THEORETISCHE UND MATHEMATISCHE GRUNDLAGEN DER PHYSIK (MP)

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ÜBERSICHT DER HAUPTVORTRÄGE UND FACHSITZUNGEN

Hauptvorträge

MP 1.1	Di	10:15	(TU MA043)	**Knotted soliton-a candidate for the QCD string**, Ludvig Faddeev
MP 1.2	Di	11:10	(TU MA043)	**On the statistical mechanical foundations of thermodynamics**, Jürg Fröhlich
MP 1.3	Di	12:05	(TU MA043)	**Simple models of turbulent advection**, Krzysztof Gawedzki
MP 2.1	Di	16:30	(TU MA043)	**Isometric embeddings and scaling laws in compressed elastic sheets**, Sergio Conti
MP 2.2	Di	17:25	(TU MA043)	**Symmetry classes of disordered fermions (the 10-fold way)**, Martin Zirnbauer
MP 3.1	Mi	10:15	(TU MA043)	**Swimming lessons for microbots**, Joseph Avron
MP 3.2	Mi	11:10	(TU MA043)	**Topological quantum field theories, Feynman path integrals, and R-matrices**, Atle Hahn

Fachsitzungen

MP 1	**Hauptvorträge I**	Di 10:15–13:00	TU MA043	MP 1.1–1.3
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MP 3	**Hauptvorträge III**	Mi 10:15–12:05	TU MA043	MP 3.1–3.2
MP 4	**Quantum Field Theory and String Theory**	Di 14:00–16:00	TU MA043	MP 4.1–4.6
MP 5	**Condensed Matter**	Di 14:00–16:00	TU MA141	MP 5.1–5.6
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MP 10	**Poster**	Di 13:00–16:00	Poster TU B	MP 10.1–10.10

Mitgliederversammlung des Fachverbands Theoretische und Mathematische Grundlagen der Physik

Di 18:30–19:00 TU MA 043

1. Festlegen der endgültigen Tagesordnung
2. Protokoll der Mitgliederversammlung 2004 in Ulm
3. Bericht des Leiters
4. Wahl zum Beirat
5. Verschiedenes

Fachsitzungen

– Haupt-, Fachvorträge und Posterbeiträge –

MP 1 Hauptvorträge I

Zeit: Dienstag 10:15–13:00 Raum: TU MA043

Hauptvortrag MP 1.1 Di 10:15 TU MA043

Knotted soliton-a candidate for the QCD string — •Ludvig Faddeev — Steklov Institute of Mathematics, 27, Fontanka, 191011, St.Petersburg, Russia

An exact change of variables for the Yang-Mills lagrangian in 3+1 dimensional space-time is proposed. It reveals the degrees of freedom of a particular nonlinear sigma model, which was shown to have solitonic excitations, concentrated around the knot in space. It is proposed that this string-like object could be interpreted as a QCD string.

Hauptvortrag MP 1.2 Di 11:10 TU MA043

On the statistical mechanical foundations of thermodynamics — •Jürg Fröhlich — Theoretische Physik, ETH–Hönggerberg, CH–8093 Zürich

I will discuss mathematical results concerning some of the foundations of thermodynamics, in particular of the fundamental laws, in nonequilibrium (quantum) statistical mechanics. Adequate notions of entropy will be introduced; reversible and especially reversible isothermal processes will be discussed; and the 2nd law in the form of Clausius and of Carnot will be derived. Along the way we will encounter phenomena like "Return to Equilibrium", "Convergence to Nonequilibrium Stationary and Time-Periodic States", and "Entropy Production".

Hauptvortrag MP 1.3 Di 12:05 TU MA043

Simple models of turbulent advection — •Krzysztof Gawedzki — Laboratoire de Physique, ENS Lyon

Turbulent advection of pollutants, heat, chemical agents or magnetic fields is a non-equilibrium phenomenon with applications to environmental issues, meteorology, engineering or astrophysics. The simplest models of turbulent transport study passive advection of scalar or vector quantities by random velocities with prescribed statistics and may be viewed as examples of random dynamical systems. Such reduced models show many expected features of the full-fledged hydrodynamic turbulence, including cascades of conserved quantities and intermittency. Their analysis allows to relate transport properties of flows to non standard behaviors of fluid particles that is made possible by the lack of regularity of turbulent velocities. The simplified models exhibit a new robust mechanism of intermittency involving hidden statistically conserved quantities.

MP 2 Hauptvorträge II

Zeit: Dienstag 16:30–18:20 Raum: TU MA043

Hauptvortrag MP 2.1 Di 16:30 TU MA043

Isometric embeddings and scaling laws in compressed elastic sheets — •Sergio Conti — Fachbereich Mathematik, Universitaet Duisburg-Essen, Lotharstr. 65, 47057 Duisburg

Crumpling a sheet of paper leads to the formation of complex folding patterns over several length scales. This can be understood on the basis of the interplay of a nonconvex elastic energy, which penalizes local stretching, and a small singular perturbation, which penalizes high curvature. We obtain, using a combination of explicit constructions and general results from differential geometry, an upper bound for the energy of a compressed thin sheet which scales as the thickness to the 5/3. Focussing on a simplified geometry we then prove optimality of this energy scaling.

Hauptvortrag MP 2.2 Di 17:25 TU MA043

Symmetry classes of disordered fermions (the 10-fold way) — •Martin Zirnbauer — Institut für Theoretische Physik, Universität Köln, Zülpicher Str.77, 50937 Köln

Building upon Dyson's fundamental 1962 article known in random matrix theory as 'the threefold way' we classify disordered fermion systems with quadratic Hamiltonians by their unitary and antiunitary symmetries. Important examples are afforded by noninteracting quasiparticles in disordered metals and superconductors, and by relativistic fermions in random gauge field backgrounds. The primary data of the classification are a Nambu space of fermionic field operators which carry a representation of some symmetry group. Eliminating the unitary symmetries by transferring to an irreducible block of equivariant homomorphisms, we show that each set of irreducible block data determines an irreducible classical compact symmetric space. Conversely, every irreducible classical compact symmetric space occurs in this way. This proves the correspondence between symmetry classes and symmetric spaces conjectured some time ago.

