Fachverband Theoretische und Mathematische Grundlagen der Physik (MP)

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Der Schwerpunkt der Vorträge liegt dieses Jahr auf dem spannenden und aktuellen Gebiet zwischen Quantentheorie und Gravitation. So handelt unser Plenarvortrag von Gerard 't Hooft (Nobelpreisträger) am Mittwoch früh von der Rolle der mikroskopischen Schwarzen Löcher in einer Quantentheorie der Gravitation. Gemeinsam mit den Fachverbänden GR und T sowie der AGPhil organisieren wir ein Symposium über Quantentheorie und Gravitation am Mittwoch Nachmittag. Sprecher sind Markus Aspelmeyer, Renate Loll, Hermann Nicolai und Christian Wüthrich. Eine weitere gemeinsame Sitzung, diesmal mit dem Fachverband GR, findet am Dienstag früh statt. Dazu wurden als Sprecher Gustav Holzegel, Klaus Fredenhagen, Frank Saueressig und Christian Fleischhack gewonnen. Auch die Hauptvorträge von Christopher Fewster und Rainer Verch handeln von Quanteneffekten im gekrümmten Raum. Weitere Themenkomplexe sind die Quanteninformation am späteren Dienstag Nachmittag mit einem Hauptvortrag von Marc Wolf und der statistische Zugang zu Quantentheorien am Donnerstag früh. Zwei Fachsitzungen (Dienstag Nachmittag und Donnerstag Nachmittag) handeln von Quantenfeldern im Minkowski-Raum und beginnen mit einem Hauptvortrag von Wojciech Dybalski.

Übersicht der Hauptvorträge und Fachsitzungen

(Hörsäle VMP6 HS B und VMP6 HS A)

Plenarvortrag des Fachverbands MP

PV III	Mi	9:00– 9:45	VMP4 Audimax 1	**Microscopic black holes and their significance in quantum theories of gravity** — •Gerard 't Hooft

Hauptvorträge

MP 1.1	Di	8:30– 9:00	VMP6 HS A	**The Black Hole Stability Problem** — •Gustav Holzegel
MP 1.2	Di	9:00– 9:30	VMP6 HS A	**Towards Quantum Gravity via Quantum Field Theory: Problems and perspectives** — •Klaus Fredenhagen
MP 1.3	Di	9:30–10:00	VMP6 HS A	**Asymptotically Safe Quantum Gravity** — •Frank Saueressig
MP 1.4	Di	10:00–10:30	VMP6 HS A	**Loop quantum gravity: a canonical review** — •Christian Fleischhack
MP 2.1	Di	14:00–14:45	VMP6 HS B	**Spin, Statistics and SPASs** — •Christopher Fewster
MP 2.2	Di	14:45–15:30	VMP6 HS B	**Unruh effect and Tolman temperature** — •Rainer Verch, Detlev Buchholz
MP 3.1	Di	16:45–17:30	VMP6 HS B	**(Un-)decidable problems in quantum theory** — •Michael Marc Wolf
MP 5.1	Mi	16:45–17:30	VMP6 HS B	**A criterion for asymptotic completeness in local relativistic QFT** — •Wojciech Dybalski, Christian Gerard

Hauptvorträge des fachübergreifenden Symposiums SYQG

Das vollständige Programm dieses Symposiums ist unter SYQG aufgeführt.

SYQG 1.1	Mi	13:30–14:10	VMP4 Audimax 1	**Quantum Tests of Gravity** — •Markus Aspelmeyer
SYQG 1.2	Mi	14:10–14:50	VMP4 Audimax 1	**A Practitioner's View on Quantum Gravity** — •Renate Loll
SYQG 1.3	Mi	14:50–15:30	VMP4 Audimax 1	**Standard Model Fermions and N=8 Supergravity** — •Hermann Nicolai

SYQG 1.4	Mi	15:30–16:10	VMP4 Audimax 1	**Quantum and gravity: blend or mélange?** — •Christian Wüthrich

Fachsitzungen

MP 1.1–1.4	Di	8:30–10:30	VMP6 HS A	**Mathematische Aspekte der klassischen und Quanten-Gravitation (mit GR)**
MP 2.1–2.3	Di	14:00–16:00	VMP6 HS B	**Quantenfeldtheorie im gekrümmten Raum**
MP 3.1–3.4	Di	16:45–18:40	VMP6 HS B	**Quantenmechanik und Quanteninformation**
MP 4.1–4.4	Mi	13:30–16:10	VMP4 Audimax 1	**Symposium Quantentheorie und Gravitation**
MP 5.1–5.4	Mi	16:45–18:40	VMP6 HS B	**Quantenfeldtheorie I**
MP 6	Mi	18:50–19:30	VMP6 HS B	**Mitgliederversammlung des FV Theoretische und Mathematische Grundlagen der Physik**
MP 7.1–7.3	Do	8:30– 9:30	VMP6 HS B	**Statistischer Zugang zur Quantentheorie**
MP 8.1–8.4	Do	11:00–12:30	VMP6 HS B	**Von der Gravitation zur Quantengravitation**
MP 9.1–9.4	Do	13:45–15:15	VMP6 HS B	**Quantenfeldtheorie II**
MP 10.1–10.3	Do	15:30–16:30	VMP6 HS B	**Feldtheorie und Vereinheitlichung**
MP 11.1–11.3	Di	9:30–18:00	VMP6 HS B	**Poster (permanent Di-Do)**

