FRG Meeting 2017

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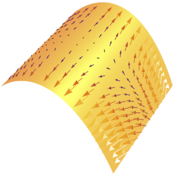
from quantum gravity and dark energy
to ultracold atoms and condensed matter

IWH Heidelberg, Hauptstraße 242, Heidelberg

March 7 – March 10, 2017



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8:50 – 9:00	**C. Wetterich**	IWH Greeting		
9:00 – 9:40	**H. Gies**	**R. Thomale**	**J. Braun**	**S. Diehl**
9:40 – 10:20	**C. Honerkamp**	**L. Classen**	**I. Boettcher**	**D. Mouhanna**
10:20 – 10:50	Coffee	Coffee	Coffee	Coffee
10:50 – 11:30	**S. Lippoldt**	**Discussions**	**M. Shaposhnikov**	**R. Percacci**
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15:10 – 15:40	Coffee	Coffee	Coffee	**J.-P. Blaizot**
15:40 – 16:20	**N. Dupuis**	**N. Christiansen**	**J. Serreau**	Closing 15:50
16:20 – 17:00	**S. Flörchinger**	**M. Reuter**	**Discussions**	
17:00 – 17:30	Snacks			
17:30 –	**Poster session**		19: 00 Conference dinner	

Chairs

Tuesday morning session: Jan Pawlowski

Tuesday afternoon session: Michael Scherer

Wednesday morning session: Gian Paolo Vacca

Wednesday afternoon session: Manfred Salmhofer

Thursday morning session: Alfio Bonnano

Thursday afternoon session: Thomas Gasenzer

Friday morning session: Tilman Enss

Friday afternoon session: Astrid Eichhorn

International poster prize committee

Léonie Canet (Université Grenoble Alpes)

Nicolas Dupuis (Université Pierre et Marie Curie)

Holger Gies (TPI Jena)

Roberto Percacci (SISSA, Trieste)

Srinivas Raghu (Stanford University)

2 General Information

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Conference dinner:

The conference dinner takes place in Haus Buhl, which is close to the IWH, see on the map below.

Useful links:

FRG-Meeting Website:
https://www.thphys.uni-heidelberg.de/~frg-meeting/

How to find the conference center (IWH):
http://www.iwh.uni-hd.de/wegbeschreibung_engl.html

Hotel Vierjahreszeiten:
http://www.4-jahreszeiten.de/hotel/en/

Institute for Theoretical Physics (Philosophenweg 16):
https://www.thphys.uni-heidelberg.de/

For dinner

Heidelberg's old town has a lot of very nice restaurants and bars. Please, ask the locals for more recommendations. The following list of hints is not exhaustive!

