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 ZEU/0250, HSZ/0003, and HSZ/0304; Poster HSZ OG3)

Plenary Talk of the Theoretical and Mathematical Physics Division

PV VIII	Wed	9:00– 9:45	HSZ/AUDI	**25 years of the AdS/CFT correspondence: Current status and future prospects** — •Koenraad Schalm

Invited Talks

MP 1.1	Mon	11:00–11:30	HSZ/0003	**Insights from random matrices on dissipative quantum dynamics** — •Pedro Ribeiro, Lucas Sá, Tomaz Prosen
MP 3.1	Tue	11:00–11:30	HSZ/0304	**Renormalization of singular stochastic partial differential equations** — •Pawel Duch
MP 3.2	Tue	11:30–12:00	HSZ/0304	**Integral decomposition of modular operators in QFT** — Henning Bostelmann, •Daniela Cadamuro, Ko Sanders
MP 3.3	Tue	12:00–12:30	HSZ/0304	**Emergence of gravity from conformal field theory** — •Nele Callebaut
MP 6.2	Wed	11:30–12:00	ZEU/0250	**Deep neural networks and the renormalization group** — •Ro Jefferson, Johanna Erdmenger, Kevin Grosvenor

Sessions

MP 1.1–1.4	Mon	11:00–12:30	HSZ/0003	**Quantum Dynamics and Quantum Information**
MP 2.1–2.4	Mon	16:30–18:00	ZEU/0250	**Quantum Field Theory I**
MP 3.1–3.3	Tue	11:00–12:30	HSZ/0304	**Quantum Field Theory II**
MP 4.1–4.3	Tue	10:30–14:00	HSZ OG3	**Poster**
MP 5.1–5.6	Tue	17:00–19:00	ZEU/0250	**Scattering Amplitudes and Conformal Field Theory**
MP 6.1–6.3	Wed	11:00–12:20	ZEU/0250	**AI Topical Day – Neural Networks and Computational Complexity (joint session MP/AKPIK)**
MP 7.1–7.4	Wed	14:00–15:20	ZEU/0250	**Classical and Quantum Gravity**
MP 8	Wed	16:00–17:30	ZEU/0250	**Members' Assembly**
MP 9.1–9.4	Thu	11:00–12:30	ZEU/0250	**AdS/CFT Correspondence and Hydrodynamic Transport**
MP 10.1–10.4	Thu	14:00–15:20	ZEU/0250	**AdS/CFT Correspondence II**
MP 11.1–11.3	Thu	16:00–17:00	ZEU/0250	**Quantum Field Theory III (QED and Particle Detection)**
MP 12.1–12.2	Thu	17:05–17:45	ZEU/0250	**Quantengravitation und Thermodynamik**

Members' Assembly of the Theoretical and Mathematical Physics Division

Wednesday 16:00-17:30 ZEU/0250

- Report
- Elections
- Any other business

MP 1: Quantum Dynamics and Quantum Information

Time: Monday 11:00–12:30 Location: HSZ/0003

Invited Talk MP 1.1 Mon 11:00 HSZ/0003

Insights from random matrices on dissipative quantum dynamics — •Pedro Ribeiro[1], Lucas Sá[1], and Tomaz Prosen[2] — [1]CeFEMA, Instituto Superior Tecnico, Lisbon, Portugal — [2]University of Ljubljana, Ljubljana, Slovenia

Understanding the dissipative dynamics of complex quantum systems is essential to describe quantum matter at large time scales. However, even within a simplified Markovian description, studying the spectral and steady-state properties of Lindblad operators remains a challenging task.

In this talk, we present some novel insights into universal features of generic open quantum systems under Markovian dissipation by using ensemble averaging based on (non-Hermitian) random matrices. We will examine three representative cases: quadratic Liouvilians, dissipative SYK models, and fully random Liouvilian operators. For this last example, we will present a recent systematic classification of many-body Lindblad superoperators based on the properties of the Lindbladian under antiunitary symmetries and unitary involutions.

MP 1.2 Mon 11:30 HSZ/0003

Markovianity in Quantum Thermodynamics — •Frederik vom Ende[1], Emanuel Malvetti[2,3], Gunther Dirr[4], and Thomas Schulte-Herbrüggen[2,3] — [1]Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, 14195 Berlin, Germany — [2]Department of Chemistry, Technische Universität München, Lichtenbergstr. 4, 85737 Garching, Germany — [3]Munich Centre for Quantum Science and Technology & Munich Quantum Valley, Schellingstr. 4, 80799 München, Germany — [4]Department of Mathematics, Julius-Maximilians-Universität Würzburg, 97074 Würzburg, Germany

In the first half of this talk – which is based on arXiv:2211.08351 – we characterize the generators of quantum-dynamical semigroups via Stinespring dilations. More precisely, we prove that the second derivative of Stinespring dilations with a bounded total Hamiltonian yields the dissipative part of some quantum-dynamical semigroup – and vice versa. As a byproduct we obtain that for semigroups which describe an open system, the evolution of the dilated closed system has to be generated by an unbounded Hamiltonian. The second half of this talk will deal with a natural application of these results to Markovianity in quantum thermodynamics, because the central object of the latter – the so-called thermal operations – are defined via their Stinespring form. This will yield a family of generators of Markovian thermal operations, and we conjecture that no further generators exist.

