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 KH 02.013 and KH 00.015)

Invited Talks

MP 1.1	Mon	14:45–15:15	KH 02.013	**The Wehrl entropy problem: mathematical physics meets complex analysis and representation theory** — •Rupert Frank
MP 1.2	Mon	15:15–15:45	KH 02.013	**News on relative entropy** — Ricardo Correa da Silva, •Markus B. Fröb, Gandalf Lechner, Leonardo Sangaletti
MP 2.1	Tue	11:00–11:30	KH 02.013	**Frustration free Hamiltonians for Finitely Correlated States – ground space structure and spectral gap** — •Norbert Schuch
MP 3.1	Tue	16:15–16:45	KH 02.013	**Osterwalder-Schrader axioms for a class of unitary 2D Conformal Field Theories** — •Maria Stella Adamo, Yuto Moriwaki, Yoh Tanimoto
MP 3.2	Tue	16:45–17:15	KH 02.013	**Schwarzian Field Theory for Probabilists** — •Peter Wildemann
MP 3.3	Tue	17:15–17:45	KH 02.013	**Local topological order and boundary algebras** — Corey Jones, •Pieter Naaijkens, David Penneys, Daniel Wallick
MP 4.1	Wed	11:00–11:30	KH 02.013	**Exact Schwinger functions for a class of bounded interactions in** $d \geq 2$ — •Wojciech Dybalski
MP 4.2	Wed	11:30–12:00	KH 02.013	**L4 bound for the energy density in thermal field theory** — •Daniela Cadamuro
MP 5.1	Wed	13:45–14:15	KH 02.013	**Nontrivial Riemann Zeros as Spectrum** — •Enderalp Yakaboylu
MP 9.1	Thu	11:00–11:30	KH 02.013	**Light Cone Structure of Quantum Spacetime Geometry** — •Wolfgang Wieland

Sessions

MP 1.1–1.2	Mon	14:45–15:45	KH 02.013	**Quantum Information: Entropy**
MP 2.1–2.4	Tue	11:00–12:15	KH 02.013	**Correlated States**
MP 3.1–3.5	Tue	16:15–18:15	KH 02.013	**Quantum Field Theory I: Axiomatic, Probabilistic, Algebraic, Conformal**
MP 4.1–4.3	Wed	11:00–12:15	KH 02.013	**Quantum Field Theory II**
MP 5.1–5.6	Wed	13:45–15:30	KH 02.013	**Quantum Mechanics: Spectral Theory and Many-Body Systems**
MP 6.1–6.4	Wed	16:15–17:15	KH 02.013	**Holography: AdS/CFT**
MP 7	Wed	17:30–18:00	KH 02.013	**Members' Assembly**
MP 8.1–8.8	Wed	18:00–18:45	Redoutensaal	**Poster Session**
MP 9.1–9.5	Thu	11:00–12:30	KH 02.013	**Geometry, Black Holes, Universality**
MP 10.1–10.7	Thu	13:45–15:30	KH 02.013	**Strong Fields**
MP 11.1–11.7	Thu	16:15–18:00	KH 00.015	**Various Topics in Relativity**

Members' Assembly of the Theoretical and Mathematical Physics Division

Wednesday 17:30–18:00 KH 02.013

- Bericht und Planung

- Aussprache
- Verschiedenes

MP 1: Quantum Information: Entropy

Time: Monday 14:45–15:45 Location: KH 02.013

Invited Talk MP 1.1 Mon 14:45 KH 02.013
The Wehrl entropy problem: mathematical physics meets complex analysis and representation theory — •Rupert Frank — LMU Munich

The coherent state transform, under various names, appears in many fields of mathematics and physics. It is associated with representations of a group. In this talk we give a gentle introduction to the (generalized) Wehrl entropy problem, which consists in minimizing the entropy of the coherent state transform of a quantum state.

Invited Talk MP 1.2 Mon 15:15 KH 02.013
News on relative entropy — Ricardo Correa da Silva[1], •Markus B. Fröb[1], Gandalf Lechner[1], and Leonardo Sangaletti[2] — [1]Department Mathematik, FAU Erlangen-Nürnberg, Germany — [2]Dipartimento di Fisica, Università di Genova, Italy

I present recent work on a new integral representation for the relative entropy (or Kullback-Leibler divergence) for general von Neumann algebras, generalizing results for matrix algebras. This representation allows easy proofs of its properties such as joint convexity and an extended version of the data processing inequality, namely monotonicity under positive unit-preserving maps. Moreover, it can be used to define Csiszár's f-divergences for von Neumann algebras, which depend on an arbitrary convex function f, and which give the relative entropy in the special case $f(x) = x \ln x$.

MP 2: Correlated States

Time: Tuesday 11:00–12:15 Location: KH 02.013

Invited Talk MP 2.1 Tue 11:00 KH 02.013
Frustration free Hamiltonians for Finitely Correlated States – ground space structure and spectral gap — •Norbert Schuch — Universität Wien, Wien, Austria

Finitely Correlated States (FCS), or Matrix Product States, form an efficiently representable class of states on infinite spin chains, with the AKLT model as a prominent example. I will present some new findings on FCS and their *parent Hamiltonians* – frustration free Hamiltonians constructed to have the FCS as an exact ground state. First, I will discuss how such Hamiltonians can have a remarkably rich ground space structure, ranging from unique ground states and critical systems all the way to systems with undecidable ground space structure. Second, I will explain how to use hierarchies of semidefinite relaxations to systematically obtain rigorous and precise lower bounds on the spectral gaps of such models, which provably improve on all known methods to bound such gaps.

MP 2.2 Tue 11:30 KH 02.013
Fractional quantum Hall states as infinite matrix product states — •Severin Schraven[1] and Simone Warzel[1,2,3] — [1]Department of Mathematics, TU Munich, Germany — [2]Munich Center for Quantum Science and Technology, Munich, Germany — [3]Department of Physics, TU Munich, Germany

In this work we present a novel matrix product representation of the Laughlin wave function on the plane. This representation enables the quantitative control of the coefficients of the Laughlin wave function when expanded in a Slater/permanent basis. It renders the properties such as factorization inherent in the Laughlin state transparent. We use the representation to show the exponential decay of connected correlations and a gap in the entanglement spectrum for the Laughlin state on a thin cylinder. All of the above also applies to the Laughlin state times a monomial symmetric polynomial.

MP 2.3 Tue 11:45 KH 02.013
Hyperinvariant Spin Network States – An AdS/CFT Model from First Principles — Fynn Otto[1], •Refik Mansuroglu[2], Norbert Schuch[2,3], Otfried Gühne[1], and Hanno Sahlmann[4] — [1]Naturwissenschaftlich-Technische Fakultät, Universität Siegen, Walter-Flex-Straße 3, 57068 Siegen, Germany — [2]University of Vienna, Faculty of Physics, Boltzmanngasse 5, 1090 Vienna, Austria — [3]University of Vienna, Faculty of Mathematics, Oskar-Morgenstern-Platz 1, 1090 Vienna, Austria — [4]Department of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Staudtstraße 7, 91058 Erlangen, Germany

As discrete implementations of the anti de-Sitter/conformal field theory (AdS/CFT) correspondence, hyperinvariant tensor networks have created bridges between the fields of quantum information theory and quantum gravity. Adding SU(2) symmetry to the tensor network allows a direct connection to spin network states, a basis of the kinematic Hilbert space of loop quantum gravity (LQG). We discuss existence and limitations for hyperinvariant tensor networks incorporating a local SU(2) symmetry and provide examples of hyperinvariant tensor networks, but also prove constraints on their existence in the form of no-go theorems that exclude absolutely maximally entangled states as well as general holographic codes from local SU(2)-invariance. We finally discuss applications of this new connection and existing examples in the form of calculations of surface areas and geodesic lengths as expectation values of the LQG area and length operators.