Mitgliederversammlung Fachverband Theoretische und Mathematische Grundlagen der Physik

Mittwoch 18:50–19:30 VMP6 HS B

- Bericht
- Jahrestagungen
- Verschiedenes

MP 1: Mathematische Aspekte der klassischen und Quanten-Gravitation (mit GR)

Zeit: Dienstag 8:30–10:30 Raum: VMP6 HS A

Hauptvortrag MP 1.1 Di 8:30 VMP6 HS A

The Black Hole Stability Problem — •Gustav Holzegel — Imperial College, London

A fundamental open problem in general relativity is to establish the non-linear stability of the Kerr-family of black holes. I will review recent progress in this field including a discussion of a proof of the linear stability of the Schwarzschild solution under gravitational perturbations, which I obtained in collaboration with Dafermos and Rodnianski.

Hauptvortrag MP 1.2 Di 9:00 VMP6 HS A

Towards Quantum Gravity via Quantum Field Theory: Problems and perspectives — •Klaus Fredenhagen — II. Institut fuer Theoretische Physik, Universität Hamburg

General Relativity is a classical field theory; the standard methods for constructing a corresponding quantum field theory, however, meet severe difficulties, in particular perturbative non-renormalizability and the problem of background independence.

Nevertheless, modern approaches to quantum field theory have significantly lowered these obstacles. On the side of non-renormalizability, this is the concept of effective theories, together with indications for better non-perturbative features of the renormalization group flow. On the side of background independence the main progress comes from an improved understanding of quantum field theories on generic curved spacetimes. Combining these informations, a promising approach to quantum gravity is an expansion around a classical solution which then is a quantum field theory on a given background, augmented by an identity which expresses independence against infinitesimal shifts of the background.

The arising theory is expected to describe small corrections to classical general relativity. Inflationary cosmology is expected to arise as a lowest order approximation.

Hauptvortrag MP 1.3 Di 9:30 VMP6 HS A

Asymptotically Safe Quantum Gravity — •Frank Saueressig — Radboud University, Nijmegen, The Netherlands

Weinberg's Asymptotic Safety scenario, building on a non-trivial fixed point of the gravitational renormalization group flow, provides an elegant mechanism to construct a quantum theory of gravity within the framework of quantum field theory. The most important tools for investigating this scenario are functional methods which allow constructing renormalization group flows of a theory without resorting to the expansion in a small parameter or specifying the fundamental action a priori. This talk will give a concise introduction to the gravitational Asymptotic Safety program before reviewing its current status and future perspectives.

Hauptvortrag MP 1.4 Di 10:00 VMP6 HS A

Loop quantum gravity: a canonical review — •Christian Fleischhack — Institut für Mathematik, Universität Paderborn, 33095 Paderborn

Over the past 25 years, loop quantum gravity has become a relevant attempt to explain the mystery of quantum gravity. However, despite several remarkable achievements, not all the initial dreams have turned into reality; e.g., the dynamics of the theory has remained a rather open territory.

In our review on the current status of loop quantum gravity, we will focus on its canonical part. After presenting the well-understood kinematical basis, we will address dynamical issues as well as an implementation of symmetries that allows to partially relate loop quantum gravity to loop quantum cosmology.

MP 2: Quantenfeldtheorie im gekrümmten Raum

Zeit: Dienstag 14:00–16:00 Raum: VMP6 HS B

Hauptvortrag MP 2.1 Di 14:00 VMP6 HS B

Spin, Statistics and SPASs — •Christopher Fewster — Department of Mathematics, University of York, York, U.K.

Many of the main problems in quantum field theory in curved spacetime (QFT in CST) stem from the fact that there is, in general, no (nontrivial) replacement for the Poincaré symmetry group. Because Poincaré symmetry is at the root of many of the main structural features of QFT in Minkowski space, such as the spin-statistics connection, axiomatic approaches to QFT in CST have been under-developed until fairly recently.

In this talk, I describe some recent progress in the locally covariant framework for QFT in curved spacetimes, taking the spin-statistics connection as the main example. I will also discuss how the framework allows one to pose and partly resolve the issue of whether a given theory can be said to describe the Same Physics in All Spacetimes (SPASs).

Hauptvortrag MP 2.2 Di 14:45 VMP6 HS B

Unruh effect and Tolman temperature — •Rainer Verch[1] and Detlev Buchholz[2] — [1]Institut für Theoretische Physik, Universität Leipzig — [2]Institut für Theoretische Physik, Universität Göttingen

The Unruh effect is often portrayed as due to a thermal gas of noninertial quantum particles in which an accelerated detector is immersed. Following this heat-bath like interpretation of the Unruh effect, the Unruh temperature of an accelerated detector is often identified with the Tolman temperature of an ideal relativistic gas in a homogeneous, static gravitational field. We show that this interpretation is in conflict with the homogeneity of the quantum field vacuum on Minkowski spacetime, and that there is a modified relation between the Unruh effect temperature and a local (Tolman-like) temperature for a quantum field. As will be pointed out, the discrepancy is due to the fact that the coupling between Unruh detector and quantum field is not only exchanging heat but also energy and particles owing to inevitable quantum fluctuations which arise from the localized coupling between detector and quantum field.