MP 3 Hauptvorträge III

Zeit: Mittwoch 10:15–12:05 Raum: TU MA043

Hauptvortrag MP 3.1 Mi 10:15 TU MA043

Swimming lessons for microbots — •Joseph Avron — Department of Physics, Technion, Haifa, Israel

Swimming at low Reynolds number is geometric. A gauge theory of swimming due to Wilczek and Shapere, and going back to the 80's, shall be described with an eye on its implications to the swimming of micron size robots (microbots). The optimization problem associated to microbot swimming shall be formulated. In two dimensions one can use conformal methods to find explicit solutions and illustrate the optimal strokes of few swimming styles.

Hauptvortrag MP 3.2 Mi 11:10 TU MA043

Topological quantum field theories, Feynman path integrals, and R-matrices — •Atle Hahn — Mathematisches Institut, Universität Bonn

Topological quantum field theories provide some of the most interesting examples for the usefulness of path integrals. One of the best known of these examples was discovered in E. Witten's paper "Quantum field theory and the Jones polynomial". In this paper Witten studied one particular topological quantum field theory, Chern-Simons theory, and was finally able to compute the so-called "Wilson loop observables" (WLOs) of this theory explicitly. These WLO are heuristic path integral expressions and the interesting thing about the values Witten obtained for them is that they are given by highly non-trivial link invariants like the Jones, the Homfly or the Kauffman polynomial. The elaboration of Witten's

ideas later led to a breakthrough in knot theory, the discovery of the universal Vassiliev invariants.

Unfortunately, it has not yet been possible to establish the aforementioned connection between path integrals and knot polynomials at a rigorous level. In the special case, however, where the base manifold M of the Chern-Simons model considered is of product form the situation looks much more promising and we believe that, at least for some of these special manifolds M, it will eventually be possible to obtain a rigorous definition of the WLOs in terms of Hida distributions (Step 1) and to prove that the values of the rigorously defined WLOs are indeed given by Witten's formulae (Step 2).

In the first part of my talk I will summarize some recent results for the manifold $M = R^3 \cong R^2 \times R$, for which Step 1 has already been carried out successfully with the help of axial gauge fixing. This manifold has the drawback of being noncompact and for this reason one cannot expect that the values of the WLOs are given by Witten's original formulae.

Fortunately, there is at least one compact manifold for which Step 1 can also be carried out, namely the manifold $M = S^2 \times S^1$. In the second part of my talk I will give an overview over the results obtained so far for this manifold with the help of what M. Blau and G. Thompson call "torus gauge fixing". In the last part of my talk I will sketch what remains to be done in order to complete Steps 1 and 2 for the latter manifold and I will explain why it is reasonable to expect that the completion of these two steps will finally give rise to a purely geometric derivation of the R-matrices of Jones and Turaev.

MP 4 Quantum Field Theory and String Theory

Zeit: Dienstag 14:00–16:00 Raum: TU MA043

Fachvortrag MP 4.1 Di 14:00 TU MA043

Cohomological gauge theories with special holonomy — •Bodo Geyer — Institut f. Theoret. Physik, Univ. Leipzig, Augustusplatz 10-11

From Minkowskian 10D super Yang-Mills theory, by dimensional reduction and continuous Weyl-rotation, the 8D Euclidean, cohomological Spin(7)-invariant action $S^{N_T=1}_{cohom}$ is derived, and by reduction to 7D the cohomological G_2-invariant action $S^{N_T=2}_{cohom}$ with global SU(2) symmetry is obtained. Compatibility of chirality with generalized self-duality and octonionic algebra is shown. Using the chiral primary operator and the 8D analogue of the Pontryagin invariant a cohomological extension of $S^{N_T=1}_{cohom}$ has been constructed.

Fachvortrag MP 4.2 Di 14:20 TU MA043

Quantized equations of motion and currents in noncommutative theories — •Tobias Reichenbach — Konradstr. 58a, 04315 Leipzig

In this talk, quantized equations of motion and currents, that means equations on the level of Green's functions, are studied within different perturbative approaches to noncommutative quantum field theories.

Time-space noncommutativity poses remarkable difficulties. The perturbative approach via modified Feynman rules has been shown to violate unitarity. Therefore, another approach has been suggested which is manifestly unitary(TOPT). We study equations of motion and currents on the level of Green's functions within this framework, and find that the classical equations are not longer valid. This causes e.g. the violation of Ward identities in NCQED.

To cure this problem, a modified time-ordering has been proposed, which we present. We derive equations of motion in the new framework.

Another approach uses retarded functions. We introduce it and analyze unitarity as well as equatons of motion and currents. Both are disturbed for the same reason.We propose a modified theory which is unitary and preserves the classical equations of motion and currents on the quantized level.

Fachvortrag MP 4.3 Di 14:40 TU MA043

Perturbative Aspects of Spectral Representations for Unitary QFTs on Space/Time NC Spaces — •Christoph Dehne — ITP, Leipzig University (Vor dem Hospitaltore 1, D – 04103 Leipzig)

We construct spectral representations for unitary quantum field theories on Space/Time noncommutative spaces and investigate the spectral measure for different Feynman rules perturbatively. Explicitly, we show how to compute nonlocal counterterms, if space does not commute with time.

Fachvortrag MP 4.4 Di 15:00 TU MA043

Spontaneous particle creation within the external field approximation of QED — •Nikodem Szpak — Institut für Theoretische Physik, J.W.Goethe Universität Frankfurt, 60054 Frankfurt/Main

It is expected that strong electrodynamic fields in QED may lead to destabilization of the vacuum if the strength of the electric field exceeds some threshold. However, rigorously, the question is still open. We treat the problem within an external field approximation of QED and study model fields in order to understand the problems appearing in the proofs. We define the spontaneous particle creation by the adiabatic limit and study it analytically and numerically. We also review the present state of the theory concerning spontaneous particle creation and report on the open theoretical problems.