MP 1.3 Mon 11:50 HSZ/0003

The Thermomajorization Polytope and its Degeneracies — Frederik vom Ende[1] and •Emanuel Malvetti[2,3] — [1]Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, 14195 Berlin, Germany — [2]Department of Chemistry, Technische Universität München, Lichtenbergstr. 4, 85737 Garching, Germany — [3]Munich Centre for Quantum Science and Technology & Munich Quantum Valley, Schellingstr. 4, 80799 München, Germany

In quantum thermodynamics thermal operations are considered free. We want to understand which states are reachable from a given initial state using thermal operations. We study the quasi-classical case of diagonal states, where the problem reduces to understanding the thermomajorization polytope. In particular we are interested in degeneracies of this polytope and its connection to the polytope of Gibbs-stochastic matrices.

MP 1.4 Mon 12:10 HSZ/0003

Particle Spin described by Quantum Hamilton equations — •Michael Beyer and Wolfgang Paul — Martin-Luther Universität Halle

The anomalous Zeeman effect made it clear that charged particles like the electron possess a magnetic dipole moment. Classically, this could be understood if the charged particle possesses an eigenrotation, i.e., spin. This classically motivated model of intrinsic rotation described in terms of a continuous stochastic process is revisited within the formalism of stochastic optimal control theory. Quantum Hamilton equations for spinning particles are derived, which reduce to their classical counterpart in the zero quantum noise limit. These equations enable the calculation of the common spin expectation values without the use of the wave function. They also offer information on the orientation dynamics of the magnetic moment of charged particles beyond the behavior of the spin averages.

MP 2: Quantum Field Theory I

Time: Monday 16:30–18:00 Location: ZEU/0250

MP 2.1 Mon 16:30 ZEU/0250

String-localized quantum field theory: the reverse side of the BRST coin — •Karl-Henning Rehren[1], Jens Mund[2], and Bert Schroer[3] — [1]Universität Göttingen — [2]Universidade Federal de Juiz de Fora, Brazil — [3]Freie Universität Berlin

Gauge symmetry is most successful at predicting the structure of all interactions among particles in the Standard Model. Yet, it addresses exclusively non-observable entities (gauge potentials and Fermi fields). One may ask how “fundamental” such a principle can be.

Quantum gauge symmetry can only be formulated on state spaces with indefinite metric (“negative probabilities”). The BRST method allows to return to a Hilbert space. Charged interacting fields are not defined on this Hilbert space, because they are not BRST-invariant.

An alternative is presented with the same (and in one instance even superior) predictive power on the structure of interactions. It proceeds directly on the physical Hilbert space, and allows to construct interacting charged fields. They exhibit a weaker localization than usual, while observables coincide with those in the BRST setup.

arxiv:2209.06133v2

MP 2.2 Mon 17:00 ZEU/0250

On the mass dependence of the modular operator for a double cone — •Christoph Minz[1], Henning Bostelmann[2], and Daniela Cadamuro[1] — [1]Institut für Theoretische Physik, Universität Leipzig — [2]University of York, Department of Mathematics

We present a numerical approximation scheme for the Tomita-Takesaki modular operator of local subalgebras in linear quantum fields, where the modular data are determined at one-particle level using time-0 formulation in position space. The technique is tested against the known results for the local subspace of a right wedge in 2-dimensional Minkowski spacetime, where one component of the modular operator is known to be a mass-independent multiplication operator. Applying the same technique to the unknown case of a double cone in 2 (and 4) dimensions, we find that the same component of the modular operator depends on the mass (and angular momentum).

MP 2.3 Mon 17:20 ZEU/0250

Information theoretic properties of soft photon clouds — •Henning Bostelmann[1], Daniela Cadamuro[2], and Wojciech Dybalski[3] — [1]Department of Mathematics, University of York, UK — [2]Institute for Theoretical Physics, University of Leipzig, Germany — [3]Adam Mickiewicz University, Poznań, Poland

In quantum field theories with massless particles, states which describe clouds of soft photons in front of the vacuum are macroscopically different from the vacuum state: in mathematical terms, they lead to inequivalent representations of the quasilocal observable algebra, and a global “photon charge” labels these representations.

Here we investigate this macroscopic difference from an information-theoretic perspective. In a massless free theory, we compute the relative entropy between a coherent photon cloud state and the vacuum with respect to the forward lightcone algebra. It turns out that this entropy is infinite if, and only if, the “photon charge” of the cloud is zero.

MP 2.4 Mon 17:40 ZEU/0250

Quantum energy inequality in the Sine-Gordon model — •Markus B. Fröb and Daniela Cadamuro — Institut für Theoretische Physik, Universität Leipzig, Germany

We consider the massless Sine–Gordon model in the finite regime $\beta^2 < 4\pi$ of the theory. We prove convergence of the renormalised perturbative series for the interacting stress tensor defined using the Bogoliubov formula in an arbitrary Hadamard state, even for the case that the smearing is only along a one-dimensional time-like worldline and not in space-time. We then show that the interacting energy density, as seen by an observer following this worldline, satisfies an absolute lower bound, that is a bound independent of the quantum state. Our proof employs and generalises existing techniques developed for free theories by Flanagan, Fewster and Smith.

MP 3: Quantum Field Theory II

Time: Tuesday 11:00–12:30 Location: HSZ/0304

Invited Talk MP 3.1 Tue 11:00 HSZ/0304

Renormalization of singular stochastic partial differential equations — •Pawel Duch — Adam Mickiewicz University, Poznan, Poland

Stochastic PDEs, i.e. partial differential equation with random terms or coefficient, play an important role in mathematical physics and have applications in areas such as quantum field theory, statistical mechanics and material science. Well-known examples of stochastic PDEs are the KPZ equation describing the motion of a growing interface or the stochastic quantization equation of the Φ^4 Euclidean QFT. Most of the interesting non-linear stochastic PDEs, including the ones mentioned above, are too singular to admit classical treatment. Solving such equations poses a formidable challenge and usually requires the regularization and renormalization of the equation.

