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 ZHG001 and ZHG002; Poster ZHG Foyer 1. OG)

Invited Talks

MP 2.1	Tue	13:45–14:15	ZHG001	**Mathematics of moire materials** — •Simon Becker
MP 2.2	Tue	14:15–14:45	ZHG001	**Approaches to Discrete Holography** — •René Meyer, Pablo Basteiro, Giuseppe Di Giulio, Johanna Erdmenger, Zhuoyu Xian, Jonathan Karl, et. al.
MP 4.1	Wed	11:00–11:30	ZHG001	**Focusing dynamics for 2d Bose gases in the instability regime** — •Lea Bossmann
MP 7.1	Wed	16:15–16:45	ZHG001	**How the "gauge principle" derives from physical principles** — •Karl-Henning Rehren
MP 7.5	Wed	17:45–18:15	ZHG001	**A BPS Road to Holography: Decoupling Limits and Non-Lorentzian Geometries** — •Niels Obers
MP 10.1	Thu	14:00–14:30	ZHG001	**Quantum field theory, quantum reference frames and the type of local algebras** — •Christopher Fewster

Invited Talks of the joint Symposium SMuK Dissertation Prize 2025 (SYMD)

See SYMD for the full program of the symposium.

SYMD 1.1	Mon	14:15–14:45	ZHG011	**Fluid-dynamic description of heavy-quark diffusion in the quark-gluon plasma** — •Federica Capellino
SYMD 1.2	Mon	14:45–15:15	ZHG011	**Fast and faithful effective-one-body models for gravitational waves from generic compact binaries** — •Rossella Gamba
SYMD 1.3	Mon	15:15–15:45	ZHG011	**Nuclear Structure Near Doubly Magic Nuclei** — •Lukas Nies
SYMD 1.4	Mon	15:45–16:15	ZHG011	**Optimisation strategies for proton acceleration from thin foils with petawatt ultrashort pulse lasers** — •Tim Ziegler

Invited Talks of the joint Symposium Quantum Mechanics and Gravity: Current Status (SYDK)

See SYDK for the full program of the symposium.

SYDK 1.1	Thu	10:45–11:15	ZHG008	**String Theory at the Edges of Relativity** — •Niels Obers
SYDK 1.2	Thu	11:15–11:45	ZHG008	**The Quantum Einstein Equations in Loop Quantum Gravity** — •Kristina Giesel
SYDK 1.3	Thu	11:45–12:15	ZHG008	**Causal Dynamical Triangulations: Lattice quantum gravity reloaded** — •Renate Loll
SYDK 1.4	Thu	12:15–12:45	ZHG008	**Taming Quantum Gravity: insights from Asymptotic Safety** — •Alessia Platania

Sessions

MP 1.1–1.4	Mon	16:45–18:05	ZHG001	**Quantum Mechanics**
MP 2.1–2.5	Tue	13:45–15:45	ZHG001	**Mathematical Materials Science and AdS/CFT**
MP 3.1–3.4	Tue	16:15–17:35	ZHG001	**Particle Physics and AdS/CFT**
MP 4.1–4.4	Wed	11:00–12:30	ZHG001	**Dynamics and Chaotic Behaviour**

MP 5.1–5.3	Wed	13:45–14:45	ZHG001	**Theory of Machine Learning (joint session MP/AKPIK)**
MP 6	Wed	14:45–15:45	ZHG001	**Members' Assembly**
MP 7.1–7.5	Wed	16:15–18:15	ZHG001	**Quantum Field Theory I and Conformal Field Theory**
MP 8.1–8.4	Wed	16:15–17:35	ZHG002	**Waves, Relativity and Quantization**
MP 9.1–9.4	Wed	16:15–18:15	ZHG Foyer 1. OG	**Poster Session: Many-body Theory**
MP 10.1–10.4	Thu	14:00–15:30	ZHG001	**Operator Algebras**
MP 11.1–11.3	Thu	16:15–17:15	ZHG001	**Quantum Field Theory II**
MP 12.1–12.4	Thu	16:15–17:35	ZHG002	**Concepts of Physics**

Members' Assembly of the Theoretical and Mathematical Physics Division

Wednesday 14:45 - 15:45 ZHG001

- Bericht und Planung
- Aussprache
- Wahl des/der Sprecher:in
- Wahl der Beiratsmitglieder
- Verschiedenes

MP 1: Quantum Mechanics

Time: Monday 16:45–18:05 Location: ZHG001

MP 1.1 Mon 16:45 ZHG001

Advances in quantum dynamics of photons in curved spacetime — •David Edward Bruschi — Institute for Quantum Computing Analytics (PGI-12), Forschungszentrum Jülich, Jülich, Germany

General relativity and quantum mechanics are the two frameworks through which we understand Nature. To date, they have been successful at providing accurate predictions of natural phenomena in their respective domains of validity. Many attempts to find a unified theory of Nature that can describe all of observable phenomena have been tried with varying degrees of success. Regardless, the quest for unification remains open, and therefore continues.

One avenue for investigating the overlap of general relativity and quantum mechanics that is less ambitious but can still provide potentially observable and measurable predictions is that of (low energy) quantum field theory in curved spacetime viewed through the lens of quantum information. In recent years, a great deal of attention has been given to this approach, which has provided novel and intriguing insights into phenomena that can be tested in the laboratory.

We present updates on the investigation into the quantum nature of the gravitational redshift, seeking to understand which are the quantum dynamics that lead to the effective classical observable effect. We present the current state-of-the-art and discuss novel discoveries. We also discuss the place that this avenue of research has in the broader context of relativistic and quantum physics.

MP 1.2 Mon 17:05 ZHG001

Quantum tunneling time via time-of-arrival operators — •Philip Caesar Flores[1], Dean Alvin Pablico[2,3], and Eric Galapon[2] — [1]Max-Born-Institute, Max-Born Straße 2A, 12489 Berlin, Germany — [2]National Institute of Physics, University of the Philippines Diliman, 1101 Quezon City, Philippines — [3]niversity of Northern Philippines, 2700 Vigan City, Ilocos Sur, Philippines

We construct all possible time-of-arrival operators via canonical quantization of the classical time-of-arrival and demonstrate that the tunneling time vanishes for all these operators, regardless of the ordering rule between the position and momentum observables.

MP 1.3 Mon 17:25 ZHG001

The GHZ state and Bohmian positions — •Robert Helling — Ludwig-Maximilians-Universität München

In the Bohmian interpretation, particle positions are realistic that is they have definite values even when not being observed. We realise the GHZ state in terms of position observables at different times and argue that violations of Bell type inequalities pose challenges to this realistic nature of positions. They can be avoided at the price of giving up predictability for outcomes of measurement at multiple times for observables that can be computed with textbook quantum mechanics.