MP 2.4 Tue 12:00 KH 02.013
Holography from Tensor Networks: An RT-like Formula from Homological codes — •Jorge Ortiz — Deutsches Elektronen-Synchrotron (DESY), Notkestr. 85, 22607 Hamburg, Germany — Universität Hamburg, Mittelweg 177, 20148 Hamburg, Germany

We present a microscopic approach to holographic duality based on tensor networks built from simple quantum error-correcting codes, specifically toric codes. We construct a layered network by gluing toric codes step by step to encode bulk degrees of freedom into boundary ones, in close analogy to holographic tensor-network models such as the HaPPY code. In this setup, bulk effective field theory operators are embedded into quantum-gravity degrees of freedom while remaining agnostic about the emergent spacetime curvature.

In the first non-trivial example, we compute entanglement entropies and obtain an RT-like formula. This realises entanglement-wedge reconstruction in a fully discrete, controllable model, dictated by the error-correcting properties of the code.

When adding further layers, the explicit computation of entropies quickly becomes intractable, which motivates a more abstract, topological-algebraic description of the network.

MP 3: Quantum Field Theory I: Axiomatic, Probabilistic, Algebraic, Conformal

Time: Tuesday 16:15–18:15 Location: KH 02.013

Invited Talk MP 3.1 Tue 16:15 KH 02.013

Osterwalder-Schrader axioms for a class of unitary 2D Conformal Field Theories — •Maria Stella Adamo[1], Yuto Moriwaki[2], and Yoh Tanimoto[3] — [1]Department Mathematik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Cauerstrasse 11, 91058 Erlangen, Germany — [2]Interdisciplinary Theoretical and Mathematical Science Program (iTHEMS) Wako, Saitama 351-0198, Japan — [3]Dipartimento di Matematica, Università di Roma "Tor Vergata", Via della Ricerca Scientifica 1, I-00133 Roma, Italy

We provide a brief overview of axiomatic frameworks for quantum field theory in the case where the spacetime is 2-dimensional and the theory is invariant under conformal transformations, with a particular focus on the Wightman formalism of quantum fields.

For a general quantum field theory, the reconstruction theorem by Osterwalder-Schrader provides conditions to be verified by correlation functions in the Euclidean space to produce a quantum field theory in the Wightman formalism. In our work, for a reasonable class of unitary full Vertex Operator Algebras describing a class of unitary 2D conformal field theories, we construct Euclidean correlation functions that verify a conformal version of the Osterwalder-Schrader axioms.

Invited Talk MP 3.2 Tue 16:45 KH 02.013

Schwarzian Field Theory for Probabilists — •Peter Wildemann — University of Geneva

What does Liouville field theory, the SYK random matrix model and JT quantum gravity have in common? If you'd ask a physicist in recent years, they would be quick to point out that the low-energy behaviour of all these models should be described by the Schwarzian field theory. In itself, the latter can be understood as a probability measure on a quotient of the group of circle-diffeomorphisms Diff(T)/PSL(2,R). We discuss a rigorous approach constructing the measure in terms of a non-linear transformation of Brownian bridges, following ideas by Belokurov–Shavgulidze. Furthermore, we present new results that uniquely characterise the measure in terms of an appropriate change-of-variables formula, which can be seen as an analogue of the Cameron–Martin theorem on the space of circle diffeomorphisms. As a byproduct, we also obtain a short proof for the calculation of the measure's partition function (i.e. total mass), confirming a prediction by Stanford–Witten. This talk is based on joint work with Roland Bauerschmidt and Ilya Losev.

Invited Talk MP 3.3 Tue 17:15 KH 02.013

Local topological order and boundary algebras — Corey Jones[1], •Pieter Naaijkens[2], David Penneys[3], and Daniel Wallick[3] — [1]North Carolina State University, Raleigh, NC, USA — [2]Cardiff University, Cardiff, UK — [3]The Ohio State University, Columbus, OH, USA

Topologically ordered phases of matter have interesting features, such as the existence of quasi-particles with braid statistics. These quasi-particles can be studied using an AQFT-inspired approach along the lines of the celebrated Doplicher-Haag-Roberts programme on superselection sectors. In this talk I will introduce an axiomatisation, called *local topological order*, of such quantum models. These axioms are defined in terms of nets of (ground state) projections satisfying certain conditions. They allow us to define a physical boundary algebra, and I will outline how in concrete models (such as Kitaev's toric code or Levin-Wen models) the bulk superselection sector ("DHR") category can be recovered from the boundary algebra, giving a mathematical framework for *topological holography*. If time permits, I will explain how these axioms can be extended to included models with *topological* boundaries, and outline how this can be used to study, for example, Walker-Wang bulk-boundary systems.

MP 3.4 Tue 17:45 KH 02.013

Applications of the Lax-Phillips Theorem in Algebraic Quantum Field Theory — •Jonas Schober — Brigham Young University, Provo, Utah, USA

Algebraic quantum field theory is one of the main attempts to provide a formal mathematical framework for quantum field theory. Its core idea is to assign to every space-time region a von Neumann algebra of local observables, subject to the Haag-Kastler axioms, which encode locality, covariance, and causality. Translating the Haag-Kastler axioms from von Neumann algebras to the simpler setting of so-called standard subspaces leads to the investigation of one-parameter semigroups of unitary endomorphisms of standard subspaces. In this talk, we show how a real version of the classical Lax-Phillips Theorem, originally developed in the context of scattering theory, can be used to represent these endomorphism semigroups in an L^2-space over the real line. We also outline how this concrete realization allows one to obtain structural results about the semigroups.

MP 3.5 Tue 18:00 KH 02.013

Operator statistics from a simple approximate CFT — Alexander Altland[1], Julian Sonner[2], and •Konstantin Weisenberger[1] — [1]Institute for Theoretical Physics, University of Cologne, 50937 Cologne, Germany — [2]Départment de Physique Théorique, Université de Genève, CH-1211 Genève 4, Switzerland

Recently, in the context of the AdS3/CFT2 correspondence, the notion of ensembles of $2d$ quantum field theories specified by distributions of OPE-coefficients and conformal dimensions $\{C_{ijk}, h_i, \bar{h}_i\}$ has been introduced (Belin et al, *JHEP09(2024)163*). These ensembles, dubbed 'approximate CFTs' (aCFTs), are expected to be conformally invariant on average while also exhibiting signatures of quantum chaos. We give the first explicit construction of such an ensemble: N_c colors of Dirac fermions in the presence of quenched gauge-field disorder. For $N_c = 1$, we present prescriptions for the calculation of moments of OPE coefficients and conformal dimensions, and use them to reconstruct all associated probability distributions of the theory. For $N_c > 1$, we apply the same methods to find the variance of OPE coefficients of bilinear fields. Finally, we also demonstrate the emergence of random matrix statistics upon perturbing the system by a mass operator.

