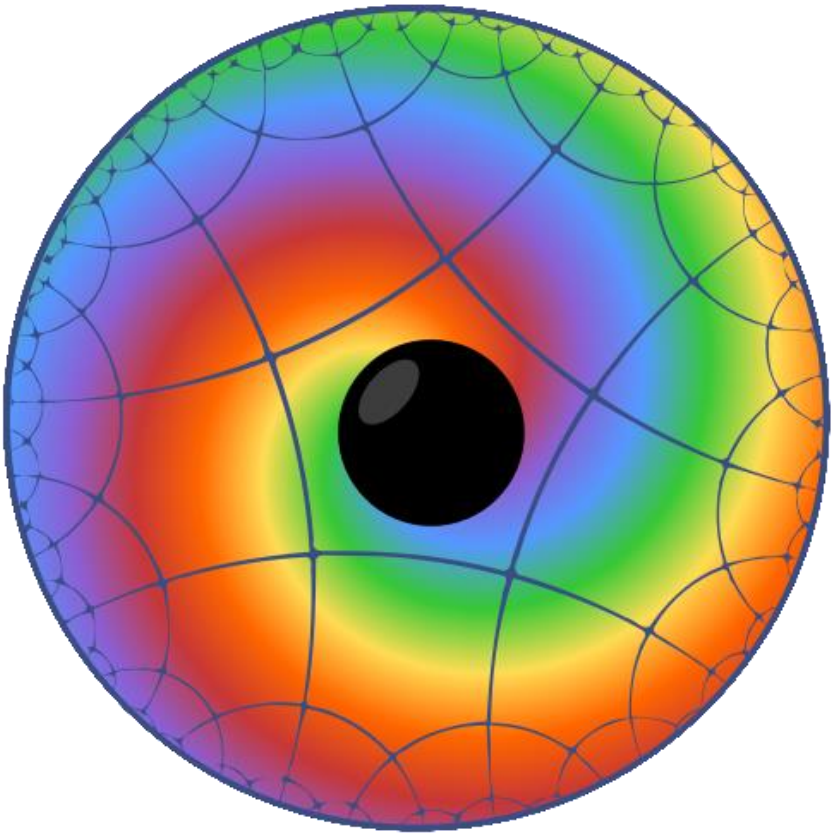
Gauge/Gravity Duality 2018
Programme and Abstracts



Julius-Maximilians-University Würzburg,

from 30th July to 3rd August 2018

Chair: Johanna Erdmenger (JMU Würzburg)

Co-Chair:

Conference Administration: Nelia Meyer (l-tp3@physik.uni-wuerzburg.de)

https://www.physik.uni-wuerzburg.de/tp3/gaugegravity-duality-2018/

Editing: Konstantin Weisenberger

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Abstracts

Talks
(Chronologically ordered)

Monday

Applied String theory: Bringing holography to the lab

Koenraad Schalm

AdS/CFT has given us an unprecedented new holographic window in strongly coupled physics. In particular the existence of charged black holes in AdS predicts the existence of novel quantum critical fixed points distinct from the conventional theory of critical phenomena. I will review how the distinct features of these novel quantum critical points show a remarkable resemblance with the profoundly mysterious behavior of exotic strange metal states of quantum matter, e.g. in high Tc superconductors. Recent experiments of the past two years strongly indicate that this resemblance is more than superficial. This has put us at the cusp of a new era in theoretical physics: we will present the case that current experiments can and will test a holographic gravity model as the theory of the strange metal state.

Holographic striped superconductors and Fermi surfaces

Sera Cremonini, Li Li, Jie Ren

In this talk I will discuss a holographic model of a striped superconductor, in which a U(1) symmetry and translational invariance are broken spontaneously at the same time. This construction provides a concrete example of intertwined orders in holography, and realizes certain key features of pair density wave order. I will also examine the behavior of a probe fermion in this background, and the formation and evolution of a Fermi surface in the presence of an explicit UV lattice. As we will see, the structure of the Fermi surface is very sensitive to the strength of lattice effects.

Pole-skipping in holographic theories

Richard Davison, Mike Blake, Saso Grozdanov, Hong Liu

I will discuss the phenomenon of 'pole-skipping' in holographic theories, which was recently proposed as a signature of the hydrodynamic origin of quantum chaos. Using a simple example, I will explicitly demonstrate why the retarded Green's function of energy density must have both a pole and a zero passing through a particular point in Fourier space. The location of this point is set by the Lyapunov exponent and butterfly velocity of the state. As a consequence, the chaotic properties of the system place a constraint on the dispersion relation of a hydrodynamic excitation. I will explain how the pole-skipping phenomenon can be understood from Einstein's equations and argue that it should be a generic feature of holographic theories coupled to matter.

Modes of Entanglement in Chern-Simons Theories

Rob Leigh

I will discuss several recent studies of entanglement in Chern-Simons theories, including multi-boundary entanglement and its relation to knot theory and the structure of entanglement across interfaces between distinct Chern-Simons regions.

TOWARDS A HOLOGRAPHIC DICTIONARY FOR THE SYK MODEL

Sumit R Das, A. Ghosh, A. Jevicki and K. Suzuki

We argue that the theory of bilocal fields in the euclidean SYK model is a three dimensional theory in a suitable background. At strong coupling, a Horava-Witten compactification of one of the dimensions reproduces the SYK spectrum, and a non-standard propagator of the 3D theory exactly reproduces the two point function including the leading finite coupling correction to the "zero mode" contribution. The lorentzian space-time on which the bilocal fields live is not, however, the dual space-time in the sense of AdS/CFT duality - rather the bilocals are related to the dual fields living on a euclidean space by a radon transform. This transform also clarifies the connection of the finite temperature version of the model with a two dimensional (euclidean) black hole.

Infrared Entanglement

G. Semenoff

Central to the cancellation of infrared divergences in quantum electrodynamics and perturbative quantum gravity is the idea that detection apparratus inevitably have limited resolution and, in any scattering process, an infinite number of arbitrarily soft photons and gravitons are produced and escape detection. Photons and gravitons have polarizations and momenta and one might suspect that those which escape can carry away a significant amount of information. In this talk, I will examine the question as to the quantity of this information loss, its consequences and suggestions for experimental tests of the theoretical ideas, including whether precision interference experiments could see quantum gravitational effects.

Transport from Gravitational Chern-Simons: Theme and Variations

Karl Landsteiener

I will briefly review how gravitational Chern-Simons terms induce transport. Then I will discuss three applications: absence of dissipation in massive gravity models, Hall viscosity in holographic Weyl semi-metals and far from equilibrium transport in holographic quenches.

Susy Q and Boomerang RG flows

Jerome Gauntlett

Q-lattices are a useful tool to study spatially modulated phases of holographic matter. We show that supersymmetric Q-lattice (Susy Q) constructions are possible. We use these tools to analyse boomerang RG flows, which start at a CFT in the UV, deformed by spatially modulated deformatons, and end up at exactly the same CFT in the IR. We analyse a top-down Susy Q example in D=4 that is dual to ABJM theory deformed by mass terms that depend on one spatial dimension and generically preserve N=3 supersymmetry.

Intertwined order in cuprates and black hole hair.

