Spielman codes defined on high-dimensional expanders (HDXs) instead of expander graphs. Toward this goal, it was proposed [PK21] to extend the theory of simplicial HDXs over $GF(2)$ to a much more general context of high-dimensional cell complexes (simplicial, cubical, polyhedral, etc.) with arbitrary local systems of abelian groups attached to them. Such objects, also known as cellular sheaves, have been studied in algebraic topology since 1960s and have found many interesting applications in computer science and coding theory in the last decade. The main idea of [PK21] was to replace the standard Hamming weight, counting the non-zero coefficients over $GF(2)$, with the block Hamming weight, counting the non-zero coefficients over abelian groups. This simple idea allows one to extend straightforwardly all the standard definitions from the theory of simplicial HDXs over $GF(2)$ (local minimality, coboundary expansion, Cheeger constants, etc.) to the general context of cellular sheaves. In this talk, I plan to focus on the coboundary expansion in the links of products of expander codes (called the product-expansion), and its important role in the constructions of good LTCs and qLDPC codes. The talk is based on the joint recent work with Gleb Kalachev.

Markus J. Pflaum: *Continuous families of GNS constructions*

Given a topological C^*-algebra fiber bundle and a continuous section of the associated bundle of pure states we show that the fiberwise GNS construction leads to a topological bundle of Hilbert spaces. We also show that if the given fiber bundle and section are smooth, the resulting Hilbert bundle is so as well; this involves proving that the group of $*$-automorphisms of a C^*-algebra is a Banach-Lie group. We also review the topology and geometry of the pure state space of a C^*-algebra and conclude with a simple example of a non-interacting quantum spin system illustrating the physical meaning of some of these results. The talk is based on joint work with A. Beaudry, M. Hermele, J. Moreno, M. Qi and D. Spiegel.

Marcello Porta: *Quantization of Edge Transport in Interacting Hall Systems*

We consider the edge transport properties of a class of interacting quantum Hall systems on a cylinder, in the infinite volume and zero temperature limit. We prove that the large-scale behavior of the edge correlation functions is effectively described by the multi-channel Luttinger model, describing interacting chiral fermions in $1 + 1$ dimensions, with linear dispersion relation and with arbitrary velocities. Furthermore, we prove that the edge conductance is universal, and equal to the sum of the chiralities of the non-interacting edge modes. The proof is based on rigorous renormalization group methods, that allow to fully take into account the effect of backscattering at the edge. Universality arises as a consequence of the vanishing of the beta function for the emergent multi-channel Luttinger liquid, combined with lattice Ward identities for the microscopic 2d theory. Joint work with Vieri Mastropietro.

Tomaz Prosen: *Random Matrix Spectral Fluctuations in Quantum Lattice Systems*

I will discuss the problem of unreasonable effectiveness of random matrix theory for description of spectral fluctuations in extended quantum lattice systems. A class of interacting spin systems has been recently identified - specifically, the so-called dual unitary circuits - where the spectral form factor is proven to match with circular ensembles of random matrix theory. The key ideas of novel methodology needed in the proofs will be discussed, as well as their extensions to explicit computation of observable and entanglement related dynamics.

Ramkumar Radhakrishnan: *Inadequacy of classical logic in classical harmonic oscillator and the principle of superposition*

In course of the development of modern science, the inadequacy of classical logic and Eastern philosophy has generally been associated only with quantum mechanics in particular, notably by Schroedinger, Finkelstein and Zeilinger among others. Our motive is to showcase a deviation from this prototypical association. So, we consider the equation of motion of a classical harmonic oscillator and demonstrate how our habit of writing the general solution, by applying the principle of superposition, can not be explained by remaining within the bounds of classical logic. The law of identity gets violated. The law of non-contradiction and the law of excluded middle fails to hold strictly throughout the whole process of reasoning consequently leading to a decision problem where we can not decide whether these two 'laws' hold or not. We discuss how we, by habit, apply our intuition to write down the general solution. Such intuitive steps of reasoning, if formalized in terms of propositions, result in a manifestation of the inadequacy of classical logic. In view of our discussion, we conclude that the middle way, a feature of Eastern philosophy, founds the basis of human reasoning. The essence of the middle way can be realised through self-inquiry, another crucial feature of Eastern philosophy, which however is exemplified by our exposition of the concerned problem. From the Western point of view, our work showcases an example of Hilbert's axiomatic approach to deal with the principle of superposition in the context of the classical harmonic oscillator. In the process, it becomes a manifestation of Brouwer's views concerning the role of intuition in human reasoning and the inadequacy of classical logic which were very much influenced by, if not founded upon, Eastern philosophy.

