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 MP-H4 and MP-H5)

Plenary Talk of MP

PV V	Wed	9:45–10:30	Audimax	**Quantum gravity, chaos, statistical physics and wormholes** — •Jan de Boer

Invited Talks

MP 1.1	Mon	9:30–10:00	MP-H5	**Long-range entanglement and the split property** — •Pieter Naaijkens, Yoshiko Ogata
MP 1.2	Mon	10:00–10:30	MP-H5	**Symmetry-resolved quantum information measures for AdS gravity and beyond** — •René Meyer, Suting Zhao, Christian Northe, Konstantin Weisenberger
MP 1.3	Mon	10:30–11:00	MP-H5	**Rapid thermalization of spin chain commuting Hamiltonians** — •Angela Capel
MP 2.1	Mon	16:15–16:45	MP-H5	**The Page curve from quantum error correction** — •Daniel Harlow
MP 2.2	Mon	16:45–17:15	MP-H5	**Classical black hole scattering from a worldline quantum field theory** — •Jan Plefka
MP 3.1	Tue	11:00–11:30	MP-H5	**Dualities and categorical symmetries in quantum spin chains** — •Frank Verstraete
MP 3.2	Tue	11:30–12:00	MP-H5	**Functional Integral and Stochastic Representations for Bosonic Ensembles** — •Manfred Salmhofer
MP 3.3	Tue	12:00–12:30	MP-H5	**Color-Flavor Transformation Revisited** — •Martin Zirnbauer
MP 5.1	Wed	11:00–11:30	MP-H5	**Falling through masses in superposition: quantum reference frames for indefinite metrics** — Anne-Catherine de la Hamette, Viktoria Kabel, Esteban Castro-Ruiz, •Caslav Brukner
MP 6.1	Wed	16:15–16:45	MP-H5	**State sum models with defects** — •Catherine Meusburger
MP 9.1	Thu	11:00–11:30	MP-H5	**Reduced phase space quantisation in Loop quantum gravity and loop quantum cosmology** — •Kristina Giesel, Bao-Fei Li, Parampreet Singh
MP 9.2	Thu	11:30–12:00	MP-H5	**Quantum fields propagating on curved backgrounds and their influence on spacetime curvature** — •Nicola Pinamonti

Invited Talks of the joint symposium SMuK Dissertation Prize 2022 (SYMD)

See SYMD for the full program of the symposium.

SYMD 1.1	Mon	14:00–14:25	Audimax	**Timeless Quantum Mechanics and the Early Universe** — •Leonardo Chataigner
SYMD 1.2	Mon	14:25–14:50	Audimax	**First tritium β-decay spectrum recorded with Cyclotron Radiation Emission Spectroscopy (CRES)** — •Christine Claessens
SYMD 1.3	Mon	14:50–15:15	Audimax	**Watching the top quark mass run - for the first time!** — •Matteo M. Defranchis, Katerina Lipka, Sven-Olaf Moch
SYMD 1.4	Mon	15:15–15:40	Audimax	**Towards beam-quality-preserving plasma accelerators: On the precision tuning of the wakefield** — •Sarah Schröder

Invited Talks of the joint symposium The Nature of Science (SYNS)

See SYNS for the full program of the symposium.

SYNS 1.1	Tue	14:00–14:30	Audimax	**The Role of Nature of Science Education for Science Media Literacy** — •Dietmar Höttecke
SYNS 1.2	Tue	14:30–15:00	Audimax	**What kinds of identities are deemed in/our of place in physics?** — •Lucy Avraamidou
SYNS 1.3	Tue	15:00–15:30	Audimax	**Some thoughts on the status of theoretical physics** — •Daniel Harlow

Prize Talks of the joint Awards Symposium (SYAW)

See SYAW for the full program of the symposium.

SYAW 1.1	Wed	14:10–14:40	Audimax	**Wie überprüft man die Ziele der Lehramtsausbildung Physik?** — •Horst Schecker
SYAW 1.2	Wed	14:40–15:10	Audimax	**Astronomy at Highest Angular Resolution - Adaptive Optics, Interferometry and Black Holes** — •Frank Eisenhauer
SYAW 1.3	Wed	15:10–15:40	Audimax	**Turbulence in one dimension** — •Alexander M. Polyakov

Sessions

MP 1.1–1.3	Mon	9:30–11:00	MP-H5	**Entanglement; Thermalization**
MP 2.1–2.6	Mon	16:15–18:35	MP-H5	**Gravity, Amplitudes, AdS/CFT**
MP 3.1–3.3	Tue	11:00–12:30	MP-H5	**Quantum dynamics**
MP 4.1–4.7	Tue	16:15–18:35	MP-H5	**Quantum field theory, AdS/CFT, non-equilibrium and quantum dynamics**
MP 5.1–5.4	Wed	11:00–12:30	MP-H5	**Quantum information**
MP 6.1–6.1	Wed	16:15–16:45	MP-H5	**Mathematical physics**
MP 7.1–7.6	Wed	16:45–18:45	MP-H5	**Quantum field theory**
MP 8.1–8.3	Wed	17:25–18:25	MP-H6	**Alternative approaches**
MP 9.1–9.4	Thu	11:00–12:40	MP-H5	**Quantum gravity (joint session MP/GR)**
MP 10.1–10.3	Thu	16:15–17:15	MP-H5	**Classical and quantum gravity**
MP 11.1–11.5	Thu	16:35–18:15	MP-H6	**Thermodynamics and fundamental aspects of field theory**
MP 12.1–12.3	Thu	17:15–18:15	MP-H5	**Quantum field theory for particle physics and plasmas**
MP 13	Thu	19:30–20:30	MP-MV	**Annual General Meeting**

Annual General Meeting of the Theoretical and Mathematical Physics Division

Thursday 19:30–20:30 MP-MV

MP 1: Entanglement; Thermalization

Time: Monday 9:30–11:00 Location: MP-H5

Invited Talk MP 1.1 Mon 9:30 MP-H5
Long-range entanglement and the split property — •Pieter Naaijkens[1] and Yoshiko Ogata[2] — [1]School of Mathematics, Cardiff University, United Kingdom — [2]Graduate School of Mathematical Sciences, The University of Tokyo, Japan

Long-range entanglement has been crucial in understanding topologically ordered phases of matter. In particular, it is believed to be a necessary condition for the existence of non-trivial anyons in 2D. In this talk I will explain how we can prove this statement in the context of superselection sector theory. In particular, we show that if a ground state is not long-range entangled, in a way that we make precise, then we only have the trivial superselection sector. I will also indicate how this is related to the split property of certain von Neumann algebras generated by the observables of the system.