J. Zaanen, Instituut Lorentz for Theoretical Physics, Leiden University, The Netherlands

The non-Fermi-liquid "strange metals" found in cuprates are in all likelihood densely many body entangled states of matter that can only be reliably addressed by a quantum computer [1]. The confusing "intertwined order" in underdoped cuprates may then be viewed as some generalized BCS-type instability departing from the entangled metallic state. It appears that the AdS/CFT duality may reveal ubiquitous principles associated with such genuine quantum matter [2]. Remarkably, resting on highly general effective field principles on the gravitational side the most salient features of the intertwined order including the mysterious pair desnity waves roll out naturally in terms of highly fanciful black hole hair [3]. The latest development is to incorporate a periodic background potential. We find a genuine holographic Mott insulating state which upon doping even mimicks in a rather literal fashion the famous stripes [4].

References [1.] B. Keimer, S.A. Kivelson, M.R. Norman, S. Uchida and J. Zaanen, Nature 518, 179 (2015). [2.] J. Zaanen, Y. Liu. Y.-W. Sun and K. Schalm , "Holographic duality in condensed matter physics" (Cambridge Univ. Press, 2015). [3.] R.-G. Cai, L. Li, Y.-Q. Wang and J. Zaanen, Phys. Rev. Lett. 119, 181601 (2017). [4.] T. Andrade, A. Krikun, K. Schalm and J. Zaanen, Nature Phys., in press: arXiv:1710.05791.

Fine Grained Chaos in AdS2 Gravity

Felix M. Haehl, Moshe Rozali

Quantum chaos can be characterized by an exponential growth of the thermal out-of-time-order four-point function up to a scrambling time uˆ∗. We discuss generalizations of this statement for certain higher-point correlation functions. For concreteness, we study the Schwarzian theory of a one-dimensional time reparametrization mode, which describes AdS2 gravity and the low-energy dynamics of the SYK model. We identify a particular set of 2k-point functions, characterized as being both "maximally braided" and "k-OTO", which exhibit exponential growth until progressively longer timescales uˆ(k)∗=(k−1)uˆ∗. We suggest an interpretation as scrambling of increasingly fine-grained measures of quantum information, which correspondingly take progressively longer time to reach their thermal values.

Chiral transport in strong magnetic fields from hydrodynamics & holography

Martin Ammon, Sebastian Grieninger, Juan Hernandez, Matthias Kaminski, Roshan Koirala, Julian Leiber, Jackson Wu

We derive the hydrodynamic transport coefficients governing a quantum field theory with a chiral anomaly, in a charged thermal plasma state, subjected to a strong external magnetic field. As a proof of existence, within a holographic model, we compute most of these transport coefficients. In our model, charged magnetic black branes in Einstein-Maxwell-Chern-Simons theory, the accessible transport coefficients are nonzero, while they show non-trivial dependence on the magnetic field, anomaly coefficient, and/or charge of the plasma. Some novel transport effects arise from the presence of a chiral anomaly, charge, and/or a magnetic field.

Tuesday

Holographic Tools for Beyond the Standard Model Physics

Nick Evans

Many strongly coupled Beyond the Standard Model theories exist in the literature with dynamics spread over wide energy scales. The lattice struggles here but I argue holography provides some new tools to understand these theories. I will review top down holographic systems with symmetry breaking to argue that these models use the running anomalous dimension of the quark mass as input to predict the spectrum. One can tentatively adapt the models to look at how the spectrum responds to different gamma(mu). As an example, I holographically construct technicolour models with low S and a light higgs and compare their spectra, which are very different to QCD, to LHC data. The enhancement of the quark condensate by walking dynamics is also easily understood in holography. Such models typically include strong four fermion operators which holographically can be included with Witten's multi-trace prescription. I look at the gauged NJL model and its applications to models such as top condensation, extended technicolour and ideal walking theories. This holographic tool kit allows a new understanding of these strongly coupled systems.

Holographic Pomeron in low-x QCD

A. Amorim, R. Carcassés-Quevedo. M.S. Costa

Regge theory has a long history in particle physics, particularly in QCD and String Theory. In the case of QCD, the forward limit of elastic processes is dominated by the exchange of a Reggeon, known as the Pomeron. In such processes the partonic structure of hadrons is largely dominated by a dense gluon medium, which undermines perturbative QCD techniques. In the gauge/string duality the Pomeron is mapped into the graviton Regge trajectory. In this talk we use the framework of Regge theory for strings in asymptotically AdS spaces to develop a dual phenomenological approach for Pomeron physics. We focus on the case of deep inelastic scattering at low-x, and reproduce experimental data with a chi squared of 1.1 over a vast kinematical range, including regions where perturbative QCD techniques break down.

From p-adic AdS/CFT to prospects in cold atoms

Steven S. Gubser

p-adic AdS/CFT is a version of the gauge-gravity duality where the boundary theory is defined over the p-adic numbers and the bulk is a discrete graph. I will exhibit simple correlation functions in this duality and describe a theory of gravity on the graph. A variant of p-adic field theories has emerged from recently proposed cold atom experiments based on sparse couplings. I will explain how a simplified version of these theories interpolates between an ordinary continuum field theory and p-adic field theory as a spectral exponents is dialed.

Graphene and Boundary Conformal Field Theory

Cristopher Herzog, in collaboration with Kuo-Wei Huang,Kristan Jensen, Itamar Shamir, and Julio Virrueta

The infrared fixed point of graphene under the renormalization group flow is a relatively under studied yet important example of a boundary conformal field theory. This fixed point along with its supersymmetric cousins all possess an exactly marginal coupling -- the charge of the electron -- which allows for straightforward perturbative calculations in the weak coupling limit. Making use of recent progress in the understanding of boundary contributions to the anomalous trace of the stress tensor, we will compute perturbatively the effect of interactions on these boundary terms. Unlike the story for the bulk central charge c in four dimensions, we will show that the corresponding boundary charges depend on the marginal coupling even in the presence of supersymmetry. The talk is based on arXiv:1707.06224, arXiv:1709.07431, and arxiv:1807.01700.

Non-relativistic geometry in limits of gauge/gravity duality

Niels Obers (et al)

Newton-Cartan geometry was originally introduced to find a geometric formulation of Newtonian gravity, but has in recent years gained renewed interest as it appears also in string theory and holography. In particular, torsional Newton-Cartan geometry has been shown to appear as the boundary geometry for Lifshitz spacetimes. which is a holographic setup for systems with non-relativistic symmetry. The reason is that non-relativistic field theories naturally couple to such geometries, in the same way that relativistic field theories couple to Riemannian geometry. In this talk, I will discuss how non-relativistic geometry appears in limits of string theory and the AdS/CFT correspondence. This includes novel Chern-Simons theories of gravity in three dimensions which follow from a well-defined limit of the AdS3/CFT2 correspondence, which I will discuss. I will also comment on how non-relativistic strings move in a Newton-Cartan target space, and a further worldsheet limit which is related to limits of AdS5/CFT4. Finally, I will talk about recent work on understanding non-relativistic gravity (including its Newtonian limit) from a new perspective.

Parallel Sessions

Lecture Hall

Holographic Complexity 101

Ro Jefferson

This talk will be an overview of holographic complexity, with an emphasis on efforts to precisely quantify this notion on the field theory side. I will give an introduction to the idea of circuit complexity in free field theories in particular, and comment on some future directions.