Roman Riser: *Power Spectrum Analysis for the Circular Unitary Ensemble*

By the Bohigas-Giannoni-Schmit conjecture (1984), the spectral statistics of quantum systems whose classical counterparts exhibit chaotic behavior are described by random matrix theory. An alternative characterization of eigenvalue fluctuations was suggested where a long sequence of eigenlevels has been interpreted as a discrete-time random process. It has been conjectured that the power spectrum of energy level fluctuations shows $1/f$ noise in the chaotic case, whereas, when the classical analog is fully integrable, it shows $1/f^2$ behavior. After introducing the power spectrum, we will present a new representation for the power spectrum for the circular unitary ensemble. In the limit of large sequences we will find a compact formula which gives a parameter-free prediction for the power spectrum expressed in terms of a fifth Painlevé transcendent.

Nicolas Rougerie: *Two modes approximation for bosons in a double well potential*

We study the mean-field limit for the ground state of a gas of bosonic particles in a double-well potential, jointly with the limit of large inter-well separation/large potential energy barrier. Two one-body wave-functions are then macroscopially occupied, one for each well. The physics in this two-modes subspace is usually described by a Bose-Hubbard Hamiltonian, yielding in particular the transition from an uncorrelated "superfluid" state (each particle lives in both potential wells) to a correlated "insulating" state (half of the particles live in each potential well). Through precise energy expansions we prove that the variance of the number of particles within each well is suppressed (violation of the central limit theorem), a signature of a correlated ground state. Quantum fluctuations around the two-modes description are particularly relevant, for they give energy contributions of the same order as the energy difference due to suppressed variances in the two-modes subspace. We describe them in terms of two independent Bogoliubov Hamiltonians, one for each potential well. Joint work with Alessandro Olgiati and Dominique Spehner

Robert Salzmann: *Total insecurity of communication via strong converse for quantum privacy amplification*

Quantum privacy amplification is a central task in quantum cryptography. Given shared randomness, which is initially correlated with a quantum system held by an eavesdropper, the goal is to extract uniform randomness which is decoupled from the latter. The optimal rate for this task is known to satisfy the strong converse property and we provide a lower bound on the corresponding strong converse exponent. In the strong converse region, the distance of the final state of the protocol from the desired decoupled state converges exponentially fast to its maximal value, in the asymptotic limit. We show that this necessarily leads to totally insecure communication by establishing that the eavesdropper can infer any sent messages with certainty, when given very limited extra information. In fact, we prove that in the strong converse region, the eavesdropper has an exponential advantage in inferring the sent message correctly, compared to the achievability region. Additionally we establish the following technical result, which is central to our proofs, and is of independent interest: the smoothing parameter for the smoothed max-relative entropy satisfies the strong converse property.

Adam Sawicki: *Haar random approximate t-designs and Gaussian Ensembles*

To any symmetric set of quantum gates, $S \in SU(d)$, one can associate an averaging operator that acts on L^2-functions on $SU(d)$. Spectral properties of this operator, and of its restrictions to irreducible representations of SU(d), are known to be closely connected to the concept of approximate t-designs. In this talk I will focus on the scenario when quantum gates are Haar random. I will show that the corresponding averaging operator can be very well approximated by a block diagonal random matrix, where the blocks are form Gaussian Unitary Ensemble or Gaussian Orthogonal Ensemble. I will discuss tightness of this approximation comparing it with some known matrix concentration inequalities and showing results of numerical simulations. This talk is partially work in progress and partially based on https://arxiv.org/abs/2202.05371

Jeff Schenker: *Localization for Gaussian Random Band Matrices up to $W << N^{1/4}$*

Random band matrices have been proposed as a model of the metal/insulator (localization/delocalization) transition. It is expected that an NxN Hermitian random matrix with non-zero entries in a band of width W around the diagonal will have localized eigenvectors in the regime $W << N^{1/2}$ and extended eigenvectors if $W >> N^{1/2}$. In this talk, I will comment on recent work, inspired by the Mermin-Wagner phenomenon of statistical mechanics, that proves localization for $W << N^{1/4}$.

Benjamin Schlein: *Correlation energy of weakly interacting Fermi gases*

In this talk, I am going to discuss Fermi gases, in a combined mean-field and semiclassical limit. To leading order, the ground state properties can be described by Hartree-Fock theory. Corrections to the Hartree-Fock energy, produced by the many-body interaction, are known as correlation energy. Through rigorous bosonization of the excitations of the Fermi sea, we obtain a precise estimate for the correlation energy, recovering a formula first derived in the physics literature by Gell-Mann and Brueckner in 1957. This talk is based on joint works with N. Benedikter, P.T. Nam, M. Porta and R. Seiringer.