Schnitzelhaus
Neckarmünzgasse 10, 240m from IWH

Kulturbrauerei
Brewery, Leyergasse 6, 250m from IWH

Gasthaus Weisses Rössel
Hauptstraße 210, 350m from IWH

Wirtshaus Nepomuk
Obere Neckarstraße 2, 550m from IWH

For drinks *et al.*

Bent Bar
Cocktails, Leyergasse 2, 270m from IWH

Kulturbrauerei
Brewery, Leyergasse 6, 250m from IWH

Marstallcafé Heidelberg
Student's Café, Marstallhof 1, 950m from IWH

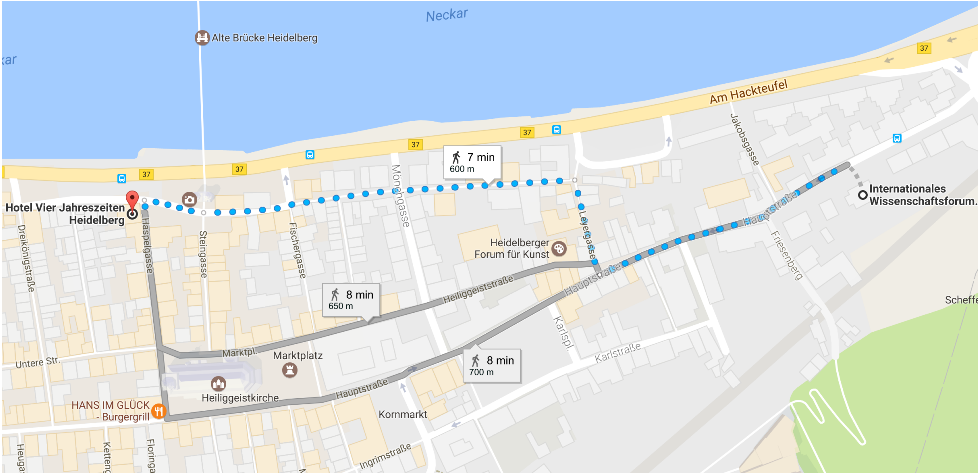
Cave 54
Jazz Club, Krämergasse 2, 550m from IWH

Destille
Untere Str. 16, 700m from IWH

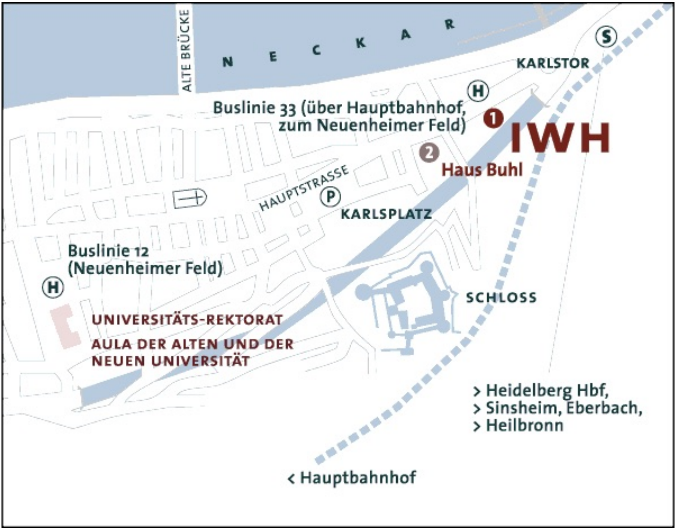
La Fée Bar Café
Cocktails, Untere Str. 29, 650m from IWH

Generally, you can try Untere Straße, 500m from IWH!

Map of Heidelberg's old town:



IWH and Haus Buhl: location of conference dinner ↩



3 Talks: Titles & Abstracts

Jean-Paul Blaizot (CEA Saclay) ↩

Remarks on the 2PI formalisms and the functional RG

Igor Boettcher (SFU Vancouver) ↩

Anisotropy induces non-Fermi liquid behavior and nemagnetic order in 3D Luttinger semimetals

We illuminate the intriguing role played by spatial anisotropy in three-dimensional Luttinger semimetals featuring quadratic band touching and long-range Coulomb interactions. For sufficiently strong anisotropy, two main effects come to light. First, the three-dimensional system features an Abrikosov non-Fermi liquid ground state. Second, qualitatively new fixed points show up which describe quantum phase transitions into phases with nemagnetic orders – higher-rank tensor orders that break time-reversal symmetry, and thus have both nematic and magnetic character. In real materials these phases may be realized through sufficiently strong microscopic short-range interactions. On the pyrochlore lattice, the anisotropy-induced fixed points determine the onset of all-in-all-out or spin ice ordering of local magnetic moments.

Jens Braun (TU Darmstadt) ↩

Ground-state properties of spin- and mass-imbalanced Fermi gases

Michael Buchhold (University of Cologne) ↩

Nonstandard universality and scaling regimes by rare events in weakly disordered Dirac metals

A unified theory for weakly disordered three-dimensional Dirac metals is provided based on the supersymmetry approach. It incorporates simultaneously both rare instanton events and the effect of long wavelength electron fluctuations in a frequency resolved manner. The presence of an instanton background and associated a spontaneous breakdown of supersymmetry destabilizes the previously known supersymmetric critical fixed point, and gives rise to a new infrared stable fixed point characterizing a different, novel universality class. The new fixed point governs physical observables in an intermediate frequency window, which is located in between an instanton-dominated and a supersymmetric scaling regime, and whose size may depend on the observable under consideration.

