Theoretical and Mathematical Physics Division
Fachverband Theoretische und Mathematische Grundlagen der Physik (MP)

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Overview of Invited Talks and Sessions

(Lecture halls 001 and 102; Poster B)

Invited Talks

MP 1.1	Mon	9:30–10:00	HL 001	**Fractional Anderson model and long range self-avoiding random walk.** — •Margherita Disertori, Constanza Rojas-Molina, Roberto Maturana
MP 3.1	Mon	15:00–15:30	HL 001	**Rigorous results on many-body localization** — •Wojciech De Roeck
MP 6.1	Tue	9:30–10:00	HL 001	**The mathematical physics of near-term quantum computing** — •Jens Eisert
MP 6.2	Tue	10:00–10:30	HL 001	**Quantum chaos, integrability, and the complexity of time evolution** — •Vijay Balasubramanian
MP 8.1	Wed	9:30–10:00	HL 001	**Embezzlement of entanglement, quantum fields, and the classification of von Neumann algebras** — •Alexander Stottmeister
MP 10.1	Thu	9:30–10:00	HL 001	**Conformal field theories from line defects and holography** — •Valentina Forini

Invited Talks of the joint Symposium Entanglement in Quantum Information, Condensed Matter and Gravity (SYQI)

See SYQI for the full program of the symposium.

SYQI 1.1	Wed	15:00–15:30	H 0105	**The Quantum Internet: Concepts, Challenges and Progress** — •Ronald Hanson
SYQI 1.2	Wed	15:30–16:00	H 0105	**Strange metals - A platform to study entanglement in condensed matter?** — •Silke Paschen
SYQI 1.3	Wed	16:00–16:30	H 0105	**Quantum black holes may not have interiors** — •Vijay Balasubramanian
SYQI 1.4	Wed	16:30–17:00	H 0105	**Gauge Symmetry-Resolved Entanglement in Lattice Gauge Theories: A Tensor Network Approach** — Noa Feldman, Johannes Knaute, Erez Zohar, •Moshe Goldstein
SYQI 1.5	Wed	17:00–17:30	H 0105	**Parameter estimation of gravitational waves with a quantum metropolis algorithm** — •Miguel Angel Martin - Delgado

Sessions

MP 1.1–1.9	Mon	9:30–13:00	HL 001	**Many-body Theory I**
MP 2.1–2.6	Mon	10:00–12:20	HL 102	**Quantum Information and Gravity**
MP 3.1–3.9	Mon	15:00–18:30	HL 001	**Quantum Dynamics**
MP 4.1–4.2	Mon	15:00–15:40	HL 102	**Quantum Field Theory I**
MP 5.1–5.4	Mon	16:00–17:20	HL 102	**Theoretical Aspects of Condensed Matter I**
MP 6.1–6.2	Tue	9:30–10:30	HL 001	**Quantum Computing and Quantum Dynamics**
MP 7.1–7.15	Tue	11:00–13:00	Poster B	**Poster (joint session MP/QI)**
MP 8.1–8.9	Wed	9:30–13:00	HL 001	**Quantum Field Theory II**
MP 9.1–9.8	Wed	9:30–12:30	HL 102	**Theoretical Aspects of Condensed Matter II**

MP 10.1–10.9	Thu	9:30–13:00	HL 001	**AdS/CFT**
MP 11.1–11.6	Thu	9:30–11:50	HL 102	**Many-body Theory II**
MP 12.1–12.2	Thu	15:00–15:40	HL 001	**Hydrodynamics**
MP 13.1–13.4	Thu	15:40–17:00	HL 001	**Quantum Field Theory III**
MP 14.1–14.2	Thu	15:45–16:25	HL 102	**Mass and Momentum**
MP 15	Thu	17:00–18:00	HL 001	**Members' Assembly**

Members' Assembly of the Theoretical and Mathematical Physics Division

Thursday 17:00–18:00 HL 001

- Report
- Organisation of future conferences and events

MP 1: Many-body Theory I

Time: Monday 9:30–13:00 Location: HL 001

Invited Talk MP 1.1 Mon 9:30 HL 001

Fractional Anderson model and long range self-avoiding random walk. — •Margherita Disertori[1], Constanza Rojas-Molina[2], and Roberto Maturana[1] — [1]University of Bonn, Bonn, Germany — [2]CY Cergy Paris University, Paris, France

The Anderson model with long-range interactions has been subject to increasing interest in recent years. I will review some properties and recent results connecting the corresponding Green's function with the two point function of a self-avoiding random walk with long range jumps. These results adapt a strategy proposed by Schenker in 2015 and are joint work with C. Rojas-Molina and R. Maturana.

MP 1.2 Mon 10:00 HL 001

Renormalization group analysis of a D-dimensional PT-symmetric non-Hermitian superfluid — •Eduard Naichuk[1,2], Jeroen van den Brink[1,3], and Flavio Nogueira[1] — [1]Institute for Theoretical Solid State Physics, IFW Dresden, Helmholtzstr. 20, 01069 Dresden, Germany — [2]Bogolyubov Institute for Theoretical Physics, 03143 Kyiv, Ukraine — [3]Institute for Theoretical Physics and Würzburg-Dresden Cluster of Excellence ct.qmat, TU Dresden, 01069 Dresden, Germany

We analyze the phase structure of a two-component non-Hermitian PT-symmetric superfluid system in 1+1 and 2+1 dimensions. The non-Hermitian character emerges from complex off-diagonal chemical potentials in field space, which in addition cause the internal symmetry of the system to be U(1) rather than U(1)*U(1). We show that this system is effectively described by an XY model with a four-state clock interaction. The quantum critical behavior 1+1 dimension is shown to lead to three line of fixed points and a continuously varying correlation length exponent ν. When the PT symmetry is broken, on the other hand, a Berezinskii-Kosterlitz-Thouless phase transition occurs. In 2+1 dimensions the critical behavior is governed by the three dimensional XY universality class in the PT-symmetric regime when the clock interaction small. The behavior in 2+1 dimensions is radically changed when the PT symmetry is broken. Despite featuring an additional fixed point, the phase transition is a weakly first-order one.

MP 1.3 Mon 10:20 HL 001

Wrestling with the finite temperature two dimensional Fermi-Hubbard Model: A Tensor Network Attempt — •Aritra Sinha[1,2], Marek M. Rams[2], Piotr Czarnik[2], and Jacek Dziarmaga[2] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Jagiellonian University, Kraków, Poland

The Fermi Hubbard Model is a simple model of interacting electrons on a lattice. However, solving it in two dimensions has been a long-standing challenge. Recently, progress has been made with tensor network methods like infinite projected entangled pair states (PEPS), especially in understanding its ground states in the infinite-size limit. Despite this, finding finite temperature solutions remains challenging, particularly for larger lattices. Our research uses the Neighborhood Tensor Update (NTU) and infinite PEPS for imaginary time evolution, achieving temperatures as low as 0.17 times the hopping rate. We've observed disruptions in the antiferromagnetic order in lattices with slight doping at strong coupling regimes. To reach even lower temperatures, we developed a new algorithm that applies minimally entangled typical thermal states (METTS) to finite PEPS. In my upcoming presentation, I'll explore the numerical challenges we faced and the innovative tensor network strategies we developed, shedding light on the physics of the under-doped Hubbard model and offering insights applicable to other models. These findings serve as valuable benchmarks for theoretical studies and experiments with ultracold atoms.

MP 1.4 Mon 10:40 HL 001

A Topological Classification of Time Reversal Symmetric Frustrated Systems and Metamaterials — •Shayan Zahedi — Institute for Theoretical Physics, University of Cologne, Zülpicher Straße 77, D-50937 Köln

Inspired by a paper by Roychowdhury and Lawler, we classify time reversal symmetric frustrated systems and metamaterials, guided by the Bott-Kitaev classification of topological insulators and superconductors, homotopically. This is done by investigating the topology of the space of rigidity matrices which mediate between linearised degrees of freedom and ground state constraints of frustrated systems and metamaterials.

We impose canonical time reversal symmetry on rigidity matrices and obtain Z_2-equivariant iterated loop spaces of complex Stiefel manifolds whose sets of path components are our sought for topological invariants. In the presence of canonical time reversal symmetry, our computations reveal novel topological invariants beyond those in the Bott-Kitaev periodic table. The symmetry impositions on our rigidity matrices lead to Z_2-equivariance conditions introducing the three symmetry classes AIII, AIII/BDI and AIII/CII depending on the existence and type of canonical time reversal symmetry.

We achieve such a classification by extending some of the methods used to construct the Bott-Kitaev periodic table for topological insulators and superconductors from Hermitian matrices to non-Hermitian matrices, such as the flattening of singular values of rigidity matrices.

20 min. break

MP 1.5 Mon 11:20 HL 001

A simple electronic ladder model harboring Z4 parafermions — Botond Osváth[1], Gergely Barcza[2], Örs Legeza[2], Balázs Dóra[3], and •László Oroszlány[1,2] — [1]Department of Physics of Complex Systems, Eötvös Loránd University, Budapest, Hungary — [2]Wigner Research Centre for Physics, H-1525, Budapest, Hungary — [3]Department of Theoretical Physics, Institute of Physics, Budapest University of Technology and Economics, H-1111 Budapest, Hungary

Parafermions are anyons with the potential for realizing non-local qubits that are resilient to local perturbations. Compared to Majorana zero modes, braiding of parafermions implements an extended set of topologically protected quantum gates. This, however, comes at the price that parafermionic zero modes can not be realized in the absence of strong interactions whose theoretical description is challenging. In the present work, we construct a simple lattice model for interacting spinful electrons with parafermionic zero energy modes. The explicit microscopic nature of the considered model highlights new realization avenues for these exotic excitations in recently fabricated quantum dot arrays. By density matrix renormalization group calculations, we identify a broad range of parameters, with well-localized zero modes, whose parafermionic nature is substantiated by their unique 8π periodic Josephson spectrum.

MP 1.6 Mon 11:40 HL 001

Role of Quantum Geometry on Spin Fluctuations and Pairing in Chiral Superconductors — •Niclas Heinsdorf and Andreas Schnyder — Max-Planck-Institut für Festkörperforschung, Heisenbergstrasse 1, 70569 Stuttgart, Germany

Recently the B20 Weyl Semimetal RhGe has been proposed to be a topological superconductor. Chiral symmetries enforce multi-fold topological band crossings in the bulk band structure of the material's normal state and strongly enhance the quantum geometry in its proximity. The imaginary part of the quantum geometry, the Berry curvature, is well-known to result in exotic transport properties such as circular photogalvanic or spin Nernst effect, whereas its real part, the Fubini-Study metric, has been shown to favor ferromagnetic spin fluctuations. Using effective modeling and random phase approximation, we separate the effective interactions into effective mass and topological contributions, analyze the effect of quantum-geometry on the pairing and gap symmetry and discuss the presence of multipole order for RhGe and chiral superconductors in general.

MP 1.7 Mon 12:00 HL 001

The Ultra quantum critical Floquet Non-Fermi Liquid — •Likun Shi[1], Inti Sodemann Villadiego[1], Oles Matsyshyn[2], and Justin Song[2] — [1]Institute for Theoretical Physics, Leipzig University, Leipzig, Germany — [2]Division of Physics and Applied Physics, Nanyang Technological University, Singapore, Republic of Singapore

We demonstrate the existence of a quantum non-equilibrium steady state of periodically driven fermions that has no analogue in equilibrium. This state is a Floquet non-Fermi liquid state that arises for periodically driven fermions coupled to a bosonic bath. It features 'higher order Floquet Fermi surfaces' where the occupation in momentum space displays cusp-like non-analyticities, but without an associated jump or quasiparticle residue.

More intriguingly, the sharpness of these higher order Floquet Fermi surfaces survives even at finite temperatures, implying that this Floquet Non-Fermi Liquid remains quantum critical at finite temperatures. This property has no analogue in equilibrium systems because finite temperature always smears out the sharpness of the Fermi surfaces, leading the fermions to behave as a classical fluid at sufficiently large distances. We discuss how monochromatic radiation in the microwave range impinging on high-quality electronic systems is a promising regime to realize these states in experiments.