MP 4: Quantum Field Theory II

Time: Wednesday 11:00–12:15 Location: KH 02.013

Invited Talk MP 4.1 Wed 11:00 KH 02.013
Exact Schwinger functions for a class of bounded interactions in $d \geq 2$ — •Wojciech Dybalski — AMU Poznan, Poland

We study scalar Euclidean quantum field theories with interactions defined by bounded, measurable functions. We assume that these functions have well-defined limits at both positive and negative infinity. In the spirit of the Buchholz-Verch approach we start from a large class of field renormalization functions and look for choices admitting interesting UV behaviour. We exhibit choices for which all connected Schwinger functions, except perhaps for the two-point function, exist non-perturbatively in the UV limit. Moreover, we obtain closed form formulas for these Schwinger functions demonstrating non-Gaussianity of the field. The remaining challenge of rigorously controlling the two-point function is also discussed. (Based on CMP(2025)406:211).

Invited Talk MP 4.2 Wed 11:30 KH 02.013
L4 bound for the energy density in thermal field theory — •Daniela Cadamuro — Institute for Theoretical Physics, University of Leipzig

Lower bounds to the energy density are of fundamental importance for physics (laws of thermodynamics, stability of spacetimes, etc) and for mathematics (self-adjointness of quantum fields, etc). In the case of thermal field theory, where particles and holes are both present and contribute to the energy density of the system, it is not expected that the energy density, or rather the Liouvillian density, fulfills energy inequalities in the usual sense. However, when the estimate is weighted with the modular Hamiltonian of the theory, a certain positivity is retained. We call this a quantum L4 inequality. We will show that in the thermal representation of the free massive scalar field, such an inequality is fulfilled by the quantum generator of the time evolution of the theory in this sector.

MP 4.3 Wed 12:00 KH 02.013
Inertial Repulsion from Quantum Geometry — •Maike Fahrensohn and Matthias Geilhufe — Condensed Matter and Materials Theory Division, Department of Physics, Chalmers University of Technology, 41258 Göteborg, Sweden

We derive a repulsive, charge-dipole-like interaction for a Dirac particle in a rotating frame, arising from a geometric $U(1)$ gauge symmetry associated with the Berry phase [1]. The Lagrangian of this system includes a non-inertial correction due to centrifugal field coupling. By imposing gauge symmetry and treating it as a full gauge theory, the Lagrangian is extended to include Berry connection and curvature terms. Upon integrating out the geometric gauge field, the effective action is obtained. This leads to the emergence of a repulsive, long-range effective interaction in the Lagrangian. Explicitly, in the non-inertial frame of the observer, the geometric gauge invariance effectively leads to a repulsive Coulomb-interaction in momentum space. In real space, the inertial repulsion manifests in a $1/|r|^2$ potential, which is symmetric about the origin of rotation and mirrors charge-dipole interaction.

[1] Maike Fahrensohn and R. Matthias Geilhufe. Inertial Repulsion from Quantum Geometry. 2025. arXiv: 2511.03510.

MP 5: Quantum Mechanics: Spectral Theory and Many-Body Systems

Time: Wednesday 13:45–15:30 Location: KH 02.013

Invited Talk MP 5.1 Wed 13:45 KH 02.013
Nontrivial Riemann Zeros as Spectrum — •Enderalp Yakaboylu — Department of Physics and Materials Science, University of Luxembourg, L-1511 Luxembourg

Define $\Upsilon(s) := \Gamma(s+1)\,(1-2^{1-s})\,\zeta(s)$, and denote by $\mathcal{Z} := \{\gamma \in \mathbb{C} \mid \Upsilon(\gamma) = 0\}$ its set of zeros, which includes both the periodic eta zeros, determined by $(1-2^{1-s}) = 0$ with $s \neq 1$, and the nontrivial zeta zeros ρ. We introduce a *non-symmetric* operator

$$\hat{\mathcal{R}} \colon \mathcal{D}(\hat{\mathcal{R}}) \subset L^2([0,\infty)) \to L^2([0,\infty))\,,$$

with spectrum

$$\sigma(\hat{\mathcal{R}}) = \{ i\,(1/2-\gamma) \mid \gamma \in \mathcal{Z}\}\ .$$

Assuming that all nontrivial zeros of the zeta function are *simple*, we construct a positive semidefinite operator $\hat{W}$ intertwining $\hat{\mathcal{R}}$ and its adjoint on the spectral subspace associated with the nontrivial zeros,

$$\hat{\mathcal{R}}^\dagger \hat{W} = \hat{W} \hat{\mathcal{R}}\,.$$

The positivity of $\hat{W}$, which represents an operator-theoretic form of *(Bombieri's refinement of) Weil's positivity criterion*, enforces $\Re(\rho) = 1/2$ for all ρ, in accordance with the Riemann Hypothesis. Furthermore, from the similarity between $\hat{\mathcal{R}}$ and $\hat{\mathcal{R}}^\dagger$, we obtain a *self-adjoint Hilbert-Pólya operator*, whose spectrum coincides with the imaginary parts of the nontrivial zeta zeros.

The presented framework can be generalized to higher-order zeta zeros, if such exist, and to any other Mellin-transformable L-function satisfying a functional equation.

MP 5.2 Wed 14:15 KH 02.013
Wegner model in high dimension: Singular continuous spectrum from AAT self-consistency and U(1) **symmetry-breaking** — •Julian Arenz — Institut für Theoretische Physik, Universität zu Köln

Adopting the self-consistent theory of localization due to Abou-Chacra, Anderson, Thouless (AAT), we analyze the $N = 1$ Wegner model in high lattice dimension. By examining in detail the non-compact symmetry-breaking mechanism underlying the field theory, we uncover a new class of solutions of the AAT self-consistency equation. Their pattern of symmetry-breaking differs from the metallic and insulating solutions and naturally leads to a singular continuous spectrum of the Wegner Hamiltonian.

MP 5.3 Wed 14:30 KH 02.013
Properties of higher-order squeezing — •Felix Fischer — FAU Erlangen

Squeezed light is a corner stone of modern quantum optics, with applications ranging from increasing measurement precision at LIGO to bosonic quantum computing. Higher-order generalizations are a promising candidate for error correction schemes in continous variable quantum computing. However their well-definedness has been the subject of longstanding debate. In this talk, we show that higher-order squeezing operators become well-defined when imposing suitable boundary conditions at infinity. We observe that different boundary conditions correspond to different dynamics and ultimately different physical systems. Furthermore, we investigate the spectra, dynamics and symmetries of higher-order squeezing operators. In particular, higher-order squeezing dynamics show, opposed to usual second order squeezing, oscillatory behaviour in time.

MP 5.4 Wed 14:45 KH 02.013
Beyond the rotating-wave approximation: error bounds for higher order approximations — •Leonhard Richter[1], Robin Hillier[2], Davide Lonigro[1], and Daniel Burgarth[1] — [1]Department of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany — [2]Department of Mathematics and Statistics, Lancaster University, UK

The rotating-wave approximation (RWA) is a widely used method for simplifying differential equations such as the Schrödinger equation in light-matter systems. However, its limitations have become more apparent with recent technological advancements highlighting the need for more sophisticated approximation schemes. Our aim is to address one particular drawback of the RWA: the error it introduces accumulates over time eventually rendering its application unjustified. In the case of bounded time-periodic Hamiltonians, the RWA is known to be the first order in the Floquet-Magnus expansion. Recently, a novel perspective on this expansion allowed to provide explicit error bounds that capture the time-dependence of each order reasonably well.

We extend this perspective to the unbounded case where the Floquet-Magnus expansion is generally not known to converge. Our approach iteratively constructs effective Hamiltonians that are time-independent in the interaction picture and scale with a specified order in frequency. Crucially, we are also able to provide explicit error bounds for the difference between the effective and original dynamics.

This work is in collaboration with Robin Hillier, Davide Lonigro, and Daniel Burgarth.