Aspects of bulk reconstruction for subregions

R. Espindola, A. Guijosa and J. Pedraza

In the holographic correspondence, subregion duality posits that knowledge of the mixed state of a finite spacelike region of the boundary theory allows full reconstruction of a specific region of the bulk, known as the entanglement wedge. In this talk, specializing for simplicity to AdS_3, we examine whether curves (as opposed to points) can be reconstructed within the two main examples of entanglement wedges. A challenge is encountered already in the Poincare wedge, where standard hole-ography does not in fact allow reconstruction of arbitrary spacelike curves. We show that this challenge can be overcome using a variant of hole-ography involving 'null alignment'. We then examine the same question in a Rindler wedge, and find that generic curves are not fully reconstructible with entanglement entropies in the corresponding boundary region, even after using null alignment. This limitation is an analog of the familiar phenomenon of entanglement shadows, which we call `entanglement shade'. We show that the information about the non-reconstructible segments of the curves is encoded in a slight generalization of the concept of entanglement of purification, whose holographic dual has been discussed very recently.

Holographic second laws of black hole thermodynamics

Federico Galli, based on work done in collaboration with Alice Bernamonti, Robert Myers, and Jonathan Oppenheim

Recently, it has been shown that for out-of-equilibrium systems, there are additional constraints on thermodynamical evolution besides the ordinary second law. These form a new family of second laws of thermodynamics, which are equivalent to the monotonicity of quantum Renyi divergences. In black hole thermodynamics, the usual second law is manifest as the area increase theorem. We study these constraints within the AdS/CFT correspondence to explore whether these additional laws imply new restrictions for gravitational dynamics, such as for out-of-equilibrium black holes. For a certain class of excited CFT states, dual to a particular bulk solution of a minimally coupled gravity-scalar system, we show that there exist transitions which are allowed by the traditional second law, but forbidden by the additional thermodynamical constraints.

A complexity/fidelity susceptibility g-theorem for AdS3/BCFT2

Mario Flory

We use a recently proposed holographic Kondo model as a well-understood example of AdS/boundary CFT (BCFT) duality and show explicitly that in this model the bulk volume decreases along the RG flow. We then obtain a proof that this volume loss is indeed a generic feature of AdS/BCFT models of the type proposed by Takayanagi in 2011. According to recent proposals holographically relating bulk volume to such quantities as complexity or fidelity susceptibility in the dual field theory, this suggests the existence of a complexity or fidelity susceptibility analogue of the Affleck-Ludwig g-theorem, which famously states the decrease of boundary entropy along the RG flow of a BCFT. We comment on this possibility.

Holographic reconstruction in flat spacetimes

Yegor Korovin

We identify the boundary data on the null infinity of asymptotically flat spacetimes which describes the boundary geometry and the stress-energy tensor of the putative holographically dual field theory. The construction is carried out in the first order formalism which is well adapted to the non-Riemannian geometry on the null infinity.

Gauge-Gravity, just add honey !!

Matteo Baggioli, more than one paper...

I will review the recent progress regarding the holograhic duals for viscoelastic and solid materials. I will discuss the linear and non-linear elastic features, the nature of the phononic excitations and the sound speeds. I will comment about the analogies with the EFT methods and I will analyze the convergence properties of the elastic expansion. Finally I will speculate about recent experiments claiming that fluids are "a bit" solids and I will ask holography if it knows about it.

Spontaneous symmetry breaking of translations in holography

Andrea Amoretti and Daniel Arean

In this talk we will illustrate how to construct an effective holographic theory of charge density waves in the context of holography. We will rely on a homogeneous model which breaks translations spontaneously. Due to its homogeneity the model seems to be particularly promising to capture in a simple manner the features of a charge density wave. The electric transport properties and the Goldstone bosons spectrum of the theory will be analyzed and compared to the hydrodynamics result for a charge density waves system.

From Q-lattices to Bad Metals

Andrea Amoretti and Daniel Arean

We consider a holographic model where translations are broken pseudo-spontaneously in a homogeneous manner. By studying its electric conductivity and QNM spectrum we show it captures features observed in the so-called 'Bad Metals'.

Holographic topological semimetals

Yan Liu

Topological states of matter have been a research focus in condensed matter physics in the past few years. We will introduce the holographic models for strongly coupled gapless topological semimetal states, including strongly coupled Weyl semimetals and topological nodal-line semimetals. We will show in these holographic models there exists a quantum phase transition between the topologically trivial semimetal states and the topologically nontrivial Weyl/nodal-line semimetal states. We further show the anomalous transport properties, "ARPES" calculations as well as predictions for possible new transport properties, including the presence of odd viscosity associated with the mixed gauge-gravitational anomaly. We will also discuss the properties of nontrivial topological invariants from the dual fermion Green functions. Our holographic model provides a new avenue towards investigating the properties of strongly coupled topological gapless states of matter.

Seminar Room 418

News about heavy quarks in strongly coupled plasmas

Carlo Ewerz, Andreas Samberg, Konrad Schade, Paul Wittmer

We report on recent results concerning heavy quarks and heavy quark-antiquark pairs in conformal and non-conformal plasmas at strong coupling. In particular, we study various aspects of screening at high temperature and chemical potential of the plasma. In gauge/gravity duality, heavy quark properties are encoded in Wilson lines and loops. We discuss an issue concerning the renormalization of these quantities that had long been overlooked in the literature. With the correct renormalization procedure, we calculate the free energy or potential of a static pair, as well as several quantities derived from it, including entropy, internal energy and running coupling, and compare them to results from lattice QCD. All of these quantities are found to exhibit universal behavior at strong coupling. We further discuss the computation of a complex quark-antiquark potential and its limitations. Time permitting, we comment on the application of this complex potential for the calculation of spectral functions of quark-antiquark bound states.

Analytic results for nonconformal plasmas

Matti Jarvinen

I discuss recent results for the dynamics of strongly coupled nonconformal plasmas, which are obtained as holographic duals to Einstein-Dilaton gravity with a potential having exponential IR asymptotics. The nonhydrodynamic quasi normal modes of the plasma can also be solved analytically in a critical limit, where they accumulate into a branch cut on the real axis of the complex frequency plane. The results generalize to a class of charged black branes and to hyperscaling Lifshitz geometries.

Dense Quark Matter and Baryonic Black Branes

Oscar Henriksson, Carlos Hoyos, Niko Jokela

Gauge/gravity duality provides an opportunity to better understand dense systems of quark and nuclear matter through first-principles calculations. While the exact dual of QCD is unknown, several theories with at least qualitative similarities are well-understood. In this talk I will discuss one such theory, the SU(N)xSU(N) conifold gauge theory. I will show how to construct black brane solutions dual to states with non-zero "baryon" chemical potential and explicit conformal symmetry breaking. I will also compute thermodynamic properties of the solutions, and discuss the resulting phase diagram.

Fermi arcs in holographic doped Mott insulator

A. Krikun, F. Balm, A. Romero-Bermudez, K. Schalm and J. Zaanen

I will discuss the features of the lock-in state which is formed when the holographic strange metal develops spontaneous charge density wave on top of the crystal lattice. This state is claimed to be a holographic dual of the doped Mott insulator phase of hight Tc cuprates. I will focus on the fermionic response in this state in order to discern the characteristic Fermi-arcs, which are among the signatures of the pseudogap phase.