After giving a brief overview of the tremendous progress in the area of singular stochastic PDEs in the past decade, I will present a novel approach to such PDEs proposed in my recent work. The approach uses the framework of the Wilsonian renormalization group theory and is based on a certain flow equation that plays an analogous role to the Polchinski equation in QFT. The approach allows to solve a large class of singular stochastic PDEs in a systematic manner and avoids algebraic and combinatorial problems arising in different approaches.

Invited Talk MP 3.2 Tue 11:30 HSZ/0304

Integral decomposition of modular operators in QFT — Henning Bostelmann[1], •Daniela Cadamuro[2], and Ko Sanders[3] — [1]Department of Mathematics, University of York, UK — [2]Institute for Theoretical Physics, University of Leipzig, Germany — [3]Department of Mathematics, FAU Erlangen-Nürnberg

The Tomita-Takesaki modular operator of local algebras (or, in linear field theories, of standard subspaces) is a structurally important concept in quantum field theory; unfortunately little can be said about its explicit form in most concrete situations. We develop a general decomposition theory for standard subspaces along direct integrals, making some new examples available to explicit treatment.

Invited Talk MP 3.3 Tue 12:00 HSZ/0304

Emergence of gravity from conformal field theory — •Nele Callebaut — Institute for Theoretical Physics, University of Cologne

I will discuss several mechanisms by which gravity emerges from conformal field theory: through holography, entanglement dynamics or irrelevant deformations.

MP 4: Poster

Time: Tuesday 10:30–14:00 Location: HSZ OG3

MP 4.1 Tue 10:30 HSZ OG3

Nonlinear Compton scattering and nonlinear Breit-Wheeler pair production including the damping of particle states — •Tobias Podszus[1], Victor Dinu[2], and Antonino Di Piazza[1] — [1]Max Planck Institute for Nuclear Physics, Heidelberg, Germany — [2]Department of Physics, University of Bucharest, Romania

In the presence of an electromagnetic background plane-wave field, electron, positron, and photon states are not stable, because electrons and positrons emit photons and photons decay into electron-positron pairs. This decay of the particle states leads to an exponential damping term in the probabilities of single nonlinear Compton scattering and nonlinear Breit-Wheeler pair production. We present analytical and numerical investigations for the probabilities of nonlinear Compton scattering and nonlinear Breit-Wheeler pair production including the particle states decay. For this we first give new spin- and polarization-resolved expressions of the probabilities, verify that they are gauge invariant, provide some of their asymptotic behaviors, and show that the results of the total probabilities are independent of the spin and polarization bases. In plots from numerical computations we observe that it is crucial to take into account the damping of the states in order the probabilities to stay always below unity and we show that the damping factors also scale with the pulse duration of the background field. In the case of nonlinear Compton scattering we show numerically that the total probability behaves like a Poissonian distribution for sufficiently low initial electron energies such that the photon recoil is negligible.

MP 4.2 Tue 10:30 HSZ OG3

Exploring anomalies by many-body correlations — •Klaus Morawetz — Münster University of Applied Sciences, Stegerwaldstrasse 39, 48565 Steinfurt, Germany — International Institute of Physics- UFRN, Campus Universitário Lagoa nova,59078-970 Natal, Brazil

The quantum anomaly can be written alternatively into a form violating conservation laws or as non-gauge invariant currents seen explicitly on the example of chiral anomaly. By reinterpreting the many-body averaging, the connection to Pauli-Villars regularization is established which gives the anomalous term a new interpretation as arising from quantum fluctuations by many-body correlations at short distances. This is exemplified by using an effective many-body quantum potential which realizes quantum Slater sums by classical calculations. It is shown that these quantum potentials avoid the quantum anomaly but approaches the same anomalous result by many-body correlations. A measure for the quality of quantum potentials is suggested to describe these quantum fluctuations in the mean energy. Consequently quantum anomalies might be a short-cut way of single-particle field theory to account for many-body effects. This conjecture is also supported since the chiral anomaly can be derived by a completely conserving quantum kinetic theory. [Eur. Phys. J. B 92 (2019) 176, Phys. Lett. A 383 (2019) 1362, Phys. Status Solidi B (2021) 2100316]

MP 4.3 Tue 10:30 HSZ OG3

Correlational entropy by nonlocal quantum kinetic theory — •Klaus Morawetz — Münster University of Applied Sciences, Stegerwaldstrasse 39, 48565 Steinfurt, Germany — International Institute of Physics- UFRN, Campus Universitário Lagoa nova,59078-970 Natal, Brazil

The nonlocal kinetic equation unifies the achievements of the transport in dense quantum gases with the Landau theory of quasiclassical transport in Fermi systems. Large cancellations in the off-shell motion appear which are hidden usually in non-Markovian behaviors [1]. The remaining corrections are expressed in terms of shifts in space and time that characterize the non-locality of the scattering process [2]. In this way quantum transport is possible to recast into a quasi-classical picture [3]. The balance equations for the density, momentum, energy and entropy include besides quasiparticle also the correlated two-particle contributions beyond the Landau theory [4]. The medium effects on binary collisions are shown to mediate the latent heat, i.e., an energy

conversion between correlation and thermal energy. For Maxwellian particles a sign change of the latent heat is reported at a universal ratio of scattering length to the thermal De Broglie wavelength. This is interpreted as a change from correlational heating to cooling [5]. [1] Ann. Phys. 294 (2001) 135, [2] Phys. Rev. C 59 (1999) 3052, [3] "'Interacting Systems far from Equilibrium -Quantum Kinetic Theory"' Oxford University Press, (2017) ISBN 9780198797241, [4] Phys. Rev. E 96 (2017) 032106, [5] Phys. Rev. B 97 (2018) 195142