MP 5.5 Wed 15:00 KH 02.013

Renormalization of generalized spin-boson models with critical ultraviolet divergences — Benjamin Alvarez[1], Sascha Lill[2], •Davide Lonigro[3], and Javier Valentín Martín[4] — [1]Aix Marseille Univ, Univ Toulon, CNRS, CPT, Marseille, France — [2]Department of Mathematical Sciences, Universitetsparken 5, DK-2100 Copenhagen, Denmark — [3]Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstraße 7, 91058 Erlangen, Germany — [4]Universität Paderborn, Institut für Mathematik, Institut für Photonische Quantensysteme, Warburger Str. 100, 33098 Paderborn, Germany

We provide a rigorous construction of generalized spin-boson models with commuting transition matrices and form factors exhibiting critical ultraviolet (UV) divergences. That is, we cover all divergences where a self-energy renormalization, but no non-Fock representation, is required. Our method is based on a direct definition of the renormalized Hamiltonian on a sufficiently large test domain, followed by a Friedrichs extension. We then prove that this Hamiltonian coincides with the one obtained by cut-off renormalization. Furthermore, we show that for specific supercritical cases, i.e., when a non-Fock representation is required, the renormalized Hamiltonian is trivial.

MP 5.6 Wed 15:15 KH 02.013

Complexity transitions in Krylov basis for random and time-periodic unitary circuits — Himanshu Sahu[1,2,3], •Aranya Bhattacharya[4,5], and Pingal Pratyush Nath[6] — [1]Perimeter Institute for Theoretical Physics, Waterloo, ON, N2L 2Y5, Canada. — [2]Department of Physics and Astronomy and Institute for Quantum Computing,University of Waterloo, ON N2L 3G1, Canada. — [3]Department of Physics and Department of Instrumentation & Applied Physics, Indian Institute of Sciences, C.V. Raman Avenue, Bangalore 560012, India. — [4]Institute of Physics, Jagiellonian University, Lojasiewicza 11, 30-348 Krakow, Poland. — [5]School of Mathematics, University of Bristol, Fry Building Woodland Road, Bristol BS8 1UG, UK — [6]Centre for High Energy Physics, Indian Institute of Science, C.V. Raman Avenue, Bangalore 560012, India.

We study the growth and saturation of complexity in Krylov basis in random quantum circuits. In Haar-random unitary evolution, we show that, for large system sizes, this notion of complexity grows linearly before saturating at a late-time value of d/2, where d is the Hilbert space dimension, at times proportional to d. In brick-wall case, complexity in Krylov basis exhibits dynamics consistent with Haar-random unitary evolution, while the inclusion of measurements significantly slows its growth down. For Floquet random circuits, we show that localized phases lead to reduced late-time saturation values of the complexity, which we utilise to probe the transition between thermal and many-body localized phases.

MP 6: Holography: AdS/CFT

Time: Wednesday 16:15–17:15 Location: KH 02.013

MP 6.1 Wed 16:15 KH 02.013

Deriving Area Metric Dynamics from Entanglement — •Lavish Chawla[1,2], Aranya Bhattacharya[1,3], Mario Flory[1], and Mateusz Kulig[1] — [1]Jagiellonian University in Krakow, Poland — [2]Friedrich-Schiller-Universität Jena, Germany — [3]University of Bristol, United Kingdom

In this talk, we will present recent progress on deriving the equations of motion for a generalised geometric structure-area metrics-linearised around empty Anti-de Sitter (AdS) spacetime within the framework of the AdS/CFT correspondence. The discussion is organized into three parts. First, we will introduce the defining properties of area metric tensor and briefly discuss their emergence in various approaches of quantum gravity, as well as why they are relevant in holography. In the second part, we focus on spherical entangling regions in three-dimensional CFTs, and, by combining the first law of entanglement with the Ryu-Takayanagi formula, we determine how leading order area metric fluctuations in the asymptotic AdS expansion contribute to the holographic stress tensor. This provides a new entry in the holographic dictionary linking area metric perturbations to boundary energy momentum data. Finally, using this dictionary, we show that for finite spherical subregions, the combined requirements of the first law of entanglement and holographic entanglement entropy impose non-trivial constraints on the dynamics of area metric perturbations.

MP 6.2 Wed 16:30 KH 02.013

Bulk actions and equations for Area Metrics in AdS/CFT — Aranya Bhattacharya[1,2], Lavish Chawla[1,3], •Mario Flory[1], and Mateusz Kulig[1] — [1]Jagiellonian University, Cracow, Poland — [2]University of Bristol, Bristol, UK — [3]Friedrich-Schiller-Universität, Jena, Germany

Continuing the talk by L. Chawla, we investigate possible bulk Lagrangians for linearised area metric perturbations around AdS space. Beyond the Ryu-Takayanagi formula and the first law of entanglement, we expect these Lagrangians to be severely constrained by the requirement of consistency with holographic renormalisation. To make progress in this direction, we analyse the asymptotic behaviour allowed for the area metric fluctuations by generic model Lagrangians and their equations of motion. Finally, we show that expressing these fluctuations in terms of Lanczos-like potentials leads to a particularly elegant formulation of the linearised theory.

MP 6.3 Wed 16:45 KH 02.013

Deformations of the Chiral SYK Model and its Gravity Dual — Dmitry Bagrets[2], Konstantin Weisenberger[1], and •Sarina Michael[1] — [1]Universität zu Köln, Zülpicher Straße 77, 50937 Köln — [2]Forschungszentrum Jülich, Wilhelm-Johnen-Straße, 52428 Jülich

Based on previous work [Altland2025], we construct an extension of the (1+1)-dimensional chiral SYK model, which provides a microscopic realization of a maximally chaotic yet exactly solvable system, and also it turned out to be the holographic dual of a BTZ black hole. In the deep infrared, both are governed by a generalization of the Schwarzian theory, the Alekseev-Shatashvili (AS) action, which captures the dynamics of soft-mode fluctuations. On the gravity side, we include rotating BTZ geometries, giving a split into left- and right-moving temperatures in the dual CFT, and we add fermions on this background to find the boundary correlators. We rederive these also from pure AdS_3 via diffeomorphisms and extend this construction to genuinely off-shell boundary reparametrizations. On the CFT side, we study a bilocal deformation of the IR description using renormalization-group methods and show that it induces a crossover in the power law of the propagator, leading to a phase diagram with a critical line separating the two regimes.

MP 6.4 Wed 17:00 KH 02.013

Determining masses of hadronic bound states using a holographic ansatz — •Konrad Becker — Julius Maximilians Universität Würzburg

Holography has been found to be an exceptional tool in particle physics. In this talk I will introduce a holographic bottom-up model based on AdS/CFT which we use to describe a QCD-like theory. In this model one can calculate masses of scalar and vector mesons as well as baryons. I also introduce a way of including an additional global symmetry on the field theory side. This can be used to include flavor symmetry in such a model. Breaking this symmetry by giving different masses to the quarks gives predictions for the lightest QCD baryons which match the measured results surprisingly well.

MP 7: Members' Assembly

Time: Wednesday 17:30–18:00 Location: KH 02.013

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

MP 8: Poster Session

Time: Wednesday 18:00–18:45 Location: Redoutensaal

MP 8.1 Wed 18:00 Redoutensaal

Newton Revisited: Modifications and Practical Insights into Classical Mechanics — •Amritpal Singh Nafria — IEC University

This paper challenges the foundational principle of applied force in classical mechanics by systematically addressing the limitations of Newton's second law in real-world scenarios. It demonstrates that the standard formulation is insufficient for accurate prediction when non-conservative forces are present.