MP 1.8 Mon 12:20 HL 001

Landau quantization near generalized van Hove singularities: magnetic breakdown and orbit networks — •Vladimir A. Zakharov[1], Ahmet Mert Bozkurt[2,3], Anton R. Akhmerov[2], and Dmytro O. Oriekhov[2] — [1]Instituut-Lorentz, Universiteit Leiden, P.O. Box 9506, 2300 RA Leiden, The Netherlands — [2]Kavli Institute of Nanoscience, Delft University of Technology, Delft 2600 GA, The Netherlands — [3]QuTech, Delft University of Technology, Delft 2600 GA, The Netherlands

We develop a theory of magnetic breakdown (MB) near high-order saddle points in the dispersions of two-dimensional materials, where two or more semiclassical cyclotron orbits approach each other. MB occurs due to quantum tunneling between several trajectories, which leads to non-trivial scattering amplitudes and phases. We show that for any saddle point this problem can be solved by mapping it to a scattering problem in a 1D tight-binding chain. Moreover, the occurrence of magnetic breakdown on the edges of the Brillouin zone facilitates the delocalization of the bulk Landau level states and the formation of 2D orbit networks. These extended network states compose dispersive mini-bands with finite energy broadening. This effect can be observed in transport experiments as a strong enhancement of the longitudinal bulk conductance in a quantum Hall bar. In addition, it may be probed in STM experiments by visualizing bulk current patterns.

MP 1.9 Mon 12:40 HL 001

Unified description of the Aharonov–Bohm effect in isotropic multiband electronic systems — •Róbert Németh and József Cserti — Department of Physics of Complex Systems, ELTE Eötvös Loránd University, Pázmány Péter sétány 1/A, H-1117 Budapest, Hungary

A unified treatment of the Aharonov–Bohm (AB) effect is presented for two-dimensional multiband electronic systems possessing isotropic band structures. We propose a complex contour integral representation of the AB scattering states of an electron scattered by an infinitely thin solenoid. Moreover, we derive the asymptotic forms of these scattering states and obtain the differential cross section from those. A remarkable result is found, namely, that this cross section is the same for all isotropic systems and agrees with that obtained first by Aharonov and Bohm for spinless free-particle systems [Phys. Rev. **115**, 485 (1959)]. To demonstrate the generality of our theory, it is applied to several specific multiband systems relevant to condensed matter physics. Finally, we extend our approach to the case of the non-Abelian AB effect, that is, the scattering of particles on a gauge field corresponding to a noncommutative Lie group.

MP 2: Quantum Information and Gravity

Time: Monday 10:00–12:20 Location: HL 102

MP 2.1 Mon 10:00 HL 102

Overlapping qubits from non-isometric maps and de Sitter tensor networks — ChunJun Cao[1], Wissam Chemissany[2], •Alexander Jahn[3], and Zoltan Zimboras[4] — [1]Virginia Tech, Blacksburg, VA, USA — [2]University of Pennsylvania, Philadelphia, PA, USA — [3]Freie Universität Berlin, Berlin, Germany — [4]Wigner Research Centre, Budapest, Hungary

We construct approximately local observables, or “overlapping qubits”, using non-isometric maps and show that processes in local effective theories can be spoofed with a quantum system with fewer degrees of freedom, similar to our expectation in holography. Furthermore, the spoofed system naturally deviates from an actual local theory in ways that can be identified with features in quantum gravity. For a concrete example, we construct two MERA toy models of de Sitter space-time and explain how the exponential expansion in global de Sitter can be spoofed with many fewer quantum degrees of freedom and that local physics may be approximately preserved for an exceedingly long time before breaking down. We highlight how approximate overlapping qubits are conceptually connected to Hilbert space dimension verification, degree-of-freedom counting in black holes and holography, and approximate locality in quantum gravity.

MP 2.2 Mon 10:20 HL 102

Algebras and entanglement entropy of subregions in quantum field theory and quantum gravity — •Leo Shaposhnik and Alexander Jahn — Freie Universität Berlin, Berlin, Germany

Entanglement entropy of a subregion in quantum field theory is UV-divergent and as such it is hard to find a sensible definiton for it that survives the removal of the cutoff. The apparent impossibility of its computation is rooted in the nature of the algebras associated to subregions in local quantum field theories. These are von Neumann Algebras of so-called type III_1 and do not allow neither the definition of a trace, nor of density matrices associated to them, which are necessary to define entanglement entropy. In the past two years this problem appears to have found a solution by introduction of an extra degree of freedom in the subregion, which is generically called an "observer" and is analogous to an edge mode. A subsequent dressing of the algebra of quantum fields in the subregion to this observer turns out to result in an algebra of type II, which allows the definition of traces and density matrices. Computing the von Neumann entropy $S = -\mathrm{Tr}(\rho \log \rho)$ associated to these subregion algebras for "semiclassical" states in perturbation theory then results in the generalized entropy of the subregion, which thus provides a rigorous definition of entropy in quantum field theory. In this talk I will summarize these recent developments and outline potential research directions that can be tackled with this new method, which allows for a rigorous study of subregions and their entanglement entropy in quantum field theory and quantum gravity.

MP 2.3 Mon 10:40 HL 102

Correlations of the Toric code at finite temperature — •Sebastian Stengele[1], Cambyse Rouzé[2], Angela Capel[3], and Simone Warzel[1] — [1]Department of Mathematics, Technical University of Munich, 85748 Garching, Deutschland — [2]Inria, Télécom Paris - LTCI, Institut Polytechnique de Paris, 91120 Palaiseau, France — [3]AB Mathematische Physik, Universität Tübingen, 72076 Tübingen, Deutschland

The toric code is a key example of a topological quantum error-correcting code and a potential candidate for a scalable quantum memory. We explore the decay of correlations of distant observables at finite temperatures. Leveraging techniques from classical statistical mechanics, we bound the correlations of the $D \geq 2$ dimensional toric code by truncated correlation functions of certain Ising models with many-body interactions. Furthermore, we show that these correlations decay exponentially at very high temperatures.

20 min. break

MP 2.4 Mon 11:20 HL 102

Area laws and thermalization from classical entropies — Yannick Deller[1], Martin Gärttner[1,2,3,4], •Tobias Haas[5], Markus Oberthaler[1], Moritz Reh[1], and Helmut Strobel[1] — [1]Kirchhoff-Institut für Physik, Universität Heidelberg, Germany — [2]nstitut für Theoretische Physik, Universität Heidelberg, Germany — [3]Physikalisches Institut, Universität Heidelberg, Germany — [4]Institute of Condensed Matter Theory and Optics, Friedrich-Schiller-University Jena, Germany — [5]Centre for Quantum Information and Communication, Université libre de Bruxelles, Belgium

The scaling of local quantum entropies is of utmost interest for characterizing quantum fields, many-body systems and gravity. Despite their importance, being nonlinear functionals of the underlying quantum state often hinders their theoretical as well as experimental accessibility. Here, we show that suitably chosen classical entropies of standard measurement distributions capture the very same features as their quantum analogs.

We demonstrate the presence of the celebrated area law for classical entropies for typical states such as ground and excited states of a scalar quantum field. Further, we consider the post-quench dynamics of a multi-well spin-1 Bose-Einstein condensate from an initial product state, in which case we observe the dynamical build-up of quantum correlations signaled by the area law, as well as local thermalization revealed by a transition to a volume law, both in regimes characterized by non-Gaussian quantum states and small sample numbers.

MP 2.5 Mon 11:40 HL 102

Random pure Gaussian states and Hawking radiation — Erik Aurell[1], Lucas Hackl[2], Paweł Horodecki[3], •Robert Jonsson[4], and Mario Kieburg[2] — [1]KTH, Stockholm, Sweden — [2]School of Mathematics and Statistics & School of Physics, The University of Melbourne, Australia — [3]International Centre for Theory of Quantum Technologies & Faculty of Applied Physics and Mathematics, University of Gdánsk, Poland — [4]Nordita, Stockholm, Sweden

The black hole information paradox revolves around the question whether the formation of a black hole, its emission of Hawking radiation and finally its evaporation are to be described by a unitary process, or not. Central to this problem is the question whether the total quantum state of all emitted radiation can be pure, or not. We show that restoring unitarity and a pure total state after evaporation does not require strong quantum entanglement between any pair of Hawking modes. To this end, we introduce a new method to the study of random Gaussian states: We consider the family of all N-mode pure Gaussian states with a fixed set of given marginals. This set of states is compact and can be equipped with a natural measure induced from the Haar measure of the symplectic group. This enables us to find the probability distribution over correlations between two modes. This theory of of constrained symplectic transformations should be relevant to many areas beyond black hole physics.

E. Aurell, L. Hackl, P. Horodecki, R. H. Jonsson, and M. Kieburg, Random pure Gaussian states and Hawking radiation. arXiv.2311.10562.

MP 2.6 Mon 12:00 HL 102

Particle Production by Gravitational Fields and Black Hole Evaporation — •Michael F. Wondrak[1,2], Walter D. van Suijlekom[2], and Heino Falcke[1] — [1]Department of Astrophysics/IMAPP, Radboud Universiteit, Nijmegen, The Netherlands — [2]Department of Mathematics/IMAPP, Radboud Universiteit, Nijmegen, The Netherlands

This talk presents a new avenue to black hole evaporation using a heat-kernel approach in the context of effective field theory analogous to deriving the Schwinger effect. Applying this method to an uncharged massless scalar field in a Schwarzschild spacetime, we show that spacetime curvature takes a similar role as the electric field strength in the Schwinger effect. We interpret our results as local pair production in a gravitational field and derive a radial production profile. The resulting emission peaks near the unstable photon orbit. Comparing the particle number and energy flux to the Hawking case, we find both effects to be of similar order. However, our pair production mechanism itself does not explicitly make use of the presence of a black hole event horizon and might have cosmological implications.

The presentation is based on Phys. Rev. Lett. 130 (2023) 221502.

MP 3: Quantum Dynamics

Time: Monday 15:00–18:30 Location: HL 001

Invited Talk MP 3.1 Mon 15:00 HL 001

Rigorous results on many-body localization — •Wojciech De Roeck — K.U. Leuven, Belgium

The concept of many-body localization was introduced around 2005. It is supposed to be a phase of matter in which thermalization is absent, as such violating basic laws of thermodynamics. Despite a lot of work, there is currently still a debate about the question whether this phase actually exists. In this talk I will present recent results that aim to shed light on this question. I will only consider mathematically rigorous results. Tentatively, these results support the view that many-body localization actually exists in one-dimensional quantum chains.

MP 3.2 Mon 15:30 HL 001

Unique Decompositions of Generators of Dynamical Semigroups — •Frederik vom Ende — Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany

Since the 1970s it is well known that every generator L of a completely positive, trace-preserving dynamical semigroup is of the form $L = -i[H, \cdot] + \Phi - \frac{1}{2}\{\Phi^*(\mathbf{1}), \cdot\}$ for some Hamiltonian H and some completely positive map Φ. We prove that every quantum state gives rise to a unique decomposition of L into its "building blocks" by means of vanishing expectation values: More precisely, for all states ω there exist unique H, Φ with $\mathrm{tr}(H\omega) = 0$ and $\mathrm{tr}(\Phi(\omega \cdot \omega)) = 0$ such that the above decomposition holds. As a special case, for $\omega = \frac{\mathbf{1}}{n}$ one recovers the uniqueness condition of Gorini, Kossakowski, and Sudarshan involving traceless Lindblad operators (which now has a physical interpretation by means of our result). Moreover, this insight allows for a generalization of such unique decompositions to arbitrary separable Hilbert spaces.

MP 3.3 Mon 15:50 HL 001

Quantum Chaos and Complexity in Triangular Billiard Systems — Vijay Balasubramanian[1,2], •Rathindra Nath Das[3], Johanna Erdmenger[3], and Zhuo-Yu Xian[3] — [1]David Rittenhouse Laboratory, University of Pennsylvania, 209 S. 33rd Street, Philadelphia PA 19104, USA. — [2]Theoretische Natuurkunde, Vrije Universiteit Brussel (VUB), and International Solvay Institutes, Pleinlaan 2, B-1050 Brussels, Belgium. — [3]Institute for Theoretical Physics and Astrophysics and Würzburg-Dresden Cluster of Excellence ct.qmat, Julius-Maximilians-Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

In view of quantifying quantum chaos in dynamical systems and motivated by the search for viable definitions of complexity in quantum field theory and holography, we revisit quantum billiards and examine the recently proposed measure of Krylov state complexity known as spread complexity. In particular, we investigate the growth of Krylov state complexity and spectral complexity in triangular billiard systems. While classically, these billiards exhibit a zero Lyapunov exponent, quantum mechanically they display spectral statistics intermediate between Poissonian and the Gaussian Orthogonal Ensemble (GOE), the exact form depending on the three angles. Using spectral complexity and statistics, we identify a hierarchy in the chaotic behaviour of different billiards. We find a direct correlation between Lanczos coefficients, a key ingredient of Krylov complexity, and the level repulsion present in the system. The effects of symmetry sectors on the system's dynamics are also explored.