Fachvortrag MP 4.5 Di 15:20 TU MA043

Geometry of spin-field couplings on the worldline — •Jens Hämmerling and Holger Gies — Institut für theoretische Physik, Philosophenweg 16, 69120 Heidelberg

We derive a geometric representation of spin-field couplings within the worldline approach to perturbative QFT. This results in a spin factor that associates the information about spin with zigzag motion of the fluctuating field. We concentrate on the case of QED in external fields where we obtain a purely geometric representation of the Pauli term. As an illustrative example, we rederive the well-known Heisenberg-Euler action from the interplay between spin factor and holonomy.

Fachvortrag MP 4.6 Di 15:40 TU MA043

Nonabelian 2-Forms: Strings, Loop Space, Gerbes and 2-Bundles — •Urs Schreiber — Universität Duisburg-Essen, 45177 Essen

The higher-order generalization of gauge theory involves nonabelian 2-forms coupled to worldsheets instead of 1-forms coupled worldlines. Such theories arise notably on stacks of M/NS 5-branes.

The investigation of such higher gauge theories involves a fascinating interplay between the physics of strings and mathematical concepts like fiber bundles over loop spaces, categorified fiber bundles (2-bundles) and nonabelian gerbes.

We give a brief overview and present recent insights.

MP 5 Condensed Matter

Zeit: Dienstag 14:00–16:00 Raum: TU MA141

Fachvortrag MP 5.1 Di 14:00 TU MA141

Ferromagnetism in the Hubbard-HFz, for large coupling and small filling. — •Marcos Travaglia[1], Volker Bach[1], and Elliott Lieb[2] — [1]Mainz University — [2]Princeton Universtiy

By HFz-Hubbard model we mean the usual Hubbard model defined on the set of Slater determinants (Hartree-Fock states), whose spin-waves don't have a spiral motion w.r.t. the lattice but they stay in a plane (z-plane). For this model with small filling we proved that the ferromagnetism takes place for large enough, but finite coupling.

Fachvortrag MP 5.2 Di 14:20 TU MA141

Renormierungsfluss von Fermiflächen — •Walter Pedra und Manfred Salmhofer — Theoretische Physik, Universität Leipzig, 04109 Leipzig

Wir definieren einen nichtperturbativen Renormierungsfluss für eine sehr allgemeine Klasse d–dimensionaler ($d \geq 2$), nichtrelativistischer, fermionischer Gittermodelle mit schwacher Kopplung. Diese Klasse enthält

insbesondere das Hubbard-Modell. Neu hier ist die Tatsche, dass die Fermiflächen dynamische Objekte sind, sodass man auf Gegenterme für das Infrarotproblem verzichten kann. Wir zeigen mit dieser Methode die C^2–Regularität der wechselwirkenden Fermiflächen, und dass die elektronische Dichte durch Wahl eines geeigneten chemischen Potentials fixiert werden kann, solange die Kopplungskonstante λ im Bezug zur Temperatur T genügend klein ist. Für 2–dimensionale Modelle mit strikt positiv gekrümmten freien Fermiflächen kann gezeigt werden, dass das System bei Temperaturen $T > \exp(-const/|\lambda|)$ Fermiflüssigkeitsverhalten aufweist.

Fachvortrag MP 5.3 Di 14:40 TU MA141

Lokale Skaleninvarianz in Alterungsphaenomaenen — •Malte Henkel[1], Michel Pleimling[2] und Jérémie Unterberger[3] — [1]LPM, Université Nancy I, B.P. 239, F - 54506 Vandœuvre les Nancy, Frankreich — [2]Theorie I, Universität Erlangen — [3]Dép. de Math., Université Nancy I, Frankreich

Die zeitliche Evolution von Systemen fern vom Gleichgewicht läßt sich durch folgende Symmetrieeigenschaften charakterisieren: (i) Brechung der zeitlichen Translationsinvarianz (ii) dynamisches Skalenverhalten, das durch den dynamischen Exponenten z beschrieben wird. Für ein Spinsystem mit einer rein relaxierenden Dynamik und das unterhalb der kritischen Temperatur abgeschreckt wird, gilt$z = 2$. Wir schlagen vor, das dynamische Skalenverhalten zu einer lokalen Skaleninvarianz zu erweitern. Diese lokalen Skalentransformationen werden in eine neue Darstellung der konformen Gruppe eingebettet [1]. Damit lassen sich explizite Ausdrücke für Antwort- und Korrelationsfunktionen von alternden Spinsystemen angeben, die sehr gut mit den Ergebnissen numerischer Simulationen uebereinstimmen [2]. Die Sugawarakonstruktion der konformen Feldtheorie läßt sich auf diese Systeme übertragen.

[1] M. Henkel und J. Unterberger, Nucl. Phys. B660, 407 (2003). [2] M. Henkel, A. Picone und M. Pleimling, Europhys. Lett. 68, 191 (2004).

Fachvortrag MP 5.4 Di 15:00 TU MA141

Renormalization group flows into phases with broken symmetry — •Oliver Lauscher[1], Manfred Salmhofer[1], Carsten Honerkamp[2], and Walter Metzner[2] — [1]Institut für Theoretische Physik, Universität Leipzig, Augustusplatz 10, 04109 Leipzig, Germany — [2]Max-Planck-Institut für Festkörperforschung, Heisenbergstraße 1, 70569 Stuttgart, Germany

We describe a way to continue the fermionic renormalization group flow into phases with broken global symmetry. The method does not require a Hubbard-Stratonovich decoupling of the interaction. Instead an infinitesimally small symmetry-breaking component is inserted in the initial action, as an initial condition for the flow of the selfenergy. Its flow is driven by the interaction and at low scales it saturates at a nonzero value if there is a tendency for spontaneous symmetry breaking in the corresponding channel. For the reduced BCS model we show how a small initial gap amplitude flows to the value given by the exact solution of the model. We also discuss the emergence of the Goldstone boson in this approach.