Through a series of innovative experiments and detailed theoretical analyses, the work quantitatively reveals significant discrepancies between ideal theoretical predictions and empirical observations. The investigation meticulously accounts for the effects of friction and air resistance, and extends the analysis to consider celestial variations across different planetary environments.

The study employs advanced methodologies, including the use of weighing scales for the direct measurement of resistance forces. It integrates calculations across a wide spectrum of contexts, from terrestrial conditions to the low-gravity environment of Pluto, thereby providing a comprehensive and nuanced view of force dynamics.

The findings underscore the critical necessity for refined mechanical models that explicitly incorporate resistance effects. This work establishes a framework for more accurately predicting and managing force interactions in practical engineering and physics applications, paving the way for more effective force measurement and application techniques in both terrestrial and extraterrestrial environments.

MP 8.2 Wed 18:00 Redoutensaal

Addition of relativistic velocities with arbitrary directions in four-dimensional space — •Roland Alfred Sprenger — Herford, Germany

A vectorial construction method for adding relativistic velocities with arbitrary directions is presented and justified. Without using oblique Minkowski diagrams with scale changes, but using an additional auxiliary dimension, vector addition is performed purely geometrically in a four-dimensional Euclidean space and projected back into three-dimensional real space. This forces all velocities to be limited to the speed of light purely geometrically. The auxiliary dimension represents the time component of the motion geometrically and has no independent physical dynamics. The approach is completely equivalent to special relativity and offers an alternative geometric perspective on the role of time in relativistic motions.

MP 8.3 Wed 18:00 Redoutensaal

Testing Non-Commutative Spacetime and Dark Matter Coupling via X-Ray Binary QPO Observations — •Batuhan Çil[1,2] and Ertan Güdekli[3] — [1]Faculty of Sciences and Literature, Department of Mathematics, Haliç University, Istanbul 34060, Turkey — [2]Graduate School of Engineering and Science, Istanbul University, Istanbul 34134, Turkey — [3]Department of Physics, Istanbul University, Istanbul 34134, Turkey

This study investigates the orbital dynamics and quasi-periodic oscillations (QPOs) of test particles around a charged non-commutative Schwarzschild black hole immersed in perfect-fluid dark matter (PFDM). Using the effective-potential formalism, we derive the specific energy, angular momentum and ISCO radii as functions of α, β and Q. PFDM introduces logarithmic corrections to the metric, while non-commutativity smooths the near-horizon geometry and shifts the epicyclic frequency profiles inward. We also compare the model with QPO data from four X-ray binaries via MCMC, obtaining bounds on α, β and Q and showing that PFDM and non-commutative effects leave observable signatures in strong-field QPO behaviour.

MP 8.4 Wed 18:00 Redoutensaal

Symmetry-breaking constraints from higher-group structure in axion electrodynamics — •Timo Schulze — II. Institut für Theoretische Physik, Universität Hamburg

Over the past decade, generalised symmetries have opened a new perspective on global symmetries by describing them in terms of higher categorical structures. In a d-dimensional QFT, a q-form symmetry is generated by topological defects supported on closed $(d-q-1)$-manifolds, acting on q-dimensional charged operators. In axion electrodynamics, electric and magnetic 1-form symmetries as well as axionic 0- and 2-form symmetries can combine into a higher-group structure. Building on previous work by Brennan and Cordova, we study and attempt to formalise how higher-group data constrain the order of emergence of these symmetries along RG flows. We suggest further constraints on explicit breaking terms for both electric and magnetic 1-form symmetries below the breaking scale of the axionic 0-form shift symmetry. In particular, this implies that magnetically charged probe particles below that scale must also be electrically charged.

MP 8.5 Wed 18:00 Redoutensaal

An Algorithm with Positive Geometry and Polynomials $P(2\pi)$ for Elementary Particle Physics — •Helmut Schmidt — Grasbrunn, Germany

The new field of positive geometry draws on algebraic geometry, which describes shapes and spaces by solving systems of polynomial equations. The neutron mass $m_{Neutron}/m_e = (2\pi)^4 + (2\pi)^3 + (2\pi)^2 - (2\pi)^1 - (2\pi)^0 - (2\pi)^{-1} + 2(2\pi)^{-2} + 2(2\pi)^{-4} - 2(2\pi)^{-6} + 6(2\pi)^{-8} = 1838.6836611$ is accurate to 10 decimal places. The formula can be divided into 3 objects, each with 3 spatial coordinates and a common time. The first term corresponds to 3 gluons. The second term contains two electrons and a superposition of the quarks u and d. The third term contains the detection in the measuring device in the form of a cascade with streams of electrons. The proton mass m_P/m_e differs from that of the neutron $E_{C+} = -\pi^1 + 2\pi^{-1} - \pi^{-3} + 2\pi^{-5} - \pi^{-7} + \pi^{-9} - \pi^{-12} - 2\pi^{-14}$ and contains the binding energy, or charge. The electron is weightless with $(2\pi) = 1$ and is the center for a circular inversion of all other particles. For each of the three spatial dimensions, the torque and angular momentum are conserved with $2\pi c$. From this, an algorithm is developed that describes the rest masses and standard deviations of all elementary particles, with the symmetries for matter/antimatter, attraction/repulsion, and creation and annihilation. The Earth's diameter, sidereal time, and synodic time are the required parameters. $2\pi c\ m\ day = {D_{equatorial\ Earth\ diameter}}^2$

MP 8.6 Wed 18:00 Redoutensaal

Modeling and simulation of diffraction efficiency growth during holographic grating recording — •Alexei Meshalkin, Elena Achimova, Vladimir Abaskin, Veronica Cazac, Constantin Losmanschii, and Vladislav Botnari — Institute of Applied Physics, Moldova State University, Chisinau, Moldova

This work presents theoretical and numerical studies on the modeling of wave propagation and light matter interaction during the recording of holographic diffraction gratings. The simulations focus on the evolution of diffraction efficiency as a function of the grating profile, spatial period, and phase-relief depth. Numerical modeling was implemented in MATLAB using the Angular Spectrum Method for light propagation, where all grating parameters were defined based on corresponding experimental data. The obtained simulation results were compared with experimental measurements for holographic gratings recorded in thin films of azopolymers and chalcogenide amorphous materials. A good correlation between the simulated and measured diffraction efficiencies confirms the applicability of the proposed numerical model for describing holographic recording processes. Moreover, the developed approach enables solving the inverse problem: determining grating parameters from measured diffraction efficiency.

MP 8.7 Wed 18:00 Redoutensaal

Speed Limits from Symmetries in Quantum Control — •Marco Weidmann[1], Santana Lujan[1,2], and Daniel Burgarth[1] — [1]Friedrich-Alexander Universität Erlangen-Nürnberg — [2]German Aerospace Center (DLR)

We present lower bounds on the time needed to implement any given unitary operation in a given control system. The bound crucially depends on the size of the minimal perturbation to the control system that renders the target operation unreachable. This reachability analysis is carried out using the tools of geometric control theory, which are deeply rooted in the theory of Lie Algebras and their commutants. Using Semidefinite programming (SDP) and gradient optimization techniques, we calculate the smallest perturbation that increases the dimension of the commutant of the tensor-square representation.