MP 3.4 Mon 16:10 HL 001

Spread complexity for measurement-induced non-unitary dynamics and quantum Zeno effect — •Aranya Bhattacharya[1], Rathindra Nath Das[2], Bidyut Dey[3], and Johanna Erdmenger[2] — [1]Institute of Physics, Jagiellonian University, Łojasiewicza 11, 30-348 Kraków, Poland — [2]Institute for Theoretical Physics and Astrophysics and Würzburg-Dresden Cluster of Excellence ct.qmat Julius-Maximilians-Universität Würzburg
Am Hubland, 97074 Würzburg, Germany — [3]Indian Institute of Technology Kanpur, Kanpur 208016, Uttar Pradesh, India

We study the behaviour of spread complexity and spread entropy in quantum systems evolving under non-unitary dynamics. For non-hermitian Hamiltonians, we extend the bi-Lanczos construction of the Krylov basis to the Schrödinger picture. Also, a specialized algorithm is implemented for complex symmetric Hamiltonians, effectively reducing the computational memory requirements by half. We apply this construction to the one-dimensional tight-binding Hamiltonian subject to repeated measurements at fixed small time intervals. These result in effective non-unitary dynamics. In analogy to measurement-induced phase transitions, we consider a quench between hermitian and non-hermitian Hamiltonian evolution induced by turning on regular measurements at different frequencies. As a function of the measurement frequency, we find a transition that shifts the time at which the spread complexity starts growing, indicating the onset of the quantum Zeno effect.

MP 3.5 Mon 16:30 HL 001

Towards exact factorization of quantum dynamics via Lie algebras — •David Edward Bruschi[1], André Xuereb[2], and Robert Zeier[3] — [1]Institute for Quantum Computing Analytics (PGI-12), Forschungszentrum Jülich, Jülich, Germany — [2]Department of Physics, University of Malta, Malta — [3]Quantum Control (PGI-8), Forschungszentrum Jülich, Jülich, Germany

Determining exactly the dynamics of a physical system is the paramount goal of any branch of physics. Quantum dynamics are characterized by the non-commutativity of operators, which implies that the dynamics usually cannot be tackled analytically and require ad-hoc solutions or numerical approaches. A priori knowledge on the ability to obtain exact results would be of great advantage for many tasks of modern interest, such as quantum computing, quantum simulation and quantum annealing.

In this work we lay the foundations for an approach to determine the dimensionality of a Hamiltonian Lie algebra by appropriately characterizing its generating terms. This requires us to develop a new tool to construct sequences of operators that determine the final dimension of the algebra itself. Our work is exact and fully general, therefore providing statements on the ultimate ability to exactly control the dynamics or simulate specific classes of physical systems. This work has important implications not only for theoretical physics, but it also aids our understanding of the structure of the Hilbert space, as well as Lie algebras.

20 min. break

MP 3.6 Mon 17:10 HL 001

Quantum Scattering upon Local Deformations in Configuration Space — •Benjamin Schwager, Lars Meschede, and Jamal Berakdar — MLU Halle-Wittenberg, Halle (Saale), Germany

When a quantum particle is subjected to spatial constraints, its dynamics have to be modelled based on a configuration space that is a more general Riemannian manifold than Euclidean space. The resulting effective quantum wave equations contain correction terms in dependence of the geometric properties of this space. We apply the confinement potential approach to the Schrödinger equation to obtain an effective wave equation in reduced dimensions, and show that position-dependent modulations of the geometric invariants and the metric tensor cause lower-dimensional scattering events. It is found that theire characteristics differ significantly from the case of more familiar potential scattering. Furthermore, we present consequences for transport properties.

MP 3.7 Mon 17:30 HL 001

Almost everything about the unitary almost Mathieu operator — •Christopher Cedzich[1], Jake Fillman[2], and Darren Ong[3] — [1]Heinrich Heine Universität Düsseldorf, Universitätsstr. 1, 40225 Düsseldorf, Germany — [2]Texas State University, San Marcos, TX 78666, USA — [3]Xiamen University Malaysia, Jalan Sunsuria, Bandar Sunsuria, 43900 Selangor, Malaysia

We introduce the unitary almost-Mathieu operator, which is obtained from a two-dimensional quantum walk in a uniform magnetic field. We exhibit a version of Aubry-André duality for this model, which partitions the parameter space into three regions: a supercritical region and a subcritical region that are dual to one another, and a critical regime that is self-dual. We exactly compute the Lyapunov exponent on the spectrum in terms of the given parameters. We also characterize the spectral type for each value of the coupling constant, almost every frequency, and almost every phase. Namely, we show that for almost every frequency and every phase the spectral type is purely absolutely continuous in the subcritical region, pure point in the supercritical region, and purely singular continuous in the critical region. In some parameter regions, we refine the almost-sure results.

MP 3.8 Mon 17:50 HL 001

Ergodicity breaking and deviation from Eigenstate Thermalisation in relativistic QFT — •Miha Srdinsek[1,2,3], Tomaz Prosen[4], and Spyros Sotiriadis[5,6] — [1]ISCD - Sorbonne Universite — [2]IMPMC - Sorbonne Universite — [3]PASTEUR - Ecole Normale Superieure, PSL — [4]Faculty of Mathematics and Physics, University of Ljubljana — [5]Institute of Theoretical and Computational Physics, Department of Physics, University of Crete — [6]Dahlem Center for Complex Quantum Systems, Freie Universita *t Berlin

The validity of the ergodic hypothesis in quantum systems can be rephrased in the form of the Eigenstate Thermalisation Hypothesis (ETH), a set of statistical properties for the matrix elements of local observables in energy eigenstates, which is expected to hold in any ergodic system. We test ETH in a nonintegrable model of relativistic Quantum Field Theory (QFT) using the numerical method of Hamiltonian Truncation in combination with analytical arguments based on Lorentz symmetry and Renormalisation Group theory. We find that there is an infinite sequence of eigenstates with the characteristics of Quantum Many Body Scars, that is, exceptional eigenstates with observable expectation values that lie far from thermal values, and we show that these states are one-quasiparticle states. We argue that in the thermodynamic limit the eigenstates cover the entire area between two diverging lines, the line of one-quasiparticle states, whose direction is dictated by relativistic kinematics, and the thermal average line. Our results suggest that the strong version of ETH is violated in any relativistic QFT whose spectrum admits a quasiparticle description.

MP 3.9 Mon 18:10 HL 001

Emergent Born's statistics via colored noise driven quantum state reduction models. — •Aritro Mukherjee and Jasper van Wezel — Institute of Physics, University of Amsterdam, Science Park 904, 1098XH

While quantum mechanics successfully predicts ensemble averaged observable expectation values, unitary evolution cannot yield dynamics corresponding to a single shot projective measurement which is irreversible, stochastic and leads to one steady-state outcome. While decoherence is inherently an ensemble averaged phenomena and quantum interpretations posit no changes to the Schrodinger's unitary evolution, a possible way out are objective collapse theories which modifies the quantum evolution such that for microscopic systems, superpositions are unaffected whilst, for macroscopic systems, the quantum state is reduced to a classical mixture.

Here, I shall present a dynamical objective collapse model which derives its motivation from spontaneous symmetry breaking and its corresponding irreversibility. In particular, I will discuss a recent class of spontaneous unitarity violating models, which are driven by colored (correlated) noise and demonstrate the emergence of Born*s rules given a fluctuation-dissipation relationship holds. In such a scenario, the ensemble averaged dynamics is shown to be a Gorini-Kossakowski-Sudarshan-Lindblad master equation which also guarantees no-superluminal signaling, and this is shown for any Hilbert space dimension.

MP 4: Quantum Field Theory I

Time: Monday 15:00–15:40 Location: HL 102

MP 4.1 Mon 15:00 HL 102

An approach to a 2-dimensional weakly interacting thermal QFT — •Ian Koot — Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

It is known that one can construct a 2-dimensional integrable quantum field theory out of a 2-dimensional (non-local) free scalar fermionic field theory using Tomita-Takesaki theory. We discuss an approach to extend this construction towards a thermal quantum field theory, with the aim of constructing a weakly interacting quantum field theory at nonzero temperature.

MP 4.2 Mon 15:20 HL 102

Wave Function Renormalizations in Non-Local Field Theories — •Johannes Thürigen — Mathematisches Institut, Universität Münster

In combinatorially non-local field theories, propagating degrees of freedom interact similar to matrix or tensor interactions. Then, both from a perturbative (Hopf algebraic) and non-perturbative (FRG) perspective there are indications that renormalization is inconsistent with a single wave function renormalization parameter, even when the propagator is the same as in local QFT. We show how to improve this in terms of several wave function renormalizations and how, consequently, the renormalization group is modified. This is based on arXiv:2305.06136 and ongoing work.

MP 5: Theoretical Aspects of Condensed Matter I

Time: Monday 16:00–17:20 Location: HL 102

MP 5.1 Mon 16:00 HL 102

First-principles study of armchair SiS nanoribbons with F and Cl functionalization — •Rachana Yogi[1], Alok Shukla[1], and Neeraj K. Jaiswal[2] — [1]Department of Physics,Indian Institute of Technology Bombay, Powai, Mumbai 400076 India — [2]2D Materials Research Laboratory, Discipline of Physics, Indian Institute of Information Technology Design & Manufacturing, Jabalpur, 482005, India.

Fluorine (F) and Chlorine (Cl) are amongst the toxic gases which are highly reactive and hazardous to the environment. Therefore, to comprehend the quantum of lethality they pose, it is crucial to identify and quantify their concentration in substances. Accordingly, in the present research, the first-principles calculations based on density functional theory have been employed to reveal the structural stability, electronic and transport properties of armchair SiS nanoribbons (ASiSNR), functionalized with Cl, F and H. Our observations based on binding energy analysis suggest that all the considered structures are thermodynamically stable. It is also observed that the semiconducting behavior persists on passivation of Cl and F. However, the stability of the structure has enhanced compared to their bare and pristinecounterparts. our investigation on the transport properties of considered structures using the two-probe model revealed that the obtained current-voltage (I-V) characteristics have of current as a function of bias voltage. From these results, it is certain that the upcoming epochs of nano-electronic devices may use ASiSNR as a potential material for nano-electronics and chemical sensors.

MP 5.2 Mon 16:20 HL 102

Unidirectional Wave Propagation in a Topological Plasmonic Ring Resonator via a Symmetry-Broken Excitation Scheme — •Fatemeh Davoodi and Nahid Talebi — Institute of Experimental and Applied Physics, Kiel University, 24098 Kiel, Germany

Topological plasmonics, at the intersection of topology and plasmonics, offers an innovative approach to light manipulation, leveraging the Su-Schrieffer-Heeger model to create resilient ring-shaped plasmonic chains with topologically protected edge modes. This study thoroughly investigates the design, characterization, and manipulation of these topological plasmonic chains comprised of nano-discs. Emphasis is placed on understanding the unique properties of resonators, particularly their potential to support topologically protected edge modes within rotationally symmetric optical modes in a ring geometry. Utilizing a symmetry-breaking excitation technique with electron beams, topological edge modes are observed in rotationally symmetric chains. We analyze the influence of parameters like dimerization and loop numbers on the presence of the Edge modes. Additionally, the electron impact is suggested as a parameter to control the direction of propagation and selectively excite specific bulk or edge modes. These findings hold important implications for the advancement of nanoscale plasmonic systems with tailored functionalities, and unidirectional propagation of light in topological ring resonators coupled to point-like emitters such as quantum dots and defect centers.

MP 5.3 Mon 16:40 HL 102

Semiclassical quantization of quantum plasmons in spatially inhomogeneous media — •Koen Reijnders, Timur Tudorovskiy, and Mikhail Katsnelson — Radboud University, Institute for Molecules and Materials, Nijmegen, The Netherlands

We present a novel semi-analytical method to describe plasmons, collective excitations of the conduction electrons in solids, in spatially inhomogeneous media. Since these systems do not exhibit translational invariance, the Fourier transform cannot be used to construct a solution. However, when we demand that the characteristic scale of the inhomogeneities is much larger than the plasmon wavelength, we can instead employ techniques taken from the semiclassical approximation. In this way, we construct an asymptotic solution that is independent of the precise shape of the inhomogeneity [1]. Technically, we study a system of equations of motion that is equivalent to the random phase approximation, and which can also be viewed as a quantum generalization of the Vlasov–Poisson system. We solve this system self-consistently using the correspondence between quantum mechanical operators and classical observables on phase space. In this way, we obtain a classical Hamiltonian that describes the dynamics of quantum plasmons, given by the Lindhard function with spatially varying parameters. We then find the energy levels using Bohr–Sommerfeld quantization. Our results provide a theoretical basis to describe plasmonic waveguides and other setups in quantum plasmonics.