Leonie Canet (LPMMC, Université Grenoble Alpes) ↩

Correlation functions in homogeneous and isotropic turbulence

Turbulence is an ubiquitous phenomenon in natural and industrial flows. Yet, calculating its statistical properties, and in particular what is generically called intermittency effects, that is violations of standard scale invariance, remains an unsolved issue. In this talk, I will focus on isotropic and homogeneous turbulence in three-dimensional incompressible flows. I will explain how one can derive closed FRG flow equations, which are exact in the limit of large wave-numbers, for the two-point, and more generally n-point, correlation functions of the turbulent stationary state. I will present the full space time dependent fixed point solution of these equations for the two-point function, and show that it encompasses intermittency effects. These predictions are compared to results from direct numerical simulation of Navier-Stokes equations and experimental results, showing a remarkable agreement.

Nicolai Christiansen (ITP Heidelberg) ↩

Interplay of gravity and gauge theories at the Planck scale

I study the coupling of gauge theories to quantum gravity. A general mechanism how graviton fluctuations induce higher order operators in the gauge sector is discussed. It is shown how asymptotically safe gravity can cure the triviality problem in Abelian gauge theories and the status of asymptotic freedom and asymptotic safety in non-Abelian gauge theories coupled to gravity is investigated.

Laura Classen (BNL Brookhaven) ↩

Phase transitions and critical behavior in 2D Dirac materials

We study the quantum phase transitions occurring in low-dimensional Dirac materials for sufficiently large interactions at the example of a spin and a charge density wave, and a Kekulé bond order. We describe these systems by effective Gross-Neveu-Yukawa theories with order parameter fields of different symmetry. The spin and charge density waves are characterised by an $O(3)$ or Z_2 field, respectively. The Kekulé order displays a more exotic Z_3 symmetry. With the help of a functional RG approach, we determine the nature of the corresponding phase transitions and give estimates for the critical exponents in case of continuous transitions. The fixed point structure and its stability properties thereby strongly depend on the number of Dirac fermions. The coupling of the different order parameters induces multicritical behavior and describes the phase diagram in the vicinity of the point, where different symmetry-broken phases meet. This allows us to investigate the competition of spin and charge density waves as expected for equivalent interactions strengths in these channels.

Bertrand Delamotte (Université Pierre et Marie Curie) ↩

Bound states in the three-dimensional ϕ^4 model

Sebastian Diehl (Cologne University) ↩

Fate of Kosterlitz-Thouless Physics in Driven Open Quantum Systems

Recent developments in diverse areas – ranging from cold atomic gases to light driven semiconductors to microcavity arrays – move systems into the focus which are located on the interface of quantum optics, many-body physics and statistical mechanics. They share in common that coherent and driven-dissipative quantum dynamics occur on an equal footing, creating genuine non-equilibrium scenarios without immediate counterpart in equilibrium condensed matter physics. We study such systems in two dimensions on the basis of a duality transformation mapping the problem into a non-linear noisy electrodynamics, where the charges represent vortices. In the absence of vortices, the problem is equivalent to the

Kardar-Parisi-Zhang equation. We show that the paradigmatic quasi-long range order of equilibrium systems at low temperature must be absent asymptotically. More precisely, the non-equilibrium drive generates two independent scales, leading to distinct but subalgebraic behavior of the asymptotic correlation functions. Although the usual Kosterlitz-Thouless phase transition does thus not exist out of equilibrium, a new phase transition into a vortex turbulent state is found, which occurs as a function of increasing non-equilibrium strength.