Fachvortrag MP 5.5 Di 15:20 TU MA141

Momentum-conserving decoherence suited for three dimensions — •Ivo Knittel and Uwe Hartmann — Institute of experimental physics, University of Saarbrücken, 66041 Saarbrücken

The decoherence rate of a quantum particle can be much higher than the rate of momentum change. An example is a free particle moving with a constant velocity in a dephasing environment. Such a particle is described by a wavepacket whose half-width is determined by the dephasing rate. In the single-particle Green's function, dephasing is described by a non-hermitian part of the the self-energy. However in the standard Green's function theory, it is not clear how to obtain the actual time evolution of a quantum particle. We present a scheme to describe the time evolution of a quantum particle in real space under the influence of momentum-conserving dephasing. In contrast to earlier approaches, as [1], the scheme is suited for problems in two and three dimensions. The description of a free dephasing particle as a moving wavepacket is discussed as an example. [1]I. Knittel, F. Gagel, M. Schreiber; Quantum transport and momentum conserving dephasing Phy. Rev B 60, 916 (1999)

Fachvortrag MP 5.6 Di 15:40 TU MA141

Control of chaos in Hamiltonian systems and applications — •Guido Ciraolo — Centre de Physique Theorique, Luminy, France

In this talk I will present a technique to control chaotic diffusion in Hamiltonian systems. The general idea is to build barriers in phase space by a small apt modification of the Hamiltonian. This technique can be adapted to Hamiltonian flows or symplectic maps. Application to paradigmatic models and to chaotic transport in plasma physics will be discussed. A first experimental check on a Traveling Wave Tube will be presented.

MP 6 Wave Equations and Scattering Theory

Zeit: Mittwoch 12:05–13:05 Raum: TU MA043

Fachvortrag MP 6.1 Mi 12:05 TU MA043

"Normalization" and "Completeness" of the Volkov Solutions — •Stephan Zakowicz — Institut für Theoretische Physik, Justus-Liebig-Universität Giessen, Heinrich-Buff-Ring 16, 35392 Gießen

The (non-square-integrable) Volkov solutions [1] fulfil the Dirac equation for a charged spin-1/2 particle in the field of a classical plane electromagnetic wave.

It was demonstrated before [2] that under certain assumptions on the external electromagnetic vector potential, square-integrable wave packets may be constructed from these Volkov solutions. Two commonly believed conjectures have been rigorously proved by the author recently and will be discussed in this contribution [3]: (1) Wave packets from "electronic" and "positronic" Volkov solutions are orthogonal to each other when the vector potential and its first derivative are bounded; this fact leads to the correct "normalization" of wave packets. (2) On the same assumptions as in (1), the wave packets fulfil the Dirac equation.

Apart from the "normalization" of the Volkov solutions, their "completeness" is also of relevance for the computation of physical processes. The current state of a possible proof of this supposition is briefly addressed.

[1] D. M. Wolkow, Z. Phys. **94**, 250 (1935)
[2] S. Zakowicz, Verhandl. DPG (VI) **39**, 5/2004, p. 27
[3] S. Zakowicz, J. Math. Phys. (in print, 2005); Preprint: http://www.ma.utexas.edu/mp_arc-bin/mpa?yn=04-234

Fachvortrag MP 6.2 Mi 12:25 TU MA043

Erweiterung der Cox-Thompson-Methode für das Inverse Streuproblem bei fester Energie auf Potentiale mit einem asymptotischen Coulombabfall — •Oliver Melchert[1] und Barnabás Apagyi[2] — [1]Institut für Theoretische Physik, Justus-Liebig-Universität Giessen, Heinrich-Buff-Ring 16, 35392 Giessen — [2]Department of Theoretical Physics, Budapest University of Technology and Economy, Budapest, Ungarn

Ausgehend von der Povzner-Levitan-Darstellung der regulären Streuwellenfunktion und unter Berücksichtigung der asymptotischen Eigenschaften der auftretenden Funktionen erhalten wir in Anlehnung an die Vorgehensweise in [1] ein System komplexwertiger, nichtlinearer Gleichungen.

Der Input der Inversionsprozedur ist eine endliche Menge komplexer Phasenverschiebungen. Mit dem nichtlinearen Gleichungssystem werden die zu den Phasenverschiebungen korrespondierenden komplexwertigen asymptotischen Normierungskonstanten und verallgemeinerten komplexwertigen Drehimpulse ermittelt. Diese Informationen ermöglichen es, das invertierte Potential zu berechnen.

[1] B. Apagyi, Z. Harman und W. Scheid, J. Phys. A **36** (2003) 4815

Fachvortrag MP 6.3 Mi 12:45 TU MA043

Perturbation theory for scattering at a slightly changed object — •Ivo Knittel[1], Andreas Ziroff[2], and Uwe Hartmann[1] — [1]Institute of Experimental Physics, University of Saarbrücken, 66041 Saarbrücken — [2]Siemens AG, Unternehmensbereich CT PS 7, Otto-Hahn-Ring 6, 81730 München

In the engineering of microwave and photonic devices, the definition of tolerances is an important problem. We sugggest a perturbation approach to the scattering matrix of an arbitrary object after a slight change in the geometry, in particular a small shift of a reflecting surface that is part of the object. We present the theory for electromagnetism, but the approach is valid for any time-symmetric wave equation.