Invited Talk MP 1.2 Mon 10:00 MP-H5
Symmetry-resolved quantum information measures for AdS gravity and beyond — •René Meyer, Suting Zhao, Christian Northe, and Konstantin Weisenberger — Institut für Theoretische Physik und Astrophysik, Julius-Maximilians-Universität Würzburg, Am Hubland, 97074 Würzburg

Quantum entanglement is the key resource employed in modern quantum computation. Different entanglement measures such as the entanglement entropy and Renyi entropies also provide useful information about the entanglement structure of quantum field theories, in particular at critical points. I will discuss the symmetry resolved entanglement and Renyi entropies, a fine-grained version of the usual entanglement and Renyi entropies, both in the context of quantum field theory and AdS/CFT. In the presence of global conserved charges, they quantify the entanglement content of the reduced density matrix in a fixed charge sector. These entanglement measures can in particular be calculated in two-dimensional conformal field theories with U(1) Kac-Moody structure at level k, and are found to not depend on the value of the charge. This charge independence is called equipartition of entanglement, and implies that no charge sector is distinguished in terms of its entanglement content. Finally, I will discuss the symmetry resolved entanglement in the AdS3/CFT2 dual of the U(1) Kac-Moody CFT. Agreement with CFT results provides a further test of the AdS3/CFT2 correspondence. I finish with some results about the violation of the equipartition property in CFTs with W3 symmetry. This talk is based on hep-th/2012.11274 and hep-th/2108.09210.

Invited Talk MP 1.3 Mon 10:30 MP-H5
Rapid thermalization of spin chain commuting Hamiltonians — •Angela Capel — Universität Tübingen

In this talk, we will show that spin chains weakly coupled to a large heat bath thermalize rapidly at any temperature for finite-range, translation-invariant commuting Hamiltonians, reaching equilibrium in a time which scales logarithmically with the system size. From a physical point of view, this result establishes the absence of dissipative phase transition for Davies evolutions over translation-invariant spin chains. The result also applies in the case of Symmetry Protected Topological phases where the evolution is respecting the symmetry of the phase. We will comment on the possible extensions of this result to higher dimensions, as well as on some applications to the study of many-body in and out-of-equilibrium quantum systems.

MP 2: Gravity, Amplitudes, AdS/CFT

Time: Monday 16:15–18:35 Location: MP-H5

Invited Talk MP 2.1 Mon 16:15 MP-H5
The Page curve from quantum error correction — •Daniel Harlow — Massachusetts Institute of Technology, Cambridge, Massachusetts, USA

The "Page curve", meaning the von Neumann entropy of the radiation of a black hole plotted as a function of time, is one of the main tools for diagnosing the black hole information problem. Recently semiclassical calculations of this curve were given, but they have several mysterious features. In particular, it is not so clear how they can be interpreted from a Hilbert space point view, as one would like in a real theory of quantum gravity. In this talk I'll explain how these calculations can be given such an interpretation through a novel generalization of quantum error correction to "non-isometric" codes.

Invited Talk MP 2.2 Mon 16:45 MP-H5
Classical black hole scattering from a worldline quantum field theory — •Jan Plefka — Humboldt Universität zu Berlin, Germany

When two massive, gravitationally interacting bodies (black holes, neutron stars or stars) fly past each other they are deflected and emit gravitational Bremsstrahlung. I shall discuss how this classical two-body problem in general relativity can be efficiently described using worldline quantum field theory methods. Including spin (i.e. Kerr Black Holes or spinning neutron stars) leads to an effective N=2 supersymmetric description valid up to quadratic order in spins. The emitted gravitational waveform, scattering angle and spin-kick may be efficiently computed in a weak gravitational field (post Minkowskian) expansion and represent state of the art results. The worldline quantum field theory approach innovates over traditional approaches and imports modern technology from perturbative quantum field theory to classical perturbative GR.

MP 2.3 Mon 17:15 MP-H5
Sustained convergence of hydrodynamics in rapidly spinning quark-gluon plasma — •Matthias Kaminski[1], Casey Cartwright[1], Markus Garbiso Amano[1], Jorge Noronha[2], and Enrico Speranza[2] — [1]Department of Physics and Astronomy, University of Alabama,514 University Boulevard, Tuscaloosa, AL 35487, USA — [2]Illinois Center for Advanced Studies of the Universe, Department of Physics, University of Illinois at Urbana-Champaign, Urbana, IL 61801, USA

We compute the radius of convergence of the linearized relativistic hydrodynamic gradient expansion around a non-trivially rotating strongly coupled $\mathcal{N} = 4$ Super-Yang-Mills plasma. Our results show that the validity of hydrodynamics is sustained and can even get enhanced in a highly vortical quark-gluon plasma, such as the one produced in intermediate-energy heavy-ion collisions. The hydrodynamic dispersion relations are computed using a rotating background that is an analytical solution of the ideal hydrodynamic equations of motion with non-vanishing angular momentum and large vorticity gradients, giving rise to a particular boost symmetry. Analytic equations for the transport coefficients of the rotating plasma as a function of their values in a plasma at rest are given.

MP 2.4 Mon 17:35 MP-H5
Scalar flat holography — •Lorenzo Iacobacci[1,2] and Massimo Taronna[1,2,3] — [1]Dipartimento di Fisica Ettore Pancini, Università degli Studi di Napoli Federico II Via Cintia, 80126 Napoli, Italy — [2]Istituto Nazionale di Fisica Nucleare, Sezione di Napoli Via Cintia, 80126 Napoli, Italy — [3]Scuola Superiore Meridionale, Università degli Studi di Napoli Federico II, Largo San Marcellino 10, 80138 Napoli, Italy

Recently, flat space holography has played a central role in the study of scattering amplitudes. In particular, the (d+2)-dimensional holographic flat space-time is closed in the far past and in the far future by a d-dimensional boundary, called celestial sphere. On this boundary, a d-dimensional conformal field theory lives; therefore, researchers have been studying the imprint of the d-dimensional conformal symmetry in (d+2)-dimensional scattering amplitudes.

Further, it is well-known that the (d+2)-dimensional Minkowski space-time can be sliced in (d+1)-dimensional AdS spaces inside the light-cone and by (d+1)-dimensional dS spaces outside. This suggests us that a connection between flat, dS and AdS holography should exist.

In our talk, we shall see the strict connection between the holography realized on AdS, dS and Minkowski. By analogy with the AdS case, we will arrive to write down a dictionary to pass between AdS, dS and flat holography. Moreover, these stringent connections will allow us to exploit the results obtained in AdS holography to compute scattering amplitudes both in flat and dS holography.

MP 2.5 Mon 17:55 MP-H5

Hyperbolic tilings and discrete holography — •Giuseppe Di Giulio — 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 discretising the Anti-deSitter spacetime. Within this program, we consider the Poincaré disk (fixed time slice of three-dimensional Anti-deSitter spacetime) discretised by introducing a regular hyperbolic tiling on it. This breaks the isometry group of the Poincaré disk down to a discrete subgroup. In a possible discrete version of the AdS/CFT correspondence, such a discrete group is expected to characterise also the quantum theory living on the boundary of the hyperbolic tiling. In this talk, we discuss the properties that such a boundary theory must have. The bulk tessellation we study induces an aperiodic spatial modulation on any model defined on the boundary. This provides an interesting bridge with the aperiodic quantum chains, well-known systems in the literature of condensed matter theory. Furthermore, in view of examining possibilities for establishing a duality in this setup, we investigate the entanglement properties of the tiled bulk (obtained through a discretised version of the Ryu-Takayanagi formula for the holographic entanglement entropy) and of some possible boundary theories.