MP 5: Scattering Amplitudes and Conformal Field Theory

Time: Tuesday 17:00–19:00 Location: ZEU/0250

MP 5.1 Tue 17:00 ZEU/0250

One–loop six–particle Feynman integral to higher orders in dimensional regulator — Johannes M. Henn, •Antonela Matijašić, and Julian Miczajka — Max-Planck-Institut für Physik, Werner-Heisenberg-Institut, 80805 München, Germany

The state–of–the–art in current two–loop QCD amplitude calculations is at five-particle scattering. In contrast, very little is known at present about two–loop six–particle scattering processes. Computing two–loop six–particle processes requires knowledge of the corresponding one–loop amplitudes to higher orders in the dimensional regulator. In this talk, I will show the analytic results for the one–loop hexagon integral to higher orders in dimensional regulator obtained via differential equations. I will discuss the function alphabet for general D–dimensional external states, function space up to weight two and one–fold integral representation up to weight four for all integrals in the integral basis. Finally, I will discuss the difference between the conventional dimensional regularization and the four–dimensional helicity scheme at the level of the master integrals. With this, the one–loop integral basis is ready for two–loop amplitude applications.

MP 5.2 Tue 17:20 ZEU/0250

new results from computing planar and non-planar three-loop integrals for Higgs plus jet process — •Jungwon Lim — Max Planck Institute for Physics, Munich, Germany

We present new results for Feynman integrals relevant to Higgs plus jet production at three loops, including first results for a non-planar class of integrals. The results are expressed in terms of generalized polylogarithms up to transcendental weight six. We also provide the full canonical differential equations, which allows us to make structural observations on the answer. In particular, find a counterexample to previously conjectured adjacency relations, for a planar integral of the tennis court type. Moreover, for a non-planar triple ladder diagram, we find two novel alphabet letters. This information may be useful for future bootstrap approaches.

MP 5.3 Tue 17:40 ZEU/0250

Gravitational Waves from Worldline Quantum Field Theory — •Gustav Mogull — Institut für Physik und IRIS Adlershof, Humboldt Universität zu Berlin, Zum Großen Windkanal 2, 12489 Berlin, Germany — Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Am Mühlenberg 1, 14476 Potsdam, Germany

Following the groundbreaking first detection by both LIGO observatories (Hanford/Livingston) of gravitational waves in 2015, a new era of gravitational wave astronomy has begun. The waves strong enough for us to detect on Earth are caused by the orbit, deceleration and eventual merger of pairs of extremely massive objects: primarily black holes, but also neutron stars. We aim to model these binary mergers mathematically, so that we may predict the gravitational waves emitted and thus learn about the black holes and neutron stars themselves - how they form, their internal composition - and Einstein's theory of gravity.

The Worldline Quantum Field Theory (WQFT) is a new formalism that we have developed, using tools and technologies from QFT to describe these gravitational merger events. The gravitational two-body problem is remarkably similar to our description of fundamental particles scattering in collider experiments such as CERN's Large Hadron Collider (LHC), and there is considerable overlap in our theoretical descriptions of these events. In this talk I will discuss the WQFT's fundamentals, its applications to gravitational wave physics and its supersymmetric extension to describe spinning black holes and neutron stars.

MP 5.4 Tue 18:00 ZEU/0250

Non-supersymmetric string backgrounds — •Ida Zadeh — Mainz Institute for Theoretical Physics, Mainz, Germany

New constructions of non-supersymmetric backgrounds arising from compactifications of superstring theories on Ricci-flat compact manifolds will be discussed. Such constructions give new insights on properties of theories of quantum gravity. I will discuss the problem within the framework of conformal field theories, namely the exact string worldsheet description. We will see how the conformal field theory formulation gives novel descriptions of the underlying semi-classical field theories and their associated moduli (parameter) spaces.

MP 5.5 Tue 18:20 ZEU/0250

Torus Conformal Blocks of 2D Conformal Field Theories — •Jakob Hollweck — Theoretisch-Physikalisches Institut, Jena, Germany

We compute higher point sl(2,R) conformal blocks on different topologies like the sphere and the torus. The usual methods, like the direct use of the Casimir equations, shadow operator representations, or successive use of the operator product expansion, quickly become complicated for higher point conformal blocks. The use of oscillator representations reproduces the known results and promises further insights, like the computation of (semi-classical) Virasoro conformal blocks, or conformal blocks in higher dimensions than two, which have recently spiked in interest.

MP 5.6 Tue 18:40 ZEU/0250

Quantum energy inequalities in integrable models with bound states and several particle species — •Jan Mandrysch[1], Daniela Cadamuro[1], and Henning Bostelmann[2] — [1]Institute for Theoretical Physics, Uni Leipzig — [2]Department of Mathematics, University of York, United Kingdom

In quantum theory negative energy densities appear and should be constrained in physically reasonable models. Otherwise, one expects instabilities and violations of the 2nd law of thermodynamics.

I present lower bounds of the time-smeared energy density, so-called quantum energy inequalities (QEI), in the class of integrable quantum field theory models. Our main results are a state-independent QEI for interactions which have a constant scattering function and a QEI at one-particle level for generic models including bound states and several particle species. Examples include the Bullough-Dodd, the Federbush, and the O(n)-nonlinear sigma model.