Severin Schraven: *Bogoliubov Theory for Trapped Bosons in the Gross-Pitaevskii Regime*

We consider systems of N bosons in R^3, trapped by an external potential. The interaction is repulsive and has a scattering length of the order N^{-1} (the so-called Gross-Pitaevskii regime). We determine the ground state energy and the low-energy excitation spectrum up to errors that vanish in the limit $N \to \infty$. This is joint work with C. Brennecke and B. Schlein.

Tatyana Shcherbina: *Supersymmetric approach to the deformed Ginibre ensemble*

TBA

Daniel Spiegel: *The Projective Hilbert Bundle of a 1d Parametrized System*

The phase of a quantum system, with finitely many degrees of freedom and Hamiltonian parametrized by a space X, is characterized by a cohomology class in $H^2(X, Z)$. This cohomology class may be viewed as the (quantized) de Rham cohomology class of the Berry curvature, or equivalently, as the isomorphism class of the system's line bundle of ground states. Similarly, parametrized spin systems on an infinite lattice in one spatial dimension are characterized by an $H^3(X, Z)$ invariant, which can be understood through a generalization of the Berry curvature to higher dimensional systems as constructed by Kapustin and Spodyneiko in 2020. In this talk, I will take the bundle perspective and show that the $H^3(X, Z)$ class can alternatively be obtained from the isomorphism class of a bundle of projective Hilbert spaces over the parameter space. This technique will be demonstrated explicitly on an exactly solvable 1d parametrized system over $X = S^3$, introduced in a recent paper by Xueda Wen, et al. This talk will be based on joint work in progress with Beaudry, Hermele, Moreno, Qi, Pflaum, and Wen.

Michal Studzinski: *Optimal universal quantum circuits for unitary complex conjugation*

Let $U(d)$ be a unitary operator representing an arbitrary d-dimensional unitary quantum operation. In our work we present optimal quantum circuits for transforming a number k of calls of unknown $U(d)$ into its complex conjugate $U^*(d)$. Our circuits admit a parallel implementation and are proven to be optimal for any k and d with an average fidelity of $F = (k+1)/d(d-k)$. Optimality is shown for average fidelity, robustness to noise, and other standard figures of merit. This extends previous works which considered the scenario of a single call ($k = 1$) of the operation $U(d)$, and the special case of $k = d - 1$ calls. We then show that our results encompass optimal transformations from k calls of $U(d)$ to $f(U(d))$ for any arbitrary homomorphism f from the group of d-dimensional unitary operators to itself, since complex conjugation is the only non-trivial automorphisms on the group of unitary operators. Finally, we apply our optimal complex conjugation implementation to design a probabilistic circuit for reversing arbitrary quantum evolutions. Our methods strongly rely on group representation theory, in particular famous Schur-Weyl duality, and semidefinite programming (SDP).

Ethan Sussman: *Hydrogen-like Schrodinger Operators at Low Energies*

Recently, some microlocal tools of Vasy have allowed a precise study of the asymptotics of solutions to the Schrodinger-Helmholtz equation at low energy. We will summarize the result of applying these tools to the case of a potential of attractive Coulomb-like type, for which full asymptotic expansions have recently been derived.

Zhongkai Tao: *Resonances for Axiom A flows*

We prove upper and weak lower bounds for number of Pollicott-Ruelle resonances in a strip for Axiom A flows. As a byproduct, we extended the local trace formula of Jin-Zworski to Axiom A flows. This is joint work with Long Jin.

Siddharth Vadnerkar: *Dynamic Abelian Quantum Double Models*

The Quantum Double Hamiltonians are a family of exactly solvable toy quantum spin models on the square lattice with anyonic excitations. As this class of models has a commuting Hamiltonian, this model does not have interesting dynamics. In this talk I will discuss a family of perturbations of the Hamiltonian by adding hopping terms that create non-trivial dynamics for anyons. I will present an analysis of the spectrum of this family of Hamiltonians restricted to the invariant subspaces of a pair of magnetic and electric charges. I will show that for a certain range of parameters the electric and magnetic charges form bound states that behave as anyonic particles with non-trivial statistics.