Hall viscosities in Dirac systems without rotational invariance

Francisco Pena-Benitez, Kush Saha, and Piotr Surowka

We investigate parity-odd non-dissipative transport in an anisotropic Dirac semi-metal in two spatial dimensions. The analysis is relevant for interacting electronic systems with merging Dirac points at charge neutrality. For such systems the dispersion relation is relativistic in one direction and non-relativistic in the other. We give a proposal how to calculate the Berry curvature for this system and use it to derive more than one odd viscosities, in contrast to rotationally invariant systems.

Perturbative locality and bulk metric reconstruction from boundary entanglement

Shubho R. Roy and Debajyoti Sarkar

Motivated by a recent construction of free local bulk operators from the modular Hamiltonian data of boundary subregions, without a priori knowledge of the bulk metric or bulk equations of motion of the fields, in this work, we extend the prescription to formulate a recipe to extract the bulk metric itself. Furthermore, we extend the previous formalism to incorporate the first order perturbative locality for AdS scalars. As a proof of principle, we consider three dimensional bulk and selected CFT states such as the vacuum and the thermofield double states. We show that they indeed reproduce the pure AdS and the regions outside the Rindler wedge and the BTZ black hole up to a constant conformal factor. This is expected from a purely CFT construction. Our approach provides a CFT perspective of the bulk field redefinition ambiguity, that even with the knowledge of the full field theory data (including modular Hamiltonians of subregions), it is possible to reproduce the metric only up to a conformal factor. We discuss several future applications, in particular a potential construction for operators and metric beyond the causal wedge of a boundary region and bulk reconstruction for the boundary excited states.

Solving the connection problem for perturbations of AdS2 and near-AdS2

Achilleas P. Porfyriadis

The direct products of a two-sphere with AdS2 or near-AdS2 are exact solutions of four-dimensional Einstein-Maxwell theory without a cosmological constant. I will present the analytic solutions to the coupled gravitational and electromagnetic perturbation equations of AdS2xS2 and near-AdS2xS2 in this theory. While AdS2 and near-AdS2 are locally diffeomorphic, the corresponding solutions to the perturbation equations give rise to distinct answers for the so-called connection problem. This is the problem of extending anti-de Sitter solutions away from the near-horizon region of (near-)extreme black holes and connecting them with solutions in the far asymptotically flat region. I will present analytic solutions to the connection problem for perturbations of AdS2xS2 and near-AdS2xS2 in the extreme and near-extreme Reissner-Nordstrom black holes, respectively.

Axiomatic complexity in quantum field theory

Run-Qiu Yang, Yu-Sen An, Chao Niu, Cheng-Yong Zhang, and Keun-Young Kim

Holographic duality shows increasing evidence of a deep relation between quantum entanglement in quantum field theory (QFT) and gravity. While the 'entanglement entropy' may capture spacetime physics outside a black hole horizon, the 'complexity' is proposed as a probe inside a horizon. Contrary to much progress on the 'holographic complexity', the complexity in QFT has not been defined well yet, although there are a few promising proposals. In this talk, we propose a definition of the complexity in QFT based on three axioms for the complexity and general symmetry properties of QFT.

Holographic entanglement entropy relations

Veronika Hubeny, Mukund Rangamani, Massimiliano Rota

Holographic entanglement entropy has been shown to satisfy inequalities which are not valid for arbitrary quantum states, providing interesting constraints on the structure of states which are geometric in the bulk. However so far only some examples have been found, and no organizing principle is known. I will present a new framework which allows to systematize the search of these constraints. As an example, I will explain how the tripartite information, whose sign-definiteness is the best known example of these inequalities (monogamy of mutual information), can be derived within this framework from purely holographic considerations.

Seminar Room 411

holographic plasmons

Tobias Zingg based on collaboration with Marcus Aronsson and Ulf Gran

The holographic correspondence can be extended to identify plasmonic excitations in strongly correlated systems. These modes have relevance in the growing field of plasmonics, and play also a crucial role in relating properties of holographic 'screened' density-density response response functions to 'physical' density-density response functions, which are more directly related to experimental observation. based on results from [1712.05672] and [1804.02284]

Black hole with intertwined order: holographic pair density wave

Rong-Gen Cai, Li Li, Yong-Qiang Wang, Jan Zaanen

We present a holographic model for translational symmetry breaking that naturally gives rise to pair density waves. We construct stationary inhomogeneous black hole solutions in which both the U(1) symmetry and spatially translational symmetry are spontaneously broken at a finite temperature and charge density. This novel solution provides a dual description of a superconducting phase intertwined with charge, current, and parity orders. Holographic crystallization in the presence of a background lattice and the optical conductivity are discussed.

A Cardy formula for off-diagonal three-point coefficients; or, how the geometry behind the horizon gets disentangled

A. Romero-Bermudez, P. Sabella-Garnier and K. Schalm

In the context of AdS3/CFT2, eternal black holes can be viewed as a specific entanglement between two copies of the CFT: the thermofield double. The statistical CFT Wightman function can be computed from a geodesic between the two boundaries of the Kruskal extended black hole and therefore probes the geometry behind the horizon. We compute the average off-diagonal matrix element squared of a primary operator that enters in the Wightman function. With these matrix elements we compute the Wightman function for an arbitrary entanglement between the double copies and probe the emergent geometry between a left- and right-CFT that are not thermally entangled. - [arXiv:1804.08899]

Holographic Entanglement Entropy in Electric Field

Kyung Kiu Kim, Chanyong Park, Jung Hun Lee, Byoungjoon Ahn

We studied the holographic entanglement entropy for a strip and sharp wedge entangling regions in momentum relaxation systems. In the case of strips, we found analytic and numerical results for the entanglement entropy and showed the effect on the minimal surface by the electric field. We also studied the entanglement entropy of wedges and confirmed that there is a linear change in the electric field. This change is proportional to the thermoelectric conductivity, α.

Universal Features of the Holographic Quantum Complexity of Bulk Singularities

S. Bolognesi (Pisa U.), E. Rabinovici (Hebrew U. & IHES, Bures-sur-Yvette) and Shubho R. Roy (Indian Inst. Tech., Hyderabad)

We perform a comparative study of the time dependence of the holographic quantum complexity of some space like singular bulk gravitational backgrounds. This is done by considering the two available notions of complexity, one that relates it to the maximal spatial volume and the other that relates it to the classical action of the Wheeler-de Witt patch. We calculate and compare the leading and the next to leading terms and find some universal features. The complexity decreases towards the singularity for both definitions, for all types of singularities studied. In addition the leading terms have the same quantitative behavior for both definitions in restricted number of cases and the behaviour itself is different for different singular backgrounds. The quantitative details of the next to leading terms, such as their specific form of time dependence, are found not to be universal. They vary between the different cases and between the different bulk definitions of complexity. We also address some technical points inherent to the calculation.