MP 2.6 Mon 18:15 MP-H5

Classical and quantum gravitational scattering with Generalized Wilson Lines — Domenico Bonocore, Anna Kulesza, and •Johannes Pirsch — Institut für Theoretische Physik, WWU Münster, Münster, Germany

The all-order structure of scattering amplitudes is greatly simplified using Wilson line operators, describing eikonal emissions from straight lines extending to infinity. A generalization at subleading powers in the eikonal expansion, known as Generalized Wilson Line (GWL), has been proposed some time ago, and has been applied both in QCD phenomenology and in the high energy limits of gravitational amplitudes. In this talk I discuss the construction of the gravitational GWL starting from first principles in the worldline formalism. This includes identifying the correct Hamiltonian, which leads to a simple correspondence between the soft expansion and the weak field expansion. The resulting path integral representation of the GWL makes it possible to isolate the relevant contributions to the classical limit.

MP 3: Quantum dynamics

Time: Tuesday 11:00–12:30 Location: MP-H5

Invited Talk MP 3.1 Tue 11:00 MP-H5

Dualities and categorical symmetries in quantum spin chains — •Frank Verstraete — Ghent University

Categorical symmetries play a central role in the characterization of the entanglement features of quantum spin systems exhibiting topological order in 2+1D or criticality in 1+1D. In this talk, we will discuss those symmetries from the point of view of tensor networks, and demonstrate that matrix product operators realize representations of the corresponding module categories. This on its turn allows for a constructive approach to building dualities for quantum spin chains.

Invited Talk MP 3.2 Tue 11:30 MP-H5

Functional Integral and Stochastic Representations for Bosonic Ensembles — •Manfred Salmhofer — Institut für theoretische Physik, Universität Heidelberg, Philosophenweg 19, 69120 Heidelberg

I discuss rigorously defined coherent-state functional integral representations for the partition function and correlation functions of many-boson systems, both for the canonical and the grand-canonical ensemble, and the relation of these representations to ensembles of interacting random walks. I will highlight a few essential differences between the canonical and grand-canonical ensemble, outline a simplified proof of equivalence of different functional integral representations in the time-continuum limit, and discuss their use in obtaining convergent expansions for the correlation functions.

Invited Talk MP 3.3 Tue 12:00 MP-H5

Color-Flavor Transformation Revisited — •Martin Zirnbauer — Institute for Theoretical Physics, Uni Köln, Germany

The "color-flavor transformation", conceived as a kind of generalized Hubbard-Stratonovich transformation, is a variant of the Wegner-Efetov supersymmetry method for disordered electron systems. Tailored to quantum systems with disorder distributed according to the Haar measure of any compact Lie group of classical type (A, B, C, or D), it has been applied to Dyson's Circular Ensembles, random-link network models, quantum chaotic graphs, disordered Floquet dynamics, and more. We review the method and, in particular, explore its limits of validity and some implications for the theory of Anderson localization-delocalization transitions.

MP 4: Quantum field theory, AdS/CFT, non-equilibrium and quantum dynamics

Time: Tuesday 16:15–18:35 Location: MP-H5

MP 4.1 Tue 16:15 MP-H5

Wormholes from Berry phases in AdS_3/CFT_2 — Souvik Banerjee, Moritz Dorband, Johanna Erdmenger, René Meyer, and •Anna-Lena Weigel — Institute for Theoretical Physics and Astrophysics and Würzburg-Dresden Cluster of Excellence ct.qmat, Julius-Maximilians-Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

The AdS/CFT correspondence states that certain CFTs admit a description in terms of a gravitational theory in asymptotically AdS geometries of one dimension more. A central question in understanding the mechanism behind the duality is how the geometry in the bulk spacetime is encoded in the dual CFT state. Berry phases present a useful tool for understanding this. In their most general form, Berry phases are geometric phases acquired by states due to the presence of holonomies when parallel transported around a closed loop in parameter space. The AdS/CFT correspondence admits the description of bulk geometries with semi-classical spacetime wormholes in terms of two entangled CFTs. Wormholes are a topological feature of the bulk spacetime that presents as a holonomy and thus can be probed with Berry phases. The entanglement induced by the wormhole in the bulk geometry implies the dual CFTs no longer factorize. We show that non-factorization in the dual entangled CFTs is evident in Berry phases for such systems. We briefly discuss further applications of Berry phases for probing spacetime holonomies in geometries without wormholes and their CFT interpretation.

MP 4.2 Tue 16:35 MP-H5

Quantum Complexity as Hydrodynamics — •Pablo Basteiro[1,2], Johanna Erdmenger[1,2], Pascal Fries[1], Florian Goth[1,2], Ioannis Matthaiakakis[1,2], and René Meyer[1,2] — [1]Institut für Theoretische Physik und Astrophysik, Julius-Maximilians-Universität Würzburg, 97074 Würzburg, Germany — [2]Würzburg-Dresden Cluster of Excellence ct.qmat

In recent years, many concepts of quantum information theory have been introduced to the AdS/CFT correspondence and have lead to several meaningful insights. In particular, quantum computational complexity has been suggested as a candidate to describe the late-time behavior of black hole interiors. We contribute to its understanding by considering Nielsen's geometric approach to operator complexity for the $SU(N)$ group. We develop a tractable large N limit which leads to regular geometries on the manifold of unitaries. To achieve this, we introduce a particular basis for the $\mathfrak{su}(N)$ algebra and define a maximally anisotropic metric with polynomial penalty factors. We implement the Euler-Arnold approach to identify incompressible inviscid hydrodynamics on the two-torus as a novel effective theory for the evaluation of operator complexity of large qudits. We discuss the resulting complexity geometry in view of essential properties of holographic complexity measures, such as ergodicity and conjugate points.

MP 4.3 Tue 16:55 MP-H5

The free energy of the two-dimensional dilute Bose gas — •Andreas Deuchert[1], Simon Mayer[2], and Robert Seiringer[2] — [1]Institute of Mathematics, University of Zurich — [2]Institute of Science and Technology Austria (IST Austria)

We prove bounds for the specific free energy of the two-dimensional Bose gas in the thermodynamic limit. We show that the free energy at density ϱ and inverse temperature β differs from the one of the non-interacting system by the correction term $4\pi\varrho^2|\ln(a^2\varrho)|^{-1}(2-[1-\beta_c/\beta]_+^2)$. Here a is the scattering length of the interaction potential, $[x]_+ = \max(0,x)$ and β_c is the inverse Berezinskii–Kosterlitz–Thouless critical temperature for superfluidity. The result is valid in the dilute limit $a^2\varrho \ll 1$ and if $\beta\varrho \gtrsim 1$.

MP 4.4 Tue 17:15 MP-H5

Analytical and numerical methods for nonlinear diffusive transport and shock acceleration — •Dominik Walter[1], Horst Fichtner[1], Frederic Effenberger[1], and Yuri Litvinenko[2] — [1]Ruhr-Universität-Bochum; Institut theoretische Physik IV — [2]University of Waikato, Department of Mathematics, New Zealand

We explore a nonlinear diffusive type of particle/cosmic ray transport. A special focus will be put on particles/cosmic rays, escaping from a shock or other localized acceleration sites and their acceleration process. Instead of solving coupled differential equations, as is the more common method of describing the interaction of diffusing particles with the backgrond medium, we analyse a single nonlinear advection-diffusion equation. In a first step we analyse the effect of the nonlinear model on particle transport, we apply an analytical expansion technique to cartesian and spherical symetrical geometries, to derive approximate solutions to the resulting equations and establish numerical models to compare and expand on this results. As a foundation for the numerical models we use the grid based Code VLUGR3, to provide numerical solutions, when there is no analytical way of solving distinct models. As a second step we construct a model for shock acceleration, to investigate the impact of nonlinear diffusion on shock acceleration, again using VLUGR3. We recreate a linear cartesian case of reference and use it as a groundwork to investigate the effects of nonlinearity.