MP 1.4 Mon 17:45 ZHG001

Quantum Analytical Mechanics: What is it and what is it good for? — •Wolfgang Paul — Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06099 Halle

The question whether the Schrödinger equation has to be considered the complete description of (non-relativistic) quantum phenomena or not, has occupied a part of the physics community since the famous controversy between Einstein and Bohr at the 1927 Solvay conference. Based on Nelson's derivation of the Schrödinger equation from the Newtonian dynamics of a time-inversion invariant diffusion process in 1966, by now a complete theory of quantum analytical mechanics has been developed. I will present its structure and discuss applications to the tunneling phenomenon, the dynamic stability of the hydrogen atom in the ground state and the violation of Bell's inequalities in the Einstein-Podolski-Rosen-Bohm thought experiment.

M. Beyer, W. Paul, Foundations of Physics **54**, 20 (2024).

MP 2: Mathematical Materials Science and AdS/CFT

Time: Tuesday 13:45–15:45 Location: ZHG001

Invited Talk MP 2.1 Tue 13:45 ZHG001

Mathematics of moire materials — •Simon Becker — ETH Zurich, CH

We review recent developments in the field of moire materials from a mathematics perspective. Starting from effective one-particle models for magic angle twisted bilayer graphene, we continue to interacting theory and models for twisted semiconductors (TMDs).

Invited Talk MP 2.2 Tue 14:15 ZHG001

Approaches to Discrete Holography — •René Meyer[1], Pablo Basteiro[1], Giuseppe Di Giulio[1,2], Johanna Erdmenger[1], Zhuoyu Xian[1,3], Jonathan Karl[1], and et. al.[1] — [1]Institute for Theoretical Physics and Astrophysics, Julius-Maximilians-Universität Würzburg, 97074 Würzburg — [2]Stockholm University, AlbaNova, 10691 Stockholm — [3]Freie Universität Berlin, Arnimallee 14, 14195 Berlin

I will review recent progress towards a discrete version of the AdS/CFT duality based on hyperbolic lattices. After an introduction to these lattices, I will show that the Breitenlohner-Freedman stability bound for a scalar field on such hyperbolic tilings is unaffected by the type of lattice, and present a realization of this bound in a hyperbolic electric circuit [1]. I will then present simulations [2] of a scalar field on a hyperbolic lattice with a black hole horizon, which successfully recover not only the conformal scaling of two- and three-point functions, but also determine a discretely quantized black hole temperature. In the second part of the talk, I will discuss XXZ type spin chains on the aperiodic space obtained by cutting off a hyperbolic tiling at a large radial distance. I will discuss the emergence of a non-trivial disordered fixed point [3], the logarithmic scaling of the entanglement entropy, and the effective central charge of that fixed point. I will end with an outlook on recent work on aperiodic chains of coupled SYK quantum dots [4]. [1] Phys. Rev. Lett. 130 (9), 2023; [2] Phys. Rev. Lett. 133 (6), 2024; [3] SciPost Physics 13 (5), 2022; [4] 2410.23397.

MP 2.3 Tue 14:45 ZHG001

Random Matrix Universality as a tool in 2d Quantum Gravity: Beyond the orientable case — •Torsten Weber[1], Jarod Tall[2], Fabian Haneder[1], Marco Lents[1], Juan Diego Urbina[1], and Klaus Richter[1] — [1]Universität Regensburg, Regensburg, Deutschland — [2]Washington State University, Pullman, USA

In recent years the discovery of an AdS/CFT-like correspondence of quantum JT gravity and a distinct matrix model has led to an intense cross-fertilisation of the a priori distinct fields of quantum gravity and quantum chaos. In this spirit we use random matrix universality, ubiquitous in quantum chaos, and study its implications on JT gravity. Specifically we focus on the spectral form factor (SFF), a prime example of universality on the matrix model side and thus a key characteristic of quantum chaos. While in the orientable setting the study reveals the perturbative expansion of the SFF in JT gravity to show behaviour non-perturbative from the point of view of random matrices and cancellations within key geometric quantities to match the universal prediction, this becomes even more interesting when including unorientable contributions. This is due to perturbative contributions in this setting, requiring regularisation and being more complicated to compute already, even at the regularisation-independent level showing apparent deviations from the universal prediction. We show how these deviations can be made sense of for the regularisation independent part by employing a bootstrapping-like argument and how this leads to agreement, and thus a strong sign for the presence of chaos, in full unorientable JT gravity.

MP 2.4 Tue 15:05 ZHG001

The chiral SYK model in holography — •Konstantin Weisenberger[1], Alexander Altland[1], Nele Callebaut[1], and Dmitry Bagrets[2] — [1]Universität zu Köln — [2]Forschungszentrum Jülich

We propose a (1+1)-dimensional chiral extension of the SYK model which in the infrared limit is described by the (1+1)-dimensional generalization of the Schwarzian action, namely the Alekseev-Shatashvilli (AS)-action. This action has been proposed to govern boundary gravitons in pure AdS3 gravity, giving our model the interpretation of capturing fluctuations around the BTZ saddle point. From the AS-action, correlation functions of Majorana operators can be calculated by means of Liouville field theory on the hyperbolic disk, where we solve two-point functions and out-of-time-order correlation functions using semi-classical methods. In accordance with general expectations, this theory encodes the vacuum block of a 2d CFT, leading to the expected maximal Lyapunov exponent.

MP 2.5 Tue 15:25 ZHG001

Towards identifying a genus expansion in the Selberg trace formula — •Fabian Haneder, Juan Diego Urbina, Torsten Weber, and Klaus Richter — Universität Regensburg, Regensburg, Deutschland

Jackiw-Teitelboim (JT) gravity has been a useful tool for advancing our understanding of several features believed to be generic in quantum gravity, such as the density of states (exponentially growing for black hole systems), wormholes and topological expansions of the gravitational path integral.

Key progress in doing so has been made using random matrix universality, both for orientable [Saad et al., arXiv:2210.11565, Weber et al., Weber et al., 2023 J. Phys. A: Math. Theor. 56 205206] and unorientable [Weber et al., J. High Energ. Phys. 2024, 267 (2024), Tall et al., arXiv:2411.08129] JT gravity, establishing the quantum chaoticity of the theory. In an effort to go beyond the universal regime, we use periodic orbit theory, which has been used precisely to derive universality, and study non-universal features, for quantum chaotic systems.

After reviewing recent success [Haneder et al., arXiv:2410.02270] in capturing the exact (leading genus) density of states and wormhole amplitude of JT gravity with a single quantum chaotic system, we report on our progress in identifying a topological expansion, reminiscent of the one in JT gravity, in the same system, a particle moving on a high-dimensional hyperbolic manifold. To describe the system, we make use of the Selberg trace formula, which renders periodic orbit theory exact.