Dynamically probing strongly-coupled field theories with critical point

Hajar Ebrahim, Mohammad Ali-Akbari

The dependence of the rescaled equilibration time on different parameters of the field theories with a holographic dual has been investigated in this paper. We consider field theories with nonzero chemical potential at finite temperature which are dual to asymptotically AdS charged black holes. We examine a dynamical probe scalar operator where its dynamics is due to a time-dependent source, quantum quench, or out-of-equilibrium initial condition in field theory with fixed or varying temperature and chemical potential. We observe that the behavior of the scalar operator equilibration time with respect to temperature or chemical potential can not be predicted merely by field theory parameters and depends on how fast the energy is injected into the system. It is shown that in field theories with critical point the rescaled equilibration time is shorter for thermodynamically stable systems. We also observe that the rescaled equilibration time as one approaches the critical point enhances and acquires an infinite slope though its value remains finite. We show that for fast quenches, even though the system is far from equilibrium, the dynamical critical exponent is the same as the one reported for quasi-normal modes in the same background. However for slow quenches the dynamical critical exponent picks up a different value.

More on turbulent strings in AdS

Takaaki Ishii, Keiju Murata, Kentaroh Yoshida

It was found that the classical open strings in Poincare AdS dual to the flux tube for quark-antiquark potential in N=4 SYM exhibit turbulent behavior when perturbed nonlinearly. Meanwhile, string theory in AdS spacetime is known to be integrable. In this talk, I will study the turbulent behavior on the nonlinear perturbed open strings in global AdS and show how it changes compared with the case of Poincare AdS. I will also discuss connections between the string turbulence and integrability of the string in AdS.

Numerical relativity in AdS/CFT with spNDSolve, a Mathematica package for solving PDEs by the pseudospectral method

Jie Ren

Stationary, asymptotically (locally) AdS spacetimes are much richer than asymptotically flat spacetimes, due to the absence of uniqueness theorems. The scope of applying the AdS/CFT correspondence is significantly enlarged by allowing dependence of spatial coordinates besides the AdS radial coordinate. I developed an open-source Mathematica package, spNDSolve for solving PDEs by the pseudospectral method. It makes solving PDEs more accessible by deploying systematic procedures to any (stationary) PDEs. It has constructions of various grids, built-in continuation method, two-domain decomposition, and arbitrary precision. A detailed example is given by solving holographic superconductors to illustrate the use of this package. Another example is a charged black funnel, which is a new solution.

Holographic local quench and effective complexity

D. Ageev, I. Arefeva, A. Bagrov, M. Katsnelson

We study the evolution of holographic complexity of pure and mixed states in 1+1-dimensional conformal field theory following a local quench using both the "complexity equals volume" (CV) and the "complexity equals action" (CA) conjectures. We compare the complexity evolution to the evolution of entanglement entropy and entanglement density, discuss the Lloyd computational bound and demonstrate its saturation in certain regimes. We argue that the conjectured holographic complexities exhibit some non-trivial features indicating that they capture important properties of what is expected to be effective (or physical) complexity.

Seminar Room 410

Second simplest higher spin theory

Dmitry Ponomarev

I will discuss some recent results on chiral higher spin theories -- cubic higher spin theories, which are consistent to all orders in the coupling constant. It turns out that these can be reformulated as self-dual Yang-Mills theories, which entails a number of remarkable properties.

Higher Spin interactions in particular dimensions

Karapet Mkrtchyan, Pan Kessel

I will review the status of interactions for massless Higher Spin fields in different dimensions. In particular, I will describe recent classification of cubic vertices for massless fields of any spin in three dimensions, which reveals useful information about 3pt functions of 2d CFT's.

Fermions in Geodesic Witten diagrams

Mitsuhiro Nishida, Kotaro Tamaoka

We develop the embedding formalism for odd dimensional Dirac spinors in AdS and apply it to the (geodesic) Witten diagrams including fermionic degrees of freedom. We first show that the geodesic Witten diagram (GWD) with fermion exchange is equivalent to the conformal partial waves associated with the spin one-half primary field. Then, we explicitly demonstrate the GWD decomposition of the Witten diagram including the fermion exchange with the aid of the split representation. The geodesic representation of CPW indeed gives the useful basis for computing the Witten diagrams.

Partially Massless Higher Spin Gravity at One Loop

T. Basile, E. Joung, S. Lal and W. Li

Holographic dualities involving Higher-Spin (HS) theories display some interesting properties, namely they do not require supersymmetry and should hold in arbitrary dimensions. On top of that, the conjectured dual CFTs are free, and hence these dualities constitute a privileged playground to study the AdS/CFT correspondence. In this talk the computation of the one-loop free energy of various HS theories, as well as the comparison with the putative dual CFTs, will be reviewed and extended to the case of partially massless HS theories. In particular, we will show how their one-loop free energy can be computed analytically in arbitrary dimensions.

Hyperbolic and spherical black holes with hyperscaling violation

Juan Pedraza, Watse Sybesma, Manus Visser

In this talk I present a family of charged, hyperscaling violating black hole solutions with hyperbolic and spherical horizons. In particular, I will focus on the phase structures of these black holes and discuss special properties of the hyperbolic solution.

Holographic signatures of resolved cosmological singularities

Norbert Bodendorfer, Fabio Mele, Johannes Münch, Andreas Schäfer, John Schliemann

A common strategy to investigate the fate of gravitational singularities in asymptotically AdS spacetimes is to translate the question from the gravitational side to a dual field theory using the gauge/gravity correspondence and to do a field theory computation. Given recent progress in singularity resolution via non-perturbative quantum gravity, it is natural to now turn the question around and to ask about field theory signatures of resolved singularities. We present an investigation along this line, where a finite-distance pole exhibited by the two-point correlator in the dual field theory, which has previously been linked directly to the gravitational bulk singularity, is resolved in this way.

Black holes and scale dependence

Benjamin Koch

Allowing for scale dependent gravitational couplings leads to modifications of the effective gravitational field equations and to more general black hole solutions. Is there a corresponding gauge dual to this class of solutions?

Chaos and quantum complexity in holographic charged operator growth

Dmitry Ageev, Irina Aref'eva

We investigate holographic description of the chaotic growth of the precursor operators and their holographic complexity evolution in different models. In particular, we study strongly coupled systems at finite chemical potential, where we find that chaos is suppressed for charged operators.

Wednesday

Black Holes in 3D Higher Spin Gravity

Alejandra Castro, Eva Llabres and Nabil Iqbal

In this talk I will report new developments in 3D gravity. The emphasis will be on how to treat and characterize black holes in 3D higher spin gravity using the Chern-Simons formulation.

Wilson line and anomalous dimensions in AdS/CFT

Per Kraus

I will discuss the use of Wilson line in computing anomalous dimensions of in the context of the AdS/CFT correspondence

Characters of the conformal algebra in higher-spin holographic duality

Xavier Bekaert, from joint work with Thomas Basile and Euihun Joung

The various types of higher-spin holographic duality are determined by the following three key representations of the higher-spin algebra: the singleton playing the role of the fundamental representation, the twisted adjoint representation (determined by the tensor product of two singletons) and the adjoint representation. We explore the relation between the singleton and adjoint modules of higher-spin algebras via so(2,d) characters. In order to relate the tensor product of the singleton and its dual to the adjoint module, we consider a formula involving symmetrization over the variables of the character. We show that our formula reproduces correctly the adjoint-module character for type-A (and its high-order extensions) and type-B higher-spin gravity theories in any dimension.