MP 4.5 Tue 17:35 MP-H5

Electrons and their interactions: A deduction from Quantum Field Theory — •Nadine Cetin and Nils Schopohl — Institut für Theoretische Physik, Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen

We suggest a new unitary transformation of the fundamental electron-positron field theory Hamiltonian of Quantum Electrodynamics (QED), that brings with help of Wegner's flow equation method this Hamiltonian to a block-diagonal form, each block labeled by an eigenvalue of the operator $\hat{N} = \hat{N}^{(e)} + \hat{N}^{(p)}$, with $\hat{N}^{(e)}$ counting the number of electrons and $\hat{N}^{(p)}$ counting the number of positrons, while keeping all interactions with with long wavelength photons $\lambda_{ph} \gg \frac{h}{m_e c}$ intact. A representation of that block-diagonal Hamiltonian as a perturbation series with regard to the fine structure constant $\alpha_{FS} \approx \frac{1}{137}$ establishes to order α_{FS}^2 the well known gauge invariant and particle number conserving Hamiltonian for nonrelativistic electrons and positrons in its second quantized guise. Our derivation of the effective two-particle interactions between particles carrying mass, charge and spin while moving at nonrelativistic speed arises directly from QED throughout treating electron fields and positron fields in an entire symmetrical fashion. Similarities and salient contrast with related early work of Cohen-Tannoudji et al., Takashi Itoh and I. Bialynicki-Birula are discussed in detail.

MP 4.6 Tue 17:55 MP-H5

Recenr Results on Quantum Spin Glasses — •Chokri Manai[1], Simone Warzel[1], Hajo Leschke[2], and Rainer Ruderer[2] — [1]Department of Mathematics, TU München, Garching bei München, Germany — [2]Institut für Theoretische Physik, FAU Erlangen, Erlangen, Germayn

In the past few decades, the theory of spin glasses has become a major field of interest in condensed matter physics, mathematical physics and proabbility theory. While in the classical spin glass theory many problems remain unsolved, at least a rough understanding of the underlying physics has been established. The milestone so far has been the derivation of a formula for the free energy in the classical Sherrington-Kirkpatrick model by this year's Nobel price winner Giorgio Parisi based on his replica method and its rigorous proof by Guerra and Talagrand.

The situation is vastly different for quantum spin glasses, where quantum effects are for example incorporated via a transversal field. In this case no closed formula has been found for the Quantum SK-model; and most physical results are based on numerical simulations. In this talk, I will give an introduction to the topic of quantum spin glasses. I will discuss recent results on hierarchical Quantum spin glasses, where one can rigorously prove a formula for the free energy. Moreover, we will have a quick look on the Quantum SK model, where one can at least prove the existing of replica symmetry breaking.

MP 4.7 Tue 18:15 MP-H5

Local composite operators in the Sine-Gordon model — Daniela Cadamuro and •Markus B. Fröb — Institut für Theoretische Physik, Universität Leipzig

The Sine-Gordon model is a widely studied two-dimensional quantum field theory, which depending on the value of the coupling β is finite (for $\beta^2 < 4\pi$), super-renormalizable ($4\pi \leq \beta^2 < 8\pi$) or just renormalizable ($\beta^2 = 8\pi$). However, local composite operators have not been studied in the theory, apart from a few simple examples. We show that even in the finite range $\beta^2 < 4\pi$ composite operators need additional renormalization beyond the free-field normal-ordering at each order in perturbation theory, and prove convergence of the renormalized perturbative series.

MP 5: Quantum information

Time: Wednesday 11:00–12:30 Location: MP-H5

Invited Talk MP 5.1 Wed 11:00 MP-H5

Falling through masses in superposition: quantum reference frames for indefinite metrics — Anne-Catherine de la Hamette[1,2], Viktoria Kabel[1,2], Esteban Castro-Ruiz[3], and •Caslav Brukner[1,2] — [1]Institute for Quantum Optics and Quantum Information, Vienna, Austria — [2]Faculty of Physics, University of Vienna, Vienna, Austria — [3]Institute for Theoretical Physics, ETH Zürich, Zürich, Switzerland

The current theories of quantum physics and general relativity on their own do not allow us to study situations in which the gravitational source is quantum. In my talk, I will propose a strategy to determine the dynamics of objects in the presence of mass configurations in superposition, and hence an indefinite spacetime metric, using quantum reference frame (QRF) transformations. Specifically, I will show that as long as the mass configurations in the different branches are related via isometries, one can use an extension of the current framework of QRFs to "quantum isometries" to change to a frame in which the mass configuration becomes definite. Assuming covariance of dynamical laws under quantum coordinate transformations, this allows to use known physics to determine the dynamics. I will apply this procedure to find the motion of a probe particle and the behavior of clocks near the mass configuration, and thus find the time dilation caused by a gravitating object in superposition.

MP 5.2 Wed 11:30 MP-H5

Exploiting Graph Symmetries for Quantum Dynamics — Armin J. Römer[1,2], Emanuel Malvetti[1,2], Robert Zeier[3], and •Thomas Schulte-Herbrüggen[1,2] — [1]Technical University of Munich (TUM) — [2]Munich Centre for Quantum Science and Technology (MCQST) and Munich Quantum Valley (MQV) — [3]Forschungszentrum Jülich GmbH, Peter Grünberg Institute, Quantum Control (PGI-8)

Systems of coupled spins can easily be represented by coloured graphs, where the vertices relate to the local spins while the edges stand for pairwise couplings of different type (colour). Potential graph symmetries then naturally simplify quantum dynamics in terms of generators.

We present the background for an efficient algorithmic way to exploit the graph symmetry for arriving (automatically) at a symmetry-adapted basis. It avoids explicit calculation of the entire underlying graph automorphism groups (usually taking the form of wreath products of permutation groups). It connects the well-known Weisfeiler-Leman algorithm (occurring in the context of graph isomorphism problems) with cutting-edge versions of calculating central and orthogonal idempotents.

Worked examples illustrate principles and practice as well as the advantageous connections to graph theory in a widely applicable manner.

MP 5.3 Wed 11:50 MP-H5

Markovian Quantum Systems with Full and Fast Hamiltonian Control — •Emanuel Malvetti[1,2], Frederik vom Ende[1,2], Thomas Schulte-Herbrüggen[1,2], and Gunther Dirr[3] — [1]Dept. Chem., TU-München (TUM) — [2]Munich Centre for Quantum Science and Technology (MCQST) and Munich Quantum Valley (MQV) — [3]Institute of Mathematics, Universität Würzburg

Markovian quantum systems with full and fast Hamiltonian control can be reduced to an equivalent control system on the eigenvalues of the density matrix describing the state. First we consider the case of a single qubit, presenting explicit solutions of the optimal control problem for a large family of Lindblad operators. For the cases where analytic solutions seem out of reach, we can still efficiently compute numerical solutions. Second we consider quantum systems of arbitrary finite dimension. While analytic solutions to optimal control problems do not exist in the general case, the reduced control system on the eigenvalues is still a powerful tool. As an example, we derive necessary and sufficient conditions for a Markovian quantum system to be coolable.