10 Minuten Pause

MP 2.3 Di 15:40 VMP6 HS B

The Lieb-Liniger model at the critical point as toy model for Black Holes — •Mischa Panchenko — Ludwig Maximilian Universität, München

In a previous series of papers it was proposed that black holes can be understood as Bose-Einstein condensates at the critical point of a quantum phase transition. Therefore other bosonic systems with quantum criticalities, such as the Lieb-Liniger model with attractive interactions, could possibly be used as toy models for black holes. Even such simple models are hard to analyse, as mean field theory usually breaks down at the critical point. Very few analytic results are known. In this paper we present a method of studying such systems at quantum critical points analytically. We will be able to find explicit expressions for the low energy spectrum of the Lieb-Liniger model and thereby to confirm the expected black hole like properties of such systems. This opens up an exciting possibility of constructing and studying black hole like systems in the laboratory.

MP 3: Quantenmechanik und Quanteninformation

Zeit: Dienstag 16:45–18:40 Raum: VMP6 HS B

Hauptvortrag MP 3.1 Di 16:45 VMP6 HS B

(Un-)decidable problems in quantum theory — •Michael Marc Wolf — Technische Universität München

In the talk I will review recent results on the (un-)decidability of problems in quantum many-body physics and quantum information theory. In both fields there is a natural integer limit that opens the door to undecidability of some of the central properties: the thermodynamic limit in quantum many-body theory and the large block-size limit in information theory. I will try to illuminate the thin line between computable and uncomputable and to illustrate possible physical consequences of unprovable properties.

10 Minuten Pause

MP 3.2 Di 17:40 VMP6 HS B

Quantum theory from questions — •Philipp Höhn[1] and Christopher Wever[2] — [1]Institute for Quantum Optics and Quantum Information, Austrian Academy of Sciences, Vienna, Austria — [2]Institute for Theoretical Particle Physics, Karlsruhe, Germany

In contrast to relativity, quantum theory has evaded a commonly accepted apprehension, in part because of the lack of physical statements that fully characterize it. In an attempt to remedy the situation, we summarize a novel reconstruction of the explicit formalism of quantum theory (for arbitrarily many qubits) from elementary rules on an observer's information acquisition. Our approach is purely operational: we consider an observer O interrogating a system S with binary questions and define S's state as O's "catalogue of knowledge" about S; no ontic assumptions are necessary. From the rules, one can derive, among other things, the state spaces, the unitary group, the von Neumann evolution and show that the binary questions correspond to Pauli operators. The reconstruction also offers new structural insights in the form of novel informational charges and informational complementarity relations which define the state spaces and the unitary group. This reconstruction permits a new perspective on quantum theory.

MP 3.3 Di 18:00 VMP6 HS B

Controlling a d-level atom in a cavity — •Michael Keyl — TU München, Fakultät Mathematik, 85748 Garching

In this talk we discuss quantum control theory for a d-level atom in a cavity. The atom is described by a Graph Γ with energy levels as vertices and edges e as allowed transitions. For each such e the atom interacts (via a Jaynes-Cummings like interaction term) with a different mode of the cavity. We consider controllability of the overall system (i.e. atom and cavity) under the assumption that all atom-cavity interactions can be switched on and off individually and that the atom itself is fully controllable. Our main tools are symmetry based arguments recently introduced for the discussion of the two-level case [M. Keyl, R. Zeier, T. Schulte-Herbrüggen, NJP 16 (2014) 065010]. The basic idea is to divide the control Hamiltonians into two sets. One which is invariant under the action of an Abelian symmetry group G and a second set which breaks this symmetry. We will discuss how the group G and its action are related to the graph Γ and its fundamental groupoid, and how these structure can be used to prove full controllability – at least if Γ is acyclic. For Graphs containing cycles the situation is more difficult and the universal covering graph has to be used. We demonstrate this, using the fully connected graph on three vertices as an example.

MP 3.4 Di 18:20 VMP6 HS B

Quantum control for a Jaynes-Cummings-Hubbard model — •Margret Heinze and Michael Keyl — Zentrum Mathematik, M5, Technischen Universität München, Boltzmannstraße 3, D-85748 Garching

We examine the control of a quantum system consisting of several two-level atoms with each atom interacting with a different mode of an electromagnetic field.

More precisely, the system is a Jaynes-Cummings-Hubbard model where each cavity contains an atom and a bosonic excitation that can tunnel to the neighbouring cavities. The interaction strengths can be time dependently tuned in order to achieve controllability.

We discuss if it is possible that every pure state can be reached from a given reference state (pure-state controllability). This analysis is lifted to the level of operators where each unitary has to be approximated with arbitrarily small error by a time evolution operator for appropriate control functions and finite time (strong controllability).

The challenge of this infinite dimensional control problem is met, by firstly examining the symmetries of the system. A finite dimensional block diagonal decomposition is obtained for the control Hamiltonians that obey an abelian symmetry and due to a cut-off finite dimensional Lie analysis can be applied. By then adding a Hamiltonian that breaks the symmetry pure state and strong controllability are examined, c.f. [Michael Keyl, Robert Zeier, Thomas Schulte-Herbrüggen. "Controlling several atoms in a cavity". New Journal of Physics 16.6 (2014): 065010].