MP 3: Particle Physics and AdS/CFT

Time: Tuesday 16:15–17:35 Location: ZHG001

MP 3.1 Tue 16:15 ZHG001

An Effective Hadronic Field Theory for B-Meson Decays at Large Recoil — •Jack Jenkins, Thorsten Feldmann, and Jaime del Palacio Lirola — University of Siegen

We construct an effective hadron Lagrangian for heavy-meson decays into light energetic particles. In this theory the dynamical degrees of freedom are given by quasi-static heavy meson fields coupled to soft and collinear pions, kaons and eta mesons. We give a few examples of how weak-decay operators in soft-collinear effective theory can be represented in the effective hadronic Lagrangian, and discuss potential phenomenological applications.

MP 3.2 Tue 16:35 ZHG001

Composite Higgs models and the AdS/CFT Correspondence — Johanna Erdmenger, Werner Porod, and •Deepali Singh — Julius-Maximilians-Universität Würzburg, Germany

Symmetry groups and their representations play a crucial role in understanding fundamental physics, from particle phenomenology to holographic duality. Symmetries have also given us an insight into solving issues like the hierarchy problem. One such example is the framework of Composite Higgs models which addresses the hierarchy problem by interpreting the Higgs boson as a pseudo-Nambu-Goldstone boson arising from a global symmetry breaking. We will discuss how AdS/CFT offers powerful tools to study Composite Higgs scenarios by leveraging the duality between strongly coupled gauge theories and weakly coupled gravitational theories in one higher dimension. In particular, we will consider models in which the global group SU(4)xSU(4) gets broken to the diagonal SU(4). We will use gauge/gravity duality to calculate the spectrum of bosonic bound states emerging in Composite Higgs models.

MP 3.3 Tue 16:55 ZHG001

Quasi-static time evolution of the speed of sound and sound attenuation in Bjorken expanding holographic plasma — •Matthias Kaminski[1], Jun Zhang[1], Durdana Ilyas[1], Marco Knipfer[2], and Casey Cartwright[3] — [1]University of Alabama, Tuscaloosa, AL, U.S.A. — [2]FAU Erlangen-Nurnberg, Erlangen, Germany — [3]Utrecht University, Utrecht, Netherlands

The speed of sound is a key parameter for characterizing equilibrium states, but sound waves also propagate through media far from equilibrium, such as the quark-gluon plasma created in heavy-ion collisions. Using $\mathcal{N} = 4$ Super-Yang-Mills theory as a toy model, this study numerically explores the time evolution of the speed and attenuation of sound modes in a plasma undergoing a Bjorken expansion after being prepared in a far-from-equilibrium state. These results provide new insights into the dynamic properties of sound modes in anisotropic and rapidly evolving plasma systems.

MP 3.4 Tue 17:15 ZHG001

Three-dimensional gravity as Kodaira-Spencer theory — Johanna Erdmenger, Jonathan Karl, Jani Kastikainen, René Meyer, and •Henri Scheppach — Institut für Theoretische Physik und Astrophysik, Julius-Maximilians-Universität Würzburg, D-97074 Würzburg, Germany

Twisted holography provides a promising framework for exploring holographic dualities beyond the strict large N limit. However, a formulation of the duality in the traditional form is lacking. In this talk, I will present a construction to identify degrees of freedom of three-dimensional gravity in six-dimensional Kodaira-Spencer (KS) theory, featuring prominently in twisted holography. The construction works by embedding solutions of 3D gravity with a negative cosmological constant into a 6D manifold whose complex structure solves the KS equations of motion. This allows us to apply the well-understood holographic dictionary for 3D gravity and 2D conformal field theories to twisted holography. Furthermore, the construction allows for an embedding of black hole geometries into KS theory.

MP 4: Dynamics and Chaotic Behaviour

Time: Wednesday 11:00–12:30 Location: ZHG001

Invited Talk MP 4.1 Wed 11:00 ZHG001

Focusing dynamics for 2d Bose gases in the instability regime — •Lea Bossmann — FAU Erlangen-Nürnberg

We consider the dynamics of a 2d Bose gas with singular attractive interactions in the instability regime, where the corresponding focusing nonlinear Schrödinger equation (NLS) has a blow-up. We show that the evolution of the condensate is effectively described by this NLS for all times before the blow-up. Moreover, we prove the validity of the Bogoliubov approximation for the fluctuation dynamics, resulting in a norm approximation of the many-body dynamics. This is joint work with Charlotte Dietze and Phan Thành Nam.

MP 4.2 Wed 11:30 ZHG001

Chaotic Quantum Scattering and Supersymmetry: Exact Distributions in the Symplectic Case — •Nils Gluth and Thomas Guhr — Universität Duisburg-Essen, Duisburg, Deutschland

Scattering theory is a powerful tool with applications to a large variety of different systems in quantum physics and in the physics of classical waves. Often, such systems are complex or in a broad sense chaotic, calling for statistical approaches, in particular Random Matrix Theory. A few years ago, we put forward a variant of the Supersymmetry method to exactly calculate full distributions of scattering matrix elements and cross sections. Here, we focus on the previously not considered symplectic symmetry class which is relevant for certain spin systems. We exploit similarities in superspace to the unitary as well as to the orthogonal class. We extend and reformulate previous work on the corresponding supermanifolds.

MP 4.3 Wed 11:50 ZHG001

Complex symmetric, self-dual, and Ginibre random matrices: Analytical results for three classes of bulk and edge statistics — •Noah Ayguen — Bielefeld University, Bielefeld, Germany

The energy eigenvalues of chaotic quantum systems are expected to follow random matrix statistics, where closed systems relate to Hermitian random matrices while open systems with complex eigenvalues relate to non-Hermitian matrices. The random matrix model depends on the corresponding symmetry class of the physical systems under consideration. Recently, based on numerics, it has been conjectured that among such classes of non-Hermitian random matrices only three different local bulk statistics of complex eigenvalues exist. Motivated by these new insights, we find new analytic results for expectation values of characteristic polynomials, using the technique of Grassmann variables. The simplest representatives of these 3 bulk statistics are the Gaussian ensembles of well-known complex Ginibre matrices, complex symmetric, and complex self-dual random matrices. In the Cartan classification scheme of non-Hermitian random matrices they are labelled as class A, $\mathrm{AI}^\dagger$ and $\mathrm{AII}^\dagger$, respectively. (Based on joint work with G. Akemann, M. Kieburg, P. Päßler arXiv:2410.21032)

MP 4.4 Wed 12:10 ZHG001

Quantum chaos and complexity from string scattering amplitudes — •Aranya Bhattacharya[1] and Aneek Jana[2] — [1]Institute of Physics, Jagiellonian University, Lojasiewicza 11, 30-348 Krakow, Poland — [2]Centre for High Energy Physics, Indian Institute of Science, C.V. Raman Avenue, Bangalore 560012, India

We introduce Krylov spread complexity in the context of black hole scattering by studying highly excited string states (HESS). Krylov complexity characterizes chaos by quantifying the spread of a state or operator under a known Hamiltonian. In contrast, quantum field theory often relies on S-matrices, where the Hamiltonian density becomes non-trivially time-dependent rendering the computations of complexity in Krylov basis exponentially hard. We define Krylov spread complexity for scattering amplitudes by analyzing the distribution of extrema, treating these as eigenvalues of a fictional Hamiltonian that evolves a thermo-field double state non-trivially. Our analysis of black hole scattering, through highly excited string states scattering into two or three tachyons, reveals that the Krylov complexity of these amplitudes mirrors the behavior of chaotic Hamiltonian evolution, with a pre-saturation peak indicating chaos. This formalism bridges the concepts of chaos in scattering and state evolution, offering a framework to distinguish different scattering processes.