Integrability, One-point Functions and Tests of AdS/dCFT

Charlotte Kristjansen et al.

We consider a defect version of the gauge/gravity correspondence (AdS/dCFT) where N=4 SYM has gauge groups of different ranks on the two sides of a co-dimension one defect and where the dual string theory picture is that of a probe-brane set-up of either D3-D5 or D3-D7 type with either background gauge field flux or non-trivial instanton number. The main results obtained concerning one-point functions of the above AdS/dCFT are reviewed. First, we present a closed formula for tree-level one-point functions of all conformal operators constructed from the scalar fields of N=4 SYM in the case of the D3-D5 set-up. Using the language of integrability, the one-point functions are expressed in terms of the spin chain rapidities of the conformal operators in question. Important ingredients in the formula are the Gaudin determinant, various Baxter polynomials as well as quantities closely related to the transfer matrix of the integrable spin chain involved. We furthermore present a closed one-loop order formula for one-point functions in the SU(2) sub-sector of the same set-up. Subsequently, we discuss the status of similar studies pertaining to the D3-D7 set-up. Finally, we present a positive test of AdS/dCFT at the next to leading order in a certain double scaling parameter both for the half supersymmetric D3-D5 probe brane set-up and for a non-supersymmetric D3-D7 probe brane set-up.

Aspects of Gauge-Strings Duality

Carlos Nunez

I will discuss recent developments in the duality between gauge fields and strings. The focus will be on dualities for N=2 and N=1 SCFTs in four dimensions.

Thursday

Gravity, Quantum Fields and Information

Michal P. Heller

This will be a subjective overview of developments at the intersection of gravity, quantum fields and (quantum) information science. The focal points will be kinematic space, tensor networks, path integral optimalization, holographic complexity proposals and, finally, complexity in quantum field theory.

Tensor Networks and their use for Lattice Gauge Theories

Mari Carmen Banuls

Tensor Network States are ansatzes for the efficient description of the state of a quantum many-body system. They can be used to study static and dynamic properties of strongly correlated states. In this talk I will present some recent work on the application of these techniques to study Lattice Gauge Theories. In particular, using the Schwinger model as a testbench, we have shown that these ansatzes are suitable to approximate low energy states precisely enough to allow for accurate finite size and continuum limit extrapolations of ground state properties, mass gaps and temperature dependent quantities. Beyond this case the feasibility of the method has already been tested also for non-Abelian models, out-of-equilibrium scenarios, and non-vanishing chemical potential in 1+1 dimensions.

Holography for N=1 SQFT and the uplift of GPPZ solution

M. Petrini, H. Samtleben, S. Schmidt and K. Skenderis

I will discuss the classification of N=1 SQFTs which are (a) deformations of N=4 SYM and (b) can be studied holographically. I will then focus on the simplest such theory, the N=1* SYM, and discuss the uplift of the GPPZ solution to IIB supergravity.

Holography and thermalization in optical pump-probe spectroscopy

Ben Craps

Using holography, we model experiments in which a 2+1D strange metal is pumped by a laser pulse into a highly excited state, after which the time evolution of the optical conductivity is probed. We consider a finite-density state with mildly broken translation invariance and excite it by oscillating electric field pulses. At zero density, the optical conductivity would assume its thermalized value immediately after the pumping has ended. At finite density, pulses with significant DC components give rise to slow exponential relaxation, governed by a vector quasinormal mode. In contrast, for high-frequency pulses the amplitude of the quasinormal mode is strongly suppressed, so that the optical conductivity assumes its thermalized value effectively instantaneously.

A tale of tails

Igor Novak, Julian Sonner, Benjamin Withers

I will describe a large family of nonequilibrium steady states (NESS) corresponding to forced flows over obstacles. The spatial structure at large distances from the obstacle is shown to be universal, and can be quantitatively characterised in terms of certain collective modes of the strongly coupled many body system, which holographically are space-like generalisations of quasinormal modes. The decay lengths of certain modes are set by η/s, suggesting a new route to experimentally measuring this ratio.

Holographic viscoelastic hydrodynamics

Matteo Baggioli, Alex Buchel

Relativistic fluid hydrodynamics, organized as an effective field theory in the velocity gradients, has zero radius of convergence due to the presence of non-hydrodynamic excitations. Likewice, theory of elasticity of bittle solids, organized as an effective field theory in the strain gradients, has zero radius of convergence due to the process of the thermal nucleation of cracks. Viscoelastic materials share properties of both fluids and solids. We use holographic gauge theory/gravity correspondence to study all order hydrodynamics of relativistic viscoelastic media.

Generalized Particle/Vortex Duality from Holography

Andreas Karch

I will discuss how to use the gauge/gravity correspondence as a tool to construct new field theory dualities for non-supersymmetric gauge theories in 2+1 dimensions.

Exotic Holographic RG flows at zero and finite temperature and curvature

J. Ghosh, U. Gursoy, E. Kiritsis, F. Nitti, L. Silva-Pimenta, L. Witkowski.

Holographic RG flows are studied in a general setup. The scope is to uncover novel properties of the flows, and to apply them to related issues, like the F-functions and F-theorems, the non-perturbative stability of AdS vacua and the structure of the space of QFTs. Bounces, that are non-analytic points of beta-functions are generic in the space of flows. Examples of holographic theories that do not exist at zero curvature but do at finite curvature are given

Friday

Probing holographic dualities through Penrose limits and dual spin chains

Horatiu Nastase, with: T. Araujo, G. Itsios, E. O'Colgain; and G.Itsios, C. Nunez, K. Sfetsos, S. Zacarias

It is known that the string description, as well as the field theory description, become easier and more calculable in the Penrose limit of AdS/CFT. We apply this method for cases where the AdS/CFT duality is less understood: for the GJV duality the gravity background is known, but questions remain about the field theory, for which we have an IR limit. Another case we consider is of the abelian and nonabelian T-duals of AdS_5xS^5, for which there is a proposal for the dual CFT, but there are unknonwns. In both cases, we find that the AdS/CFT matching is not complete, showing that these cases are more interesting than the standard AdS_5xS^5.

Bulk and Witten Rules in Bilocal Holography

R. de Mello Koch, A. Jevicki,Kenta Suzuki and JungGi yoon

We discuss emergence of AdS bulk in bi-local holography.It is seen to be given by a simple momentum map of collective fields with corresponding all order Witten diagrams.Their locality is discussed.

Holographic duals of 5dim SCFTs

Eric D'Hoker, Michael Gutperle and Christoph Uhlemann

This talk is a review of recent type IIB supergravity solutions which are dual to five dimensional SCFTs.

A nAttractor Mechanism for AdS(2)/CFT(1) duality

Finn Larsen

The holographic correspondence between AdS(2) and CFT(1) can be made precise in the sense of conformal perturbation theory away from the strict AdS(2) limit. We study this ``nearly" AdS(2) limit in the context of string theory and show that it is controlled by a novel attractor mechanism. This establishes a precise map between the moduli space of nearly extremal black holes and their corresponding microscopic descriptions.