[1] K. J. A. Reijnders, T. Tudorovskiy, M. I. Katsnelson, Ann. Phys. (NY) 446, 169116 (2022)

MP 5.4 Mon 17:00 HL 102

Autonomous atomic Hamiltonian construction and active sampling of X-ray absorption spectroscopy by adversarial bayesian optimization — •Yixuan Zhang[1], Ruiwen Xie[1], Teng Long[2], Damian Günzing[3], Heiko Wende[3], Katharina J.ollefs[3], and Hongbin Zhang[1] — [1]Institute of Materials Science, Technical University of Darmstadt, 64287, Darmstadt, Germany — [2]School of Materials Science and Engineering, Shandong University, 250061, Jinan, China — [3]Faculty of Physics, University of Duisburg-Essen, 47057, Duisburg, Germany

X-ray absorption spectroscopy (XAS) is a well-established method for in-depth characterization of electronic structure. In practice hundreds of energy-points should be sampled during the measurements, and most of them are redundant. Additionally, it is also tedious to estimate reasonable parameters in the atomic Hamiltonians for mechanistic understanding. We implement an Adversarial Bayesian Optimization (ABO) algorithm comprising two coupled BOs to automatically fit the many-body model Hamiltonians and to sample effectively based on active learning (AL). Taking NiO as an example, we find that less than 30 sampling points are sufficient to recover the complete XAS with the corresponding crystal field and charge transfer models, which can be selected based on intuitive hypothesis learning. Further applications on the experimental XAS spectra reveal that less than 80 sampling points give reasonable XAS and reliable atomic model parameters. Our ABO algorithm has a great potential for future applications on automated physics-driven XAS analysis and AL sampling.

MP 6: Quantum Computing and Quantum Dynamics

Time: Tuesday 9:30–10:30 Location: HL 001

Invited Talk MP 6.1 Tue 9:30 HL 001

The mathematical physics of near-term quantum computing — •Jens Eisert — Freie Universität Berlin — Helmholtz Center Berlin — Heinrich-Hertz-Institute Berlin

Quantum computers promise the efficient solution of some computational problems that are classically intractable. For many years, they have been primarily objects of theoretical study, as only in recent years, protagonists have set out to actually build intermediate-scale quantum computers. This creates an interesting state of affairs, but also begs for an answer to the question what such devices are possibly good for. In this talk, we discuss such questions from the perspective of mathematical physics. While we cannot provide a comprehensive answer, this talk will be dedicated to a number of results offering substantial progress along these lines. We will discuss rigorous quantum advantages in paradigmatic problems [1,2], and will explore the use of quantum computers in machine learning [3,4,5] and optimization [6]. We will also discuss limitations, by providing efficient classical algorithms for instances of quantum algorithms, hence "de-quantizing" them, and by identifying limitations to quantum error mitigation [9]. The talk will end with an invitation to view such near-term problems from the perspective of mathematical physics.

[1] Rev. Mod. Phys. 95, 035001 (2023). [2] arXiv:2307.14424 (2023). [3] Quantum 5, 417 (2021). [4] arXiv:2303.03428, Nature Comm. (2024). [5] arXiv:2306.13461, Nature Comm. (2024). [6] arXiv:2212.08678 (2022). [7] arXiv:2309.11647 (2023). [8] Phys. Rev. Lett. 131, 100803 (2023). [9] arXiv:2210.11505 (2022).

Invited Talk MP 6.2 Tue 10:00 HL 001

Quantum chaos, integrability, and the complexity of time evolution — •Vijay Balasubramanian — University of Pennsylvanian, Philadelphia, PA 19004, USA

I will discuss recent work characterizing chaos and integrability in quantum systems in terms of the complexity of time evolution seen as a quantum computation, and in terms of the dynamical spread of the wavefunction over the Hilbert space.

MP 7: Poster (joint session MP/QI)

Time: Tuesday 11:00–13:00 Location: Poster B

MP 7.1 Tue 11:00 Poster B

Machine Learning Quantum Mechanical Ground States based on Stochastic Mechanics — •Kai-Hendrik Henk and Wolfgang Paul — Martin-Luther-University, Halle(Saale), Germany

The Rayleigh-Ritz variation principle is a proven way to find ground states and energies for bound quantum systems in the Schrödinger picture. Advances in machine learning and neural networks make it possible to extend it from an analytical search from a subspace of the complete Hilbert space to the a numerical search in the almost complete Hilbert space. In this paper, we extend the Rayleigh-Ritz principle to Nelson's stochastic mechanics formulation of non-relativistic quantum mechanics, and propose a new algorithm to find the osmotic velocities $u(x)$, which contain the information of a quantum systems in this picture. As a proof of concept, we calculated $u(x)$ for one dimensional systems, the harmonic oscillator, the double well and the Pöschl-Teller potential. To obtain exited states, we calculate ground states of super symmetrical partner Hamiltonians for each of these potentials. We will show that this method is more efficient than the stochastic optimal control algorithm, that was the usual method to obtain osmotic velocities without going back to the Schrödinger equation.

MP 7.2 Tue 11:00 Poster B

Quantum Dynamics on a Two-dimensional Comb: A Numerical Investigation — •Ognen Kapetanoski and Irina Petreska — Ss. Cyril and Methodius University in Skopje, Faculty of Natural Sciences and Mathematics, Institute of Physics, Skopje, Macedonia

This study explores the quantum dynamics in anisotropic and heterogeneous media, using the comb model - a unique branched structure characterized by a backbone and lateral fingers. The focus is on the two-dimensional comb, which constitutes a simplified yet comprehensive model for theoretical investigation of the quantum motion under geometric constraints. The comb-like constraints are achieved by incorporating the Dirac delta function into the kinetic energy operator of the Schrödinger equation. Employing the finite difference approximation and the fourth-order Runge-Kutta method, the time-dependent Schrödinger equation is numerically solved. This enables the calculation of the wave functions and analysis of the probability density function. From the obtained results, localization of the wave packet due to the comb-like geometric constraints is evident. We also recall the previously derived analytical solutions on an infinite domain, expressed in terms of the Fox H-function. The comparative analysis between the analytical and numerical solution highlights the complexity of quantum transport phenomena, underscoring the challenges and potential of theoretical and computational approaches in quantum mechanics.

[1] T. Sandev, I. Petreska, E.K. Lenzi, *J. Math. Phys.* **59**, 012104 (2018).

MP 7.3 Tue 11:00 Poster B

How to model an EUV-polariton? — •Fridtjof Kerker[1,2], Christina Bömer[1,3], and Dietrich Krebs[1,2,3] — [1]The Hamburg Centre for Ultrafast Imaging, Hamburg, Germany — [2]Department of Physics - Universität Hamburg, Germany — [3]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

In recent studies of x-ray parametric down-conversion (XPDC), unexpected imprints of a polaritonic excitation in the extreme ultraviolet (EUV) regime have been revealed. While polaritons, i.e., hybridized states of light and matter, exist in numerous contexts, they are largely unexplored at short wavelengths, such as the EUV spectral range. Under these conditions, new theoretical approaches are necessary to understand the phenomenon.

In this poster presentation, we introduce a first model of the EUV-polariton, which allows us to simulate its generation inside a diamond sample during XPDC. We derive the full scattering signal according to our model and find good agreement with the experimental XPDC data. We further employ our model to analyze the coupling strength of the observed EUV-polariton and discover it to reach up to the strong-coupling regime - notably without requiring an external enhancement-cavity. Our results provide first theoretical insights into this new kind of polariton and constitute a basis for future investigations into strong EUV-light-matter coupling.

MP 7.4 Tue 11:00 Poster B

Driving chiral matter by chiral light — •Alexandra Schrader, Benjamin Schwager, Christian Bohley, and Jamal Berakdar — Martin-Luther-Universität Halle-Wittenberg

Many chiral materials display a magneto-electric response which, in lowest order, can be expressed by a complex cross-coupling of the electric (magnetic) dipole moments to the magnetic (electric) fields. A number of physical properties depend on the material's chirality state and hence it is important to find ways to drive and separate objects according to their chirality. E.g., chiral molecules, which are crucial in drug manufacturing, can be chirality-specific separated by optical forces which act differently on different types of enantiomer. This theory contribution discusses how engineering the chiral characteristics of light through structuring both the spatial polarization and orbital phase allow to optimize the chiral forces and torques to steer chiral matter.

MP 7.5 Tue 11:00 Poster B

Particle dynamics on quantum membranes — •Lars Meschede, Benjamin Schwager, and Jamal Berakdar — Martin-Luther-Universität Halle-Wittenberg

We are working on an approach for an effective description of particles confined to a thin tubular neighborhood of a curved, dynamical, lower-dimensional submanifold (e.g. membranes). In addition to the well-known geometric potential due to confinement to a static submanifold, the dynamical degrees of freedom give rise to new effective, dynamical scalar and vector potentials. The coupling of the particles to the underlying space itself allows the transfer of energy and momentum to the manifold. In the case of membranes, the coupled dynamics of the particles and the membrane can be described by a (quantum) field theory of two interacting fields, which also yields an equation governing the membrane dynamics in the presence of particles confined to it. This setup can be seen as an elastic field analog of an electromagnetic cavity. If one considers the non-relativistic case, the Lagrangian and the necessity of the existence of a new effective vector potential follow from the invariance requirement under Galilean transformations. An additional coupling of the particles to the external electromagnetic field allows radiative excitations of vibrational modes of the membrane. This approach could be of interest for the description of the long-wavelength coupled electron-membrane dynamics on flexible 2D structures.

MP 7.6 Tue 11:00 Poster B

Electron-phonon and Coulomb intercation in twisted bilayer graphene aligned on WSe_2 — •Sonia Haddad[1,2] and Jihang Zhu[3] — [1]Laboratoire de Physique de la Matière Condensée, Faculté des Sciences de Tunis, Université Tunis El Manar, Campus Universitaire 1060 Tunis, Tunisia — [2]Institute for Theoretical Solid State Physics, IFW Dresden, Helmholtzstr. 20, 01069 Dresden, Germany — [3]Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Strasse 38, Dresden 01187, Germany

The origin of the superconducting state, emerging at the so-called magic-angle (MA), in twisted bilayer graphene (TBG) is still an open question. However, there is a general consensus on the key role of the flat electronic bands occuring at the MA. Recently, a stable superconducting state has been observed in TBG aligned on WSe_2 at small twist angles compared to MA, which calls into question the relevance of the flat bands. Here we address the role of SOC induced in TBG by its proximity to WSe_2. Based on the continuum model, we study the effect of the SOC on the electron-phonon interaction and on the screened Coulomb potential. Our results show that the latter is the key factor for the stability of the superconducting phase, which is expected to be due to a Kohn-Luttinger mechanism.

MP 7.7 Tue 11:00 Poster B

Microscopic mechanism of photo-induced tip-surface currents driven by near-infrared pulses — •Carlos Bustamante[1], Franco Bonafé[1], Simon Maier[2], Rupert Huber[2], and Angel Rubio[1] — [1]Max Planck Institute for the Structure an Dynamics of Matter, Hamburg, Germany. — [2]Department of Physics, University of Regensburg, Regensburg, Germany.

The control of photo-induced currents from a tip using terahertz laser pulses, when combined with electronic microscopy, has allowed the study of ultrafast dynamics at the atomic scale. Although the charge transfer process has been described by simplified models, further improvement of this technique to achieve shorter time scales and better resolution at the atomic scale requires an ab initio framework. In this work, we have studied the electron dynamics of a tip-surface arrangement described atomistically, when interacting with near-infrared single-cycle laser pulses using TDDFT. Our results provide further insight into the nature of the photo-current induced by the laser pulse, its dependence on the electric field amplitude of the laser and the role of multiphoton absorption.

MP 7.8 Tue 11:00 Poster B

Slow Modes in Dissipatively Stabilized Superconductors — •Tom Zander and Sebastian Diehl — Universität zu Köln, D-50937 Cologne, Germany

Topological states of fermionic matter can be induced by purely dissipative dynamics. Other interesting states can exhibit superfluidity or superconductivity. The states which are cooled into, irregardless of the initial state, are called 'dark states'.

We construct an interacting field theory using the Keldysh formalism to investigate a system of 1d fermions cooling into a superconducting dark state. Using the Hubbard-Stratonovich transformation, as well as other tools of quantum field theory, we derive, in the long wavelength limit, the effective slow mode action for the Goldstone and hydrodynamic modes.