Nicolas Dupuis (Université Pierre et Marie Curie) ↩

Thermodynamics and transport near a quantum critical point

We discuss the application of non-perturbative functional renormalization group (FRG) to the relativistic quantum O(N) model in two space dimensions. This model describes the critical regime of many condensed-matter systems including quantum antiferromagnets and the superfluid–Mott-insulator transition of bosons in an optical lattice. We discuss both the universal equation of state (which, thanks to the quantum-classical mapping, can be compared with Monte Carlo simulations of classical 3D systems in a finite geometry) and the zero-temperature conductivity. The universal value of the latter at the quantum critical point is in good agreement with quantum Monte Carlo estimates and conformal bootstrap results. In the ordered phase, we find that the conductivity has a "super-universal" component which is independent of both the distance to the quantum critical point and the value of N.

Stefan Flörchinger (ITP Heidelberg) ↩

Effective dissipation

I will discuss how effectively dissipative dynamics can arise in quantum field theories, why this is interesting from an information theoretic point of view and how understanding these phenomena in more detail could help to solve some interesting open problems in cosmology and condensed matter physics.

Holger Gies (TPI Jena) $\hookleftarrow$

Renormalization flow of fermionic systems

We review the present status of functional renormalization group applications to low dimensional relativistic fermion systems. We report on quantitative progress within systematic and consistent approximation schemes, highlight new conceptual aspects, and discuss open questions and puzzles.

Carsten Honerkamp (RWTH Aachen) $\hookleftarrow$

Truncated unity fRG on square and honeycomb lattices

Recently the truncated-unity functional renormalization group (TUfRG) has been put forward as a systematic technique for treating the evolving structure of the four-point vertex in interacting many-fermion systems on the lattice. It incorporates previous channel-decomposition approaches and allows for an efficient evaluation by parallel computing. We present results of first studies on square and honeycomb lattices. We also describe how the now-achieved momentum resolution can be employed to study correlation functions and the effect of longer-range interactions in more detail.

Stefan Lippoldt (ITP Heidelberg) ↩

Quantum gravity and Standard-Model-like fermions

We discover that chiral symmetry does not act as an infrared attractor of the renormalization group flow under the impact of quantum gravity fluctuations. Thus, observationally viable quantum gravity models must respect chiral symmetry. In our truncation, asymptotically safe gravity does, as a chiral fixed point exists. A second non-chiral fixed point with massive fermions provides a template for models with dark matter. This fixed point disappears for more than 10 fermions, suggesting that an asymptotically safe ultraviolet completion for the standard model plus gravity enforces chiral symmetry.

Daniel Litim (University of Sussex) ↩

From exact asymptotic safety to physics beyond the Standard Model

The concept of an interacting UV fixed point in quantum field theory is of high interest per se; for particle physics it opens up theory space for model building. In this talk, we discuss theorems and exact results for asymptotic safety in general 4d gauge theories weakly coupled to matter. The pivotal role of Yukawa interactions is highlighted. Minimal asymptotically safe extensions of the Standard Model are put forward and their signatures at colliders (such as R-hadrons, diboson signatures, the evolution of the strong and weak coupling constants) are worked out.

Dominique Mouhanna (Université Pierre et Marie Curie) ↩

Statistical physics of polymerized membranes

The physics of polymerized membranes has known a renewed interest due to the fact that novel carbon materials like graphene are, as for their elastic properties, very well described by these systems. Thus for practical considerations, notably design of novel materials with outstanding graphene-like mechanical, optical or electronically properties, as well as from a more fundamental point of view, a well controlled description of these systems is highly needed. Physical, i.e. two dimensional, polymerized membranes are from the field theoretical point of view strongly interacting systems whose qualitative and quantitative analysis call for efficient tools like self-consistent screening approximation or nonpertubative renormalization group. I show in my talk how these techniques allow to describe various physical effects taking in place in classical or quantum, pure or disordered, isotropic or anisotropic, membranes.