MP 8.8 Wed 18:00 Redoutensaal

Self-adjoint extensions of the higher order Rabi model — •Felix Knapp and Davide Lonigro — Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Erlangen, Germany

The quantum Rabi model is a paradigmatic system for studying light–matter interactions, describing the linear coupling between a two-level system and a single bosonic mode. In this work, we investigate higher-order quantum Rabi models of the form

$$\omega a^\dagger a + g\big((a^\dagger)^k + a^k\big)\sigma_x + \Delta\sigma_z,$$

where the interaction term is nonlinear in the bosonic creation and annihilation operators. The operator is defined on a natural dense domain given by finite photon-number states tensored with the two-level system. By analyzing the deficiency indices, we show that for $k \geq 3$ the operator is not essentially self-adjoint on this domain and explicitly characterize its self-adjoint extensions. Moreover, we prove that the spectrum of this operator is purely discrete.

MP 9: Geometry, Black Holes, Universality

Time: Thursday 11:00–12:30 Location: KH 02.013

Invited Talk MP 9.1 Thu 11:00 KH 02.013

Light Cone Structure of Quantum Spacetime Geometry — •Wolfgang Wieland — Lehrstuhl für Theoretische Physik III, Friedrich-Alexander-Universität Erlangen-Nürnberg

In Einstein's theory of general relativity, the causal structure of spacetime is itself dynamical. Causality is encoded into the geometry of light cones that bend under the influence of gravity. Quantum theory, on the other hand, tells us that nature is intrinsically probabilistic. A sharply defined causal structure, as it appears in classical general relativity, contradicts quantum theory. A more general framework is needed. This talk outlines a research programme in quantum gravity to develop a mathematical understanding of the causal structure at the quantum level. This is, in fact, a problem common to different approaches from local quantum field theory, to the perturbative S-matrix approach and loop quantum gravity. After a brief introduction into the conceptual aspects of the problem, we will report on several new results on this frontier. First, we explain how to construct physical observables using the light cone geometry. Then, building upon earlier results in loop quantum gravity, we take the description to the quantum level. Finally, we explain how a fundamental quantum discreteness of geometry can alter the spectrum of highly luminous gravitational wave events. The talk is based on arXiv:2504.10802, 2402.12578, 2401.17491, 2104.05803.

MP 9.2 Thu 11:30 KH 02.013

Finite Projective Physics: the world as a process of events — •Klaus Mecke — Universität Erlangen-Nürnberg, Germany

Modern physics is based on the assumption that natural phenomena are the result of force fields and elementary particles moving in a continuous space-time, whereby the dynamics can be described mathematically using differential equations. An alternative to this substance ontology is the assumption that phenomena are processes of elementary events that are causally linked to each other, so that space, time, and matter properties emerge from fundamental process relations. This process ontology - proposed by Alfred North Whitehead - can be formulated mathematically as a finite projective geometry of event points, whereby the dynamics is simply given by local quadratic forms, i.e., by a finite metric field. The task remains to derive from this geometric structure the dynamical laws that are known to be empirically adequate. To this end, finite projective analogues of classical mechanics (time dependence), electrodynamics (spatial gauge fields), and quantum mechanics (random particle events) are formulated and their equivalence to standard analytical theories is demonstrated in the continuum limit. The origin of important concepts such as Legendre transformation, gauge symmetry, and commutator relations can be explained by fundamental features of finite projective geometry, which characterizes any event process. Finally, the possibility of a unified theory of general relativity and quantum field theory of elementary particles is outlined, in which finite projective geometry is the basic structure instead of a differentiable Riemannian manifold.

MP 9.3 Thu 11:45 KH 02.013

Rényi second laws for Charged AdS Black Hole — Alice Bernamonti[1], Federico Galli[1], and •Emiliano Rizza[2] — [1]Università degli Studi di Firenze, Florence, Italy — [2]Jagiellonian University, Krakow, Poland

Hawking's black hole area theorem offers a geometric interpretation of the second law of thermodynamics, imposing fundamental constraints on gravitational dynamics. By examining entropic inequalities following from the monotonicity of Rényi entropies, it is shown that these constraints often set stricter bounds than those imposed by the area theorem in asymptotically AdS space.

This work aims to explore in detail the case of charged AdS black holes, which exhibit rich thermodynamic phase structures in the canonical ensemble. In particular, we study the coalescence of charged black holes in AdS, establishing a lower bound on the mass of the final state and an efficiency bound on the amount of gravitational radiation.

MP 9.4 Thu 12:00 KH 02.013

A New Universality Emerging in the Generic Approach to Stochastic Quantum Scattering — •Simon Köhnes and Thomas Guhr — Universität Duisburg-Essen, Duisburg, Deutschland

Scattering theory is indispensable to understand a variety of systems ranging from nuclei and atoms to systems in mesoscopic and condensed matter physics, but also to wireless communication. These systems often exhibit chaotic dynamics in a broad sense which prompted generic stochastic approaches. Recently we succeeded in deriving the distributions for off-diagonal scattering matrix elements and cross sections by using Random Matrix Theory and Supersymmetry. We arrive at integrals over Goldstone modes, more precisely over a coset supermanifold. These results now facilitate to prove a 60 year old conjecture: Ericson argued that the mentioned distributions become Gaussian or exponential, respectively, in the regime of strongly overlapping resonances. Our proof is based on an asymptotic expansion which we carry out after a proper reparameterization of the multidimensional integration manifold.

MP 9.5 Thu 12:15 KH 02.013

Work versus force: Simultaneous processes for describing interactions — •Grit Kalies[1], Duong D. Do[2], and Cornelia Breitkopf[3] — [1]HTW University of Applied Sciences, Dresden, Germany — [2]The University of Queensland, Brisbane, Australia — [3]Technical University of Dresden, Dresden, Germany

A consistent description of nature is an essential goal that has not been achieved by current theoretical physics, which uses four different fundamental forces to describe interactions. This could change when interactions are described by processes (work is actio) rather than by forces, not only at the macroscopic level but also at the quantum level. We discuss and contrast the two distinct concepts of interaction and interpret the idea of an acting force (force is actio) as a helpful geometric substitute, obscuring the simultaneous processes that actually take place. Using examples such as the lifting, acceleration or displacement of a body as well as of quantum objects, we demonstrate the advantages of applying process equations, including those that describe a change in the momentum of a particle or body. The results indicate that simultaneous processes allow for a more detailed energetic analysis of quantum objects and pave a path for reconciling classical thermodynamics and quantum physics towards a deterministic description of quantum objects.

MP 10: Strong Fields

Time: Thursday 13:45–15:30 Location: KH 02.013

MP 10.1 Thu 13:45 KH 02.013

Dynamically assisted nuclear fusion — Daniil Ryndyk[1,3], Christian Kohlfürst[1], Friedemann Queisser[1], and •Ralf Schützhold[1,2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Germany — [2]Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden, Germany — [3]Forschungszentrum Jülich GmbH, Wilhelm-Johnen-Straße, 52428 Jülich, Germany

We study the enhancement of tunneling through a potential barrier, such as the Coulomb potential in nuclear fusion, by an additional electromagnetic field, such as an x-ray free electron laser (XFEL). In addition to the known effects of pre-acceleration and potential deformation already present in the adiabatic regime, as well as energy mixing in analogy to the Franz-Keldysh effect in the non-adiabatic regime, the field can enhance tunneling by pushing part of the wave function out of the rear end of the barrier. We find that the XFEL field strengths required for these dynamical assistance mechanisms are challenging, but still well below the Schwinger critical field.