MP 7 Integrability and Variational Methods

Zeit: Mittwoch 12:05–13:05 Raum: TU MA141

Fachvortrag MP 7.1 Mi 12:05 TU MA141

Noncompact $SL(2,R)$ spin chains — •Marc Kirch[1] and Alexander N. Manashov[2,3] — [1]Institut für theoretische Physik II, Ruhr-Universität Bochum, D-44780 Bochum — [2]Institut für theoretische Physik, Universität Regensburg, D-93040 Regensburg — [3]Department of theoretical physics, St.-Petersburg State University, 199034, St.-Petersburg, Russia

We consider completely integrable spin chain models whose spin operators are the generators of unitary representations of the noncompact group $SL(2,R)$. Within the framework of the Quantum Inverse Scattering Method we construct $\mathcal{R}$-operators, being solutions to the Yang-Baxter equation. These act on the corresponding vector spaces on wich the representations are realized. Examine the possible combinations of representations, the solutions exhibit different properties. Using the method of the separated variables and the Baxter Q-operator technique we construct and solve a spin chain model realized on the principal continuous series representation of $SL(2,R)$. The main motivation for the study of such objects comes from the remarkable fact that various dilatation operators, governing the scaling behaviour of some composite field operators in certain (SUSY) Yang-Mills theories, have been found to be integrable. In fact they are in one to one correspondence with the Hamiltonian of a completely integrable spin chain - among them those with a noncompact symmetry group.

Fachvortrag MP 7.2 Mi 12:25 TU MA141

Higher Orders of Large-D Expansion From Variational Perturbation Theory — •Axel Pelster[1] and Sebastian Brandt[2] — [1]Fachbereich Physik, Universität Duisburg-Essen, Essen, Germany — [2]Department of Physics, Campus Box 1105, Washington University St. Louis, MO 63130-4899, USA

We derive recursively the perturbation series for the ground-state energy of the D-dimensional anharmonic oscillator and resum it using variational perturbation theory. Extrapolating the exponentially-fast converging approximants, we extract the coefficients of the large-D expansion to higher orders. The calculation effort is much smaller than in the standard field-theoretic approach based on the Hubbard-Stratonovich transformation.

Fachvortrag MP 7.3 Mi 12:45 TU MA141

The Dirichlet Hopf algebra of arithmetics: From numbers to renormalization — •Bertfried Fauser — Max-Planck-Institut für Mathematik, 04103 Leipzig

We study the coalgebraic counterparts of addition and multiplication. This allows to construct two Hopf convolutions, also called Hopf gebras, for both addition and multiplication. Neither of this convolutions is forming a Hopf algebra, however, the multiplicative convolution embodies the Dirichlet convolution of number theoretic functions. There is an opportunity to introduce a new coalgebra structure, called renormalized, such that a nice Hopf algebra structure emerges in such a way that the primitive elements are identical. A subtraction scheme, which might be related to renormalization in quantum field theory, allows to use the nice algebra for computations while actually dealing with the original Hopf convolution. There is a deeper relation of addition and multiplication which relies on n-categories. We give as examples the normal ordering in quantum mechanics and its relation to Stirling numbers and Baxter operators as also the construction of the renormalization coproduct employed in renormalization of quantum fields. An outlook will show how quantum field theoretic methods may be used in number theory.

MP 8 Quantum Gravity

Zeit: Mittwoch 14:00–15:40 Raum: TU MA043

Fachvortrag MP 8.1 Mi 14:00 TU MA043

Quantum Dynamics of Loop Quantum Gravity — •Thomas Thiemann — Albert–Einstein Imstitute, Golm, and Perimeter Institute

We report on the current status of the dynamics of Loop Quantum Gravity.

Fachvortrag MP 8.2 Mi 14:20 TU MA043

An alternative Quantisation of the Flux Operator in Loop Quantum Gravity — •Kristina Giesel[1,2] and Thomas Thiemann[1,2] — [1]Albert-Einstein-Institut für Gravitationsphysik, Am Mühlenberg 1, 14476 Golm — [2]Perimeter Institute for Theoretical Physics, 31 Caroline Street, Waterloo, Ontario N2L 2Y5, Canada

We will introduce an alternative way of quantising the flux operator that is usually used in Loop Quantum gravity (LQG). For this purpose we will use the same quantisation procedure that was used in quantising the Hamiltonian Constraint of LQG. In comparing the action of the alternative flux operator with the one of the usual flux operator, we can verify whether this quantisation procedure leads to the expected result.

Fachvortrag MP 8.3 Mi 14:40 TU MA043

On the Universality of the Hawking Effect — •Ralf Schützhold[1] and William G. Unruh[2] — [1]TU Dresden — [2]UBC Vancouver, Canada

Addressing the question of whether the Hawking effect depends on degrees of freedom at ultra-high (e.g., Planckian) energies/momenta, we propose three rather general conditions on these degrees of freedom under which the Hawking effect is reproduced to lowest order. As a generalization of Corley's results, we present a rather general model based on non-linear dispersion relations satisfying these conditions together with a derivation of the Hawking effect for that model. However, we also demonstrate counter-examples, which do not appear to be unphysical or artificial, displaying strong deviations from Hawking's result. Therefore, whether real black holes emit Hawking radiation remains an open question and could give non-trivial information about Planckian physics.

Fachvortrag MP 8.4 Mi 15:00 TU MA043

Singularities of General Relativity in the Framework of Loop Quantum Gravity — •Johannes Brunnemann — Max Planck Institut fuer Gravitationsphysik, Am Muehlenberg 1, D-14476 Golm

A quantum theory of gravity is expected to solve one of the main problems of General Relativity: the occurrence of singularities, such as the big bang.

Recently, remarkable progress has been made in understanding symmetry reduced cosmological models within the program of Loop Quantum Cosmology *(LQC)*, leading to striking results like the absence of a big bang singularity in these quantum-cosmologies .

One might worry, however, that the performed symmetry reductions could be too restrictive and therefore one should look at the full theory of Loop Quantum Gravity *(LQG)* in order to check the obtained results.

In this talk I will give an overview of what can be said about the (dis)appearance of classical singularities within the **full theory**, *LQG*, and show possible connections to the results within *LQC* .