MP 6: AI Topical Day – Neural Networks and Computational Complexity (joint session MP/AKPIK)

Time: Wednesday 11:00–12:20 Location: ZEU/0250

MP 6.1 Wed 11:00 ZEU/0250

A universal approach to state and operator complexities — •Souvik Banerjee[1] and Mohsen Alishahiha[2] — [1]Julius-Maximilians-Universität Würzburg, Würzburg, Germany — [2]IPM, Tehran, Iran

In this talk, I shall present a general framework in which both Krylov state and operator complexities can be put on the same footing. In our formalism, the Krylov complexity is defined in terms of the density matrix of the associated state which, for the operator complexity, lives on a doubled Hilbert space obtained through the channel-state map.

This unified definition of complexity in terms of the density matrices enables us to extend the notion of Krylov complexity, to subregion or mixed state complexities and also naturally to the Krylov mutual complexity. We show that this framework also encompasses nicely, the holographic notions of complexity and explains the universal late-time growth of complexity, followed by a saturation.

Invited Talk MP 6.2 Wed 11:30 ZEU/0250

Deep neural networks and the renormalization group — •Ro Jefferson[1], Johanna Erdmenger[2], and Kevin Grosvenor[3] — [1]Utrecht University — [2]University of Würzburg — [3]Leiden University

Despite the success of deep neural networks (DNNs) on an impressive range of tasks, they are generally treated as black boxes, with performance relying on heuristics and trial-and-error rather than any explanatory theoretical framework. Recently however, techniques and ideas from physics have been applied to DNNs in the hopes of distilling the underlying fundamental principles. In this talk, I will discuss some interesting parallels between DNNs and the renormalization group (RG). I will briefly reivew RG in the context of a simple lattice model, where subsequent RG steps are analogous to subsequent layers in a DNN, in that effective interactions arise after marginalizing hidden degrees of freedom/neurons. I will then quantify the intuitive idea that information is lost along the RG flow by computing the relative entropy in both the Ising model and a feedforward DNN. One finds qualitatively identical behaviour in both systems, in which the relative entropy increases monotonically to some asymptotic value. On the QFT side, this confirms the link between relative entropy and the c-theorem, while for machine learning, it may have implications for various information maximization methods, as well as disentangling compactness and generalizability.

MP 6.3 Wed 12:00 ZEU/0250

Analytic continuation of Greens' functions using neural networks — Johanna Erdmenger, René Meyer, Martin Rackl, and •Yanick Thurn — JMU Würzburg

In quantum many-body physics, the analytic continuation of Greens' functions is a well-known problem. The problem is ill-posed in the sense that the transformation kernel becomes chaotic for large energies and thus small noise creates huge differences in the resulting spectral density function. Some techniques in the field of machine learning, in particular neural networks, are known for handling this kind of problem. Using a neural network and for the problem-optimized loss functions and hyperparameters, a network is trained to determine the spectral density from the imaginary part of the Greens function given by quantum Monte Carlo simulations. The network is able to recover the overall form of the spectral density function, even without adding constraints such as normalization and positive definiteness. There is no need to encode these constraints as regularizations since they are reflected automatically by the solution provided by the network. This indicates the correctness of the inversion kernel learned by the neural network. In the talk, I will explain the structure of the methods used to train the network and highlight the central results.

MP 7: Classical and Quantum Gravity

Time: Wednesday 14:00–15:20 Location: ZEU/0250

MP 7.1 Wed 14:00 ZEU/0250

Geometry of charged rotating discs of dust in Einstein-Maxwell theory — •David Rumler — Friedrich-Schiller-Universität Jena, Germany

Within the framework of Einstein-Maxwell theory geometric properties of charged rotating discs of dust, using a post-Newtonian expansion up to tenth order, are discussed. Investigating the disc's proper radius and the proper circumference allows us to address questions related to the Ehrenfest paradox. In the Newtonian limit there is an agreement with a rotating disc from special relativity. The charged rotating disc of dust also possesses material-like properties. A fundamental geometric property of the disc is its Gaussian curvature. The result obtained for the charged rotating disc of dust is checked by additionally calculating the Gaussian curvature of the analytic limiting cases (charged rotating) Maclaurin disc, electrically counterpoised dust-disc and uncharged rotating disc of dust. We find that by increasing the disc's specific charge there occurs a transition from negative to positive curvature.

MP 7.2 Wed 14:20 ZEU/0250

A geometric view on local Lorentz transformations in teleparallel gravity — •Manuel Hohmann — University of Tartu, Estonia

Local Lorentz transformations play an important role in teleparallel gravity theories, in which a tetrad is conventionally employed as a fundamental field variable describing the gravitational field. It is commonly understood that modifications of general relativity in the teleparallel framework break a certain notion of local Lorentz invariance, which is present in the pure tetrad formulation of such theories, while another notion present in the covariant formulation is preserved. We illuminate these different notions from a geometric perspective, and distinguish them from what is commonly understood as breaking of local Lorentz invariance in the context of gravity phenomenology. Based on physical arguments, we present a geometric interpretation of the dynamical fields in teleparallel gravity, which unifies and refines the conventional approaches.

MP 7.3 Wed 14:40 ZEU/0250

Investigating Quantum Field Theory on Curved Spaces through Quantum Simulation — •Christian Friedrich Schmidt — Theoretisch-Physikalisches-Institut, Jena, Deutschland

In recent years, high-energy-phenomena like Hawking radiation or cosmological particle creation have been successfully simulated in laboratories by means of so-called quantum simulators. A prominent example among these are Bose-Einstein condensates, in which low-energetic (acoustic) fluctuations of the condensate wavefunction behave like a scalar quantum field on a curved spacetime. Excitations of this field are realized as phonons, which experience an effective, gravitational field set by the condensate background. The curved geometry is essentially realized through a time- and space-dependent speed of sound. In particular, a stationary background condensate yields an FLRW metric. Hence, this analogy gives an exciting opportunity to study phenomena of quantum fields in cosmological and also more general spacetimes in a controllable, experimental setup.