MP 7.9 Tue 11:00 Poster B

Energy conserving adaptive QM/MM method using an extended Hamiltonian approach — •Marvin Nyenhuis and Nikos Doltsinis — Institute for Solid State Theory, University of Münster, Wilhelm-Klemm-Straße 10, 48149 Münster

We present an extended Hamiltonian formalism that introduces a fictitious switching particle with mass μ_k which propagates a system between two different potential energy surfaces ($V_{k-1} \to V_k$) during a hybrid ab initio (QM) and classical force field (MM) molecular dynamics simulation by mixing both potentials via a switching function $g(\lambda_k) \in [0, 1]$.

$$\mathcal{H} = \sum_{I=1}^{N} \frac{\mathbf{P}_I^2}{2M_I} + \sum_{j=1}^{k} \frac{\Delta V_j}{|\Delta V_j|} \frac{1}{2} \mu_j \dot{\lambda}_j^2 + \underbrace{g(\lambda_k) V_{k-1}(\mathbf{R}) + \{1 - g(\lambda_k)\} V_k(\mathbf{R})}_{V_{\text{mix}}}$$

The Hamiltonian consists of the kinetic energy of all nuclei $I \in \{1, \ldots, N\}$ with mass M_I, kinetic energy of all completed λ_j, $j \in \{1, \ldots, (k-1)\}$ and running switching procedures (λ_k) as well as the mixed potential energy V_{mix} depending on all nuclear positions $\mathbf{R}$. Each λ_k is propagated from 0→1 and describes the progress of switching.

MP 7.10 Tue 11:00 Poster B

Numerical simulations of stochastic optimal control model for navigation of finite size microswimmers — •Malte Thumann — Institut für Numerische und Angewandte Mathematik, Universität Göttingen

Using stochastic optimal control theory, we study the optimal navigation of finite size microswimmers in the presence of a fluid flow and thermal fluctuations in two-dimensional space. The resulting Hamilton-Jacobi-Bellmann (HJB) equation is a nonlinear convection-diffusion type partial differential equation (PDE) that describes the optimal torque an active swimmer must satisfy to navigate towards a desired target. This equation is numerically solvable in a three-dimensional phase space (position and orientation) for a given set of initial conditions. We discretise the HJB equation in a finite element framework known as the discontinuous Galerkin method, which operates over a trial space of functions that are only piecewise continuous. This allows for a more stable and flexible discretisation scheme, in particular to cope with the challenging task of implementing singular boundary conditions arising from the stochastic optimal control approach. Using the optimal torque solution, we perform stochastic simulations to determine the optimal mean microswimmer path. Our work emphasises that finite element methods are a suitable discretisation technique to handle PDEs arising in theoretical biophysics in a non-trivial setting with complex geometries, singularities, or higher order local approximations.

MP 7.11 Tue 11:00 Poster B

Perturbative Series Expansions for Two-Particle Bound-State Energies in the Thermodynamic Limit: A Green's Function Approach — •Maximilian Bayer, Patrick Adelhardt, and Kai Phillip Schmidt — Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Staudtstr. 7, 91058 Erlangen, Germany

The investigation of (quasi-)particle bound states has been a focal point in quantum mechanics research, tracing its roots back to the solutions of the Hydrogen atom. In the realm of solid-state systems, the emergence of two-quasi-particle bound-states, such as excitons, Cooper pairs or magnon-magnon bound-states in spin systems, gives rise to unique material properties. Our interest lies in developing general techniques for systematically computing the energies associated with such bound-states on lattice systems in a perturbative manner.

We introduce an approach based on zero-temperature Green's functions (Resolvents), capable of generating series expansions for these energies in the thermodynamic limit, eliminating the need for exact diagonalization and Rayleigh-Schrödinger perturbation theory on finite systems. This technique is universal in the dimensionality of the system and accommodates fermionic, bosonic, and hard-core bosonic particles, only requiring finite-range interactions.

By reducing the eigenvalue equation into the determinant of a finite matrix we obtain a finite expression even for infinite systems. This expression allows for the extraction of bound-state energies either exactly for fixed perturbation parameters or in the form of a power series, if such a series exists.

MP 7.12 Tue 11:00 Poster B

Comparison the determination techniques of the effective re-

fractive index of all-dielectric metasurface as a graphene layer substrate using finite-element electromagnetic simulations — •Zoya Eremenko and Aliaksei Charnukha — Leibniz Institute for Solid State and Materials Research

We proposed the use of the resonant all-dielectric metasurface as a graphene layer substrate. The task is to define the effective refractive index of such a metasurface to have the possibility to control the surface plasmon polariton propagation length. We studied some techniques to define the effective refractive index of the metasurface. The first one is determining the band structure of a two-dimensional photonic crystal with a square lattice of the defined metasurface structure and obtained the eigen frequencies at definite relation between metasurface unit cell parameters. The second one is retrieval of the effective parameter technique from S-parameters defined from simulations results. Thus, such techniques give the opportunity to use any structure configuration of the resonant all-dielectric metasurfaces.

MP 7.13 Tue 11:00 Poster B

Thermalization of black holes and the SYK model — •Zhuo-Yu Xian[1], Yuxuan Liu[2], Shao-Kai Jian[3], Yi Ling[4], and Jiasheng Liu[5] — [1]Julius-Maximilians-Universität Würzburg, 97074 Würzburg, Germany — [2]Institute of Quantum Physics, School of Physics, Central South University, Changsha 418003, China — [3]Department of Physics and Engineering Physics, Tulane University, New Orleans, Louisiana, 70118, USA — [4]Institute of High Energy Physics, Chinese Academy of Sciences, Beijing 100049, China School of Physics, University of Chinese Academy of Sciences, Beijing 100049, China — [5]Ludwig-Maximilians-Universität München, Geschwister-Scholl-Platz, 1 D-80539 München

We investigate the evolution of entanglement and Heisenberg operators within open and strongly coupled systems interacting with its environment, in the frameworks of both the doubly holographic model and the Sachdev-Ye-Kitaev (SYK) model. In both cases, the entanglement within the system initially increases as a result of internal interactions; however, it eventually dissipates into the environment. We also study the operator size growth in the Lindbladian SYK model and analytically obtain the suppression of the growth due to the dissipation. The dynamic behaviors of the entanglement and the opeartor size observed in these two models are attributable to the competition between the internal interaction of the system and the external interaction with the environment.

MP 7.14 Tue 11:00 Poster B

Conceptual-Mathematical Approach for the Derivation of Effective Field Theories from QCD- & Gauge Theories (Large 48x48 matrices in QCD from Hubbard-Stratonovich transformations) — •Bernhard Mieck — Keine Institution

An effective field theory of BCS quark pairs is derived from an ordinary QCD-type path integral with SUc(Nc=3) non-Abelian gauge fields. We consider the BCS quark pairs as constituents of nuclei and as the remaining degrees of freedom in a coset decomposition SO(N,N) /U(N) x U(N) of a corresponding total self-energy matrix taking values as generator within the so(N,N) Lie algebra. The underlying dimension (N = Nf x 4 x Nc) is determined by the product of isospin- 'Nf = 2' (flavour- 'Nf = 3') degrees of freedom, by the 4x4 Dirac gamma matrices with factor '4' and the colour degrees of freedom 'Nc = 3'; therefore, the smallest, total self-energy generator has Lie algebra so(N,N) with N = 24. We distinguish between a total unitary sub-symmetry U(N) for purely density related parts of the quarks, which are taken into account as background fields and as invariant vacuum states in a SSB, and between the BCS terms of quarks as coset elements so(N,N) / u(N). These HST's are sufficient to achieve a path integral entirely determined by self-energy matrices for the coset decomposition. Concerning homotopies, we attain the nontrivial Hopf mapping Π_{3}(S^2)=Z from consideration of Fujikawa-anomalies and would like to point again the possibility for further nontrivial homotopies, as e.g. Π_{7}(S^4) = Z or Π_{2^n -1}(S^(2^(n-1))) = Z.

MP 7.15 Tue 11:00 Poster B

Wave function of the universe in the presence of trans-Planckian censorship — •Vikramaditya Mondal — School of Physical Sciences, Indian Association for the Cultivation of Science, Kolkata 700032, India

The wave function for a closed de Sitter universe has been computed, demanding consistency with the recently proposed Trans-Planckian Censorship Conjecture (TCC). We extend the Einstein-Hilbert action to contain a complex-valued term that provides an exponentially decaying weight for the geometries violating TCC in the Lorentzian path integral sum while working in the minisuperspace approach to quantum cosmology. This postulated modification suppresses the probability of the evolution of the universe into configurations that violate TCC. We show that due to the presence of this suppression factor, the Hubble rate of the universe at the end of the inflation gets subdued and assumes a value less than what is expected classically. Moreover, the consequences of this quantum gravity-motivated correction in the primordial power spectrum are discussed as well.

MP 8: Quantum Field Theory II

Time: Wednesday 9:30–13:00 Location: HL 001

Invited Talk MP 8.1 Wed 9:30 HL 001

Embezzlement of entanglement, quantum fields, and the classification of von Neumann algebras — •Alexander Stottmeister — Leibniz University Hannover

Embezzlement refers to the counterintuitive possibility of extracting entangled quantum states from a reference state of an auxiliary system (the "embezzler") via local quantum operations while hardly perturbing the latter. We report a deep connection between the mathematical classification of von Neumann algebras and the operational task of embezzling entanglement: The performance of a general state at the task of embezzling is measured by the flow of weights. In particular, embezzling states, having the best performance, are fixed points of the flow of weights. For a type III factor, its subtype is precisely recovered by the worst possible performance. Our result implies, under typical assumptions, that relativistic quantum fields are universal embezzlers, thereby providing an operational characterization of the infinite amount of entanglement present in the vacuum state: Any entangled state of any dimension can be embezzled from them with arbitrary precision.

This is joint work with L. van Luijk, H. Wilming, and R.F. Werner.

MP 8.2 Wed 10:00 HL 001

The Bałaban variational problem in the non-linear sigma model — •Wojciech Dybalski[1], Alexander Stottmeister[2], and Yoh Tanimoto[3] — [1]AMU Poznań — [2]University of Hannover — [3]University of Rome "Tor Vergata"

The minimization of the action of a QFT with a constraint dictated by the block averaging procedure is an important part of the Bałaban's approach to renormalization. It is particularly interesting for QFTs with non-trivial target spaces, such as gauge theories or non-linear sigma models on a lattice. We analyse this step for the O(4) non-linear sigma model in two dimensions and demonstrate in this case how various ingredients of the Bałaban approach play together. First, using variational calculus on Lie groups, the equation for the minimum is derived. Then this non-linear equation is solved by the Banach fixed point theorem. This step requires detailed control of the lattice Green functions and their integral kernels via random walk expansions.

MP 8.3 Wed 10:20 HL 001

On separable states in relativistic QFT — •Ko Sanders — Friedrich-Alexander Universität Erlangen-Nürnberg

In quantum theory, entanglement is the rule rather than the exception: systems naturally entangle themselves with their environment at no cost to the experimenter. On the contrary, to prevent this decoherence is difficult and expensive in terms of effort and energy. In this talk I will discuss a recent quantitative result on the amount of energy needed to ensure the existence of separable (i.e. non-entangled) states in relativistic quantum field theory, which are physically perfectly reasonable (quasi-free, Hadamard, highly symmetric). This result can be seen as a first step in a general investigation of the balance between energy and entanglement in relativistic QFT.

MP 8.4 Wed 10:40 HL 001

Quantum energy inequalities in integrable models — •Jan Mandrysch — Department Mathematik, FAU Erlangen

While the positivity of the total energy in a system, also in quantum physics, is a hallmark of stability, locally, energy may be negative. For physically reasonable models a reminiscent notion of stability can be captured by weaker conditions often referred to as quantum (weak) energy inequalities (QEIs). Such inequalities have been proven in many free QFT models and are known to be equivalent to other common stability properties. However, there exist only few results in theories with self-interaction.

In this talk, we will focus on a certain class of two-dimensional interacting QFTs known as *integrable models*. In particular, we present results on the O(N)-nonlinear-sigma and sinh-Gordon model at one- and two-particle level.

The talk is partly based on 2302.00063.

20 min. break

MP 8.5 Wed 11:20 HL 001

Stochastic quantization of two-dimensional $P(\Phi)$ Quantum Field Theory — Paweł Duch, Wojciech Dybalski, and •Azam Jahandideh — Adam Mickiewicz University in Poznań, Poznań, Poland

We give a simple and self-contained construction of of the $P(\Phi)$ Euclidean Quantum Field Theory in the plane and verify the Osterwalder-Schrader axioms: translational and rotational invariance, reflection positivity and regularity. In the intermediate steps of the construction we study measures on spheres. In order to control the infinite volume limit we use the parabolic stochastic quantization equation and the energy method. To prove the translational and rotational invariance of the limit measure we take advantage of the fact that the symmetry groups of the plane and the sphere have the same dimension. This talk is based on [arXiv: 2311.04137].