MP 4: Symposium Quantentheorie und Gravitation

Zeit: Mittwoch 13:30–16:10 Raum: VMP4 Audimax 1

Hauptvortrag MP 4.1 Mi 13:30 VMP4 Audimax 1

Quantum Tests of Gravity — •Markus Aspelmeyer — University of Vienna, Faculty of Physics, Vienna Center for Quantum Science and Technology (VCQ), Vienna, Austria

The early pioneering experiment by Colella, Overhauser and Werner demonstrates the effect of Earth's gravitational potential on quantum interference fringes in a neutron interferometer. It was the first experiment that required the use of both Planck's constant and Newton's constant to describe the observed fringe pattern. Over the following decades, the development of new tools significantly expanded the available quantum experiments that test the effects of weak gravitational fields, including atom interferometers, gravitationally bound states of neutrons or atomic clock tests of the gravitational red shift. The last few years have seen a renewed interest and a significant increase of experiments and experimental proposals to explore the interface between quantum physics and gravity. Quantum optics and cold atom experiments have been pushing the sensitivity of measurements of space and time to unprecedented regimes. Recent proposals even suggest that table-top experiments may allow to falsify low-energy consequences of quantum theories of gravity. On the other hand, the fast progress in macroscopic quantum experiments may soon allow to study quantum superposition states involving clocks or of increasingly massive objects, opening up a completely new regime of experiments in which the source mass character of the quantum system starts to play a role. I will review the current state of the art and discuss some of the challenges and prospects for such quantum tests of (quantum) gravity.

Hauptvortrag MP 4.2 Mi 14:10 VMP4 Audimax 1

A Practitioner's View on Quantum Gravity — •Renate Loll — Radboud University, Nijmegen, The Netherlands

Quantum gravity is a subject difficult to grasp for outsiders. Which lofty ideas of exotic structures at the Planck scale will turn out to be right? Do theorists agree on what "quantum gravity" means and what questions such a theory should answer? How far are we from obtaining answers?

My collaborators and I are trying to show by explicit construction that understanding nonperturbative quantum gravity does not require hitherto unseen symmetries, dimensions, strings, loops or branes, which appear to lead us ever further away from a unique theory. Staying within the framework of quantum field theory, but adapting it to the situation where spacetime itself is dynamical, Quantum Gravity from Causal Dynamical Triangulations (CDT) is a promising candidate theory of this type. It is a gravitational analogue of obtaining nonperturbative QCD as the scaling limit of a lattice theory, and is unique in producing evidence of a good semiclassical limit. Not only may this approach lead us to the correct theory of quantum gravity,

it also provides a concrete and extremely useful computational framework to study fundamental questions, as I will try to illustrate. One example is the recent demonstration that a renormalization group analysis can be set up and performed in CDT quantum gravity despite its background-free character.

Hauptvortrag MP 4.3 Mi 14:50 VMP4 Audimax 1
Standard Model Fermions and N=8 Supergravity — •Hermann Nicolai — Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Am Mühlenberg 1, Potsdam-Golm

In a scheme originally proposed by Gell-Mann, and subsequently shown to be realized at the SU(3) × U(1) stationary point of maximal gauged SO(8) supergravity, the 48 spin-1/2 fermions of the theory remaining after the removal of eight Goldstinos can be identified with the 48 quarks and leptons (including right-chiral neutrinos) of the Standard model, provided one identifies the residual SU(3) with the diagonal subgroup of the color group $SU(3)_c$ and a family symmetry $SU(3)_f$. However, there remained a systematic mismatch in the electric charges by a spurion charge of $\pm$ 1/6. We here identify the "missing" U(1) that rectifies this mismatch, and that takes a surprisingly simple, though unexpected form, and show how it is related to the conjectured R symmetry K(E10) of M Theory.

Hauptvortrag MP 4.4 Mi 15:30 VMP4 Audimax 1
Quantum and gravity: blend or mélange? — •Christian Wüthrich — University of Geneva

Do we need to quantize gravity, as it is tacitly assumed in much of fundamental physics? The standard lore falls short of justifying an affirmative answer. Black hole thermodynamics is widely considered, faint though it may be, our firmest hint at a quantum theory of gravity—despite the failure to date to observe Hawking radiation or any other effect that would require going beyond a classical description of black holes. Hawking radiation hitherto merely enjoys a theoretical derivation in a semi-classical theory combining quantum matter with classical gravity. But how can a semi-classical mélange of physical principles possibly justify that the quantum and gravity are blended into a unified fundamental theory when the latter is generally expected to reject at least some of the principles in the former?