Roberto Percacci, (SISSA, Trieste) ↩

The Ward identity of scale transformations

The arbitrariness of the background-quantum split gives rise at the classical level to a shift symmetry. I will derive the Ward identities for a subclass of such shift transformations, namely those where the background and fluctuation fields are subjected to a scale transformation. The Ward identity can be solved together with the flow equation, reducing the number of arguments in the Effective Average Action.

Srinivas Raghu (Stanford University) ↩

Two dimensional metallic phases from disordered QED$_3$

With few exceptions, the existence of 2d metallic phases at zero temperature requires electron-electron interactions. Consequently, experimental observations of such metallic behavior have largely defied explanation. We show that (2+1)D quantum electrodynamics (QED$_3$) with a large, even number of fermion flavors remains metallic in the presence of weak scalar potential disorder due to the dynamic screening of disorder by gauge fluctuations. We also show that QED$_3$ with weak mass disorder is governed by a stable fixed point with finite disorder and interaction strengths.

Martin Reuter (Mainz University) ↩

Viability of the Asymptotic Safety scenario
beyond renormalizability?

An acceptable quantum field theory of gravity and spacetime geometry must comply with a number indispensable physical principles such as Hilbert space positivity and background independence in addition to (nonperturbative) renormalizability. We discuss some of them in a simplified two-dimensional setting where the tools of conformal field theory are available.

Francesco Sannino (DIAS, CP3) ↩

Exact Nonperturbative results for Asymptotic (Un)Safety

Frank Saueressig (Nijmegen) ↩

Asymptotic Safety and the Arnowitt-Deser-Misner formulation of gravity

I will review recent progress on formulating and evaluating gravitational renormalization group flows in the presence of a foliation structure of spacetime. The foliation gives rise to a preferred direction which may naturally play the role of time in a Lorentzian setting. In this talk, I will contrast the fixed point structures and phase diagrams arising from the renormalization group flows in the covariant and foliated settings and present first results on the inclusion of matter fields in the foliated setting. The relevance of the construction for the Causal Dynamical Triangulations program, Horava-Lifshitz gravity, and cosmological fluctuation spectra will be discussed.

Julien Serreau (Université Paris Diderot) ↩

NPRG techniques for quantum scalar fields in de Sitter space

I review recent developments concerning the use of NPRG techniques for describing the nontrivial infrared regime of light scalar fields in de Sitter space. Long wavelength fluctuations (in units of the spacetime curvature) undergo a dramatic gravitational amplification which is responsible for dramatic phenomena, such as the radiative restoration of spontaneously broken symmetries.

Misha Shaposhnikov (EPF Lausanne) ↩

TBA

Nikos Tetradis (University of Athens) ↩

Effective Description of Dark Matter as a Viscous Fluid

Ronny Thomale (Würzburg University) ↩

History, Present, Future: Functional RG for unconventional superconductors

Functional renormalization group has become a fundamental element of contemporary methods in condensed matter to identify Fermi surface instabilities. Among them, unconventional superconductivity has triggered particular importance, where the methodological edge of FRG against e.g. random phase approximation has revealed itself in different material contexts such as iron pnictides, strontium ruthenate, and many more. I will give a review on promising current topical directions of unconventional superconductors where the fRG promises to be of particular use.

4 Posters: Titles & Abstracts

Anton Cyrol (ITP Heidelberg) ↩

Yang-Mills Correlation Functions at Finite Temperature

We calculate Landau gauge Yang-Mills correlation functions at finite temperature with the functional renormalization group. Our self-consistent computation fully includes the splitting into magnetic and electric components of the gluon propagator and the classical tensor structures, but is limited to zeroth mode correlation functions. In the limit of zero temperature, the results of our parameter-free computation converge to the vacuum results from arXiv:1605.01856 [hep-ph].