MP 5.4 Wed 12:10 MP-H5

On the Alberti-Uhlmann Condition for Unital Channels — Sagnik Chakraborty[1], Dariusz Chruściński[1], Gniewomir Sarbicki[1], and •Frederik vom Ende[2,3] — [1]Institute of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus University, Grudziadzka 5/7, 87-100 Toruń, Poland — [2]Department of Chemistry, Technische Universität München, 85747 Garching, Germany — [3]Munich Centre for Quantum Science and Technology & Munich Quantum Valley, Schellingstr. 4, 80799 München, Germany

We address the problem of existence of quantum channels between two sets of density matrices. We refine the result of Alberti and Uhlmann and derive a necessary and sufficient condition for the existence of a unital channel between two pairs of qubit states which ultimately boils down to three simple inequalities.

MP 6: Mathematical physics

Time: Wednesday 16:15–16:45 Location: MP-H5

Invited Talk MP 6.1 Wed 16:15 MP-H5

State sum models with defects — •Catherine Meusburger — Department Mathematik, FAU, Cauerstr. 11, 91058 Erlangen

State sum models arise in topological quantum field theories, quantum topology, 3d quantum geometry, in the quantisation of Chern-Simons gauge theories and are also closely related to topological models in condensed matter physics such as Kitaev's quantum double model and Levin-Wen models. The inclusion of defects into such models is of interest in several of these research fields.

In the talk I introduce a model that includes defects in Turaev-Viro-Barrett-Westbury state sum models. It involves defect surfaces, defect lines and defect points decorated with higher categorical data and yields topological invariants.

MP 7: Quantum field theory

Time: Wednesday 16:45–18:45 Location: MP-H5

MP 7.1 Wed 16:45 MP-H5

Fermionic integrable models and graded Borchers triples — •Henning Bostelmann[1] and Daniela Cadamuro[2] — [1]University of York, Department of Mathematics, York YO10 5DD, United Kingdom — [2]Universität Leipzig, Institut für Theoretische Physik, Brüderstraße 16, 04103 Leipzig, Germany

The operator-algebraic construction of 1+1-dimensional integrable quantum field theories has received substantial attention over the past decade. These models are characterized by their asymptotic particle spectrum and their two-particle S-matrix; so far, those particles have been bosonic. By contrast, we consider the case of asymptotic fermions. Abstractly, they arise from a grading of the underlying operator algebraic structures (Borchers triples). Many of the technical methods required can be carried over from the bosonic case, *mutatis mutandis;* most importantly, existing results on the technically hard part of the construction (i.e., establishing the modular nuclearity condition) do not require modification.

Thus we are lead to a new family of rigorously constructed quantum field theories which are physically distinct from the bosonic case (with a different net of local algebras and a different scattering theory). Their local operators fulfill modified form factor axioms, consistent with the physics literature.

MP 7.2 Wed 17:05 MP-H5

Interacting massless infraparticles in 1+1 dimensions — •Wojciech Dybalski[1] and Jens Mund[2] — [1]AMU Poznań — [2]Universidade Federal de Juiz de Fora - UFJF

The Buchholz' scattering theory of waves in two dimensional massless models suggests a natural definition of a scattering amplitude. We computed such a scattering amplitude for charged infraparticles that live in the GNS representation of the 2d massless scalar free field and obtained a non-trivial result. It turns out that these excitations exchange phases, depending on their charges, when they collide. Perspectives for obtaining a similar effect in higher dimensions will also be discussed.

MP 7.3 Wed 17:25 MP-H5

Quantum energy inequalities in integrable QFT models — •Jan Mandrysch — Institut für theoretische Physik, Leipzig

Many results in general relativity rely crucially on classical energy conditions imposed on the stress-energy tensor. Quantum matter, however, violates these conditions since its energy density can become arbitrarily negative at a point. Nonetheless quantum matter should have some reminiscent notion of stability, which can be captured by the so-called quantum (weak) energy inequalities (QEIs), lower bounds of the smeared quantum-stress-energy tensor. QEIs could be proven in many free quantum field theory (QFT) models on both flat and curved spacetimes. In interacting theories only few results exist. We are here presenting numerical and analytical results on QEIs in interacting integrable QFT models in 1+1 dimension, in particular the O(N)-nonlinear-sigma model at 1-particle level.

MP 7.4 Wed 17:45 MP-H5

Dyson-Schwinger Equations in Tensorial Φ^4 Theory — •Johannes Thürigen — Mathematisches Institut der Westfälischen Wilhelms-Universität, Münster, Deutschland

In quantum field theory, the Connes-Kreimer Hopf algebra captures not only the structure of perturbative renormalization but allows also to describe the non-perturbative regime in terms of "combinatorial" Dyson-Schwinger equations. This algebra generalizes from usual Feynman diagrams to "strand graphs", the combinatorial objects underlying a broad class of non-local theories, in particular tensorial field theory. Here we show how this can be used to derive Dyson-Schwinger equations in the case of Φ^4 theory with tensorial interactions.

MP 7.5 Wed 18:05 MP-H5

Dyson series approach for understanding quadratic interactions — •Ayush Paliwal[1] and Karl Henning Rehren[2] — [1]Institut für Theoretische Physik, Universität Göttingen — [2]Institut für Theoretische Physik, Universität Göttingen

We analyze for general quadratic interactions whether, and in which sense, the two point function of the perturbed field, written in terms of the unperturbed field as a Dyson expansion, taken in the vacuum state of the unperturbed field, converges to the vacuum state of the perturbed field when the adiabatic limit is taken. The answer is affirmative in a number of simple cases, where the perturbed field is explicitly known. The result is not in conflict with Haag's theorem. It suggests to use the same method to compute the two-point function in some cases of interest where the perturbed field is not known.

MP 7.6 Wed 18:25 MP-H5

A C^*-algebraic approach to the classical limit of quantum systems — •Christiaan van de Ven[1] and Valter Moretti[2] — [1]Max Planck Institute for Mathematics in the Sciences, Leipzig,Germany — [2]Università di Trento, Trento, Italy

Quantization refers to the passage from a classical to a corresponding quantum theory. The converse problem, called the classical limit of quantum theories, is considered as a much more difficult issue and poses an important question for various areas of modern mathematical physics.

In this talk I will present this notion, first by introducing a natural framework based on the theory of deformation quantization. Subsequently, I will show that this setting is perfectly suitable to model the classical limit of quantum theories. More precisely, the corresponding quantization maps allow us to take the limit for $\hbar \to 0$ of a suitable sequence of algebraic states induced by $\hbar$-dependent eigenvectors of several quantum models, in which the sequence converges to a probability measure on the pertinent phase space.

In addition, since this C^*-algebraic approach allows for both quantum and classical theories, it provides a convenient way to study the theoretical concept of spontaneous symmetry breaking (SSB) as an emergent phenomenon when passing from the quantum realm to the classical world by switching off the semi-classical parameter $\hbar$. This is illustrated for several physical models, e.g. Schrödinger operators and mean-field quantum spin systems.