MP 5: Quantenfeldtheorie I

Zeit: Mittwoch 16:45–18:40 Raum: VMP6 HS B

Hauptvortrag MP 5.1 Mi 16:45 VMP6 HS B
A criterion for asymptotic completeness in local relativistic QFT — •Wojciech Dybalski[1] and Christian Gerard[2] — [1]Technische Universität München — [2]Universite Paris-Sud

It is well-known that the conventional property of asymptotic completeness fails in general in quantum field theory due to the possible presence of pairs of oppositely charged particles in the vacuum sector. In this talk we formulate a generalized concept of complete particle interpretation which takes this phenomenon into account: With the help of suitable asymptotic observables (Araki-Haag detectors) we construct a canonical 'charged-pairs free' subspace. The generalized property of asymptotic completeness requires that this subspace coincides with the subspace of Haag-Ruelle scattering states. We show that this property holds in any massive quantum field theory satisfying the Haag-Kastler axioms. Our result can be reformulated as a criterion for conventional asymptotic completeness which should be sharp in theories with trivial superselection structure. The crucial technical step is the proof of convergence of the Araki-Haag detectors on all states from a suitable spectral subspace of the energy-momentum operators. This step is accomplished with the help of a novel propagation estimate, which is also relevant to scattering theory of quantum mechanical dispersive systems.

MP 5.2 Mi 17:30 VMP6 HS B
Strengthened Reeh-Schlieder Condition and Construction of Scattering States in QFT without Mass Gaps — •Maximilian Duell and Wojciech Dybalski — Zentrum Mathematik, Technische Universität München, D-85747 Garching, Germany

We outline the construction of a scattering theory for Wigner particles in local relativistic quantum field theories without requiring a mass gap condition or any other restrictions on the spectrum of the mass operator near its eigenvalues. Our novel approach is based on assuming a strengthened form of the Reeh-Schlieder property.

10 Minuten Pause

MP 5.3 Mi 18:00 VMP6 HS B
Wedge-local fields in interacting quantum field theories with bound states — •Daniela Cadamuro[1] and Yoh Tanimoto[2] — [1]Mathematisches Institut, Georg-August Universität Göttingen, Göttingen, Deutschland — [2]Graduate School of Mathematical Sciences, The University of Tokyo, Tokyo, Japan

In the context of constructive QFT in the operator-algebraic approach, wedge-local fields play an important role. After the work of Lechner to construct factorizing scattering matrix models with scalar S-matrices without bound states, we recently extended this construction to scalar S-matrices with poles in the physical strip ("bound states") by exhibiting wedge-local fields which arise as a deformation of Lechner's fields with the so called "bound state operator". Similar techniques allow us to extend this construction to the Z(N)-Ising and the sine-Gordon models, namely models with a richer particle spectrum and which are believed to have bound states. In this talk I will present the construction of such interacting quantum fields and an overview on the open problems to complete the construction.

MP 5.4 Mi 18:20 VMP6 HS B
Towards a non-perturbative construction of the Operator Product Expansion — •Jan Holland — Universität Leipzig, Germany

Our current understanding of Quantum Field Theory (QFT) is based to a large extent on perturbative - i.e. approximate - methods. Exact constructions in QFT are not only of fundamental conceptual interest, but they offer insights into physical phenomena that are intractable by perturbative means.

In this talk, I present progress on a novel approach towards the non-perturbative construction of the Operator Product Expansion (OPE). The OPE is a structure encoding the complete algebraic skeleton as well as the short distance properties of a Quantum Field Theory. Our construction method is based on a recently found recursion formula for the OPE, which will be discussed along with recent results on mathematical properties of the OPE in perturbation theory.

MP 6: Mitgliederversammlung des FV Theoretische und Mathematische Grundlagen der Physik

Zeit: Mittwoch 18:50–19:30 Raum: VMP6 HS B

Bericht, Jahrestagungen, Verschiedenes

MP 7: Statistischer Zugang zur Quantentheorie

Zeit: Donnerstag 8:30–9:30 Raum: VMP6 HS B

MP 7.1 Do 8:30 VMP6 HS B

A Unified Lie Systems Theory for Closed and Open Markovian Dynamical Quantum Systems — •Thomas Schulte-Herbrüggen[1] and Gunther Dirr[2] — [1]Technical University of Munich (TUM) — [2]University of Würzburg

Lie groups and Lie semigroups with their symmetries provide a unified framework to pinpoint the dynamic behaviour of closed and open quantum systems under all kinds of controls.

Recently, we showed that all *Markovian quantum maps* can be represented by *Lie semigroups*. These semigroups come with the geometry of affine maps, whose translational parts determine the respective fixed points. We exploit this geometry for dissipative fixed-point engineering of unique target states be they pure or mixed.

We extend capabilities by combining coherent control with simplest noise controls. Particular light is shed on reachability and open-loop versus closed-loop control design.

MP 7.2 Do 8:50 VMP6 HS B

Stochastic optimal control, forward-backward stochastic differential equations and the Schrödinger equation — •Wolfgang Paul[1], Jeanette Köppe[1], and Wilfried Grecksch[2] — [1]Institut für Physik, Martin Luther Universität, 06099 Halle — [2]Institut für Mathematik, Martin Luther Universität, 06099 Halle

The standard approach to solve a non-relativistic quantum problem is through analytical or numerical solution of the Schrödinger equation. We show a way to go around it. This way is based on the derivation of the Schrödinger equation from conservative diffusion processes by E. Nelson [1] and the establishment of (several) stochastic variational principles leading to the Schrödinger equation under the assumption of a kinematics described by Nelsons diffusion processes, in particular by M. Pavon [2].