Mott transition and Hubbard Model in Holography

Yunseok Seo, Geunho Song, Yong-Hui Qi , Sang-Jin Sin

We show that the competition between the fermi liquidity and the gap generation, which is the physics of the Hubbard model, can be realized in a canonical holographic model of a fermion with bulk mass and a dipole interaction. The bulk mass near 1/2 tends to protect the fermi liquidity while large dipole coupling attempts to generate the mass gap so that the model is equipped with the basic mechanism of the Mott transition and expected to play the role of Hubbard model in holographic context. In fact, the spectral densities of the holographic model agree with the dynamical mean field theory (DMFT) calculation in two features: the 'three peaks' and 'the transfer' of the degree of freedom from the quasi-particle peak to the side peak. The phase diagram of our holographic model contains six phases including bad metals and pseudo-gap as well as the Fermi liquid and Mott insulator, and a line connecting the last two defines a Holographic version of Hubbard model. The experimental data for spectral densities of Vanadium Oxide materials seem to be well fit by our theory.
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Central Charge of Self-Dual Strings from Holographic Entanglement Entropy

John Estes, Darya Krym, Andy O'Bannon, Brandon Robinson, Ronnie Rodgers

M-theory is currently our best candidate for a theory of everything, but remains mysterious. We know M-theory has M2- and M5-branes. The low-energy theory on a stack of coincident M2-branes is well-understood: it is maximally supersymmetric Chern-Simons-matter theory. However, the low-energy theory on a stack of coincident M5-branes remains poorly-understood: it is a maximally supersymmetric theory of self-dual strings with zero tension. In this talk I will discuss one type of probe of the M5-brane theory, namely self-dual strings with infinite tension. These play a role analogous to Wilson lines in gauge theories, but are two-dimensional surfaces rather than lines. I will describe holographic calculations of entanglement entropy associated with these infinite-tension self-dual strings, from which we extract a key parameter characterizing them, their central charge. This provides a count of the number of massless degrees of freedom living on them, and thus may shed light on some of the fundamental degrees of freedom of M-theory.

Three-dimensional Bosonization and Higher-spin Gravity

S. Giombi, V.Kirillin, S. Prakash, Gurucharan, E. Sezin, E.Skvortsov, Y.Zh

I will review the three-dimensional bosonization conjecture and present the results confirming the duality based on the anomalous dimensions of higher-spin currents. The gravitational dual is supposed to be Higher-Spin Gravity and I will show how some of the correlation functions can be reproduced from the gravitational side.

Einstein Double Field Equations

Stephen Angus, Kyoungho Cho, Kevin Morand, Jeong-Hyuck Park

Upon treating the whole closed string massless sector as stringy graviton fields, Double Field Theory may evolve into Stringy Gravity, i.e. the stringy upgrade of General Relativity. Equipped with an O(D,D) covariant differential geometry beyond Riemann, we spell out the definition of the Energy-Momentum tensor in Stringy Gravity and derive its on-shell conservation law from doubled general covariance. Equating it with the recently identified stringy Einstein curvature tensor, all the equations of motion of the closed string massless sector are unified into a single expression, G_{AB}=8πGT_{AB}, which we dub the Einstein Double Field Equations. String Gravity unifies SUGRA and various non-Riemannian theories, such as Newton-Cartan, Carroll and Gomis-Ooguri non-relativistic chiral theories.

Posters
(Ordered by Topic)

Glueball decay rates in the Sakai-Sugimoto model

Frederic Brünner, Josef Leutgeb, Anton Rebhan

I present recent results on glueball decay rates in the Sakai-Sugimoto model, which is a specific string-theoretic realization of gauge/gravity duality based on D8 and anti-D8 probe branes in Witten's holographic model of nonsupersymmetric Yang-Mills theory. This model reproduces various features of low-energy QCD, such as chiral symmetry breaking and yields a good approximation to meson and glueball mass spectra. In particular I consider the pseudovector glueball, which is even under parity but odd under charge conjugation. It is dual to fluctuations in the background Kalb-Ramond field and has a mass of about 2300 MeV. Calculating the decay rates using the highly restricted Chern-Simons action of the D8 branes I find interesting results for the decay width. The decay pattern includes decays into two and three pseudoscalar and vector mesons.

Holographic QCD phase structures at finite temperature and density - Entanglement and criticality of a critical point

J. Knaute, R. Zöllner, B. Kämpfer

We use two holographic QCD models to explore the resulting phase structure at finite temperature and chemical potential. In the first setup, we consider a gravity-dilaton model at finite temperature and clarify the relation between the dilaton potential and emerging phase structure. We analyze the ability of this framework to simultaneously account for QCD consistent thermodynamics and proper in-medium modifications of vector mesons in the probe limit. In the second setup, we study a Einstein-Maxwell-dilaton model, which is adjusted to lattice QCD data, to explore the resulting phase diagram over the temperature-chemical potential plane. The model exhibits a critical point at a temperature of about 112 MeV and a baryo-chemical potential of 612 MeV. We analyze its criticality and characterize the first-order phase transition by analyzing the critical pressure and behavior of isentropes. In addition, we calculate the holographic entanglement entropy for this model and discuss its ability to characterize the relevant QCD phase structures.

Semiholography for Heavy Ion Collisions

Alexander Soloviev, Christian Ecker, Ayan Mukhopadhyay, Florian Preis and Anton Rebhan

To understand the time-evolution of systems like the Quark-Gluon Plasma (QGP), it is necessary to include both weakly and strongly coupled degrees of freedom at various energy scales. Semiholography is a non-perturbative framework that combines perturbative methods for weakly coupled partons with the holographic duality for the strongly coupled infrared in a wide range of energy scales. I will discuss the first results in the fully dynamical non-equilibrium regime featuring energy transfer from a classical Yang-Mills sector to the strongly coupled sector.

Finite coupling corrections to gauge fields in AdS/CFT

Sebastian Waeber

In my talk I will focus on finite 't Hooft coupling corrections to observables related to the retarded propagator of a U(1) gauge field in a strongly coupled N=4 supersymmetric Yang-Mills plasma. The derivation of coupling corrected equations of motion of gauge fields found in the literature so far contained several mistakes with large impact. An overview of the correct derivation of the finite 't Hooft coupling EoM of gauge fields will be presented. As a consequence of these changes the higher derivative corrections to the considered observables, including the conductivity, quasinormal mode frequencies, in and off equilibrium spectral density and photoemission rates become much smaller. This suggests that infinite coupling results obtained within AdS/CFT are not dramatically modified for the real QCD coupling strength.

All AdS4 and AdS3 supergravity backgrounds with N>16 supersymmetries - uniqueness and (non-) existence

A. S. Haupt, S. Lautz and G. Papadopoulos

We investigate all warped AdS4 x M^{D-4} and AdS3 x M^{D-3}backgrounds with the most general allowed fluxes that preserve more than 16 supersymmetries in D=10- and 11-dimensional supergravities. Assuming either that the internal manifold is compact without boundary or that the isometry algebra of the background decomposes into that of AdS4/AdS3 and that of the transverse space, we find that there are no AdS4 backgrounds in IIB supergravity. Similarly, in IIA supergravity, we find a unique such background with 24 supersymmetries, locally isometric to AdS4 x CP^3, and in D=11 all such backgrounds are locally isometric to the maximally supersymmetric AdS_4\times S^7 solution. Finally, we establish a non-existence theorem for AdS3 solutions preserving strictly more than 16 supersymmetries.