MP 7.4 Wed 15:00 ZEU/0250

Wilson Line approach to gravitational scattering of spinning particles — Domenico Bonocore[1], Anna Kulesza[2], and •Johannes Pirsch[2] — [1]Theoretische Elementarteilchenphysik, TUM, München, Germany — [2]Institut für Theoretische Physik, WWU Münster, Münster, Germany

Wilson lines provide a useful tool to reveal the all-order structure of scattering amplitudes. Recently it has been shown how a generalization that takes into account subleading eikonal effects (hence known as Generalized Wilson Line or GWL) clarifies the connection between the soft expansion in the Regge limit and the Post-Minkowskian expansion in the classical limit.

In this talk I will discuss the derivation of the spin 1/2 GWL starting from a N=1 supersymmetric worldline model. The resulting path integral expression exhibits a clear separation between purely classical and quantum contributions, which can conveniently be computed using Feynman diagrams in position space. Using this result, we are able to derive Low's soft theorem for off-shell gravitons and compute classical observables for spinning compact binaries.

MP 8: Members' Assembly

Time: Wednesday 16:00–17:30 Location: ZEU/0250

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

MP 9: AdS/CFT Correspondence and Hydrodynamic Transport

Time: Thursday 11:00–12:30 Location: ZEU/0250

MP 9.1 Thu 11:00 ZEU/0250

Ultraviolet-regulated theory of non-linear diffusion — •Matthias Kaminski[1] and Navid Abbasi[2] — [1]University of Alabama, Tuscaloosa, AL, U.S.A. — [2]School of Nuclear Science and Technology, Lanzhou University, Lanzhou, China

In a system with a single conservation law the inverse relaxation time plays the role of an ultraviolet (UV) regulator for the low energy diffusion of the conserved charge. In order to calculate renormalization effects through self-interactions stemming from fluctuations in such a system, we include the slowest non-conserved UV mode which relaxes at a system-specific relaxation time. Quantum fluctuations are computed in addition to statistical fluctuations for the first time in this framework. We show that the relaxation time is protected from renormalization while the diffusion constant is renormalized independent of the UV mode. Furthermore, the retarded Green*s function acquires four branch points, corresponding to threshold energies for generation of double-mode states from single diffusion or single UV modes. We report on the fate of long time tails in the current-current correlator, the dynamic susceptibility, and the conductivity. These results are relevant for the high temperature Hubbard model and also for the quark gluon plasma droplet near the critical point of quantum chromodynamics.

MP 9.2 Thu 11:30 ZEU/0250

Obtaining Transport Coefficients from Functional Renormalization Group Methods — •Tim Stötzel[1], Lars Heyen[2], and Stefan Flörchinger[1] — [1]Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany — [2]Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg, Germany

The description of transport processes requires knowledge of their respective transport coefficients like viscosities or conductivities. Determining these quantities from a first principle approach can be done by the use of quantum field theories.

We make use of the well known Kubo formulas and apply them to a field theory at finite temperature in a non-perturbative approach. The transport coefficients can be derived by the use of renormalization group flow equations resulting in a flow equation for the near-equilibrium coefficients.

The method is applied to a massive, self-interacting scalar field and the shear viscosity is calculated for this toy model at finite temperature. We show a possible truncation ansatz for the Wetterich equation that generates a flow of the shear viscosity coefficient and comment on its relation to the properties of the microscopic theory.

MP 9.3 Thu 11:50 ZEU/0250

Critical and near-critical relaxation of holographic superfluids — •Mario Flory[1], Sebastian Grieninger[2], and Sergio Morales-Tejera[3] — [1]Institute of Theoretical Physics, Jagiellonian University, Lojasiewicza 11, 30-348 Krakow, Poland — [2]Center for Nuclear Theory, Department of Physics and Astronomy, Stony Brook University, NY 11794-3800, USA — [3]Instituto de Fisica Teorica UAM-CSIC, c/ Nicolas Cabrera 13-15, 28049, Madrid, Spain

We investigate the relaxation of holographic superfluids after quenches, when the end state is either tuned to be exactly at the critical point, or very close to it. By solving the bulk equations of motion numerically, we demonstrate that in the former case the system exhibits a power law falloff as well as an emergent discrete scale invariance. The later case is in the regime dominated by critical slowing down, and we show that there is an intermediate time-range before the onset of late time exponential falloff, where the system behaves similarly to the critical point with its power law falloff. We further postulate a phenomenological Gross-Pitaevskii-like equation that is able to make quantitative predictions for the behaviour of the holographic superfluid after near-critical quenches.

MP 9.4 Thu 12:10 ZEU/0250

Towards Explicit Discrete Holography: Aperiodic Spin Chains from Hyperbolic Tilings — Pablo Basteiro, Rathindra Nath Das, •Giuseppe Di Giulio, Johanna Erdmenger, Jonathan Karl, René Meyer, and Zhuo-Yu Xian — Julius-Maximilians-Universität Würzburg

The AdS/CFT correspondence is one of the most important breakthroughs of the last decades in theoretical physics. A recently proposed way to get insights on various features of this duality is achieved by discretizing the Anti-de Sitter spacetime. Within this program, we consider the Poincaré disk and we discretize it by introducing a regular hyperbolic tiling on it. The features of this discretization are expected to be identified in the quantum theory living on the boundary of the hyperbolic tiling. In this talk, we discuss how a class of boundary Hamiltonians can be naturally obtained in this discrete geometry via an inflation rule that allows constructing the tiling using concentric layers of tiles. The models in this class are aperiodic spin chains. Using strong-disorder renormalization group techniques, we study the entanglement entropy of these boundary theories, identifying a logarithmic growth in the subsystem size, with a coefficient depending on the bulk discretization parameters.