Jian Wang: *Mathematics of internal waves in a 2D aquarium*

Internal waves are waves occurring in density stratified fluids. A fascinating feature of internal waves is the appearance of wave attractors in certain shapes of domains in the linear regime (Maas et al, 1997). The formation of the attractors are related to the dynamics of homeomorphisms of the circle, and some parts of the study can be regarded as a microlocal continuation of the work the Dirichlet problem for hyperbolic equations by John (1941). This is joint work with Dyatlov and Zworski.

Simone Warzel: *Quantum Spin Glasses*

I will give an overview over recent results on mean-field spin-glass models with a transversal magnetic field. For such models both thermodynamic quantities such as the free energy and its fluctutions, as well as spectral and localizationpropertiess of eigenvectors are of interest to a diverse list of communites. A full mathematical analysis of properties is completed for the simplest, yet ubiquitous quantum random energy model. For models with a more complicated (classical) correlation structure such as the Sherrington-Kirkpatrick model, a more qualitative analysis proves the existence of a phase transition.

Mark Wilde: *Quantum Algorithms for Testing Hamiltonian Symmetry*

Symmetries in a Hamiltonian play an important role in quantum physics because they correspond directly with conserved quantities of the related system. In this paper, we propose quantum algorithms capable of testing whether a Hamiltonian exhibits symmetry with respect to a group. We demonstrate that familiar expressions of Hamiltonian symmetry in quantum mechanics correspond directly with the acceptance probabilities of our algorithms. We execute one of our symmetry-testing algorithms on existing quantum computers for simple examples of both symmetric and asymmetric cases. Joint work with Margarite LaBorde and available at https://arxiv.org/abs/2203.10017

Andreas Winter: *TBA*

TBA

Jared Wunsch: *Wave propagation on rotating cosmic string backgrounds*

A rotating cosmic string spacetime has a singularity along a timelike curve corresponding to a one-dimensional source of angular momentum. Such spacetimes are not globally hyperbolic: there exist closed timelike curves near the "string". Nonetheless, I will describe joint work with Katrina Morgan in which we explore the possibility of obtaining forward solutions to the wave equation, appropriately interpreted.

Haoren Xiong: *Complex absorbing potential method for calculating scattering resonances*

Complex absorbing potential (CAP) method, which is a computational technique for scattering resonances first used in physical chemistry. The method shows that resonances of the Hamiltonian P are limits of eigenvalues of CAP-modified Hamiltonian $P - itx^2$ as $t \to 0+$. I will show that this method applies to exponentially decaying potential scattering, and many other things will be presented, including the Davies harmonic oscillator and the method of complex scaling.

Mengxuan Yang: *Diffraction and Scattering of the Aharonov–Bohm Hamiltonian*

I want to discuss about propagation of singularities of the magnetic Hamiltonian with singular vector potentials, which is related to the so-called Aharonov–Bohm effect. In addition, I shall discuss some results related to the wave trace and the resolvent, as well as some applications to scattering resonances in this setting.

Giorgio Young: *Ballistic Transport for Limit-periodic Schrödinger Operators in One Dimension*

In this talk, I will discuss the transport properties of the class of limit-periodic continuum Schrödinger operators whose potentials are approximated exponentially quickly by a sequence of periodic functions. For such an operator H, and $X_H(t)$ the Heisenberg evolution of the position operator, we show the limit of $\frac{1}{t}X_H(t)\psi$ as $t \to \infty$ exists and is nonzero for $\psi \neq 0$ belonging to a dense subspace of initial states which are sufficiently regular and of suitably rapid decay. This is viewed as a particularly strong form of ballistic transport, and this is the first time it has been proven in a continuum almost periodic non-periodic setting. In particular, this statement implies that for the initial states considered, the second moment grows quadratically in time.

Amanda Young: *A bulk gap in the presence of edge states for a truncated Haldane pseudopotential*

In this talk, we discuss the bulk gap for a truncated 1/3-filled Haldane pseudopotential for the fractional quantum Hall effect. For this Hamiltonian with either open or periodic boundary conditions, we establish a spectral gap above the highly degenerate ground-state space which is uniform in the volume and particle number. These bounds are proved by identifying invariant subspaces to which we apply gap-estimate methods previously developed only for quantum spin Hamiltonians. In the case of open boundary conditions, the lower bound on the spectral gap accurately reflects the presence of edge states, which do not persist into the bulk. Customizing the gap technique to the invariant subspace, we avoid the edge states and establish a more precise estimate on the bulk gap in the case of periodic boundary conditions. The same approach can also be applied to prove a bulk gap for the analogously truncated Haldane pseudopotential with maximal half filling, which describes a strongly correlated system of spinless bosons in a cylinder geometry. This is based off joint work with S. Warzel.