MP 8.6 Wed 11:40 HL 001

Mourre theory and asymptotic observables in local relativistic quantum field theory — •Janik Kruse — Adam Mickiewicz University in Poznań, Uniwersytetu Poznańskiego 4, Poznań, Poland

A classical problem in scattering theory is the problem of asymptotic completeness (i.e. interpreting quantum theories in terms of particles). Asymptotic completeness is settled in non-relativistic quantum mechanics for many-body systems but a widely open problem in local relativistic quantum field theory (QFT). Many proofs of asymptotic completeness in quantum mechanics rely on the convergence of asymptotic observables. In QFT, Araki-Haag detectors have been identified as natural asymptotic observables. The convergence of Araki-Haag detectors on scattering states of bounded energy was established relatively early by Araki and Haag, but the convergence on arbitrary states has remained an open problem for decades. First convergence results of Araki-Haag detectors on arbitrary states have been obtained relatively recently by Dybalski and Gérard by translating quantum mechanical propagation estimates to QFT. They covered products of two or more Araki-Haag detectors sensitive to particles with distinct velocities, but the convergence of a single detector was not treated. The technical reason for this omission was a missing low velocity propagation estimate, which is usually proved by Mourre's conjugate operator method. So far, Mourre theory resisted any extension from quantum mechanics to quantum field theory. In a recent publication, we closed this gap and established the convergence of a single Araki-Haag detector. Based on https://arxiv.org/abs/2311.18680.

MP 8.7 Wed 12:00 HL 001

Quantum Field Theory at Finite Temperature — •Johannes Grosse and Gandalf Lechner — Department of Mathematics, FAU Erlangen-Nürnberg

In this work, we study the finite temperature behaviour of a $(1+1)$-dimensional fermionic quantum field theory of two particle types. As the thermal equilibrium behaviour of one particle type is well-known, the main work focuses on extending thermal equilibrium states from a theory consisting of one particle type to that of two particle types. The issue of extending thermal equilibrium states can be naturally framed in the language of Tomita-Takesaki modular theory and $\mathbb{Z}_2$ crossed products.

MP 8.8 Wed 12:20 HL 001

Lorentz symmetry violating Lifshitz-type field theories — •Emiliano Rizza[1,2] and Dario Zappalà[2] — [1]Jagiellonian University, Krakow, Poland — [2]Università di Catania, Catania, Italy

We discuss the ultraviolet sector of 3+1 dimensional Lifshitz-type anisotropic higher derivative scalar, fermion and gauge field theories, with anisotropy exponent z=3 and with explicit breaking of Lorentz symmetry. By discarding from the action all momentum dependent vertex operators, which is essential to avoid phenomenologically unacceptable deformations of the light cone, we find that renormalizable scalar self-interaction and Yukawa-like couplings are, in general, asymptotically free. However, the requirement of cancelling momentum dependent vertex operators is incompatible with gauge symmetry and, therefore, for this kind of theories, gauge symmetry as well as Lorentz symmetry are recovered only as emergent properties below some energy scale M, that must be constrained from experiments. The quantum corrections to the scalar mass and their impact on the hierarchy problem are also analyzed.

MP 8.9 Wed 12:40 HL 001

Resummations for semiclassical effective actions — •Sebastián A. Franchino-Viñas[1], César García Pérez[2], Diego Mazzitelli[3], Vincenzo Vitagliano[2], and Ulises Weinstein Haimovichi[4] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Università di Genova, Genoa, Italy — [3]Instituto Balseiro, Bariloche, Argentina — [4]Universidad Nacional de La Plata, Argentina

The effective action determines the quantum behaviour of a quantum field. In a variety of situations when the field interacts with other fields, it is enough to approximate the latter fields as classical backgrounds. Employing heat-kernel methods, we show that resummations can be obtained for a variety of background fields, obtaining thus Euler–Heisenberg-type effective actions.

MP 9: Theoretical Aspects of Condensed Matter II

Time: Wednesday 9:30–12:30 Location: HL 102

MP 9.1 Wed 9:30 HL 102

Wegner model on a tree graph: U(1) symmetry breaking — •Julian Arenz — Institut für theoretische Physik, Zülpicher Str. 77, 50937 Köln

The Anderson transition between localized and metallic states is traditionally analyzed by assuming a one-parameter scaling hypothesis. However, there exists mounting evidence that the transition in $d \geq 3$ dimensions may have a second branch and that two relevant parameters are needed in order to describe the universal behavior at criticality. Doubt of the standard hypothesis also comes from field theory. Indeed, increasing the space dimension moves the Anderson transition point in the strong disorder regime. Here, a strong coupling approach very different from the usual weak-coupling analysis of the σ-model is called for.

In the process of developing the field theory at strong coupling we first investigate the $N = 1$ Wegner model on a Bethe lattice assuming the self-consistent theory of localization due to Abou-Chacra et al. We derive a self consistency equation for the Fourier Laplace transform of a local matrix Green's function. Its degree of freedom is a matrix field whose target is a space foliated by hyperboloids.

Our main observation is that the $U(1)$ symmetry which distinguishes retarded from advanced fields may undergo spontaneous symmetry breaking. Put in other words, in the high dimension and large disorder regime there exist stable solutions that break $U(1)$ symmetry.

MP 9.2 Wed 9:50 HL 102

Spectral localizer for line-gapped non-Hermitian topological matter — •Lars Koekenbier — Friedrich-Alexander Universität Erlangen-Nürnberg, Erlangen, Germany

Topological matter, described by short-ranged and line-gapped non-Hermitian Hamiltonians, has associated strong topological invariants that determine its phases. I will present an approach to accessing these invariants via a suitable spectral localizer, which is an operator constructed without using the band structure of the material. An example of this numerical technique with relevance to the design of topological photonic systems, such as topological lasers, is shown.

MP 9.3 Wed 10:10 HL 102

Rigorous Bounds on Tc in the Eliashberg Theory of Superconductivity — •Michael Kiessling[1], Boris Altshuler[2], and Emil Yuzbashyan[3] — [1]Rutgers University, Dept. of Mathematics — [2]Columbia University, Dept. of Physics — [3]Rutgers University, Dept. of Physics and Astronomy

The BCS theory of superconductivity uses Tc as empirical input. By contrast, the Eliashberg theory allows one to compute Tc in principle. In this talk rigorous lower and upper bounds are presented explicitly for (a) the realization of the theory with dispersionless phonons, and (b) the so-called gamma-model. For small phonon frequencies in model (a) the lower bound agrees to three significant digits with previously established numerical results. Upper and lower bounds for model (b) converge to each other when gamma goes to infinity.

20 min. break

MP 9.4 Wed 10:50 HL 102

Boundary Superconductivity in BCS Theory — •Barbara Roos[1] and Robert Seiringer[2] — [1]University of Tübingen, Germany — [2]ISTA, Klosterneuburg, Austria

We study the BCS theory of superconductivity for systems with a boundary. It has been observed numerically, that in BCS theory superconductivity persists at higher temperatures at the boundary than in the bulk. We give a rigorous proof that the BCS critical temperature increases in the presence of an interface in dimensions one, two and three, at least at weak coupling.

MP 9.5 Wed 11:10 HL 102

Magnus effect on a Majorana zero-mode — •Gal Lemut[1], Michal Jan Pacholski[2], Stephan Plugge[3], Carlo Willem Joannes Beenakker[4], and Inanc Adagideli[5] — [1]Dahlem Center for Complex Quantum Systems and Fachbereich Physik, Freie Universität Berlin, Berlin, Germany — [2]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [3]Silicon Quantum Computing, Sydney, New South Wales, Australia — [4]Instituut-Lorentz, Universiteit Leiden, Leiden, The Netherland — [5]Faculty of Engineering and Natural Sciences, Sabanci University, Orhanli-Tuzla, Istanbul, Turkey

A supercurrent on the proximitized surface of a topological insulator can cause a delocalization transition of a Majorana fermion bound to a vortex core as a zero-mode. Here we study the dynamics of the deconfinement, as a manifestation of the Magnus effect (the coupling of the superflow to the velocity field in the vortex). The initial acceleration of the Majorana fermion is $\pm 2v_f^2 K\hbar$, perpendicular to the Cooper pair momentum K, for a $\pm 2\pi$ winding of the superconducting phase around the vortex. The quasiparticle escapes with a constant velocity from the vortex core, which we calculate in a semiclassical approximation and compare with computer simulations

MP 9.6 Wed 11:30 HL 102

Dynamical simulation of the injection of vortices into a Majorana edge mode — Ian Matthias Flor[2], •Alvaro Donis Vela[1], Carlo Beenakker[1], and Gal Lemut[3] — [1]Leiden University — [2]KTH Royal Institute of Technology — [3]Freie Universitat Berlin

The chiral edge modes of a topological superconductor can transport fermionic quasiparticles, with Abelian exchange statistics, but they can also transport non-Abelian anyons: Edge-vortices bound to a π-phase domain wall that propagates along the boundary. A pair of such edge-vortices is injected by the application of an h/2e flux bias over a Josephson junction. Existing descriptions of the injection process rely on the instantaneous scattering approximation of the adiabatic regime [Beenakker et al. Phys.Rev.Lett. 122, (2019)], where the internal dynamics of the Josephson junction is ignored. Here we go beyond that approximation in a time-dependent many-body simulation of the injection process, followed by a braiding of mobile edge-vortices with a pair of immobile Abrikosov vortices in the bulk of the superconductor. Our simulation sheds light on the properties of the Josephson junction needed for a successful implementation of a flying topological qubit.

MP 9.7 Wed 11:50 HL 102

Charge-Transport Mechanisms in the Conductive Fiber Network of Cable Bacteria — •Stefani Valianti[1], Jasper van der Veen[1], Filip Meysman[2], Herre van der Zant[1], and Yaroslav Blanter[1] — [1]Kavli Institute of Nanoscience, Delft University of Technology, Lorentzweg 1, 2628 CJ Delft, The Netherlands — [2]Centre of Excellence for Microbial Systems Technology, University of Antwerp, Universiteitsplein 1, 2610 Wilrijk, Belgium.

Charge transfer is fundamental to life, and organisms have developed various conductive structures to support vital processes.The distance of biological charge transport has long been thought to be limited to nm scale, yet recent studies suggest that electric currents can run along cm-long wires.The most studied bacterial species that produce conductive structure are those of the cable bacteria family.They display a high electrical conductivity, opening perspectives for novel bioelectronic technologies.Here, we shed light on conductive charge-transport (CT) mechanisms by developing CT theoretical models in metal-cable bacterium filament-metal junction, based on incoherent classical and quantum hopping formalisms, that describe conductance experiments for which, there is no theoretical modelling.We propose that conduction through cable bacteria at high temperatures follows an activated Arrhenius temperature-dependence with low activation energy that is a clear signature of classical hopping mechanism including nearest-neighboring near-resonant hopping centers.When lowering the temperature below 80K, the conductivity remains elevated due to quantum-assisted hopping and eventually stabilizes regardless of temperature.

MP 9.8 Wed 12:10 HL 102

Multiple Manifestations of Negative Local Partial Density of States — •Kanchan Meena and Prosenjit Singha Deo — S. N. Bose National Centre for Basic Sciences, Kolkata, 700106, India

Mesoscopic physics has new achievements in miniature sample fabrication. With leads, one can have a hierarchy of density of states in Larmor Clock (LC) theory. New phenomena have been seen with these local entities or formulas, like local partial density of states can become negative in the presence of Fano resonances. So such new phenomena, like negative partial states, transmission zeros, π phase shift and breakdown of parity effect etc have seen in recent works. In the presence of negative electrons can behave like positron. If one electron can attract one positron, it can attract another positrons also, which can also be seen as electron-electron attraction in mesoscopic physics. In this work, we are showing that can become negative and that can be experimentally detectable. For that, we are working with two approaches. One is a continuum model and the other is discrete or tight binding model. One can see there are multiple manifestations of time travel.

MP 10: AdS/CFT

Time: Thursday 9:30–13:00 Location: HL 001

Invited Talk MP 10.1 Thu 9:30 HL 001
Conformal field theories from line defects and holography — •Valentina Forini — Humboldt-Universität zu Berlin, Germany

Wilson lines are a prototypical example of defect in quantum field the- ory. I will discuss the superconformal case, in which the one-dimensional defect conformal field theory that they define is particularly interesting. There, a number of techniques can be used (among them, the conformal bootstrap, supersymmetric localization and holography) to learn more about their behaviour in the nonperturbative regime.