Tobias Denz (ITP Heidelberg) ↩

Towards apparent convergence in asymptotically safe quantum gravity

The asymptotic safety scenario in gravity is accessed within the systematic vertex expansion. In the present work this expansion scheme is extended to the dynamical graviton four-point function. For the first time, this provides us with a closed flow equation for the graviton propagator: all vertices and propagators involved are computed from their own flows. In terms of a covariant operator expansion the current approximation gives access to Λ, R, R^2 as well as $R_{\mu\nu}^2$ and higher derivative operators. We find a UV fixed point with three attractive and two repulsive directions, thus confirming previous studies on the relevance of the first three operators. In the infrared we find trajectories that correspond to classical general relativity and further show non-classical behaviour in some fluctuation couplings. We also find signatures for the apparent convergence of the systematic vertex expansion. This opens a promising path towards establishing asymptotically safe gravity in terms of apparent convergence.

Aaron Held (ITP Heidelberg) ↩

Constraining quantum gravity by recovering the Standard Model

We propose a scenario to constrain the couplings of a quantum field theory of gravity. We assume that such a theory incorporates both gravity and matter degrees of freedom. Renormalization group flows connect the high energy scale directly with physics at the electroweak scale under the assumption that no new physics exists at intermediate scales. We discuss how the requirement of recovering the correct low-energy limit in the matter sector could constrain the gravitational parameter space. Specifically, we explore constraints on the gravitational couplings arising in a simple Higgs-Yukawa model.

Bernhard Ihrig (ITP Heidelberg) ↩

Critical behavior of Dirac materials:
Gross-Neveu-Yukawa model at three loops

Dirac and Weyl fermions appear as quasi-particle excitations in many condensed-matter systems. They display various quantum transitions which fall into the universality class of the Gross-Neveu model. We study its bosonized version – the Gross-Neveu-Yukawa model – at three-loop order and calculate critical exponents in $D = 4 - \epsilon$. The comparison to other approaches, namely FRG and Monte Carlo methods, paves the road to a more comprehensive understanding of this paradigmatic example of interacting QFTs. We discuss applications of the results for the metal-insulator transition in graphene and the disorder-induced quantum transition in Weyl semimetals.

Benjamin Knorr (TPI Jena) ↩

Towards a local potential approximation in quantum gravity

We show how to calculate the renormalization group flow of correlation functions in quantum gravity to arbitrary power of the fluctuation field. The new approach thus for the first time allows to resolve arbitrarily strong fluctuations and an infinite number of fluctuation couplings. It also allows for a check of the apparent convergence of the vertex expansion.

Ken Kikuchi (Nagoya University) ↩

On three-dimensional trace anomaly
from holographic local RG

Odd-dimensional quantum field theories (QFTs) can have non-zero trace anomalies if external fields and the Levi-Civita tensor are supplied, which are needed to construct Lorentz singlets with appropriate mass dimensions (or weights). We have studied a three-dimensional QFT and explicitly computed the trace of the stress tensor using the holographic (local) renormalization group (RG). We have checked that our result reproduce all known properties of vector beta functions and the Wess-Zumino consistency condition. However, we found the anomalies are proportional to beta functions, and the trace vanishes on fixed points. We clarify what is responsible for the vanishing trace anomalies.

Steven Mathey (University of Cologne) ↩

Non-Equilibrium interface dynamics with correlated noise: Emergent symmetries and non-universal observables

In this contribution I investigate the physics of a 1D KPZ interface that is subjected to a noise with smooth spatio-temporal correlations. This problem was previously studied numerically as well as with the Replica Trick in a Gaussian variational approach. It was found that the small scale features depend on the details of the microscopic noise while (up to the overall amplitude factors) the exact solution with white noise governs the large scales. In the present work, Functional Renormalization Group (FRG) methods are employed in order to resolve the non-perturbative features of KPZ dynamics. The FRG makes it possible to follow the renormalization group flow from its initial conditions all the way down to its fixed point. I show that the exact solution emerges on large scales independently of the details of the noise correlations. Moreover the small scale features (and their dependence on the particular choice of the noise correlations) are resolved and compared to direct numerical simulations.