Fachvortrag MP 8.5 Mi 15:20 TU MA043

Wodurch ist die Geometrie von 3-Mannigfaltigkeiten bestimmt? — •Torsten Asselmeyer-Maluga — FhG, Kekulestr. 7, 12489 Berlin

Die einzigartige Vielfalt an Differentialstrukturen auf 4-Mannigfaltigkeiten ist nicht nur eine mathematische Kuriosität, sondern gewinnt zunehmend an Bedeutung bei der Diskussion in der Quantengravitation: selbst solche topologisch trivialen Räume wie der 4-dimensionale Euklidische Raum besitzt unendlich viele unterschiedliche Differentialstrukturen.

Im Vortrag wird ausgehend von einer Analyse der Differentialstrukturen in 4 Dimensionen mittels virtuell flacher Bündel und dem Spektrum eines Dirac-Operators eine eingebettete Homologie-3-Sphäre konstruiert. Durch eine Beziehung zwischen dem Dirac-Operator auf der 4- und 3-Mannigfaltigkeit wird nun eine Korrespondenz zwichen den Geometrien (im Sinne von Thurston) auf der Homologie-3-Sphäre und den unterschiedlichen Differentialstrukturen der 4-Mannigfaltigkeit hergestellt. Die Auswirkungen auf eine mögliche Quantengravitation werden diskutiert.

MP 9 Quantum Information Theory

Zeit: Mittwoch 14:00–15:20 Raum: TU MA141

Fachvortrag MP 9.1 Mi 14:00 TU MA141

Quantum state estimation and large deviations — •Michael Keyl — Univ. Pavia, QUIT Group, Dipartimento Di Fisica "A. Volta", via Bassi 6, I-27100 Pavia, Italy

In this paper we propose a method to estimate the density matrix ρ of a d-level quantum system by measurements on the N-fold system in the joint state $\rho^{\otimes N}$. The scheme is based on covariant observables and representation theory of unitary groups and it extends previous results concerning the estimation of the spectrum of ρ. We show that it is consistent (i.e. the original input state ρ is recovered with certainty if $N \to \infty$) and analyze its large deviation behavior. In addition we calculate explicitly the corresponding rate function which describes the exponential decrease of error probabilities in the limit $N \to \infty$. For pure input states, or if ρ is mixed but only information about its spectrum is required, we then show that the proposed scheme is optimal in the sense that it provides the fastest possible decay of error probabilities. In the general case, however, the optimality question remains open.

Fachvortrag MP 9.2 Mi 14:20 TU MA141

Entanglement in fermionic systems and its application to spin chain models — •Dirk Schlingemann — Institute for Mathematical Physics, Technical University of Braunschweig

The concept of entanglement in fermionic systems is investigated. We consider a bipartite fermionic system, that is, the fermion fields of Alice's system anti-commute with the fermion fields of Bob's. Thus Alice's observables, which are generated by even products of fermion fields, commute with the observables of Bob. Restricting to observables, we are faced with a bipartite system in the usual sense.

The entanglement of a bipartite fermion state is given by the entanglement of its restriction to the corresponding observable algebras. The main problem is now to compute explicitly the standard entanglement measures, like entanglement of formation, for the restricted state. Note that the restricted state is not pure in general although it may be pure on the fermion algebra. Even if the given state is quasi-free (determined by the correlation function of two fermi field operators), we need to find optimal convex decompositions into pure states which need not to be quasi-free.

To overcome this difficulty we show, by using the concept of "twisted EPR doubles", that there is a quasi-free state for which the restriction to the observable part is indeed maximally entangled. Then we introduce an appropriate fidelity which measures how much a given pure state (pure on the fermion algebra) deviates from the maximally entangled one.

The results are applied to ground states of spin chain models which are related to quasi-free states via the Jordan-Wigner transformation.

Fachvortrag MP 9.3 Mi 14:40 TU MA141

Automatic ensemble teleportation even under sub-optimal conditions — •Thomas Krüger — Theoretische Physik, Fakultät für Naturwissenschaften, Universität Paderborn, Warburger Str. 100, 33098 Paderborn

The possibility of teleportation is surely the most interesting consequence of quantum non-separability. So far, however, teleportation schemes have been formulated by use of state vectors and considering individual entities only. In the present contribution the feasibility of teleportation is examined on the basis of the rigorous ensemble interpretation of quantum mechanics (not to be confused with a mere treatment of noisy EPR pairs) leading to results which are unexpected from the usual point of view. Emphasis is laid on realistic situations where mixed and/or semi-separable states come into play.

Fachvortrag MP 9.4 Mi 15:00 TU MA141

Die Topologie der unitären Gruppen und die Hamilton-Darstellung von unitären Gattern — •Torsten Asselmeyer-Maluga, Matthias Kolbe, Helge Rose und Andreas Schramm — FhG FIRST, Kekulestr. 7,12489 Berlin

In dem Vortrag soll das Problem behandelt werden, wie man aus einer gegebenen unitären Transformation den zugehörigen Hamiltonian bestimmt. In den meisten Fällen führt das Standardverfahren des Logarithmieren zu einem Ergebnis, bei dem der Hamiltonian mehr als Paarwechselwirkungen aufweist. Natürlich sind solche Hamiltonian praktisch nicht realisierbar. Es gibt aber eine Uneindeutigkeit in dem Verfahren des Logarithmieren und nun besteht die Hoffnung, daß sich durch eine entsprechende Wahl des Hamiltonian alle oder fast alle unitären Transformationen ohne Mehrfach-Wechselwirkungen realisieren. Im Vortrag wird ein Beweis vorgestellt, der genau das Gegenteil zeigt. Durch eine Analyse der Topologie und Geometrie der unitären Gruppe kann gezeigt werden, daß man immer nur mit Mehrfach-Wechselwirkungen alle unitären Gatter darstellen kann.