MP 5: Theory of Machine Learning (joint session MP/AKPIK)

Time: Wednesday 13:45–14:45 Location: ZHG001

MP 5.1 Wed 13:45 ZHG001

Time Series Analysis of machine learned Quantum Systems — •Kai-Hendrik Henk and Wolfgang Paul — Martin-Luther-Universität Halle-Wittenberg, Halle(Saale), Deutschland

The Rayleigh-Ritz variation principle is a proven way to find ground states and energies for bound quantum systems in the Schrödinger picture. Advances in machine learning and neural networks make it possible to extend it from an analytical search from a subspace of the complete Hilbert space to the a numerical search in the almost complete Hilbert space. Here, we extend the Rayleigh-Ritz principle to Nelson's stochastic mechanics formulation of non-relativistic quantum mechanics, and propose an algorithm to find the osmotic velocities $u(x)$, which contain the information of a quantum systems in this picture (*Phys. Rev. A 108, 062412*). Motivated by experiments by the Aspelmeyer group at the University of Vienna using quantum levitodynamics (see for example *Nature 595, 373-377 (2021)*), we apply the algorithm to the harmonic oscillator, the Gaussian and the Lorentzian potential and analyze them using methods from time series analysis and phase portraits.

References: *Henk, K.-H., and Paul, W. Machine learning quantum mechanical ground states based on stochastic mechanics. Phys. Rev. A 108 (Dec 2023), 062412*

MP 5.2 Wed 14:05 ZHG001

Opening the Black Box: predicting the trainability of deep neural networks with reconstruction entropy — •Yanick Thurn[1], Ro Jefferson[2], and Johanna Erdmenger[1] — [1]Institute for Theoretical Physics and Astrophysics, Julius-Maximilians-University Wuerzburg — [2]Institute for Theoretical Physics, and Department of Information and Computing Sciences, Utrecht University

An important challenge in machine learning is to predict the initial conditions under which a given neural network will be trainable. We present a method for predicting the trainable regime in parameter space for deep feedforward neural networks (DNNs) based on reconstructing the input from subsequent activation layers via a cascade of single-layer auxiliary networks. We show that a single epoch of training of the shallow cascade networks is sufficient to predict the trainability of the deep feedforward network on a range of datasets (MNIST, CIFAR10, FashionMNIST, and white noise). Moreover, our approach illustrates the networks decision making process by displaying the changes performed on the input data at each layer, which we demonstrate for both a DNN trained on MNIST and the vgg16 CNN trained on the ImageNet dataset.

MP 5.3 Wed 14:25 ZHG001

Analytic continuation of Greens functions with a neural network — •Martin Rackl, Yanick Thurn, Fakher Assaad, Anika Götz, René Meyer, and Johanna Erdmenger — Julius-Maximilians University Würzburg, Am Hubland, 97074 Würzburg, Germany

An important problem in many-body physics is to reconstruct the spectral density from the imaginary-time domain Greens function. Typically, this Greens function is generated by Monte Carlo methods. As the one-point fermionic kernel diverges for large frequencies, the numerical noise present generically causes instabilities. A standard method to tackle the reconstruction of the spectral density is the maximum entropy method (MaxEnt). In this paper, we follow a different approach and use a convolutional neural network for obtaining the spectral density for a given imaginary time Greens function. The network is very sensitive to the nature of the training data that we create using random Gaussians. Here we improve the training data set available by considering collision centres for Gaussians rather than uniformly distributed Gaussians. Our network is constructed in such a way that its output fulfils the positive semidefiniteness of the spectral density and is ppropriately normalized. We compare the results of this network with results of MaxEnt for the same problem. This comparison is performed for different cases: artificial test data, spin-charge separation in the 1d Hubbard model. Using the Wasserstein distance as metric, we find that the network performs in the same order of magnitude of accuracy as MaxEnt.

MP 6: Members' Assembly

Time: Wednesday 14:45–15:45 Location: ZHG001

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

MP 7: Quantum Field Theory I and Conformal Field Theory

Time: Wednesday 16:15–18:15 Location: ZHG001

Invited Talk MP 7.1 Wed 16:15 ZHG001

How the "gauge principle" derives from physical principles — •Karl-Henning Rehren — University of Göttingen

Gauge theory is a most successful paradigm to explain the interactions of the Standard Model. Yet, it remains notoriously unclear what it actually "means" in terms of physical reality, where only gauge-invariant quantities are observable.

I discuss an "autonomous" approach to explain the (same, of course) interactions of the SM without invoking gauge theory [1]. The S-matrix is computed in terms of "string-localized" free fields, which are necessary in order to reconcile interactions of quantum particles with the physical principles of Hilbert space, locality and covariance. Some of the resulting interacting quantum fields will inherit string-localization – a most desirable feature of physical relevance, e.g., in order to make the Gauß Law of QED compatible with Einstein Causality.

I will sketch how the weak interactions, QCD, and even gravitons are covered by string-localized QFT as well.

[1] K.-H. Rehren *et al*: Found. Phys. 54 (2024) 57

MP 7.2 Wed 16:45 ZHG001

Driven conformal field theory and circuit complexity — •Jani Kastikainen[1], Johanna Erdmenger[1], and Tim Schuhmann[1,2] — [1]Institute for Theoretical Physics and Astrophysics and Würzburg-Dresden Cluster of Excellence ct.qmat, Julius-Maximilians-Universität Würzburg, Am Hubland, 97074 Würzburg, Germany — [2]Department of Physics and Astronomy, Ghent University, 9000 Ghent, Belgium

Driven quantum systems exhibit a large variety of interesting and sometimes exotic phenomena. In this talk, I study driven two-dimensional conformal field theories (CFT) from spacetime and quantum information geometric points of view. I show that a large class of quantum circuits can be realized by coupling the CFT to time-dependent background fields. In particular, unitary time-evolution of the CFT in a background metric is equivalent to a quantum circuit generated by the Virasoro algebra, known as a Virasoro circuit. Similarly, turning on a source for a primary operator deforms the Virasoro circuit in a non-trivial way. Complexity of these circuits may be measured using the Fubini-Study circuit complexity whose properties I will analyze.