Jordi Paris-Lopez (University of Graz) ↩

Properties of Bound States using the FRG

Dyson-Schwinger, Bethe-Salpether and Faddeev equations have long provided a functional way of deriving properties of bound states for many different systems. Given the complexity and numerical challenge associated to the mentioned equations, the FRG was suggested as an alternative functional method to study bound states. As a first step, properties of the bound states are to be analysed in the Quark-Meson model. Solutions to the flow equations of momentum dependent n-point functions and techniques, such as dynamical hadronization and analytical continuation using modified regulators, need to be under control in this model before working in QCD. A few examples and preliminary results will be shown.

Martin Pospiech (TU Darmstadt) ↩

A Fierz-complete NJL model study: fixed points and phase structure at finite temperature and density

Manuel Reichert (ITP Heidelberg) ↩

Quantum Gravity with a vertex expansion on curved backgrounds

We investigate the phase diagram of quantum gravity within a vertex expansion about constantly curved backgrounds. We evaluate the graviton two-point and three-point function with a spectral sum on a sphere and obtain UV fixed point functions $\mu^*(R)$, $\lambda_3^*(R)$ and $g^*(R)$. The existence of these UV fixed point functions gives further evidence for the asymptotic safety scenario. We further investigate the effect of these UV fixed point functions on the background potential. Here we find a solution to the equation of motion for small curvature.

Mahmoud Safari (INFN) ↩

Covariant and background-independent functional renormalization in scalar QFT.

In the context of scalar QFT we introduce a class of generically nonlinear quantum-background splits for which the splitting Ward identity, encoding the single-field dependence in the effective action, can be solved exactly. We show that, by appropriate choice of cutoff, this can be used to construct an effective average action which is both covariant and dependent on the background and fluctuation fields only through a single total field in a way independent from the dynamics. Moreover we discuss the criteria under which the ultraviolet symmetries are inherited at lower scales.

Giulio Schober (RWTH Aachen) ↩

Response Theory of the Electron-Phonon-Coupling

We present a systematic theoretical enquiry concerning the conceptual foundations and the nature of phonon-mediated electron-electron interactions. Starting from the fundamental many-body Hamiltonian, we propose a simple scheme to decouple the electrons and nuclei of a crystalline solid via effective interactions. These effective interactions, which we express in terms of linear response functions, are completely symmetric between electrons and nuclei. Correspondingly, we derive concrete formulae for both the effective electron interaction mediated by phonons and the effective nuclear interaction mediated by electrons. In particular, we rederive from our fundamental ansatz the well-known general expressions of the effective electron-electron interaction in terms of the elastic Green function and the phonon dispersion relation. We further show that the effective nuclear interaction coincides in the instantaneous limit with the dynamical matrix as calculated in electronic structure theory. If combined with the Kubo formalism, our general formulae lend themselves to the calculation of effective interactions from first principles. By showing the compatibility of our approach with the functional integral formalism, this work also paves the way for the derivation of ab initio initial interactions for functional renormalization group applications.

Davide Squizzato (Université Grenoble Alpes) ↩

KPZ equation for disordered out-of-equilibrium quantum systems coupled to a thermal bath

In the last few years experimental progress in the area of out-of-equilibrium exciton-polariton gases gave rise to several questions concerning the physical behaviour of Bose-Einstein condensates under pump and dissipation. Such systems can be theoretically described by a generalised Gross-Pitaevskii Equation (gGPE) in which complex coefficients and noise enrich the equilibrium picture. An analytical mapping between gGPE and the Kardar-Parisi-Zhang (KPZ) equation has been demonstrated at long wavelength if the fluctuations of the amplitude of the condensate are negligible with respect to the ones of the phase field. Hence one expects that the long-distance properties of driven-dissipative condensates belong to the KPZ universality class and a numerical proof was given in (1+1)D. However an experimental observation of such mapping is still missing. An important feature of experimental set-up is the presence of unavoidable disorder due to cavity imperfections and phonons. In this work we develop a Keldysh field-theoretical approach taking into account the role of disorder and interactions with an external phonon-reservoir at thermal equilibrium; on the one hand we derive the gGPE-KPZ mapping and perform numerical simulations of the gGPE to test our predictions, on the other hand the field-theoretical approach can serve as a basis for a future Functional-Renormalization-Group treatment.