MP 10 Poster

Zeit: Dienstag 13:00–16:00 Raum: Poster TU B

MP 10.1 Di 13:00 Poster TU B

Point contacts in flat Dirac systems — •Roland Gersch — MPI für Festkörperforschung, Heisenbergstraße 1, D-70569 Stuttgart

Motivated by Chalker and Ho's successful continuum description of the U(1) network model, we try to mathematically describe point contacts in a flat Dirac system with weak disorder. Assuming that the trajectory part of the angular momentum vanishes, we derive a boundary condition that allows us to adjust both the net probability flux through a point and a certain quantum mechanical phase. An attempt to follow Klesse and Zirnbauer, who where able to prove a conductance formula for point contacts in the U(1) network model, is met with failure. Although the proof remains elusive, we are able to specify and motivate a similar formula.

MP 10.2 Di 13:00 Poster TU B

Stochastic Schrödinger equation and quantum-classical dynamics — •Wolfgang Pfersich and Walter T. Strunz — Fakultät für Mathematik und Physik, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str.3, 79104 Freiburg

We develop a framework to derive non-Markovian stochastic Schrödinger equations for open quantum systems in any order of the coupling strength to the environment. The derivation is based on Heisenberg's equation of motion using the coherent state representation for the environmental degrees of freedom. It is further shown that this framework allows us to derive consistent time evolution equations for coupled quantum-classical dynamics. These may be applied to nonlinear baths and couplings.

MP 10.3 Di 13:00 Poster TU B

Elliptic solutions of some nonlinear wave and evolution equations and their linear superposition — •Julia Nickel and Hans Werner Schürmann — FB Physik, Universität Osnabrück

A method is presented for finding a subset of the exact (traveling-wave) solutions of various nonlinear wave and evolution equations (NLWEE).

By using an appropriate transformation $\psi \to f$ the NLWEE is transformed into an ordinary differential equation $(f_x)^2 = R$, where R is a fourth degree polynomial in f. The solutions of this differential equation are expressed in terms of Weierstrass's elliptic function $\wp$ and include periodic and solitary-wave-like solutions ("elliptic solution ") [1]. By suitable linear superposition of particular periodic elliptic solutions additional solutions of the NLWEE can be generated [2].

The aim of the project is to investigate various nonlinear wave and evolution equations with respect to the existence of elliptic solutions and the possibility to enlarge the solution set by superposition.

[1] K. Weierstrass, Mathematische Werke V, (Johnson, New York, 1915), pp. 4-16.

[2] A. Khare and U. Sukhatme, J. Math. Phys., 43 (2002).

MP 10.4 Di 13:00 Poster TU B

Dynamics of optomechanically coupled mirrors — •Jan Harms — Albert-Einstein-Institut,Am Kleinen Felde 30,30167 Hannover

The dynamics of optical systems which store light by means of suspended mirrors give rise to optical springs via an optomechanical coupling between the mirrors and the light. These springs transform the free motion of the mirrors into the motion of coupled oscillators with resonances at low acoustic frequencies. Consequently, interferometric detectors which exhibit optomechanical resonances are more sensitive to signals at frequencies close to the resonance frequencies and theoretically, measurements below the quantum limit are possible. A deeper understanding of the dynamics of such systems may help to design new topologies in order to achieve the best sensitivity within the detection frequency band.

MP 10.5 Di 13:00 Poster TU B

Über das Selbst-Verständliche als Grundlage jeder Theorie — •Helmut Hille — Metzer Str.13 74074 Heilbronn

Das Selbst-Verständliche ist ein Satz, der keiner weiteren Begründung bedarf, also ein Grund-Satz, auch "Prinzip"genannt. Auch der Mathematik liegen solche selbstevidenten, nichtwillkürlichen Annahmen zugrunde. Erhaltungssätze sind selbst-verständlich, denn nur wenn etwas sich nicht in seinem Zustand erhält, würde dies einer Erklärung, in der Physik in Form einer Ursache bedürfen. Weil Energie das physikalisch Allgemeinste ist, ist der Erhaltungssatz der Energie zugleich der allgemeinste Grund-Satz der Physik, der auch Heisenbergs Energiematrix genügt. Aber schon Newton hatte mit Selbst-Verständlichen begonnen, denn dass jeder Körper von sich aus sich in seinem Zustand erhält, ist ein Axiom, weil es keiner weiteren Begründung bedarf. Mit Selbst-Verständlichen beginnend können wir hoffen, verständigen Menschen etwas verständlich zu machen.

MP 10.6 Di 13:00 Poster TU B

Informationstheoretische Begründung von Quantenmechanik und Raum-Zeit mittels des Bohrschen Relativitätsbegriffs — •Walter Smilga — Isardamm 135 d, 82538 Geretsried

Die Bohrsche Feststellung 'Physikalische Phänomene werden relativ zu verschiedenen experimentellen Anordnungen beobachtet' wird angewandt auf ein System von binären Elementen als Träger elementarer Informationseinheiten. Im Sinne von Bohr wird eine Beschreibung relativ zu 'makroskopischen' Anordnungen solcher Elemente formuliert. Diese erfordert die Einführung eines Hilbertraum-Formalismus. Es wird gezeigt, daß der Hilbertraum symmetrisch bezüglich der deSitter-Gruppe SO(3,2) ist. Für makroskopische Anordnungen wird letztere durch die Poincare-Gruppe approximiert. Man erhält dadurch ein relativistisches Raum-Zeit-Kontinuum als Ausdruck der Orientierung makroskopischer Anordnungen relativ zueinander. Einzelnen Binärelementen läßt sich dann ebenfalls eine 'Position' relativ zu makroskopischen Bezugselementen zuordnen. Damit erscheinen die Binärelemente dem Beobachter als massive Spin-1/2-Teilchen.

Der informationstheoretische Zugang bestimmt eine Massenskala, liefert stringente Ansätze für alle vier Wechselwirkungen und legt prinzipiell Kopplungskonstanten und Massen fest. Er stellt damit trotz seiner Einfachheit eine potentielle Basis für eine Teilchentheorie dar, die über das Standardmodell hinausführt.