MP 8: Alternative approaches

Time: Wednesday 17:25–18:25 Location: MP-H6

MP 8.1 Wed 17:25 MP-H6

Speicherung elektrischer Energie — •Roland Renz — 96138 Burgebrach Treppendorf 38

Unter Vernachlässigung der elektischen Verschiebungsstromdichte ist das Maxwellsche Gleichungssystem analytisch gelöst worden. Die neue Lösung ist zugeschnitten auf einen großen Bereich von elektromagnetischen Randbedingungen, inclusive der von DC- und AC-Betrieb. Man kann diese analytische Lösung auf das älteste Problem der Energietechik anwenden, der Speicherung von elektrischer Energie. Dazu nutzen wir die in elektrischen Maschinen rotatorisch erzeugte Spannung, die jetzt analytisch berechnet werden kann. Diese rotatorisch erzeugte Spannung beruht auf der räumlich verteilten elektrischen Feldstärke, die aus einem Vektorprodukt entsteht, gebildet aus der Umlaufgeschwindigkeit des koaxialen Kondensators und der ruhenden axialen magnetischen Induktion einer DC-Spule. Die so erzeugte räumliche E-Feldstärke ist radial gerichtet und überlagert das elektrische Feld des geladenen koaxialen Kondensators. Die resultierende E-Feldstärke bestimmt die Spannung am Kondensator. Mit Hilfe des analytischen Durchgriffs optimieren wir die Maschine bezüglich aller Parameter. Wir berechnen die elektrische Ladung des Kondensators durch eine zeitliche Integration des Ladestroms, der bestimmt ist durch die Spannungsdifferenz von aktueller Kondensatorspannung und aktueller DC-Busbar-Spannung. Regelungstechnisch gesehen hat der so gebaute elektrische Energiespeicher integrale Eigenschaften, die notwendig sind, um ein HGÜ-Netz sicher und sehr stabil machen zu können.

MP 8.2 Wed 17:45 MP-H6

Physik und Sehgewohnheiten — •Helmut Hille — Fritz-Haber-Straße 34, 74081 Heilbronn

Es ist eine Sehgewohnheit, getrennt Gesehenes als getrennt Existierendes einzustufen, Das kann für das Überleben nützlich sein, können wir doch dadurch Einzelnes besser fokussieren. Aber was ist z.B. mit Erde, Sonne und Mond? Reagieren sie nicht als ein Ganzes? Das Wasser der Meere türmt sich in Richtung Mond. Und wenn Mond und Sonne in einer Linie stehen gibt es die gefürchtete Springflut. Und so ist es doch mit allen kosmischen Objekte, die ewig umeinander herumtanzen und um ein geheimes Zentrum kreisen. Keines täte es von sich aus. Einstein sagte: *Es gibt keine Fernwirkungen* Richtig! Die Dinge sind sich nicht fern, wir sehen sie nur so! Alles wurde beim Urknall miteinander verschränkt und reagiert dadurch von Anfang an als ein Ganzes. Wir nennen die Kraft die dies bewirkt Schwerkraft oder Gravitation, Das Problem der Fernwirkungen erledigt sich so ohne jede Hypothese, allein durch Beachtung unserer Sehgewohnheit. Ebenso ist es mit dem Problem der Bewegung bei Unbelebten, was näher ausgeführt wird. So wie wir Biologie und Physik unterscheiden müssen, so müssen wir die *Bewegung* von Belebten und Unbelebten unterscheiden, wollen wir physikalische Objekte angemessen verstehen.

MP 8.3 Wed 18:05 MP-H6

Die Vereinigung der vier Grundkräfte der Natur — •Adolf Bablitzka — Alpenblick 6, 88682 Salem, Baden

Der Vortrag beschreibt die Vereinigung der vier Grundkräfte der Natur durch Einführung der von mir sog. Planckkraft

Kou = h * c / Oo aus Oo = G * h / (c * c * c),

sowie der Einführung der Spannung Uo mit Ersatz von ec durch eo.

Es werden Terme vorgeschlagen, die alle genannten Naturkonstanten mit beliebiger Genauigkeit ermitteln lassen.

MP 9: Quantum gravity (joint session MP/GR)

Time: Thursday 11:00–12:40 Location: MP-H5

Invited Talk MP 9.1 Thu 11:00 MP-H5

Reduced phase space quantisation in Loop quantum gravity and loop quantum cosmology — •Kristina Giesel[1], Bao-Fei Li[2], and Parampreet Singh[2] — [1]Institute for Quantum Gravity, Department of Physics, FAU Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen, Germany — [2]Department of Physics and Astronomy, Louisiana State University, Baton Rouge, LA 70803, USA

In this talk an overview over results that apply a reduced phase space quantisation to formulate the dynamics of loop quantum gravity and loop quantum cosmology will be presented. It will be briefly discussed how a reduced phase space for GR can be derived by coupling additional reference matter. The reduced phase space for GR is taking as a starting point for a loop quantisation either in full LQG or in the symmetry reduced case of LQC. Different choices of reference matter yield in general different quantum models and several existing models will be compared. In the framework of LQC it will be analysed how different choices of reference matter can lead to different physical properties of the models and it will be discussed what kind of conditions appropriate reference matter should satisfy in this context.

Invited Talk MP 9.2 Thu 11:30 MP-H5

Quantum fields propagating on curved backgrounds and their influence on spacetime curvature — •Nicola Pinamonti — Department of Mathematics, University of Genova, Italy

We shall review the theory of quantum fields propagating on curved backgrounds in the semiclassical approximation. Within this approximation matter is described by quantum fields propagating on a classical curved spacetime and their influence on spacetime curvature is taken into account by means of semiclassical Einstein equations. Typical known effects in this approximation are particle creation on cosmological spacetime, Hawking radiation in the case of black hole backgrounds and their evaporation. The semiclassical analysis we would like to present requires a careful study of the form of the correlation functions of the state which describes matter. The thorough analysis of their ultraviolet divergences and their renormalization is necessary to obtain meaningful expressions for the expectation values of the matter stress energy tensor. The resulting stress energy tensor will have non-trivial effects on the curvature on cosmological spacetimes too. In the latter case, semiclassical Einstein equations give origin to a well posed dynamical system provided the quantum state for matter is chosen in an appropriate way. The question of existence of exact solutions of such system will be discussed and some implication for cosmology will be presented. In the case of black hole physics, exploiting the stress tensor properties, we will give a local model of black hole evaporation.

MP 9.3 Thu 12:00 MP-H5

A master equation for gravitationally induced decoherence of a scalar field — •Max Joseph Fahn, Kristina Giesel, and Michael Kobler — Institute for Quantum Gravity, Department of Physics, FAU Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen, Germany

In the talk, we present the derivation of a decoherence model containing a scalar field coupled to a gravitational environment. With such a model, one can predict quantum gravity effects in the scalar field's dynamics that arise due to the presence of gravity. Starting with full general relativity in Hamiltonian form expressed in Ashtekar's connection formulation, we focus on weak gravitational interactions in an asymptotically flat universe, modelled by gravitational waves propagating on a fixed background, and the scalar field as matter component. Firstly, we construct appropriate observables (gauge invariant quantities) for the model which become elementary variables in the reduced phase space of the model. Afterwards a reduced phase space quantisation using Fock quantisation is performed. With the help of the projection operator technique, we derive a second order time-convolutionless master equation, that is an effective evolution equation which predicts the temporal evolution of the scalar field, including the gravitational interaction effectively in terms of certain operators, whose form is a result of the model under consideration and several physical assumptions. These additional terms lead to physical effects like dissipation or decoherence of the matter field induced by gravity. Finally, we briefly discuss possible applications of the model's master equation.