MP 7.3 Wed 17:05 ZHG001

Scale- without Conformal-Invariance in Gauge/Gravity Duality — •Mario Flory and Lavish Chawla — Jagiellonian University, Cracow, Poland

In Gauge/Gravity Duality, the isometries of the bulk spacetime determine the symmetries of the dual field theory. This lies at the heart of both AdS/CFT and its generalisations to non-relativistic theories for example. In this talk, we will try to construct models of bulk spacetimes that break the full conformal symmetry present in AdS space down to only scale-invariance in combination with Poincaré invariance. From the field theory point of view, there are well known no-go theorems that forbid unitary theories with such a symmetry, at least in certain dimensions. Our main interest is whether a dual no-go theorem from the bulk point of view exists. To address this question, we discuss a tension that arises between three conditions on the bulk spacetime: A local geometrical condition (Killing algebra of the bulk), a global condition (topology of the bulk) and a physical condition (null energy condition in the bulk).

MP 7.4 Wed 17:25 ZHG001

Number theoretic properties of two-dimensional conformal field theories — Hans Jockers[1], Pyry Kuusela[2], and •Maik Sarve[3] — [1]Johannes-Gutenberg Universität Mainz — [2]Johannes-Gutenberg Universität Mainz — [3]Johannes-Gutenberg Universität Mainz

Many two-dimensional conformal field theories with enhanced symmetry algebras, known as rational conformal field theories, are examples of non-trivial strongly interacting quantum field theories. These additional symmetries render the theories exactly solvable through algebraic methods. It is therefore a natural question to ask how these rational conformal field theories are distributed within the broader space of all two-dimensional conformal field theories. In this talk, I will demonstrate how number theoretic properties of rational conformal field theories can be used to formulate this distribution problem in a mathematically rigorous way and to provide novel insides.

Invited Talk MP 7.5 Wed 17:45 ZHG001

A BPS Road to Holography: Decoupling Limits and Non-Lorentzian Geometries — •Niels Obers — Niels Bohr Institute, Copenhagen, Denmark

I explore decoupling limits that lead to matrix theories on D-branes, focusing on their BPS nature and the emergence of non-Lorentzian target space geometries. In these limits, D-branes experience instantaneous gravitational forces, and when applied to curved geometries, it is shown that a single decoupling limit leads to the AdS/CFT correspondence. By applying two such limits, we generate new holographic examples, including those with non-Lorentzian bulk geometries.

We also examine the relationship between matrix theories and non-relativistic string theory, and their uplift to M-theory. Finally, we demonstrate that reversing these decoupling limits corresponds to deformations of matrix theories, connecting them to the TTbar deformation in two dimensions. These deformations provide a new perspective on the near-horizon brane geometry and lead to TTbar-like flow equations for the Dp-brane DBI action.

MP 8: Waves, Relativity and Quantization

Time: Wednesday 16:15–17:35 Location: ZHG002

MP 8.1 Wed 16:15 ZHG002

Impulsbasierte One-Way-Wellengleichung für die analytische Wellenberechnung in inhomogenen und anisotropen Medien — •Hans-Joachim Raida — 53639 Königswinter

Die konventionelle, in der Akustik und der Physik "standardmässig" verwendete (Two-Way)Wellengleichung 2. Ordnung $(\frac{1}{c^2}\frac{\partial}{\partial t^2} - \Delta)\vec{s} = \vec{0}$ [$\vec{s}$ =Verschiebungsvektor) beschreibt Stehwellenfelder für den trivialen Spezialfall eines homogenen isotropen Mediums. Wegen der Doppelableitungen ist die Lösung mathematisch recht aufwändig bzw. wegen der skalaren, quadrierten Wellengeschwindigkeit $c^2{=}(+c)^2{=}(-c)^2$ sind die Richtungen der Einzelwellen nicht eindeutig. Oft fehlen analytische Lösungen und es wird auf Näherungslösungen ausgewichen. Zudem können "Artefakte" entstehen. – Im Jahr 2014 wurde die impulsbasierte One-Way-Wellengleichung 1. Ordnung $(\frac{\partial}{\partial t} + \vec{c}\cdot\nabla)(E\vec{s}) = \vec{0}$ aufgestellt und in 30 Veröffentlichungen (DAGA, MDPI et al.) unterschiedliche Teilaspekte behandelt. Die One-Way-Wellengleichung ist – dank einer "kombinierten Feldvariable" ($E\vec{s}$) – sehr viel einfacher zu lösen als die Wellengleichung 2. Ordnung und die Vektor-Wellengeschwindigkeit $\vec{c}$ definiert eindeutig die Wellenausbreitungsrichtung. Die impulsbasierte "One-Way-Theorie" ist relevant für die bekannten akustischen sowie elektromagnetischen Wellen in inhomogenen oder anisotropen Medien. Nur für o.g. Spezialfall des homogenen isotropen Mediums (d.h. $\nabla\vec{c}{=}\mathbf{0}$) ist der d'Alembert-Stehwellen-Operator $\Box{=}(\frac{1}{c^2}\frac{\partial}{\partial t^2} - \Delta)$ gleich dem Produkt aus zwei One-Way-Wellenoperatoren $(\frac{\partial}{\partial t} + \vec{c}\cdot\nabla)$ $(\frac{\partial}{\partial t} - \vec{c}\cdot\nabla)$.

MP 8.2 Wed 16:35 ZHG002

Relativistic addition of velocities in a five-dimensional spacetime — •Roland Alfred Sprenger — Herford, Germany

Another method of adding relativistic velocities is shown. It uses a fifth dimension of spacetime rotating the coordinate system of the Minkowski diagram into it and thus is an indication of the existence of a fifth dimension. As proof of correctness of the rotation method it is derived from the addition theorem of velocities. Photographs of a hardware model and diagrams of a computer-generated model illustrate how to find the resulting velocity by the rotation into the five-dimensional spacetime. Alongside the paradox is resolved that any velocity added to lightspeed results in lightspeed.

MP 8.3 Wed 16:55 ZHG002

How come the quantum? Testing a proposal for the origin of Planck's quantum of action — •Christoph Schiller — Motion Moutain Research, Munich

Answers to Wheeler's question "How come the quantum?" are rare. The main reasons are presented and an answer going back to an approach by Dirac is proposed. The proposal implies a topological origin of Planck's quantum of action. The proposal is checked against numerous requirements and experiments that include non-commutativity, probabilities, spinor wave functions, Heisenberg's indeterminacy relation, the Schrödinger equation, and the Dirac equation. Complete agreement with observations is found. A model for particle mass and several experimental predictions are deduced. Unexpectedly, the checks with observations also eliminate all possible alternatives and thus provide arguments for the uniqueness of the proposal. The proposal confirms that quantum mechanics, quantum field theory, particle physics, and physical space are emergent.