[1] F. Queisser and R. Schützhold, *Dynamically assisted nuclear fusion*, Phys. Rev. C **100**, 041601(R) (2019)

[2] C. Kohlfürst, F. Queisser and R. Schützhold, *Dynamically assisted tunneling in the impulse regime*, Phys. Rev. Research **3**, 033153 (2021)

[3] D. Ryndyk, C. Kohlfürst, F. Queisser, and R. Schützhold, *Dynamically assisted tunneling in the Floquet picture*, Phys. Rev. Research **6**, 023056 (2024)

MP 10.2 Thu 14:00 KH 02.013

Towards a vacuum birefringence experiment at the Helmholtz International Beamline for Extreme Fields — •Felix Karbstein — Helmholtz Institute Jena, Fröbelstieg 3, 07743 Jena, Germany — Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany

Quantum field theory predicts a nonlinear response of the vacuum to strong electromagnetic fields of macroscopic extent. This fundamental tenet has remained experimentally challenging and is yet to be tested in the laboratory. A particularly distinct signature of the resulting optical activity of the quantum vacuum is vacuum birefringence manifesting itself in a polarization-flipped signal component. This offers an excellent opportunity for a precision test of nonlinear quantum electrodynamics (QED) in an uncharted parameter regime. In this talk I will provide an update on the status of the dark-field approach devised to measure the leading (both polarization-flipped and unflipped) quantum vacuum signals in a dedicated experiment at the European X-ray Free Electron Laser (EuXFEL) within the Helmholtz International Beamline for Extreme Fields (HIBEF) User Consortium.

MP 10.3 Thu 14:15 KH 02.013

Detection schemes for quantum vacuum birefringence — •Naser Ahmadiniaz[1], Thomas Cowan[1,2], Christian Kohlfürst[1], Roland Sauerbrey[1], Michal Smid[1], Toma Toncian[1], and Ralf Schützhold[1,3] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Germany — [2]Institut für Kern und Teilchenphysik, Technische Universität Dresden, 01062 Dresden, Germany — [3]Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden, Germany

Strong electromagnetic fields can not only create matter but also turn the quantum vacuum into an anisotropic medium. This effect is called vacuum birefringenc. Motivated by recent experimental initiatives of the BIREF@HIBEF collaboration at the Helmholtz International Beamline for Extreme Fields (HIBEF) of the HED instrument at the European XFEL, we study birefringent scattering of x-rays in the strong field of high-intensity optical lasers and compare several beam geometries. Special emphasis is placed on scenarios where signal and background photons differ in polarization, propagation direction, and possibly energy, in order to enhance detectability.

[1] N. Ahmadiniaz, C. Bähtz et al. (BIREF@HIBEF Collaboration), High Power Laser Science and Engineering 13 (2025).

[2] N. Ahmadiniaz, T.E. Cowan et al. Phys. Rev. D 108, 076005 (2023).

MP 10.4 Thu 14:30 KH 02.013

Matter from light: The Sauter-Schwinger effect — •Christian Kohlfürst[1], Naser Ahmadiniaz[1], Sebastian M. Schmidt[1,2], and Ralf Schützhold[1,2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Germany — [2]Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden, Germany

Strong electromagnetic fields can push even the quantum vacuum itself to its limits, forcing it out of equilibrium and triggering the creation of pairs of electrons and positrons. In this talk, we focus on the most extreme form of matter creation through light: the non-perturbative Sauter-Schwinger effect. In particular, we consider characteristic signatures in the particle distributions of the created electron-positron pairs and provide further context in terms of Relativistic Quantum Transport Theory.

[1] J. P. Edwards et al., Phys. Rev. D 112, L031901 (2025).

[2] C. Kohlfürst, Phys. Rev. D 110, L111903 (2024).

[3] C. Kohlfürst et al., Phys. Rev. Lett. 129, 241801 (2022).

MP 10.5 Thu 14:45 KH 02.013

Essential Nonlocality of Spin and Polarization Distributions in Strong-Field Quantum Electrodynamics — Samuele Montefiori[1], Antonino Di Piazza[2,3,1], Tobias Podszus[1], Christoph H. Keitel[1], and •Matteo Tamburini[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]University of Rochester, Rochester, USA — [3]Laboratory for Laser Energetics, Rochester, USA

Lepton spin and photon polarization are fundamental quantum degrees of freedom that govern scattering amplitudes and observable asymmetries. Advances in high-power lasers have opened the strong-field quantum electrodynamics (QED) regime, where modeling of nonlinear Compton scattering (NCS) typically relies on the collinear, locally constant field approximation (LCFA). We show that constructing angle- and polarization-resolved NCS distributions from local, instantaneous lepton states in a uniform constant crossed field can yield unphysical spin and polarization vectors with magnitudes exceeding unity, while accounting for the full photon formation length eliminates these pathologies. We introduce a new LCFA method that integrates over the entire formation region and, when applied to electron-laser interactions and to emission in strong magnetic fields, predicts qualitative and quantitative polarization differences relative to the commonly used local, collinear-emission model.

MP 10.6 Thu 15:00 KH 02.013

Comparative analysis of laser chirping schemes for compensation of ponderomotive broadening in high-intensity Compton sources — •Nikita Larin[1,2] and Daniel Seipt[1,2] — [1]Helmholtz Institute Jena, Fröbelstieg 3, 07743 Jena, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstraße 1, 64291 Darmstadt, Germany

Inverse Compton scattering (ICS) is a well-established source of X-ray and γ-ray radiation with broad applications in medicine, biology, nuclear, and material sciences. A key advantage of ICS sources is their ability to generate photon beams with high spectral brightness.

However, achieving the necessary large photon yield requires operation at relativistic laser intensities, which introduces ponderomotive broadening. This effect directly limits the desired spectral brightness. To mitigate this constraint and enhance the performance of ICS sources, the use of chirped laser pulses has been proposed as a compensation strategy [1-4].

We present a comparative study of various chirping prescriptions by applying a novel time-frequency analysis method to the nonlinear Compton emission process. This approach provides deeper insights into the effectiveness of the different chirping prescriptions and guides further refinements toward creating narrowband X-ray and γ-ray sources based on ICS.

[1] I. Ghebregziabher et al., PRSTAB 16, 030705 (2013). [2] B. Terzić et al., PRL 112, 074801 (2014). [3] V. Kharin et al., PRL 120, 044802 (2018). [4] D. Seipt et al., PRL 122, 204802 (2019).

MP 10.7 Thu 15:15 KH 02.013

Status report of the photon photon scattering experiment at

CALA — •Timo Pohle[1], Leonard Doyle[1], Fabian Schütze[2,3], Pooyan Khademi[2,3], Felix Karbstein[2,3], Matt Zepf[2,3], and Jörg Schreiber[1] — [1]CALA/LMU, Am Coulombwall 1, 85748 Garching — [2]Helmholtz Institute Jena, Fröbelstieg 3, 07743 Jena — [3]Faculty of Physics and Astronomy, Friedrich-Schiller-Universität Jena, 07743 Jena, Germany

In the Centre for Advanced Laser Applications (CALA) near Munich, an experiment is being set up with the aim of measuring photon-photon scattering in the all-optical regime. We expect tens of photon scattering when colliding two petawatt pulses from the ATLAS-3000 Laser head on. Measuring this weak signal in the environment of ultra-intense laser pulses consisting of $\mathcal{O}(10^{20})$ photons each is one of the main challenges of the experiment, which we want to overcome using the darkfield approach and a time-gated detection scheme. The quantification of this signal will help to verify the predictions made by the current theory about the quantum vacuum in a strong field environment. In my talk, I will give an overview of our planned experimental setup in combination with the expected signal yield predicted by analytical and numerical work [1] as well as report on the current progress of the implementation. Furthermore, I will show our approach to the detection of the weak signal and highlight other challenges in the realization of the experiment.

[1] Schütze et al. *Phys. Rev. D* **2024**, *109* (9), 096009.