Mathematically, the variational principle can be considered as a stochastic optimal control problem linked to the forward-backward stochastic differential equations of Nelsons stochastic mechanics. The Hamilton-Jacobi-Bellmann equation of this control problem is the Schrödinger equation. We present the mathematical background and how to turn it into a numerical scheme for analyzing a quantum system without using the Schrödinger equation and exemplify the approach for a simple 1d problem.

[1] E. Nelson, Phys. Rev. 150, 1079 (1966)
[2] M. Pavon, J. Math. Phys. 36, 6774 (1995)

MP 7.3 Do 9:10 VMP6 HS B

Spikes and what they point out in the FRG flow equation — •Tobias Hellwig, Andreas Wipf, and Omar Zanusso — Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany

After a short introduction into the exact flow equation for the functional renormalization group (FRG) I will use spike plots to obtain the fixed point solutions of the exact flow equation within a local potential approximation. The technique will be applied to a two dimensional scalar field theory with $\mathbb{Z}_2$ symmetry and a two dimensional Wess-Zumino model giving the corresponding minimal (super-)conformal models. After obtaining the fixed point solutions the critical exponents are derived using the Slac-derivative for the linearized deformations.

This talk is based on the paper arXiv:1508.02547 .

MP 8: Von der Gravitation zur Quantengravitation

Zeit: Donnerstag 11:00–12:30 Raum: VMP6 HS B

MP 8.1 Do 11:00 VMP6 HS B

Harmonic d-tensors — •Manuel Hohmann — Physikalisches Institut, Universität Tartu, Estland

Tensor harmonics are a useful mathematical tool for finding solutions to differential equations which transform under a particular representation of the rotation group SO(3). In order to make use of this tool also in the setting of Finsler geometry, where the objects of relevance are d-tensors instead of tensors, we construct a set of d-tensor harmonics for both SO(3) and SO(4) symmetries and show how these can be used for calculations in Finsler geometry and gravity.

MP 8.2 Do 11:20 VMP6 HS B

Tetrads and relativistic dynamics in and of spacetime — •David Vasak[1], Jürgen Struckmeier[1,2,3], Matthias Hanauske[1,2], Adrian Königstein[1,2], Johannes Kirsch[1], and Horst Stöcker[1,2,3] — [1]Frankfurt Institute for Advanced Studies, Ruth-Moufang-Str. 1, 60438 Frankfurt am Main — [2]Institut für Theoretische Physik, Goethe Universität, Max-von-Laue-Str. 1, 60438 Frankfurt am Main — [3]Helmholtzzentrum für Schwerionenforschung (GSI), Planckstr. 1, 64291 Darmstadt

The fundamental importance of tetrad fields for the description of observable quantities in curvilinear relativistic spacetime is derived from differential geometry. The relation to affine connections in the Lorentz and coordinate representations and to other derived quantities like torsion or curvature is shown in the tensor calculus. The covariant dynamics in the observer frame will be illustrated with help of the Klein-Gordon and Dirac fields. Implications for the dynamics of spacetime itself are discussed in the framework of canonical transformations.

10 Minuten Pause

MP 8.3 Do 11:50 VMP6 HS B

The Poincaré Symmetric String — Norbert Dragon and •Florian Oppermann — Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstr. 2, 30167 Hannover

Using the toy model of the free bosonic string we discuss Poincaré symmetric quantum theories with maps between massless and massive states.

In String Theory these maps are given by creation and annihilation operators α_n^μ which generate the Fock space and therefore connect states on different mass shells. When examined carefully the commutator relations lead to contradictions in most quantization schemes, namely empty physical Hilbert spaces, negative mass shells and problems with Lorentz generators.

It can be seen that these problems don't occur due to the method of quantization but because of a fundamental difference between massive and massless states. The Mackey theory of unitary representations of the Poincaré group shows that the latter cannot be described by global momentum wave functions (except in $D = 3, 5, 9$) but need local sections in a bundle.

MP 8.4 Do 12:10 VMP6 HS B

Correlation Functions in Quantum Gravity — Holger Gies, •Benjamin Knorr, and Stefan Lippoldt — Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena

We present some aspects of non-perturbative correlation functions of quantum gravity. In particular, the influence of curvature on gravitational correlations is investigated. Possible future applications of this include, e.g., genuine quantum gravity effects in black hole physics and gravitational waves.

MP 9: Quantenfeldtheorie II

Zeit: Donnerstag 13:45–15:15 Raum: VMP6 HS B

MP 9.1 Do 13:45 VMP6 HS B

The two-loop sunrise integral and elliptic polylogarithms — •Luise Adams[1], Christian Bogner[2], and Stefan Weinzierl[1] — [1]Institut für Physik, Johannes Gutenberg - Universität Mainz — [2]Institut für Physik, Humboldt-Universität zu Berlin

In this talk, we present a solution for the two-loop sunrise integral with arbitrary masses around two and four space-time dimensions in terms of a generalised elliptic version of the multiple polylogarithms. Furthermore we investigate the elliptic polylogarithms appearing in higher orders in the dimensional regularisation ϵ of the two-dimensional equal mass solution .

Around two space-time dimensions the solution consists of a sum of three elliptic dilogarithms where the arguments have a nice geometric interpretation as intersection points of the integration region and an elliptic curve associated to the sunrise integral.