MP 10.2 Thu 10:00 HL 001
Constant intrinsic curvature surfaces in AdS/CFT — •Mario Flory[1], Ramesh Chandra[2], Jan de Boer[2], Michal Heller[3], Sergio Hörtner[4], and Andrew Rolph[2] — [1]Jagiellonian University — [2]University of Amsterdam — [3]Ghent University — [4]Max Planck Institute for Gravitational Physics

More than 130 years ago, Jean-Gaston Darboux remarked that surfaces of constant extrinsic curvature seem to play a much more prominent role in mathematical physics than surfaces of constant intrinsic (Gaussian) curvature. At least in the AdS/CFT correspondence, this observation seems to hold true to this day, as evidenced e.g. by the success of the Ryu-Takayanagi formula. Here, motivated by recent studies of so called holographic complexity measures and their connection with the gravitational action, I will comment on a possible role that constant intrinsic curvature surfaces might play in the holographic dictionary. I will also show how such surfaces can be constructed particularly easily in an AdS_3 background.

MP 10.3 Thu 10:20 HL 001
Implications from RMT universality on orientable/unorientable Weil-Petersson Volumes — •Torsten Weber[1], Jarod Tall[2], Fabian Haneder[1], Juan Diego Urbina[1], and Klaus Richter[1] — [1]Universität Regensburg, Regensburg, Deutschland — [2]Washington State University, Pullman, USA

In recent years the discovery of an AdS/CFT like correspondence of quantum JT gravity and a distinct random matrix model has led to an intense cross-fertilisation of the a priori distinct fields of quantum gravity and quantum chaos. In this spirit we use the well-known concept of random matrix universality and study its implications on the gravitational dual. Specifically we focus here on the spectral form factor (SFF) which serves as a prime example showcasing universality on the matrix model side. We study its connection to the objects appearing in its computation on the gravitational side, the volumes of the moduli space of hyperbolic 2-manifolds known as Weil-Petersson (WP) volumes. As a first example of this program we present our results for the bosonic and orientable case of JT where we find that the universal results yields a set of non-trivial constraints to be obeyed by the WP volumes. We continue by discussing our ongoing work on the bosonic unorientable case where we find WP volumes of structures different from the orientable WP volumes. While reproducing the expected agreement with the universal result micro-canonically we find that the structure of the canonical SFF deriving from these volumes necessitates a refined computation on the universal RMT side by which we are able to reproduce its key features.

MP 10.4 Thu 10:40 HL 001
Genus expansions and non-factorisation in periodic orbit sums: a proposal for holography in two-dimensional quantum gravity — •Fabian Haneder, Torsten Weber, Camilo Moreno, Juan Diego Urbina, and Klaus Richter — Universität Regensburg, Regensburg, Deutschland

In recent years, low dimensional quantum gravitational models have found fruitful application in holography due to dualities between such models and various random matrix models [D. Stanford, E. Witten, arXiv: 1907.03363]. An open problem in the generalisation of this work to higher dimensional quantum gravity is the question of how a single quantum system can produce non-factorising correlation functions like the ones found in random matrix models and expected in generic theories with quantum gravity due to the contribution from wormhole geometries.

In this talk, we show that generic chaotic quantum systems, after introducing a novel dynamical average utilising correlations between the actions of classical periodic orbits [M. Sieber, K. Richter, Phys. Scr. 2001 128], exhibit correlation functions that take the form of genus expansions one would expect in (2-dimensional) quantum gravity. For a specific choice of system, a particle moving geodesically on a hyperbolic 3-manifold, which is described by the mathematically exact Selberg trace formula, we find agreement to leading order in the genus expansion of the one- and two-point correlation functions of the heat kernel with the corresponding partition functions of topological 2d gravity, the gravitational dual of the Kontsevich matrix model.

20 min. break

MP 10.5 Thu 11:20 HL 001
JT gravity on hyperbolic lattices as an Ising model — •Jonathan Karl, Johanna Erdmenger, Zhuo-Yu Xian, and Yanick Thurn — Julius Maximilians Universität Würzburg

In recent years the search for a holographic duality, which is based on tessellations of the hyperbolic plane has gained momentum and the construction of suitable boundary theories has been considered in the literature. We propose a discrete analog of JT gravity, defined on hyperbolic lattices as a dual bulk theory. We calculate the resolvent function, which is related to the partition function, by mapping the gravity theory to an Ising model. Furthermore, we propose a realisation of discrete JT gravity as a matrix integral.

MP 10.6 Thu 11:40 HL 001
HyperCells and HyperBloch: open-source software packages for studying hyperbolic lattices based on triangle groups — •Patrick M. Lenggenhager[1,2,3,4,5], Joseph Maciejko[4], and Tomáš Bzdušek[1,2] — [1]University of Zurich, Switzerland — [2]Paul Scherrer Institute, Villigen PSI, Switzerland — [3]ETH Zurich, Switzerland — [4]University of Alberta, Edmonton, Canada — [5]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

Hyperbolic lattices form the analogue of periodic structures in the hyperbolic plane and have been experimentally realized as networks in metamaterial platforms. The lattices possess discrete translation symmetry. However, due to the negative curvature, the resulting translation group is noncommutative which complicates not only the formulation of band theory but also the construction of periodic boundary conditions (PBC). Both infinite lattices and finite clusters with PBC can be conveniently described in terms of triangle groups.

I will introduce two recently released software packages, called HyperCells and HyperBloch, which provide convenient tools to construct connected and symmetric unit cells, including the associated translations, define arbitrary tight-binding models on them, and apply the supercell method for hyperbolic band theory to gain access at infinite-lattice eigenstates and -energies. The construction is based on an algebraic description of the lattice in terms of the corresponding triangle group, which facilitates a discussion of not only the translation symmetry but point-group symmetries as well. I will discuss examples and show some recent results.

MP 10.7 Thu 12:00 HL 001
Entanglement in interacting Majorana chains and transitions of von Neumann algebras — •Pablo Basteiro, Giuseppe Di Giulio, Johanna Erdmenger, and Zhuo-Yu Xian — Institute for

Theoretical Physics and Astrophysics and Würzburg-Dresden Excellence Cluster ct.qmat, Julius Maximilians University Würzburg, Am Hubland, 97074 Würzburg, Germany

We consider Majorana lattices with two-site interactions in the form of a general function of the fermion bilinear. The model is exactly solvable in the limit of large number N of on-site fermions. For four-site chains, we detect a first order quantum phase transition by tuning the relative hopping strength between sites, which manifests itself in a discontinuous entanglement entropy. Inspired by recent analyses of the AdS/CFT correspondence, we identify type I_∞, type II_1, and type III operator algebras in various limits of the phase diagram. In the strongly interacting limit, we find that an abrupt change between type II_1 and I_∞ algebras occurs at the phase transition point.

MP 10.8 Thu 12:20 HL 001

Page Curve Dynamics and Tunneling Effects in Fermionic Systems — •Rishabh Jha and Stefan Kehrein — Institute for Theoretical Physics, Friedrich-Hund-Platz 1, 37077 Göttingen, University of Göttingen, Germany

Motivated by the physics of Page curve in black holes, we study the entanglement dynamics in many-body physics of a fermionic chain and reproduce Page-like curve for entanglement growth between an arbitrary bi-partition where one is significantly smaller (called the system that can be free or contain interactions) than the other (called the environment that is kept free of interactions). The entanglement grows up and then bends down much like what we expect from a Page curve, thereby creating "self-purification" or "zero-variance" states for which we provide evidence by plotting the energy variance of the environment. Moreover, we find an acute sensitivity on the tunneling strength between the system and the environment for both the Page-like dynamics as well as the creation of "zero-variance" states. Interestingly all tunneling effects we find are universal across a range of spinless and spinful fermionic interactions. We finally study the entanglement structures for different interactions that give us insight behind this universality.

MP 10.9 Thu 12:40 HL 001

Entanglement Negativity in $T\overline{T}$-deformed CFT_2s — •Lavish Chawla[1,2], Debarshi Basu[2], and Boudhayan Paul[2] — [1]Jagiellonian University, 30-348, Krakow, Poland — [2]Indian Institute of Technology Kanpur, 208016 Kanpur, Uttar Pradesh, India

We apply a suitable replica technique to develop a perturbative expression for the entanglement negativity of bipartite mixed states in $T\overline{T}$-deformed CFT_2s up to the first order in the deformation parameter. Utilizing our perturbative construction we compute the entanglement negativity for various bipartite mixed states involving two disjoint intervals, two adjacent intervals, and a single interval in a $T\overline{T}$-deformed CFT_2 at a finite temperature, in the large central charge limit. Subsequently, we advance appropriate holographic constructions to compute the entanglement negativity for such bipartite states in $T\overline{T}$-deformed thermal CFT_2s dual to BTZ black holes in a finite cut-off bulk geometry and find agreement with the corresponding field theoretic results in the limit of small deformation parameter.

MP 11: Many-body Theory II

Time: Thursday 9:30–11:50 Location: HL 102

MP 11.1 Thu 9:30 HL 102

Double or nothing: a Kolmogorov extension theorem for (bi)probabilities in quantum mechanics — •Davide Lonigro — Department of Mathematics, Università degli Studi di Bari Aldo Moro, Bari, Italy — Department of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany

The family of multitime probability distributions obtained by repeatedly probing a quantum system generally violates Kolmogorov's consistency property, thus preventing us from interpreting such distributions as the result of the sampling of a single trajectory. We argue that, nonetheless, a pair of trajectories is sufficient. To this purpose, we prove a generalization of Kolmogorov extension theorem that applies to families of complex-valued bi-probability distributions (that is, defined on pairs of elements of the original sample spaces), and we employ this result in the quantum mechanical scenario. In this sense, rather than give up on trajectories, quantum mechanics requires to "double down" on them.

Joint work with D. Chruściński, Ł. Cywiński, F. Sakuldee, and P. Szańkowski.

MP 11.2 Thu 9:50 HL 102

Special techniques in the auxiliary equation method for solving nonlinear differential equations — •Alina-Maria Păuna — Department of Physics, University of Craiova, 13 A.I. Cuza Street, 200585 Craiova, Romania

This report refers to a special approach that can be used in the method of auxiliary equations to solve complex nonlinear differential equations. More precisely, we will consider the coupling between a nonlinear differential equation whose solutions are sought and an auxiliary equation with already known solutions. The coupling between the two equations allows to find the most general form of the considered nonlinear equation that remains compatible, in terms of its solutions, with the given auxiliary equation.

The approach will be illustrated for the particular case when the nonlinear equation to be solved is a second-order reaction-diffusion equation with polynomial coefficients. Such equations describe important nonlinear phenomena that occur in hydrodynamics, optics, or plasma physics. The general approach we are proposing will be illustrated on several nonlinear equations, by generating their solutions when the elliptic Jacobi equation is considered as an auxiliary equation

MP 11.3 Thu 10:10 HL 102

On the applicability of Kolmogorov's theory of probability for the description of quantum phenomena — •Maik Reddiger — Anhalt University of Applied Sciences, Germany

It is a common view that with his axiomatization of quantum mechanics von Neumann laid the foundations of a "non-commutative probability theory". As such, it is regarded a generalization of the "classical probability theory" due to Kolmogorov. Outside of quantum physics, however, Kolmogorov's axioms enjoy universal applicability. This raises the question of whether quantum physics indeed requires such a generalization of our conception of probability or if von Neumann's axiomatization of quantum mechanics was contingent on the absence of a mathematical theory of probability at the time.

Taking the latter view, I motivate an approach to the foundations of non-relativistic quantum theory that is based on Kolmogorov's axioms. It relies on the Born rule for particle position probability and employs Madelung's reformulation of the Schrödinger equation for the introduction of physically natural random variables. While an acceptable mathematical theory of Madelung's equations remains to be developed, one may nonetheless formulate a mathematically rigorous "hybrid theory", which is empirically almost equivalent to the quantum-mechanical Schrödinger theory. A major advantage of this approach is its conceptual coherence, in particular with regards to the question of measurement.

The talk is based on Reddiger, *Found. Phys.* **47**, 1317 (2017) and Reddiger & Poirier, *J. Phys. A: Math. Theor.* **56**, 193001 (2023).