Details and publications at https://motionmountain.net/research

MP 8.4 Wed 17:15 ZHG002

The missing link between quantum theory, general relativity and string theory: $c\ m\ day/r_{Earth's\ equator}{}^2 = 2/\pi$ — •Helmut Christian Schmidt — LMU, Munich, www.physics-beyond-standard-model.com

Quantum theory, general relativity and string theory are mathematically correct, but not complete. What can a person see? This can only be explained by a thought experiment. The light beam in the Michelson interferometer rotates in the same way as a Foucault pendulum. The experiment is only finished when one rotation is complete. The laboratory table for normalizing m and s rotates once a day, while a pendulum on the north pole indicates the sidereal time. Assuming a number chain for particles, we get: The spin corresponds to the apse line and is always orthogonal to the largest neighboring object and gives the gravity. For the system of Earth and photon, the pivot point of the angular momentum is the earth's surface. This gives $\sqrt{\pi/2\ c\ m\ day} = r_{Earth\ equator}(NN489m)$ Normalizing to electron, the energy of an electron is: $E_e = g_{freq}\pi + 1 - g_{pot}/\pi$. An algorithm is derived from a Christoffel symbol and similar to a lattice gauge calculation, even without the four interaction constants. It provides exact rest masses for neutrons, protons, muons, tauons, quarks u, d, and pions. The theory can be applied to the inner planetary system and the cosmos and explains quantum entanglement and the hierarchy problem.

$m_{Neutron}/m_e = (2\pi)^4 + (2\pi)^3 + (2\pi)^2 - (2\pi)^1 - 1 - (2\pi)^{-1} + 2(2\pi)^{-2} + 2(2\pi)^{-4} - 2(2\pi)^{-6} + 6(2\pi)^{-8} = 1838.6836611$

If $c\ m\ day/r_{Earth's\ equator}{}^2 = 2/\pi$ is assumed to be true, there are a number of consequences: Formulas for action, energy and centers of gravity can be summarized in a single line by polynomial $P(2\pi)$. $E_{neutron}/E_e = P(2\pi)$ is representative of all neutral objects, with the shortest formula consisting of 10 summands (3x3+1). The orbital periods result from 3 spatial dimensions $2^3 = 8$ as polynomial P(8). For example, for the system of observer, earth and bound moon, the orbital period of the moon is $month = 1/2(8^2 - 8 - 1 - 3/8) = 27.3\ days$. Further precise calculations for orbits and orbital periods in the solar system are given. It is important that the information from 2 real objects is also combined and stored in the cerebral network using the same algorithm as $E_{neutron}/E_e = P(2\pi)$ in virtual objects at a common point in time. This would explain the anthropic principle from theoretical physics.

h, G_N and c^5 result in a common constant:
$hG_N c^5 s^8/m^{10}\sqrt{\pi^4 - \pi^2 - \pi^{-1} - \pi^{-3}} = 0.999991$

This leads to an estimate for H0 and the wavelength of the CMBR. The polynomials $P(2\pi)$ give rise to new questions in physics, especially regarding Hilbert's 6th problem.

www.researchgate.net/publication/383976153

MP 9: Poster Session: Many-body Theory

Time: Wednesday 16:15–18:15 Location: ZHG Foyer 1. OG

MP 9.1 Wed 16:15 ZHG Foyer 1. OG

Exact solutions of interacting spinor Bose gases — •Hannes Köper[1] and Thomas Gasenzer[1,2] — [1]Kirchhoff-Institut für Physik, Universität Heidelberg, Im Neuenheimer Feld 227, D-69120 Heidelberg, Germany — [2]Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 16, D-69120 Heidelberg, Germany

The quantum matrix non-linear Schrödinger equation in one spatial dimension describes an integrable model of two non-relativistic SU(2) multiplets with quartic interaction between their coupled states. Due to the matrix structure of the field operators involved, the non-linear term includes spin-changing processes not captured by a plain density-density interaction. In spite of the complexity of these spin changing terms for the general $m \times n$ matrix field, symmetry analysis reveals a very simple picture in terms of Casimir operators of an associated Jordan-Schwinger representation of $\mathfrak{su}(n)$. We solve the model explicitly for the case where both multiplets are spin-1/2 giving rise to a 2×2 matrix field theory. The model is expected to describe e.g. the interactions between different hyperfine states in a Bose gas of hydrogen-like atoms. From its solution we derive exact thermodynamic quantities for the few- and many-body systems.

MP 9.2 Wed 16:15 ZHG Foyer 1. OG

Exploring Strong Correlations and Strong Disorder in Fermionic Systems: Independent Investigations — •Saurabh Kumar — Institute for Theoretical Physics, University of Cologne, Zülpicher Straße 77, D-50937, Köln, Germany

This work addresses the challenges of analyzing strongly interacting and disordered fermionic systems, focusing on two independent projects. Both projects utilize the superbosonization formula as a key analytical tool.

The first project develops a general analytical framework for studying strongly interacting systems, with a specific focus on the one-dimensional Hubbard model at half-filling. The approach utilizes bosonization within the functional integral framework, but challenges arise in defining the continuum limit in time. To overcome this, we integrate renormalization techniques into the bosonization scheme. A full implementation of these ideas is planned for future research.

The second project examines strongly disordered fermion systems in symmetry class D. Motivated by recent proposals of novel spontaneous symmetry breaking (SSB) phenomena in class A, we explore similar phenomena in class D systems. Starting with a general formulation of supersymmetric field theory applied to disordered class D systems, we focus on the strong disorder limit. We also analyze a specific system of monitored free fermions, which exhibits measurement-induced phase transitions. While we propose a reformulation of the theory to offer a fresh perspective, a comprehensive exploration of novel SSB phenomena in class D remains an open question for future investigation.

MP 9.3 Wed 16:15 ZHG Foyer 1. OG

Wegner model in high dimension: Self-consistent approximation — •Julian Arenz — Cologne University, Zülpicher Straße 77, 50937 Köln

Assuming the self-consistent theory of localization due to Abou-Chacra, Anderson and Thouless (AAT), we study the $N = 1$ Wegner model in the regime of strong disorder and high dimension.

While it is traditionally believed that the Wegner model possesses only two phases (metallic and insulating), we investigate the existence of a third phase with spontaneously broken U(1) symmetry. We do so by using a supersymmetric integral equation which follows from the AAT self-consistency equation for the advanced and retarded Green's function.