Around four space-time dimensions the sunrise integral can be expressed with the ϵ^0- and ϵ^1-solution around two dimensions, mass derivatives thereof and simpler terms.

Considering higher orders of the two-dimensional equal mass solution we find certain generalisations of the elliptic polylogarithms appearing in the ϵ^0- and ϵ^1-solutions around two and four space-time dimensions. We show that these higher order-solutions can be found by iterative integration within this class of functions.

MP 9.2 Do 14:05 VMP6 HS B

The Potential in General Linear Electrodynamics: Causal Structure, Propagators and Quantization — •Daniel Siemssen[1] and Christian Pfeifer[2,3] — [1]Department of Mathematical Methods in Physics, Faculty of Physics, University of Warsaw — [2]Institute for Theoretical Physics, Leibniz Universität Hannover — [3]Center of Applied Space Technology and Microgravity (ZARM), Universität Bremen

From an axiomatic point of view, the fundamental input for a theory of electrodynamics are Maxwell's equations $\mathrm{d}F = 0$ (or $F = \mathrm{d}A$) and $\mathrm{d}H = J$, and a constitutive law $H = \#F$, which relates the field strength 2-form F and the excitation 2-form H. In this talk we consider general linear electrodynamics, the theory of electrodynamics defined by a linear constitutive law. The best known application of this theory is the effective description of electrodynamics inside (linear) media (e.g. birefringence). We will analyze the classical theory of the electromagnetic potential A before we use methods familiar from mathematical quantum field theory in curved spacetimes to quantize it. Our analysis of the classical theory contains the derivation of retarded and advanced propagators, the analysis of the causal structure on the basis of the constitutive law (instead of a metric) and a discussion of the classical phase space. This classical analysis sets the stage for the construction of the quantum field algebra and quantum states, including a (generalized) microlocal spectrum condition.

10 Minuten Pause

MP 9.3 Do 14:35 VMP6 HS B

Lösbare Algebren und masselose Fermionen — Rein Saar[1] und •Stefan Groote[1,2] — [1]Füüsika Instituut, Tartu Ülikool, Ravila 14C, 50411 Tartu, Estonia — [2]PRISMA Cluster of Excellence, Institut für Physik, Johannes-Gutenberg-Universität, Staudinger Weg 7, 55099 Mainz, Germany

Das Standardmodell der Elementarteilchenphysik basiert auf Eichtheorien, welche die Fermionen über halbeinfache Gruppen wie $SU(2)$ und $SU(3)$ an Vektorbosonen koppeln. Dies ist ein erfolgreicher Zugang für massive Fermionen. Masselose Fermionen besitzen aber, wie wir in diesem Beitrag zeigen werden, eine andere Symmetrie und führen nicht auf halbeinfache, sondern auf lösbare Gruppen. Auch wenn nach neuesten Erkenntnissen selbst die Neutrinos Masse besitzen, ist das Konzept masseloser Fermionen insoweit auch heute noch relevant, als dass viele Rechnungen durch die Annahme masseloser Fermionen vereinfacht und damit erst durchführbar gemacht werden. In diesem Beitrag befassen wir uns mit der Lorentzstruktur der sogenannten erweiterten kleinen Gruppe, zerlegen diese in eine Kroneckersumme und decken Zusammenhänge zur Händigkeit des Teilchens auf. Verschiedene Darstellungen der erweiterten kleinen Gruppe werden zur Spache kommen.

MP 9.4 Do 14:55 VMP6 HS B

The unknown sister of Noether's theorem — •Walter Smilga — Isardamm 135d, Geretsried, Germany

Noether's theorem has gained outstanding importance in theoretical particle physics, because it leads to strong conservation laws, such as the conservation of momentum and of angular momentum. Closely related to this theorem is another law that has an opposite effect: it requires the exchange of momentum between two particles that are described by an irreducible two-particle representation of the Poincaré group. Exchange of momentum determines an interaction. On closer inspection, this interaction is uniquely identified as the electromagnetic interaction. This finding sheds new light on the phenomenon of particle interaction in general and, in particular, on the perturbation algorithm of quantum electrodynamics.

Reference: iopscience.iop.org/1742-6596/597/1/012069

MP 10: Feldtheorie und Vereinheitlichung

Zeit: Donnerstag 15:30–16:30 Raum: VMP6 HS B

MP 10.1 Do 15:30 VMP6 HS B

Three Dimensional Analytic Calculation of Magnetic Coil — •Roland Adam Renz — D-96138 Burgebrach Treppendorf 38

In diesem Vortrag diskutieren wir eine neue Lösung der reduzierten Helmholtzgleichung, die als grundlegend für die Beschreibung der Elektrischen Maschinen gilt. In der axialen Richtung wird ein gedämpfter exponentieller Verlauf der magnetischen Induktion vorausgesetzt.

Im Gegensatz zu den klassischen Lösungsansätzen wird für die radiale Abhängigkeit der magnetischen Induktion eine Zylinderfunktion von halbzahliger Ordnungszahl eingeführt. Es entstehen dadurch ausnahmslos streng konvergente Eigenfunktionen, die keine Fourierreihen sind.