MP 10.7 Di 13:00 Poster TU B

Quantisierung als Auswahlproblem nach Einstein — •Dieter Suisky[1] und Peter Enders[2] — [1]Institut für Physik, Humboldt-Universität zu Berlin, Newtonstr. 15, 12489 Berlin — [2]Siemens AG, Berlin

Einstein hat als erster Plancks Quantenhypothese ernst genommen und weiterentwickelt. Grundlegend ist seine Beobachtung, daß Quantensystemen eine geringere Anzahl von stationären energetischen Zuständen zukommt als klassischen Systemen.

Auf dieser Grundlage läßt sich die Schrödinger-Gleichung axiomatisch aus der Eulerschen Darstellung der Mechanik ableiten, ohne die üblichen Annahmen über die Natur quantenmechanischer Systeme, wie den Welle-Teilchen-Dualismus oder das Plancksche Wirkungsquantum, zu machen. Euler reduzierte die Newtonschen Axiome auf diejenigen, welche die Zustandserhaltung beschreiben, so daß weder die Kraft noch die Bewegungsgleichung axiomatisch festgelegt sind und alternative Bewegungsgesetze formuliert werden können.

Außer der Eulerschen Axiomatik werden benutzt: (a) Die universelle Gültigkeit des Energiesatzes für stationäre Zustände wechselwirkungsfreier Systeme; (b) Helmholtz' Begründung des Energiesatzes; (c) Whittakers Integraldarstellungen für die Lösungen gewisser Differentialgleichungen und die daraus resultierenden Rekursionsformeln.

Das Verhältnis von klassischer und nichtklassischer Theorie wird durch die Voraussetzungen der Ableitung weitgehend festgelegt, deshalb ist die Benutzung von Analogien nicht erforderlich.

MP 10.8 Di 13:00 Poster TU B

Einsteins Zugang zur Elektrodynamik und die mechanische Bestimmtheit der Maxwell-Gleichungen — •Peter Enders[1] und Dieter Suisky[2] — [1]Siemens AG, Berlin — [2]Institut für Physik, Humboldt-Universität zu Berlin, Newtonstr. 15, 12489 Berlin

Für Einstein war die Rolle der Relativbewegung zwischen Magneten und Leiter bei der elektromagnetischen Induktion ein entscheidendes Motiv bei der Entwicklung seines Relativitätsprinzips. Andererseits werden die Maxwellschen Gleichungen üblicherweise *neben* die Grundgleichungen der Mechanik gestellt, so als hätten beide kaum etwas miteinander zu tun. Zwischen beiden besteht jedoch ein viel engerer Zusammenhang, wie das folgende Theorem zeigt.

Theorem: Wenn es (a) mit Helmholtz ein Vektorfeld $\vec{F}_1(vecx,t)$ gibt, das die Energie eines Körpers ändert, indem es mit der Kraft $\vec{K}_1 = q_1\vec{F}_1$ wirkt (q_1 – Kopplungskonstante zwischen Körper und Feld $\vec{F}_1$), und (b) mit Lipschitz ein Vektorfeld $\vec{F}_2(vecx,t)$, das zwar die Bewegung, nicht aber die Energie eines Körpers beeinflusst, indem es mit der Kraft $\vec{K}_2 = q_2 \cdot \vec{v} \times \vec{F}_2$ wirkt (q_2 – Kopplungskonstante zwischen Körper und Feld $\vec{F}_2$, $\vec{v}$ – Geschwindigkeit des Körpers), dann genügen die Felder $\vec{F}_1$ und $\vec{F}_2$ den Maxwell-Lorentz-Gleichungen.

Mithin werden jene weitgehend durch die *Mechanik* bewegter Ladungen bestimmt.

Zur Begründung werden Eulers Darstellung der Mechanik und ihre speziell-relativistische Verallgemeinerung (Suisky & Enders, diese Konferenz) sowie der Energiesatz benutzt.

MP 10.9 Di 13:00 Poster TU B

Lattice Structure and Relativity — •helmut günther — FH Bielefeld FB Elektrotechnik, W.-Bertelsmann-Str.10, 33603 Bielefeld

We discuss a lattice model of W. Thirring's transformation $x' = (x - vt)/\gamma\,, t' = \gamma\, t, \gamma = \sqrt{1 - v^2/c^2}$, for relativistic spacetime with absolute simultaneity. Here the unprimed particular inertial frame $\Sigma_o(x,t)$ is selected arbitrarily.

We consider an unbounded lattice representing Thirring's particular frame. An infinite straight dislocation line represents the x-direction of a physical vacuum. The displacements $q = q(x,t)$ perpendicular to that dislocation line satisfy the sine-Gordon equation $\frac{\partial^2 q}{\partial x^2} - \frac{1}{c^2}\frac{\partial^2 q}{\partial t^2} = \sin q$. The soliton solutions of this equation represent the particles in that lattice-vacuum.

We find length contraction $l_v/l_o = \gamma$ and time dilatation $T_o/T_v = \gamma$ with respect to the lattice-vacuum by comparing a static kink solution with a uniformly moving one as well as a static breather solution with a uniformly moving one.

In a next step we identify the primed frame $\Sigma'(x',t')$ with an observer which is at rest with respect to a moving kink or breather particle. By synchronising the clocks in Σ' according to $t' = 0$ for $t = 0$ in Σ_o we arrive at Thirring's transformation. However, synchronising the clocks according to $t' = x\frac{T_o/T_v - l_o/l_v}{v}$ in Σ' for $t = 0$ in Σ_o leads to Lorentz

transformation, and hence the lattice no longer represents a particular frame.

MP 10.10 Di 13:00 Poster TU B

Die neuen Gravitationsfeld-Strukturgesetze zur Schwerpunktberechnung — •Peter Kümmel — Amselweg 15 c, 21256 Handeloh

In der herkömmlichen Lehrbuchphysik wurden die Gravitations-Feldstrukturen bislang sehr vernachlässigt. Grundsätzliche geometrische Erkenntnisse dienen dazu, mathematische Klarheiten über den künstlichen und den natürlichen Schwerpunktversatz zu schaffen.