In the process, we uncover solutions that are neither of metallic nor of insulating type (they break a U(1) symmetry but have a non-compact symmetry). We propose that these solutions correspond to the novel phase and describe fractal eigenstates and singular continuous spectrum.

MP 9.4 Wed 16:15 ZHG Foyer 1. OG

An analogue of the Meissner effect for a SU(2)-Yang-Mills field — •Philipp Wagner[1] and Martin Zirnbauer[2] — [1]Hahnenstraße 23, 50354 Hürth-Efferen — [2]Institut für Theoretische Physik, Zülpicher Straße 77a, 50937 Köln

The decay of the electromagnetic field in a superconducting material, described by the Meissner-Ochsenfeld effect, is a well-known phenomenon of solid state physics. Here we consider an analogous situation for the weak interaction in the presence of a Higgs condensate. Mathematical foundations from Yang-Mills theory are used to set up the Lagrangians for both the Yang-Mills field and the Higgs field. Based upon these structures, an adapted London equation with an adapted London penetration depth is derived for a SU(2)-Yang-Mills field interacting with a spacetime-independent Higgs condensate. It is shown that all gauge bosons of the weak interaction individually exhibit the same phenomenological behavior as the electromagnetic field in a superconductor.

MP 10: Operator Algebras

Time: Thursday 14:00–15:30 Location: ZHG001

Invited Talk MP 10.1 Thu 14:00 ZHG001

Quantum field theory, quantum reference frames and the type of local algebras — •Christopher Fewster — Department of Mathematics, University of York, York, UK

This talk will be a more technically-oriented discussion of the material presented as a plenary talk with the same title during the conference.

QFT assigns local algebras of type III_1 to bounded open spacetime regions. However it has been argued that in some gravitational situations one must include an observer. This happens in particular for the static patch of de Sitter spacetime. Further, the physical observables should be joint observables of the combined QFT-observer system that are invariant under the joint time-evolution of the static patch and observer Hamiltonian. This algebra turns out to be of type II_1 [1]. In this talk, I will describe some of the details of a recent generalisation [2] which places the discussion of [1] on a more operational basis using QFT measurement schemes [3] and by reinterpreting the observer as a quantum reference frame.

[1] V. Chandrasekaran, R. Longo, G. Penington, and E. Witten, An algebra of observables for de Sitter space. JHEP 2023(2) 1-56.

[2] C.J. Fewster, D.W. Janssen, L.D. Loveridge, K. Rejzner and J. Waldron, Quantum Reference Frames, Measurement Schemes and the Type of Local Algebras in Quantum Field Theory, Comm. Math. Phys., 406 (2025) 19:1-87

[3] C.J. Fewster and R. Verch, Quantum fields and local measurements, Comm. Math. Phys. 378 (2020) 851-889

MP 10.2 Thu 14:30 ZHG001

Black Hole Microstates and the Factorisation puzzle — •Jonathan Karl, Souvik Banerjee, and Johanna Erdmenger — Julius-Maximilians-Universität Würzburg

In holography, two manifestations of the black hole information paradox are given by the non-isometric nature of the bulk-boundary map and by the factorisation puzzle. By considering time-shifted microstates of the eternal black hole, we demonstrate that both these puzzles may be simultaneously resolved by taking into account non-local quantum corrections that correspond to wormholes arising from state averaging. This is achieved by showing, using a resolvent technique, that the resulting Hilbert space for an eternal black hole in Anti-de Sitter space is finite-dimensional with a discrete energy spectrum. The latter gives rise to a transition to a type I von Neumann algebra.

MP 10.3 Thu 14:50 ZHG001

Local Structure of Twisted Araki-Woods Algebras — •Ricardo Correa da Silva and Gandalf Lechner — Department of Mathematics, FAU Erlangen-Nürnberg, Erlangen, Germany

Finding models for local nets of von Neumann algebras and understanding the relative commutant $\mathcal{M} \cap \mathcal{N}'$ for the inclusion $\mathcal{N} \subset \mathcal{M}$ is a central problem in Algebraic Quantum Field Theory.

In this talk, a family of von Neumann algebras $\mathcal{L}_T(H)$ with respect to a twist T and a standard subspace H will be introduced and it will be discussed that the Fock vacuum is separating for these algebras if, and only if, the twist T satisfies two physically motivated conditions: crossing-symmetry and the Young-Baxter equation. Furthermore, some properties of the relative commutant of the inclusion $\mathcal{L}_T(K) \subset \mathcal{L}_T(H)$ will be presented.

MP 10.4 Thu 15:10 ZHG001

Finite Temperature States on Crossed Product Algebras — •Johannes Grosse, Ricardo Correa da Silva, and Gandalf Lechner — FAU Erlangen-Nürnberg, Department Mathematik

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

MP 11: Quantum Field Theory II

Time: Thursday 16:15–17:15 Location: ZHG001

MP 11.1 Thu 16:15 ZHG001

Implementing a Causal Measurement Scheme for Quantum Fields — •Jan Michael Mandrysch — Institut für Quantenoptik und Quanteninformation, Wien, Österreich

While measurement processes in standard quantum mechanics are well understood, the extension of these ideas to quantum field theory (QFT) remains a key challenge. In particular, ensuring that measurements respect fundamental principles such as relativistic causality is crucial. A persistent issue concerning measurements in QFT is, though, that microcausality alone is insufficient to prevent superluminal signaling. In this talk, I will present a concrete scheme for measuring real linear scalar fields, grounded in the Fewster-Verch measurement framework. This approach fully respects the principles of relativistic covariance, locality, and causality, offering a robust solution to the challenges of measurement in QFT.

MP 11.2 Thu 16:35 ZHG001

Large deviations in mean-field quantum spin systems — •Christiaan van de Ven[1] and Matthias Keller[2] — [1]Weierstraße 52, 52349 Düren — [2]Institut für Mathematik, Universität Potsdam, Karl-Liebknecht-Straße 24-25, 14476 Potsdam

Continuous fields of C*-algebras form an important ingredient for describing emergent phenomena, such as phase transitions and spontaneous symmetry breaking. In this talk, I consider the continuous C*-bundle generated by increasing symmetric tensor powers of the complex (lxl) matrices, which can be interpreted as abstract description of mean-field theories defining the macroscopic limit of infinite quantum systems. Within this framework I discuss the principle of large deviations for the local Gibbs state in the high temperature regime and characterize the limit of the ensuing logarithmic generating function. To this end, it has proved necessary to demonstrate the existence of a semiclassical analog of the Baker-Campbel-Hausdorff formula, defined in terms of a series of nested Poisson brackets.