MP 10: AdS/CFT Correspondence II

Time: Thursday 14:00–15:20 Location: ZEU/0250

MP 10.1 Thu 14:00 ZEU/0250

Towards a Quantum Chaotic Dual of JT Gravity — •Fabian Haneder, Torsten Weber, Camilo Moreno, Juan Diego Urbina, and Klaus Richter — Universität Regensburg, Deutschland

Jackiw-Teitelboim (JT) quantum gravity is a two-dimensional model that has received a striking amount of attention in recent years as a simple example of holography, given its duality to the low-energy regime of the SYK model, as well as full perturbative equivalence to a matrix model found by Saad, Shenker and Stanford. We take first steps towards establishing a further duality between JT gravity and the chaotic quantum dynamics of a particle on a high dimensional compact manifold of constant negative curvature. The presence of a single system, instead of an ensemble, on the non-gravitational side of the duality allows us to identify possible degrees of freedom and corresponding mechanisms responsible for the quantum-chaotic features in JT gravity. We address key aspects of JT correlation functions by showing how the Schwarzian density of states, which bridges quantum gravity and disordered systems, such as SYK, is identical to the Weyl (smooth) term of the Selberg trace formula describing exactly the quantum spectrum on the compact manifold. Time permitting, we use periodic orbit theory to derive an effective trace formula over coarse-grained bundles of geodesics, and show that it admits a genus expansion structurally identical to the JT correlators.

MP 10.2 Thu 14:20 ZEU/0250

Aspects of Holography in Three-Dimensional Asymptotically Flat Spacetimes — •Michel Pannier — FSU Jena

A well-studied realisation of the Holographic Principle is provided by the AdS/CFT duality. However, Holography is expected to hold in rather general circumstances and should be extended to different examples, such as models containing asymptotically de Sitter or flat spacetimes. The latter is the idea of the talk, in particular focusing on the introduction of propagating, massive degrees of freedom to an otherwise purely topological three-dimensional theory of gravity. Particular emphasis is laid on the utilisation of techniques that are known from the study of higher-spin gravity as a Chern-Simons gauge theory.

MP 10.3 Thu 14:40 ZEU/0250

Geometric phases describing quantum systems with or without gravity — Souvik Banerjee[1,2], •Moritz Dorband[1,2], Johanna Erdmenger[1,2], and Anna-Lena Weigel[1,2] — [1]Institute for Theoretical Physics and Astrophysics, Julius-Maximilians-University Würzburg, 97074 Würzburg, Germany — [2]Würzburg-Dresden Cluster of Excellence ct.qmat

We discuss why the geometric phase is important to fully describe a quantum system, with or without gravity, by providing knowledge about the geometry and/or topology of its microscopic phase space. We illustrate this with several examples, ranging from a single spin in a magnetic field to Virasoro Berry phases and the geometric phase associated to the eternal black hole in AdS spacetime. We explain the relevance of this realisation with respect to the recent results on operator algebras in holography.

MP 10.4 Thu 15:00 ZEU/0250

On the Boundary Conformal Field Theory Approach to Symmetry-Resolved Entanglement — Giuseppe Di Giulio[1,2], René Meyer[1,2], Christian Northe[3,1,2], •Henri Scheppach[1,2], and Suting Zhao[1,2] — [1]Institute for Theoretical Physics and Astrophysics, Julius Maximilian University Würzburg, Am Hubland, 97074 Würzburg, Germany — [2]Würzburg-Dresden Cluster of Excellence on Complexity and Topology in Quantum Matter ct.qmat — [3]Department of Physics, Ben-Gurion University of the Negev, David Ben Gurion Boulevard 1, Be'er Sheva 84105, Israel

We study the symmetry resolution of the entanglement entropy of an interval in two-dimensional conformal field theories (CFTs), by studying the decomposition of the partition function into charge sectors of the respective symmetry in the presence of boundary conditions at the entangling points. Symmetry resolution provides a more refined entanglement measure and can therefore provide more information about the nature of quantum states in QFT. We demonstrate that the decomposition already provides the symmetry resolution of the entanglement spectrum of the corresponding bipartition. Considering the various terms of the partition function associated with the same charge sector the symmetry-resolved Rényi entropies can be derived to all orders in the UV cutoff expansion without the need to compute the charged moments. We apply this idea to the theory of a free massless boson with $U(1)$, $\mathbb{R}$ and $\mathbb{Z}_2$ symmetry. We find equipartition in the $U(1)$ and $\mathbb{R}$ cases to all orders in the cutoff expansion.

MP 11: Quantum Field Theory III (QED and Particle Detection)

Time: Thursday 16:00–17:00 Location: ZEU/0250

MP 11.1 Thu 16:00 ZEU/0250

Asymptotic Completeness and Particle Detectors in Quantum Field Theory — •Janik Kruse — Adam Mickiewicz University in Poznań, Poland

A quantum field theory is asymptotically complete if every quantum state is a scattering state (i.e. a state that allows a particle interpretation). A physical criterion that is known to be necessary and sufficient for asymptotic completeness is the detector criterion: A quantum field theory is asymptotically complete if and only if every quantum state causes a click in some particle detector. In this talk, I will explain why particle detectors do not detect non-scattering states and how this result could be used to characterise asymptotically complete theories by more fundamental criteria than the detector criterion.