MP 9.4 Thu 12:20 MP-H5

Quantum (supersymmetric) black holes in loop quantum gravity — •Konstantin Eder — FAU Erlangen-Nürnberg

Black holes are immediate and unavoidable consequences of Einstein's theory of gravity whose existence nowadays has been confirmed with remarkable accuracy. Albeit leading to a huge success of the theory, there are also various open questions that point out its incompleteness. One of them is about the huge amount of microstates needed to explain the entropy of black holes as predicted by Bekenstein and Hawking: What are these micostates? Answering it poses a challenge for any formulation for quantum theory of gravity. In loop quantum gravity a very intriguing picture has been developed that suggests an answer in terms of topological Chern-Simon degrees of freedom induced by quantized geometry on the horizon. In this talk, we first give a general review on the description of black hole horizons in LQG. Then, we will give an outlook on recents results towards their generalization to the supersymmetric context. There, it turns out, using tools from super Cartan geometry, that the unique boundary theory in chiral supergravity corresponds to that of a super Chern-Simons theory. This enables one to transfer ideas from the bosonic to the supersymmetric setting.

MP 10: Classical and quantum gravity

Time: Thursday 16:15–17:15 Location: MP-H5

MP 10.1 Thu 16:15 MP-H5

Space - Time - Matter: Finite Projective Geometry as a Quantum World with Elementary Particles — •Klaus Mecke — Institut für Theoretische Physik, Universität Erlangen-Nürnberg

A unified theory for space-time and matter might be based on finite projective geometries instead of differentiable manifolds and fields. In contrast to general relativity the metric is given over a finite Galois field which defines neighbors in the finite set of points. Due to the projective equivalence of all quadratic forms in finite projective geometries this world exhibits necessarily a 4-dimensional, locally Lorentz-covariant space-time with a gauge symmetry G(3)xG(2)xG(1) for points at infinity which represent elementary particle degrees of freedom. Thus, matter appears as a geometric distortion of an inhomogeneous field of quadrics and physical properties of the standard model such as spins and charges seem to follow from its finite geometric structure in a continuum limit. The finiteness inevitably induces a fermionic quantization of all matter fields and a bosonic for gauge fields. The main difference to Einstein's general theory of relativity is the use of finite fields instead of real numbers to parametrize points of events.

K. Mecke, Biquadrics configure finite projective geometry into a quantum spacetime, EPL 120, 10007 (2017).

MP 10.2 Thu 16:35 MP-H5

On consistent gauge-fixing conditions in polymerized gravitational systems — Kristina Giesel[1], Bao-Fei Li[2], Parampreet Singh[2], and •Stefan Andreas Weigl[1] — [1]Institute for Quantum GravityDepartment of Physics, Theoretical Physics III, FAU Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen, Germany — [2]Department of Physics and Astronomy, Louisiana State University, Baton Rouge, LA 70803, USA

Gauge fixing is a standard method for deriving the physical sector of a gauge theory. In the context of symmetry reduced models of loop quantum gravity a polymerisation has been applied to gauge fixed models to obtain so called effective theories that mimic the underlying quantum theory to some extend. Motivated from the question whether gauge fixing and polymerization commute, in this talk we will discuss the subtleties of implementing dynamical consistent gauge fixings in the effective theory and present a procedure to determine in a given model the effective lapse and shift. Although we can proof for a range of models that gauge fixing and polymerization does indeed commute and discuss consequences, for most models in the literature this is not the case. We further discuss how for a given choice of effective lapse and/or shift one can obtain a corresponding gauge fixing condition and show that in general this requires non-standard polymerisations or gauge fixing conditions with different classical limits. Based on these results we will then conclude with a discussion of some models from the literature.

MP 10.3 Thu 16:55 MP-H5

Local normal forms for Riemannian metrics with infinitesimal symmetries of their pre-geodesics. — •Andreas Vollmer — Corso Duca degli Abruzzi, 24, 10129 Torino TO Italy

Projective vector fields are infinitesimal symmetries that preserve pregeodesics, i.e. geodesics up to reparametrisation. A classical problem formulated by Sophus Lie is to describe the local metrics that admit such symmetries.

The list of local normal forms in dimension two has only recently been established, by Aminova (1990, 2003), Bryant-Manno-Matveev (2009), Matveev (2012) and Manno-V (2020). In joint work with G. Manno, we have recently derived such a list for dimension three, too (arXiv:2110.06785). The talk will provide an overview of the normal forms and their projective symmetry algebras, and will explain the techniques used to obtain them.

MP 11: Thermodynamics and fundamental aspects of field theory

Time: Thursday 16:35–18:15 Location: MP-H6

MP 11.1 Thu 16:35 MP-H6

Relation between the Cartesian multipole expansion and the spherical harmonic expansion — •Nils Walter Schween and Brian Reville — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, Heidelberg 69117, Germany

The multipole expansion, which is, for example, used to approximate an electrostatic potential (or a gravitational potential), has two equivalent forms. First, it is a Taylor expansion, i.e.

$$4\pi\epsilon_0\phi(\mathbf{r}) = \int \frac{\rho(\mathbf{r}')}{|\mathbf{r}-\mathbf{r}'|}\,\mathrm{d}r'^3 = \sum_{l=0}^{\infty}\frac{1}{l!}\frac{r^{i_1}\cdots r^{i_l}\mathbf{Q}_{i_1\cdots i_l}}{r^{2l+1}}\,.$$

Note the Einstein summation convention. Secondly, it is a spherical harmonic expansion, i.e.

$$4\pi\epsilon_0\phi(\mathbf{r}) = \sum_{l=0}^{\infty}\sum_{m=-l}^{l}\frac{4\pi}{2l+1}q_l^m\frac{r^l Y_l^m(\theta,\varphi)}{r^{2l+1}}\,.$$

We show that the relation between these two expansions can be formalised as a series of basis transformations of spaces of homogeneous polynomials of increasing degree l. These basis transformations allow us to derive an algorithm to express the components of the multipole tensors, i.e. $\mathbf{Q}_{i_1\cdots i_l}$, as linear combinations of the spherical multipole moments q_l^m for an arbitrary degree l. Since the spherical multipole moments are

$$q_l^m := \int Y_l^{m*}(\theta,\varphi)r'^l\rho(\mathbf{r})\,\mathrm{d}r'^3\,,$$

this opens the opportunity to compute $\mathbf{Q}_{i_1\cdots i_l}$ solving the above integral instead of performing the derivatives and integrations needed to compute the multipole tensor components directly.