MP 11.3 Thu 16:55 ZHG001

Gauge invariance of topological charges of Noether current — •Christian Hembd — Montebellunastrasse 5, 73447 Oberkochen

Free (complex) quantum fields have an associated Noether current due to global phase invariance of their Lagrangian. By help of the degree of a mapping and the index of a zero known from algebraic topology it is possible to define Lorentz invariant topological charges of the Noether current. These charges are invariant under a group of local transformations of the quantum field. For the case of a free fermion field this leads to SU(2) gauge invariance.

MP 12: Concepts of Physics

Time: Thursday 16:15–17:35 Location: ZHG002

MP 12.1 Thu 16:15 ZHG002

The Limits of Mathematics in Physics — •Grit Kalies[1] and Duong D. Do[2] — [1]HTWD University of Applied Sciences, Dresden, Germany — [2]The University of Queensland, Brisbane, Australia

Mathematics is considered the language of physics. Starting from idealizations and kinematics, geometric-mathematical physics emerged. By analyzing processes regarding their causes and the functional dependencies of energies, we identify shortcomings in the basic energy concepts of physics, which cannot be remedied with mathematics. While formal transformations of process equations such as integration are mathematically correct, they do conceal vital physical information, suggesting that mathematics should be used with caution. We propose a physically justified approach that reconciles the mechanical, quantum mechanical and thermodynamic energy concepts and provides a revised interpretation of E = mc^2. Our results suggest that geometric approaches were built too early on a shaky physical foundation, leading to undesirable developments in recent centuries. G. Kalies, D. D. Do, AIP Adv. 14, 115225 (2024)

MP 12.2 Thu 16:35 ZHG002

What physically characterizes the present? — •Matthias Kölbel and Werner Ahrendt — welträtsel.org

Albert Einstein was convinced that time is what you measure by a clock. According to him, the concept of 'now' has no place in physics. In fact, the physical theories available to date do not provide a comprehensive explanation why time flows and what characterizes the present in the flow of time. The phenomenon of time continues to puzzle physicists and philosophers alike.

We try to solve part of this puzzle by finding out what could physically characterize the present. To do this, we conduct a thought experiment, a modified version of the well-known twin paradox. Our thought experiment suggests that the flow of time is associated with a relative change in the magnitude of the physical quantity known as action, which occurs in the same way for all physical objects.

This consideration has several interesting consequences: Firstly, it becomes understandable why all laws of motion in physics can be derived from the principle of least action. Secondly, it leads to the unexpected conclusion that the redshift of light from distant galaxies is not due to an expansion of space, as usually assumed, but is rather due to the age of the light.

To test our hypothesis and its consequences, we propose a key experiment.

MP 12.3 Thu 16:55 ZHG002

Theoretical physics based on focal-point representation of particles. — •Osvaldo Domann — Stephanstr. 42, 85077 Manching

Physical laws describe the relations between variables as interactions. General relativity describes them as geometric relations, what makes it inappropriate for the description of gravitation and incompatible with quantum mechanics. The problem of the Standard Model in general is the very primitive static representation of subatomic particles with the energy of a resting particle concentrated in a small volume (Point-Like). This representation forces the introduction of carriers (fictitious particles) to explain interactions between them. All alternative approaches like Strings, Loops, Vortex, etc., use the same static and concentrated representation and have therefor the same problems to explain interactions. The proposed approach describes particles as focal points of rays of fundamental particles (FP) with angular momenta where the energy is stored. The four forces (electromagnetic, strong, weak and gravitation) are mathematically deduced as scalar and vector products between the angular momenta of FP. The resulting gravitation description has two force components, the Newton and an Ampere component that explains the flattening of galaxies curve. It is compatible with quantum mechanics. No dark matter is required. More at www.odomann.com

MP 12.4 Thu 17:15 ZHG002

Physikalische Grundbegriffe - relational definiert — •Martin Hohelüchter — Uni Münster/Westf.

Masse kann nur paarweise auftreten und ist daher keine Eigenschaft.

2. und 3. Newtongesetz $\mathbf{0}=\mathrm{m}_1\mathbf{b}_1+\mathrm{m}_2\mathbf{b}_2=\mathbf{F}_1+\mathbf{F}_2(=\mathbf{F}=\mathrm{m}\mathbf{b})$ legen nahe: Masse ist relativ; sie basiert auf einer Relation, der Zerlegung.

Ein zerlegbarer Körper a und seine Teile a_i haben je einen Ort im 4-dim. metr. Raum. Der Ort von a ist durch die Orte der a_i darstellbar: $\mathbf{u}(\mathrm{a})=\Sigma\mathrm{k}_i\mathbf{u}(\mathrm{a}_i)$ mit $\Sigma\mathrm{k}_i=1$

Für Dichotomien heißen die beiden Koeffizienten bei gleichen Vorzeichen je a-Massen, bei verschiedenen Vorzeichen je elektro-magnetische a-Ladungen.

Trichotomien führen analog zu Farb- bzw. schwachen (Kern)Ladungen.

Nicht Trichotomien, wohl aber Dichotomien sind iterierbar; für sie gilt das Assoziativgesetz.

Spaltung von $\mathbf{u}$ in Zeit und Raum $\mathbf{u}=(\mathbf{t},\mathbf{x})$ ergibt jeweils $(\mathbf{t},\mathbf{x}(\mathrm{t}))=\Sigma\mathrm{k}_i(\mathrm{t})(\mathbf{t},\mathbf{x}_i(\mathrm{t}))$ mit $\Sigma\mathrm{k}_i(\mathrm{t})=1$

1. Ableitung nach der Zeit führt zu
$(\mathbf{1},\mathbf{v}(\mathrm{t}))=\Sigma\mathrm{k}_i(\mathrm{t})(\mathbf{1},\mathbf{v}_i(\mathrm{t}))$ mit
$\mathrm{k}_i(\mathrm{t})\mathbf{1}=:\mathbf{e}_i(\mathrm{t})$ a-Energie, $\mathrm{k}_i(\mathrm{t})\mathbf{v}_i(\mathrm{t})=:\mathbf{p}_i(\mathrm{t})$ a-Impuls von a_i zur Zt t.

2. Ableitung nach der Zeit ergibt
$(\mathbf{0},\mathbf{b}(\mathrm{t}))=\Sigma\mathrm{k}_i(\mathrm{t})(\mathbf{0},\mathbf{b}_i(\mathrm{t}))$ mit $\mathrm{k}_i(\mathrm{t})\mathbf{b}_i(\mathrm{t})=:\mathbf{F}_i(\mathrm{t})$a-Kraft von a_i z.Zt t

Speziell wird nicht Masse durch Kraft, sondern mech. Kraft durch Masse definiert. Die Sätze der Mechanik sind so beweisbar.

Alle Teile streben jeweils zum Ort des Ganzen. Für die Teile einer Masse-Dichotomie heißt dies Streben Gravitation.