Diese Rechenmethode liefert nur negative, reelle Eigenwerte, die den kontinuierlichen Übergang der magnetischen Normalenkomponente sicherstellen. Dies gilt für Gleichstrom- wie für Wechselstrombetrieb. Die berechnete Integrationskonstante bezieht sich immer auf den Draht einer Windungslage und ermöglicht die Anwendung des Prinzips der Superposition.

An Hand einer mit Gleichstrom gespeisten einfachen Spule wird ein Beispiel dargestellt, aus dem man die prinzipielle Verteilung der magnetischen Induktion ersehen kann.

MP 10.2 Do 15:50 VMP6 HS B

Emission & Regeneration UFT — •Osvaldo Domann — Stephanstr. 42, D- 85077 Manching

SM defines for each force a different field resulting the electric, magnetic, weak, strong and gravitation fields. Based on a space-like representation of Subatomic Particles (SPs) as Focal Points in space where rays of Fundamental Particles (FPs) that extend up to infinity cross, a theory is presented where all known forces are derived from one single field. The main finding of the approach is that many concepts introduced by the SM like Gluons, Gravitons, dark mater, dark energy, expansion of the universe, equivalence principle, etc. are simply helpmates which are the result of the unphysical point-like representation of SPs. Another important result of the approach is the derivation of all main equations of the Theory of Special Relativity without time and length distortions, showing no paradoxes. More at www.odomann.com

MP 10.3 Do 16:10 VMP6 HS B

Die Feinstrukturkonstante und andere Naturkonstanten — •Ferdinand Hein — 88348 Bad Saulgau, Gänsbühl 22

Seit rund 200 Jahren beschäftigen sich Physiker und Mathematiker mit der Feinstruktur-Konstanten und weiteren Naturkonstanten. Eine

Berechnung dieser Konstanten ist bislang noch nicht gelungen. Im Vortrag wird gezeigt, wie mit einer neuen Normierung die Naturkonstanten berechnet werden können. Benötigt werden Beziehungen zwischen den physikalischen Größen und den Grundregeln der Mathematik, die bislang nur teilweise benutzt wurden.

MP 11: Poster (permanent Di-Do)

Zeit: Dienstag 9:30–18:00 Raum: VMP6 HS B

MP 11.1 Di 9:30 VMP6 HS B

Special Relativity without time delay and without length contraction. — •Osvaldo Domann — Stephanstr. 42, D- 85077 Manching

SR as derived by Einstein is the product of an approach of 1905 when the quantized nature of matter was still not accepted by everybody (God doesn't throw dice). It is a rough undifferentiating approach which omits the origin of the constancy of light speed in inertial frames, arriving to wondrous results about time and space. With the findings made during the last 100 years by experimentalists, an update of Einstein*s theoretical approach is more than overdue. Based on these findings, a new theoretical approach is presented taking into consideration that the constancy of light speed in inertial frames is due to the emission of light with light speed 'c' relative to its source, which includes also refracted and reflected light in a medium with index n=1. The results are transformation rules without time and space distortions and a consistent theory without paradoxes. GR is the theory of gravitation of the SM and is based on time and space distortions, consequently a revision is also needed. A theory for gravitation without paradoxes based on the reintegration of migrated electrons and protons to their nuclei was derived. More at www.odomann.com

MP 11.2 Di 9:30 VMP6 HS B

Quasiclassical propagator of a relativistic particle via the path-dependent gauge potential — •Enderalp Yakaboylu, Karen Z. Hatsagortsyan, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

The proper time formalism for a particle propagator in an external electromagnetic field is combined with the path-dependent formulation of gauge theory to simplify the quasiclassical propagator of a relativistic particle. The latter is achieved due to a specific choice of gauge corresponding to the use of the classical path in the path-dependent formulation of gauge theory, which leads to cancellation of the interaction part of the classical action in the Feynman path integral. A simple expression for the quasiclassical propagator is obtained in all cases of the external field when the classical equations of motion in this field are integrable. As an example, simple expressions for the propagators are derived for a spinless charged particle interacting with the following fields: an arbitrary constant and uniform electromagnetic field, an arbitrary plane wave, and finally an arbitrary plane wave combined with an arbitrary constant and uniform electromagnetic field. In all these cases the quasiclassical propagator coincides with the exact result [1].

[1] E. Yakaboylu, K. Z. Hatsagortsyan, and C. H. Keitel, Phys. Rev. A 89, 032115 (2014).

MP 11.3 Di 9:30 VMP6 HS B

Pointer-based simultaneous measurements of conjugate observables in a thermal environment — •Raoul Heese and Matthias Freyberger — Institut für Quantenphysik, Universität Ulm, D-89069 Ulm, Germany

The simultaneous measurement model of Arthurs and Kelly involves two pointer systems, which are coupled to a quantum system to be measured. Originally, the pointers and the system to be measured are completely isolated from their environment. However, a more realistic treatment has to take environmental effects into consideration. We therefore extend the original model by a thermal heat bath using the Caldeira-Leggett approach, which leads to a Brownian motion of the pointer systems and allows us to observe noise, dissipation, and decoherence effects [1]. As a result, we can discuss the uncertainty of quantum measurements and their inherent transition from quantum to classical in a dynamic way.

[1] R. Heese and M. Freyberger, J. Phys. A **48**, 135304 (2015).