Imola Steib (University of Debrecen) ↩

Renormalization of bilocal potentials

The functional renormalization group (RG) method is one of the most important nonperturbative tools in quantum theory, enabling the removal of the degrees of freedom or modes of a physical system successively. In the traditional RG technique, the blocking transformation takes into account the contributions of the pure states only. Using the closed time path (CTP) formalism the RG method can be generalized to take into consideration the contribution of the mixed states, as well. This description can even account for the entanglement between the infrared (IR) and the ultraviolet (UV) modes (S.

Nagy, J. Polonyi, I. Steib, Quantum renorma- lization group, Phys.Rev. D 93 (2016), 025008). The interaction between the UV and IR modes requires the vertices to carry finite momenta. Consequently, a bilocal potential has to be introduced into the action. Thus, the new couplings become momentum dependent. We use the Wegner-Houghton equation which describes the evolution of the Wilsonian action. Due to the sharp cutoff, the equation cannot ac- count for the higher order terms in the gradient expansion. However, the inclusion of the bilocal potential provides a more general treatment in this respect. The traditional RG treatment of Euclidean action containing a bilocal potential is highly nontrivial. We determined the leading order, tree level evolution equation for the potential for a 3 dimensional one- component scalar model, and calculated the evolution of the momentum dependent couplings. Generally, the couplings cor- responding to the quadratic and quartic terms in the local action. However, we found a new relevant momentum dependent coupling, which belongs to the bilocal potential. The relevant couplings determine which interactions are important in the physical model, therefore their knowledge is necessary for the proper description of the system. Our results show that the traditionally used local potential in the RG method may not be suitable to find all the relevant interactions in the model, and the evolution of the bilocal potential has to be determined, as well.

Malo Tarpin (Université Grenoble Alpes) ↩

Exact flow equations for high order correlation functions in fully developed turbulence

To give a complete statistical description of isotropic fully developed turbu- lence is a longstanding issue of classical physics, which has seen few progresses since the pioneering work of Kolmogorov in 1941. Recently, a decisive step has been made in this direction. Using non-perturbative renormalization group (NPRG) and newly discovered symmetries, a closed ow equation for the two- point correlation function, which is exact in the large momentum limit, has been derived. This ow equation exhibits a very peculiar feature, which is non- decoupling between the large and small scales. This property is the hallmark of physics beyond the theory of Kolmogorov. In the present work, we extend this result to arbitrary order correlation functions, that is we show that the ow of any order correlation functions can be closed exactly in the large momentum limit using symmetries. We deduce from this result new predictions for their behavior and we discuss its consequence on the structure functions.

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An asymptotically safe gauge coupling

In the search for a fundamental theory of quantum gravity and matter, we use non-perturbative functional Renormalization Group methods to examine a system composed of a charged scalar and a U(1) gauge field, coupled to asymptotically safe quantum gravity. Preliminary results for the flow of the gauge coupling show evidence for the existence of two fixed points. The most significant result is the irrelevant nature of the coupling at one of the fixed points, hinting towards the possibility of predicting its value at low energies.

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Real time correlation functions at finite temperature

We present a first principle method to gain access to the general momentum and frequency dependence of correlation functions at finite temperature. This allows us to use existing frameworks and workflows developed for Euclidean theories within the FRG. We apply this method to the O(N) model in order to extract the spectral functions of the pion and sigma meson for various temperatures across the phase transition.

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