MP 11.2 Thu 16:55 MP-H6

On the unification of mechanics and thermodynamics — •Grit Kalies — HTW University of Applied Sciences, Dresden, Germany

Mechanics and thermodynamics (TD) are usually considered to be unified. This view is based on the work of Clausius and Boltzmann [1, 2], who attributed the behavior of complex systems to idealized moved material points. Nevertheless, mechanics and TD have been incompletely unified so far. They are taught separately, use different types of energy, namely the external and internal energy, and while the equations of mechanics, relativistic mechanics, and quantum mechanics are invariant under time reversal, those of TD are not.

Based on recent work [3-6], a unified formulation of mechanical and thermodynamic process equations is presented: The internal and external energies of an object are described in a unified manner. The equation of the ideal gas is derived in a simple way using process equations. Force, entropy, chemical potential, Gibbs free energy and other state variables are vividly interpreted at the fundamental level. The findings, consistent with experiment, enable a realistic and causal quantum physics and cosmology to be developed.

[1] R. Clausius, Pogg. Ann. 142 (1871) 433-461; [2] L. Boltzmann, Sitzungsber. kaiserl. Akad. Wiss. Wien 66 (1872) 275-370; [3] G. Kalies, Z. Phys. Chem. 234 (2020) 1567-1602; [4] G. Kalies, Z. Phys. Chem. 235 (2021) 849-874; [5] G. Kalies: Back to the roots: The concepts of force and energy, Z. Phys. Chem. (2021) 1-53; DOI: 10.1515/zpch-2021-3122;[6] G. Kalies: On the unification of mechanics and thermodynamics, submitted (2021).

MP 11.3 Thu 17:15 MP-H6

The fundamental role of the proper time parameter in general relativity and in quantum mechanics — •René Friedrich — Strasbourg

Special relativity provides time with a precise physical concept, splitting the absolute Newtonian time into two different time concepts, proper time and coordinate time: In a first step, time is generated by rest energy, in the form of the proper time parameter of a worldline of a particle, and in a second step, the worldline is observed, by measuring the corresponding coordinate time parameter of the observer. Conversely, from the observed coordinate time we may retrieve by calculation the underlying proper time of the worldline. Proper time is time before time dilation, and coordinate time is time after time dilation. This is why for fundamental, unresolved questions about time we should not refer to the coordinate time parameter of spacetime but to the more fundamental parameter of proper time.

MP 11.4 Thu 17:35 MP-H6

Electrodynamics and the Isoclinic Decomposition of SO(4) — •Alexander Unzicker — Pestalozzi-Gymnasium München

According to William Rowan Hamilton, quaternions are a 'fundamental building block of the physical universe'. By visualizing unit quaternions with the stereographic projection, it is shown that unit quaternions display many characteristic features of electrodynamics. The question as to the origin of this interaction thus might be approached with an alternative description of spacetime by means of quaternions.

MP 11.5 Thu 17:55 MP-H6

On Negative Mass, Dark Energy and Dark Matter — •Antoine A.J. van de Ven — Alumnus of Utrecht University, P.O. Box 19027, 3501 DA, Utrecht, The Netherlands

Back in 1957 Bondi published about negative mass in general relativity. In 2003 the author published a new formalism and redefinition of mass and energy in which antimatter has negative mass while its energy is still always positive and wrote 'It is predicted that antimatter has antigravitational properties and that antimatter is the dark energy in the universe'. In later presentations it was also further elaborated that this can also explain away dark matter without further assumptions. Antimatter with repulsive gravitational fields surrounding a galaxy will generate an extra inward gravitational force without needing dark matter. This was also presented at 'The Dark Universe Conference' in Heidelberg in 2011 and other places and has been used and cited by others. See the references in [1]. In this presentation an update will be given including an alternative formulation and interpretation of the Dirac equation with quaternions in which negative energies are avoided and in which it is derived that antimatter has negative mass in this formalism.

Reference:

[1] S. Thakur and S. Mukerji, "A Brief Study of the Universe," International Journal of Astronomy and Astrophysics, Vol. 3 No. 2, 2013, pp. 137-152. doi:10.4236/ijaa.2013.32016

MP 12: Quantum field theory for particle physics and plasmas

Time: Thursday 17:15–18:15 Location: MP-H5

MP 12.1 Thu 17:15 MP-H5

Quantum Backreaction in Laser-driven Plasma — Gudrid Moortgat-Pick, Ananta Effendie, and •Victor Rogner — Universität Hamburg

High-intensity laser-matter interactions are of interest for both experimental and theoretical physicists alike. New and more intense lasers could introduce inconsistencies into the classical approach on which the theories of the interactions have been calculated.

In light of new approaches to the quantisation of laser-driven Plasma that do not rely on particle-in-cell codes that are commonly used to model events on the quantum-scale, field theories are constructed through means including various attributes (like multi-particle effects) from the out-set.

In this Talk we will try to enable a better understanding of quantum-field-theory under the constraints given by a uniform plasma. Central to our work, we follow a different Ansatz namely the path integral quantisation of a Bi-Scalar field, which will be constructed through the successive introduction of quantum properties to the classical theory of laser driven plasma.

Starting from the classical equations governing the behaviour of laser-driven Plasma, we will extrapolate equations from the path integral quantisation and in doing so, find linearised field equations for our scalar fields that dictate the dynamics of a monochormatic Laser propagating through a uniform plasma.

We will then compare with results from literature.

MP 12.2 Thu 17:35 MP-H5

Quantum Backreaction in Laser-Driven Plasma — Gudrid Moortgat-Pick, Victor Rogner, and •Ananta Effendie — University of Hamburg

Similarly to the statistical mechanics as they pertain to gases, the sets of mechanics for a plasma will need to be modeled separately from that of other states of matter.

In particular, the electrons behave as if free inside a plasma, the intense laser-pulse interactions of which are of interest in the understanding of a laser-driven plasma. In contrast to the particle-in-cell approach already explored thoroughly and canonized in EPOCH, an approach considering multi-particle effects will yield separate mathematical insights.

The proposed method of integral quantisation utilizes the action in respect to the Lagrangian and allows quantum considerations from quantum-field-theory and quantum-electrodynamics to be introduced, the effects of which are largely ignored through the particle-in-cell approach.

This yields field equations describing a laser-driven plasma, including backreactions of quantum fluctuations, which can be linearised to describe a uniform, monochromatic laser beam propagating through a uniform plasma. The resulting quantum perturbations appear nontrivial.

MP 12.3 Thu 17:55 MP-H5

Higgs Mechanism — •Abhishek Goswami — Adam Mickiewicz University, Poznan, Poland

In the Standard Model of particle physics, the interaction of a particle with the Higgs boson is responsible for its mass generation. This principle is known as the Higgs mechanism. In this talk, I will discuss a rigorous, non-perturbative proof of the Higgs mechanism. I will start with a weakly coupled U(1) Higgs theory on a unit lattice and show the exponential decay of correlations of the observable electromagnetic field strength tensor. This is the mass gap. I will also discuss the application of a new power series cluster expansion to this problem and explain how it provides a clean and simple alternative to decoupling cluster expansions in Constructive QFT.

Reference- Goswami, A. Mass Gap in Weakly Coupled Abelian Higgs on a Unit Lattice. Ann. Henri Poincaré 20, 3955-3996 (2019).

MP 13: Annual General Meeting

Time: Thursday 19:30–20:30 Location: MP-MV

Annual general meeting