20 min. break

MP 11.4 Thu 10:50 HL 102

TBMaLT, a flexible toolkit for combining tight-binding and machine learning — •Wenbo Sun[1], Guozheng Fan[1], Adam McSloy[2], Thomas Frauenheim[3], and Bálint Aradi[1] — [1]University of Bremen, Bremen 28359, Germany — [2]University of Bristol, Bristol BS8 1TS, United Kingdom — [3]Constructor University, Bremen 28759, Germany

Tight-binding approaches, especially the Density Functional Tight-Binding (DFTB) and the Extended Tight-Binding (xTB), allow for efficient quantum mechanical simulations of large systems and long time scales. They are derived from ab initio Density Functional Theory using pragmatic approximations and some empirical terms, ensuring a fine balance between speed and accuracy. Their accuracy can be improved by tuning the empirical parameters using machine learning techniques, especially when information about the local environment of the atoms is incorporated. As the significant quantum mechanical contributions are still provided by the tight-binding models, and only short-ranged corrections are fitted, the learning procedure is typically shorter and more transferable. As a further advantage, derived quantum mechanical quantities can be calculated based on the tight-binding model without the need for additional learning.

We have developed the open-source framework TBMaLT, which allows the easy implementation of such combined approaches. The toolkit currently contains layers for the DFTB method and an interface to the GFN1-xTB Hamiltonian, but due to its modular structure, additional atom-based schemes can be implemented easily.

MP 11.5 Thu 11:10 HL 102

A Multipolar Theory for the Color Palette of Periodic Metasurfaces — •Aso Rahimzadegan[1], Kevin Vynck[2,3], and Silvia Vignolini[1,4] — [1]Sustainale and Bio-Inspired Materials, Max Planck Institute of Colloids and Interfaces, Potsdam, Germany — [2]Univ. Claude Bernard Lyon,CNRS, Institut Lumière Matière, Villeurbanne, France — [3]Univ. Bordeaux, Institut d'Optique Graduate School, CNRS, Laboratoire Photonique Numerique et Nanosciences (LP2N), Talence, France — [4]Department of Chemistry, University of Cambridge, Cambridge, United Kingdom

Optical metasurfaces consist of 2D arrangements of nanoparticles can control the amplitude, phase, and polarization of an incidence field. Here, based on a developed comprehensive theory to describe the optical response of periodic metasurfaces, we explore the possible color coverage of metasurfaces made from isotropic coreshell particles. The color palette of metasurfaces in transmission and reflection is systematically explored and fundamental limits are investigated. The research bridges the gap between simulation and design by introducing a novel framework that translates desired color and iridescence outcomes into metasurface parameters.

MP 11.6 Thu 11:30 HL 102

Birth quota of non-generic degeneracy points — •Gergo Pinter[1,2], Gyorgy Frank[1,2], Daniel Varjas[3], and Andras Palyi[1,2] — [1]Department of Theoretical Physics, Budapest University of Technology and Economics, Hungary — [2]MTA-BME Exotic Quantum Phases Group, Budapest University of Technology and Economics, Hungary — [3]Department of Physics, Stockholm University, AlbaNova University Center, 106 91 Stockholm, Sweden

Let's think of a Hamiltonian system with a parameter space of dimension three - for example, it can be either the electronic band structure of a crystal or the Hamiltonian of two electrons in a double quantum dot depending on an external magnetic field. The generic degeneracy points of such systems are the Weyl points. For small perturbations the Weyl points are robust, while a non-generic twofold degeneracy point splits into Weyl points. What is the possible number of the Weyl points born from a non-generic degeneracy point? We show a strict upper bound for this number. https://arxiv.org/abs/2202.05825

MP 12: Hydrodynamics

Time: Thursday 15:00–15:40 Location: HL 001

MP 12.1 Thu 15:00 HL 001

Bad metal data versus a theory of non-linear diffusion — •Matthias Kaminski[1], Navid Abbasi[2], and Omid Tavakol[3] — [1]University of Alabama, Tuscaloosa, USA — [2]Lanzhou University, Lanzhou, China — [3]University of Toronto, Toronto, Canada

In a system with one conserved charge the charge diffusion is modified by non-linear self-interactions within an effective field theory (EFT) of diffusive fluctuations. We include the slowest ultraviolet (UV) mode, constructing a UV-regulated EFT of non-linear diffusion. Predictions from this theory are in agreement with experimental data in a bad metal system.

MP 12.2 Thu 15:20 HL 001

Hydrodynamics of charged two-dimensional Dirac systems: the role of collective modes — •Kitinan Pongsangangan[1], Tim Ludwig[2], Henk T.C. Stoof[2], and Lars Fritz[2] — [1]Institute of Theoretical Physics, Technische Universität Dresden, 01062 Dresden, Germany — [2]Institute for Theoretical Physics and Center for Extreme Matter and Emergent Phenomena, Utrecht University, Princetonplein 5, 3584 CC Utrecht, The Netherlands

We study the hydrodynamic properties of ultraclean interacting two-dimensional Dirac electrons with Keldysh quantum field theory. We demonstrate that long-range Coulomb interactions play two independent roles: (i) they provide the inelastic and momentum-conserving scattering mechanism that leads to fast local equilibration; (ii) they facilitate the emergence of collective excitations, for instance plasmons, that contribute to transport properties on equal footing with electrons. Our approach is based on an effective field theory of the collective field coupled to electrons. Within a conserving approxima- tion for the coupled system we derive a set of coupled quantum-kinetic equations. This builds the foundation of the derivation of the Boltzmann equations for the interacting system of electrons and plasmons. We demonstrate that plasmons show up in thermo-electric transport properties as well as in quantities that enter the energy-momentum tensor, such as the viscosity.

MP 13: Quantum Field Theory III

Time: Thursday 15:40–17:00 Location: HL 001

MP 13.1 Thu 15:40 HL 001

An Oscillator Construction for 4d CFT — •Katharina Wölfl — Theoretisch-Physikalisches-Institut, FSU Jena

Conformal blocks are the building blocks of correlation functions, which encode the dynamical properties of a CFT, thus solving it. They are completely determined by conformal symmetry, however the calculations often prove to be rather tedious and restricted to special cases. I will therefore present an oscillator construction for the four-dimensional Euclidean Conformal Field Theory, which can be used to calculate lower point correlation functions and promises results for higher-point conformal blocks.

MP 13.2 Thu 16:00 HL 001

Analytic bootstrap for conformal defects — •Davide Bonomi[1], Lorenzo Bianchi[2], Elia de Sabbata[2], Aleix Gimenez-Grau[3], and Valentina Forini[4] — [1]City, University of London — [2]Università di Torino — [3]Institut des Hautes Études Scientifiques — [4]Humboldt Universitat zu Berlin

I will discuss line defects from the point of view of the analytic conformal bootstrap. These defects can represent magnetic impurities in condensed matter systems, such as quantum antiferromagnets. After reviewing a recently derived conformal dispersion relation, I will apply it to compute the two-point functions of bulk operators in presence of a localized magnetic field or a spin impurity in the critical O(N) model. I will discuss the defect and bulk CFT data that one can extract from it. Finally, I will present another dispersion relation that allows to compute the four-point function of defect operators.

MP 13.3 Thu 16:20 HL 001

Obstructions to higher-dimensional second-order superintegrability — •Andreas Vollmer — Universität Hamburg, Deutschland

Superintegrable systems are crucial models in Physics, such as the harmonic oscillator and the Kepler-Coulomb system. The talk will focus on second-order (maximally) superintegrable systems (of a special non-degenerate type) on the cotangent space of a Riemannian manifold. The classification of such systems is an ongoing problem, and to date only achieved in low dimension.

A novel geometric framework will be outlined, which is manageable for arbitrary dimension (encoding a superintegrable system via a (0,3)-tensor field) and is naturally adapted to conformal rescalings (replacing Stäckel transformations / coupling constant metamorphosis).

The main part of the talk will present concise algebraic obstructions for this type of superintegrability. These are relevant in dimensions starting from four, and they are not present in lower dimensions. In dimension four the obstruction condition leads to an algebraic variety isomorphic to a 10-dimensional spinor variety in a pseudo-Euclidean space with split signature.

Time permitting, affine hypersurfaces that are naturally associated to superintegrable systems will also be briefly discussed.

Joint projects with V. Cortés, H.-C. Graf v. Bothmer, J. Kress and K. Schöbel.

MP 13.4 Thu 16:40 HL 001

Verallgemeinerte Geometrie und Sigma-Modelle — •David Osten — IFT, Uniwersytet Wrocławski, Polen

Sigma-Modelle sind eine große Klasse an Theorien, omnipräsent in vielen Bereichen der Physik – von der Theorie der kondensierten Materien, über Teilchen- und Gravitationsphysik, bishin zu Stringtheorie. In diesem Vortrag möchte ich motivieren, wie ein mathematisches Werkzeug aus der Stringtheorie, namentlich Dualitätssymmetrien und deren mathematische Beschreibung durch sogenannte Verallgemeinerte Geometrie, benutzt werden kann, um neue Einblicke in Eigenschaften, Konstruktion und Interpretationen von Sigma-Modelle zu bekommen.

Ich werde die drei wichtigsten weiterführenden Resultate dieses Formalismus kurz skizzieren:

1.) Die Konstruktion neuer (klassisch) integrabler Feldtheorien und die Möglichkeit diese zu quantisieren.

2.) Für die Sigma-Modelle, die in String- und M-theorie auftachen, kann Dualitätssymmetrie als ein alternatives Symmetrieprinzip zu Super- oder konformer Symmetrie dienen.

3.) Sigma-Modelle können als Dynamik in nicht-kommutativen Raumzeiten verstanden werden.

MP 14: Mass and Momentum

Time: Thursday 15:45–16:25 Location: HL 102

MP 14.1 Thu 15:45 HL 102

Interpretation of the rest mass of a particle as the rotational energy of its spin — •Matthias Kölbel — Berlin

The rest mass of an elementary particle is usually explained by an interaction with the Higgs field. However, an alternative interpretation of the rest mass can be derived.

In classical mechanics, an angular momentum L is associated with a rotational energy $E_{rot} = \frac{1}{2} * L * \omega$. Therefore one should expect that elementary particles carrying an internal angular momentum (spin) of $L = h/2\pi$ (bosons) or $L = h/4\pi$ (fermions) possess a rotational energy, which depends on the rotational velocity ω of the particle. According to de Broglie, a particle has got a characteristic oscillation time $\tau = h/E$, depending on its relativistic energy $E = mc^2 = \sqrt{(p * c)^2 + (m_0c^2)^2}$. Assuming the rotational period of the spin being equal to de Broglie's oscillation time, the energy equation of the photon transforms into

$$E = h * f = h * \tau^{-1} = h/2\pi * 2\pi/\tau = L * \omega,$$

which resembles the formula for the classical rotational energy except the prefactor $\frac{1}{2}$.

Applying $E = L * \omega$ to other bosons being at rest, we get

$$E = L * \omega = \frac{h}{2\pi} * \frac{2\pi}{\tau} = \frac{h}{\tau} = \frac{h}{h} * m_0c^2 = m_0c^2.$$

In the case of fermions with $L = h/4\pi$ and $\omega = 4\pi/\tau$ (due to their rotation symmetry of 720°), we get the same result: The rest energy m_0c^2 can be equated with the rotational energy of the spin $L * \omega$.

MP 14.2 Thu 16:05 HL 102

The interpretation of Morse and Lennard-Jones energy profiles — •Grit Kalies[1] and Duong D. Do[2] — [1]HTW University of Applied Sciences, Dresden, Germany — [2]The University of Queensland, Brisbane, Australia

In mechanics, the force is interpreted as dynamics. The second Newtonian law of motion, for instance, is interpreted to mean that the force changes the velocity or momentum. The third Newtonian axiom actio = reactio is interpreted as force = counter force. Based on the idea of force interaction, this is described today by four fundamental forces, which are attempted to be unified in vain. Force fields are assumed that have been quantized in quantum field theories to become carrier particles of the force. Force is considered the most important variable in physics [1]. In thermodynamics, a process in interpreted as dynamics. According to the first law of thermodynamics (energy conservation), only a process can change a state variable of a system, and any process takes time, whereby usually several state variables change simultaneously. To resolve the contradiction in the understanding of dynamics, we proposed a change in mechanics and quantum mechanics and introduced the momentum work and the momentum energy [2]. The current interpretation of energy profiles, such as the Morse and Lennard-Jones potentials, is replaced by a process-based interpretation that reveals the forms of energy released during the spontaneous formation of a bond. [1] M. Jammer: Concepts of Force, Harper Torchbook, New York, 1962; [2] G. Kalies, D. D. Do, AIP Adv. 13 (2023), 065121, 055317, 095322, 095126.

MP 15: Members' Assembly

Agenda: 1) Report; 2) Planning of future conferences and events.

All MP members welcome, in particular those interested in joining the 'Beirat' and in future conference organisation.

Time: Thursday 17:00–18:00 Location: HL 001

All members of the Theoretical and Mathematical Physics Division are invited to participate.