MP 11.2 Thu 16:20 ZEU/0250

Electron-Positron Pair Production in High-Intensity Electromagnetic Fields — •Christian Kohlfürst[1], Naser Ahmadiniaz[1], Johannes Oertel[2], and Ralf Schützhold[1,3] — [1]Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany — [2]Universität Duisburg-Essen, 47057 Duisburg, Germany — [3]Technische Universität Dresden, 01062 Dresden, Germany

In ultra-strong electric fields energy in terms of photons can be converted into electrons and positrons. We introduce a novel approach to calculate the mean particle number in collisions of short-pulsed laser fields. In this regard, we further discuss the different regimes of pair production in terms of their unique signatures in particle phase-space and relate our findings to currently ongoing experiments.

Reference: [1] Christian Kohlfürst, Naser Ahmadiniaz, Johannes Oertel, Ralf Schützhold, Sauter-Schwinger effect for colliding laser pulses, arXiv:2107.08741 [hep-ph], to appear in Physical Review Letters.

MP 11.3 Thu 16:40 ZEU/0250

Pair production spectrum in a space-time dependent field from worldline instantons — •Gianluca Degli Esposti[1] and Greger Torgrimsson[2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Germany — [2]Department of Physics, Umeå University, SE-901 87 Umeå, Sweden

The Worldline Formalism has proven to be an efficient tool for the computation of scattering amplitudes in a number of interesting cases. In the context of Strong-Field QED, it provides a useful representation of the full propagator in a background electromagnetic field, and in the present work, we use such representation in the LSZ reduction formula to compute the pair production spectrum in a space-time dependent electric field.

Unlike the closed-loop method that provides the total integrated probability from the effective action using unitarity, we work with the LSZ on the amplitude level, which allows us to obtain the spectrum. We use the saddle-point approximation to obtain a semiclassical result.

The instantons are the saddle points of the path integral. They represent tunneling near the turning point and free real particles asymptotically. We find such instantons numerically by solving the Lorentz force equation.

MP 12: Quantengravitation und Thermodynamik

Time: Thursday 17:05–17:45 Location: ZEU/0250

MP 12.1 Thu 17:05 ZEU/0250

Allgemeine Gastheorie vs. kinetische Gastheorie — •Grit Kalies[1], Steffen Arnrich[1] und Duong D. Do[2] — [1]HTW University of Applied Sciences, Dresden, Germany — [2]The University of Queensland, Brisbane, Australia

Die moderne Physik basiert auf Newtons Bewegungsgesetzen, welche die Wechselwirkung über Kräfte beschreiben. Durch Einführung der Impulsänderungsarbeit [1,2] schlagen wir eine vereinheitlichte Formulierung von Prozessgleichungen vor und schneiden Newtons Axiome auf Prozesse zu. Indem die elastische Kollision zweier Objekte als zeitliche Abfolge von jeweils zwei Simultanprozessen beschrieben wird, wird physikalisch erklärbar, dass die Energieerhaltung zu jedem Zeitpunkt gilt, auch bei v = 0 der Objekte am Umkehrpunkt der Bewegung. In der zweiten Hälfte des 19. Jahrhunderts nutzten Maxwell und Boltzmann Newtons Axiome, um das ideale Gas und dessen Druck und Temperatur mikroskopisch zu deuten. Nach der kinetischen Gastheorie (KGT) besitzt das ideale Gas nur kinetische Energie. Wir zeigen, dass die KTG den Energieinhalt des idealen Gases weit unterschätzt, und präsentieren die allgemeine Gastheorie (AGT) als experimentell bestätigt und als Grundlage für eine vereinheitlichte Wechselwirkungstheorie.

1. G. Kalies, Z. Phys. Chem. 236 (2022) 481-533. 2. G. Kalies, S. Arnrich, D.D. Do: Coherent process equations in mechanics and thermodynamics, submitted 11/2022.

MP 12.2 Thu 17:25 ZEU/0250

Konzept Dimensionale Physik: Konstruktion einer Raumzeitdichte zur Vereinigung von ART und QM — •Christian Kos-

mak — Working Group Dimensional Physics, Würzburg

Im Konzept Dimensionale Physik heben sich der Energie- Impuls-Tensor und der Einstein-Tensor auf. Daraus resultiert eine *Raumzeitdichte*, welche die Allgemeine Relativitätstheorie (ART) und die Quantenmechanik (QM) vereinigt. Es werden alle Prinzipien der ART aus dieser *Raumzeitdichte* abgeleitet Diese Raumzeitdichte ist in der eigenen Raumzeit nicht direkt feststellbar. Feststellbar ist die Raumzeitdichte nur in Verbindung mit nieder-dimensionalen Raumzeiten. Dies stellt die Verbindung zur QM her. Die verschieden dimensionalen Raumzeiten sind über den Raum (nicht Raumzeit) als Untermannigfaltigkeit verbunden. Die Raumzeitdichte wurde aus der höherdimensionalen Raumzeit der nieder-dimensionalen Raumzeit aufgeprägt und besitzt in der nieder-dimensionalen Raumzeit keine Dynamik. In der Dimensionalen Physik stellen die Raumzeitdichten alle Objekte des Standardmodells, auf verschiedene nieder-dimensionale geometrische Abbildungen aufgeteilt, dar. Alle Quantenfelder werden durch die verschiedenen Kombinationen der Raumzeiten ersetzt. Damit sind alle Objekte und Grundkräfte des Standardmodells eine geometrische Abbildung in den Raumzeiten. Die Raumzeit ist nicht nur eine dynamische Bühne, sondern der einzige Akteur. https://dimensionale-physik.de/