MP 11: Various Topics in Relativity

Time: Thursday 16:15–18:00 Location: KH 00.015

MP 11.1 Thu 16:15 KH 00.015

A witness of superluminal signalling in quantum theory and its modifications. — •Aritro Mukherjee — University of Duisburg-Essen

Linearity of the master equations in quantum theory and in many of its proposed modifications is often taken to guarantee the absence of superluminal signalling, thereby preserving causality. However, in many scenarios master equations are not always available in closed analytic form, limiting the applicability of this argument. To address this, we first introduce a general operational witness for detecting superluminal signalling that does not rely on explicit knowledge of a master equation and may be easily assessed when analytical methods are not available. Furthermore, applying this witness reveals a surprising result: even linear master equations can permit superluminal signalling unless a specific locality condition is satisfied. Hence we show that linearity of the corresponding master equations is not a sufficient criteria for causality. In contrast, the witness we propose provides a necessary and sufficient criterion for ruling out superluminal signalling in full generality.

MP 11.2 Thu 16:30 KH 00.015

Velocity dependent potential — •Lars Callenbach — Frankfurt am Main, Germany

The four-dimensional wave equation can be transformed to Laplace's equation applying a change of coordinates. In these four-dimensional Laplace coordinates a velocity dependent potential is derived from first principles for relative coordinates and velocities and its properties are analyzed. Especially this potential is the classical three-dimensional potential when the particles are at rest with respect to each other and in general this potential represents a central force interaction. Applying the Lagrange and Hamilton formalism the solutions of the dynamics are derived - with a simple structure: a bounded periodic motion on a circle in four dimensions. The explicit formulas for gravitational (and electrodynamical) equations underlying the motion are presented and the theoretical results are applied to data of our solar system showing that the bounded motion on a circle in four dimensions has many scalar constants of motion.

MP 11.3 Thu 16:45 KH 00.015

Euclidean Relativity Describes A Mathematical Reality — •Markolf H. Niemz — Heidelberg University

Special/general relativity (SR/GR) work for all observers, but they do not provide diagrams of nature that work for all observers. This is because they do not describe nature as an absolute manifold, where all action is due to an absolute parameter. We show: Euclidean relativity (ER) achieves precisely that. It describes a mathematical Master Reality, which is *absolute* 4D Euclidean space (ES). All objects move through ES at the dimensionless speed C. There is no time in ES. All action in ES is due to an *absolute*, external evolution parameter θ. Every object experiences two projections from ES as space and time: The axis of its current 4D motion is its proper time τ. Three orthogonal axes are its 3D space x_1, x_2, x_3. An observer's physical reality is the Minkowskian reassembly of his axes x_1, x_2, x_3, τ. In this "τ-based Minkowskian spacetime" (τ-MS), τ is the new time coordinate and θ converts to parameter time ϑ. ER reproduces the Lorentz factor and gravitational time dilation, but gravity is Newtonian. Action at a distance is not a problem: Information is instantaneous in timeless ES. Only in τ-MS does the time coordinate cause a delay. Presumably, gravity is carried by gravitons and manifests itself in τ-MS as waves. ER rejects curved spacetime, cosmic inflation, expanding space, dark energy, and non-locality. Nevertheless, ER predicts time's arrow, the Hubble tension, and entanglement. There are two options: Physics either sticks to SR/GR and highly speculative concepts, or it breaks new ground with ER. www.preprints.org/manuscript/202207.0399

MP 11.4 Thu 17:00 KH 00.015

Negative square roots: Wishful thinking in spacetime physics — •René Friedrich — Strasbourg

The current approaches to quantum gravity are all based on the fundamental assumption of a Lorentzian spacetime manifold as it was understood by Minkowski in his famous lecture "Space and Time" in 1908. However, this assumption is far from being free of inconsistencies:

a) The squared metric "F" used by Minkowski does not apply to spacelike spacetime intervals (problem of negative squares), revealing that spacetime is not continuous in spacelike direction.

b) To remedy this, Minkowski introduced a sort of twofold patchwork metric ("F" and "-F").

c) This handling of the problem was not acceptable for many physicists and led to the proliferation of a multitude of different "conventions" for the spacetime interval which have become a veritable "elephant in the room" of spacetime physics.

d) Misner-Thorne-Wheeler took the problem to extremes, by setting two opposite metrics equal, a positive square with a negative square, implying a real number equal to an imaginary number. Real equals imaginary: That is just the definition of wishful thinking (!).

e) The current approaches to quantum gravity should check the basic assumptions they are relying on, because every theory is only as good as its underlying assumptions.

MP 11.5 Thu 17:15 KH 00.015

The tiny theory: a single fundamental principle yielding general relativity and the standard model — •Christoph Schiller — Motion Mountain Research, Munich

The Lagrangians of general relativity and of the standard model of particle physics with massive neutrinos, including elementary particle masses and the other fundamental constants, can be deduced from a single fundamental principle based on fluctuating strands of Planck radius. In particular, the fundamental principle explains the principle of least action, the equality of inertial and gravitational mass, and allows estimating the mass values of the elementary particles.

[1] The tiny theory: a single fundamental principle yielding general relativity, particle physics, and gauge anomaly cancellation, https://www.researchgate.net/publication/397264142

[2] https://tiny.motionmountain.net

[3] Testing a model for emergent spinor wave functions explaining elementary particles, gauge interactions and fundamental constants, https://www.researchgate.net/publication/361866270

[4] Testing the uniqueness of a unified theory based on topology and geometry, https://www.researchgate.net/publication/389673692

MP 11.6 Thu 17:30 KH 00.015

From Relativistic Conversation Law of Charged Particles to Creating of Photons — •Bin Su — Institut für theoretische Physik, TU Berlin

An application of relativistic dynamics of charged particles in Mankowski force [1] on strengthen accelerated electrons till almost to speed of light is suitable in terms of their relativistic kinematic energy and momentum to discuss. The accelerated charged particles would under the certain settings of electromagnetic apartment for example [2], create synchrotron rays, say photons, which carry the interaction between the accelerated electrons and their located electromagnetic fields and mediate their obtained Minkowski force. The both - particles and fields constitute a conservation system. The possible area of produced radiated frequency could be asserted from the parameters both of particles and their circumstance such as orbital and fields according to relativistic dynamics[1]. This frequency area and the rays direction could be roughly estimated from assumed values of velocities of accelerated electrons in a defined percentage of light velocity. For example the synchrotron ray from electron with two digit light velocity under the certain strength of the magnetic field attains nearly Hundert petaherz, are expected to be experimentally verified.

[1] B. Su *relativistic dynamics of electrical matter in Minkowski force*, Scientific Programme 2025 [2] elektronen-Stretcher: https://www.pi.uni-bonn.de/elsa/de

MP 11.7 Thu 17:45 KH 00.015

Rest length and dilated time in five-dimensional spacetime — •Roland Alfred Sprenger — Herford, Germany

This talk presents a geometric method for determining time dilation and proper length of relativistically moving bodies without the use of an affine coordinate system or scale transformations. Based on special relativity, a five-dimensional spacetime is introduced in which the constructions can be formulated consistently. The additional dimension is timelike and serves to accommodate time components that lead to formal mixing of spatial and temporal quantities in four-dimensional representations. Time dilation and proper length follow from simple geometric relations, with simultaneity defined by light spheres rather than spatial hyperplanes. The rest frame of the moving body appears as a reference system rotated about the time axis. Superluminal velocities may occur, but they affect only components associated with the additional timelike dimension and not the observable spatial direction.