Non-Equilibrium Dynamics in a Holographic Superfluid

Carlo Ewerz, Thomas Gasenzer, Markus Karl, Andreas Samberg, Paul Wittmer

The dynamics of a (2+1+1)-dimensional holographic superfluid is studied as it relaxes from initial far-from-equilibrium states exhibiting vortex--anti-vortex ensembles. A fast numerical implementation of the bulk equations of motion in the probe limit is used to evolve the system to late times on large grids. Statistics over many runs indicate the presence of a new universal late-time regime of the non-equilibrium evolution in which the occupation spectrum and different typical length scales of the superfluid exhibit scaling behavior. The results are discussed in terms of non-thermal fixed points.

Heavy Quarks and Mesons in Plasmas at Finite Chemical Potential

Carlo Ewerz, Paul Wittmer, Andreas Samberg, Konrad Schade

Studying the formation and dissociation of heavy quark bound states in heavy ion collisions is a valuable tool to probe the quark-gluon plasma. The dissociation of such states is caused by screening effects which are very sensitive to the properties of the hot medium. A key approach to this problem is to study the thermodynamic properties of such heavy quark bound states. Here we concentrate on strongly coupled plasmas and use the gauge/gravity correspondence. By computing the extremal area of temporal Wilson loops we obtain the free energy, binding energy, entropy and internal energy of heavy-quark bound states at finite temperature and finite chemical potential in N=4 SYM and in non-conformal bottom-up models. Further, we derive the coupling strength of the pair. We put particular emphasis on the renormalization of the on-shell Nambu-Goto action for the computation of the free energy. We compare the effects of temperature, chemical potential, velocity and deformations of the AdS-space on all aforementioned observables.

Holographic Instanton Calculations of Meson Decay

Maciej Matuszewski

Holographic methods have been showing increasing promise in modelling mesons. I will begin the talk by presenting a simple toy model of mesons as massless strings with massive endpoints. I will then move on to discuss how this motivates a holographic model of zero temperature mesons as string worldsheet instantons in Sakai-Sugimoto spacetime -- with meson decay being represented by a single string loop splitting into a double string loop. This will be shown to qualitatively reproduce the results for meson decay rates calculated by Casher, Neuberger and Nussinov. Methods to expand this technique to finite temperature will then be discussed.

Colliding asymmetric shocks in AdS

Andreas Rabenstein, Sebastian Waeber

In the early phase of Heavy Ion Collisions a quark-gluon plasma is created. We can make use of the AdS/CFT correspondence to map this process in a strongly coupled conformal field theory to the collision of gravitational shockwaves in the dual AdS space. Since the colliding nuclei are highly Lorentz-contracted, we use planar shocks as a first approximation. To model off-center shocks, we simulate asymmetric colliding shock waves. Einstein's equations are solved numerically using the characteristic formulation of General Relativity. We simulate symmetric shocks as well and compare the two results to find that the thermalization is almost invariant. We also want to compare our results to hydrodynamics which describes the quark-gluon plasma very well.

Dynamical Critical Phenomena of Non-equilibrium Phase Transitions in AdS/CFT Correspondence

Masataka Matsumoto and Shin Nakamura

In recent years, non-equilibrium phase transitions were discovered in D3-D7 system by using the AdS/CFT correspondence. In our presentation, we will report the analysis of the dynamical critical phenomena of the non-equilibrium phase transition. We calculate the dynamical critical exponents numerically by evaluating the relaxation into the non-equilibrium steady state near critical point.

Holographic entanglement entropy of self dual strings

John Estes, Darya Krym, Andrew O'Bannon, Brandon Robinson, Ronald Rodgers

The presence of a Wilson surface in N=(2,0) 6D SCFT may be described holographically by the presence of probe M5-brane in the dual geometry. My poster will discuss solutions dual to a Wilson surface with a Young tableau which is either a single row or single column, and the computation of the holographic entanglement entropy of these solutions. This provides a way to compute the central charge of self-dual strings, with either symmetric or antisymmetric wavefunctions, in the N=(2,0) theory.

Complexity change under conformal transformations in AdS3/CFT2

Mario Flory, Nina Miekley

Using the volume proposal, we compute the change of complexity of holographic states caused by a small conformal transformation in AdS3/CFT2. This computation is done perturbatively to second order. We give a general result and discuss some of its properties. As operators generating such conformal transformations can be explicitly constructed in CFT terms, these results might allow for a comparison between holographic methods of defining and computing computational complexity and purely field-theoretic proposals in the future.

Counting gates in AdS/CFT

Abt, Erdmenger, Hinrichsen, Melby-Thompson, Meyer, Northe, Reyes

We study the conjectured relation between codim-1 volumes and complexity in AdS3/CFT2, and show how this matches and explicit count of tensors in MERA. We introduce the notion of mutual complexity, which is universal and acts as a measure of the separability of the density matrix. We express subregion complexity as an integral of entanglement entropies in kinematic space.

Holographic Entanglement Entropy in AdS_4/BCFT_3 and the Willmore Functional

Domenico Seminara, "Jacopo Sisti", Erik Tonni

We study the holographic entanglement entropy of spatial regions with arbitrary shapes in the AdS_4/BCFT_3 correspondence for static gravitational backgrounds, focussing on the subleading term with respect to the area law term in its expansion as the UV cutoff vanishes. An analytic expression depending on the unit vector normal to the minimal area surface is obtained. When the bulk spacetime is a part of AdS_4, the formula becomes the Willmore functional with a proper boundary term evaluated on the minimal surface viewed as a submanifold of the three dimensional flat Euclidean space. Analytic expressions for some smooth domains are reproduced, including the one for a disk disjoint from a boundary which is either flat or circular. When the spatial region contains corners adjacent to the boundary, the subleading term with respect to the area law term is a logarithmic divergence whose coefficient is determined by a corner function, and also this result is recovered. From the analytic expression of the corner function we note a relation with the one-point function of the stress energy tensor that could provide insights to get an universal relation in BCFT_3 which would lead to a deeper understanding of the AdS/BCFT correspondence. Finally, a numerical approach based on Surface Evolver is employed to construct extremal surfaces anchored to entangling curves with arbitrary shape. It has been used both to check some analytic results and to find numerically the subleading term of the holographic entanglement entropy for some ellipses disjoint from a flat boundary.

Quantum Gravity from Conformal Field Theory

F. Aprile, J. M. Drummond, P. Heslop, HP

I will discuss the problem of constructing perturbative loop corrections to AdS_5 supergravity amplitudes. By using the consistency of the operator product expansion in N=4 super Yang-Mills and known tree-level supergravity results we are able to bootstrap loop corrections by imposing a consistent spectrum of double-trace operators.

Analysis of unstable bound states in holographic conductors

Shuta Ishigaki, Shin Nakamura

The non-equilibrium conductivity of charged many-body system can be calculated by using the AdS/CFT correspondence. As a result, negative differential conductivity (NDC) was found in some parameter regions. However the understanding of the physical origin of the NDC is still lacking. The NDC might be explained by the contribution from unstable bound states. Thus we calculated Quasi-Normal Modes frequencies to find lifetime of unstable bound states in holographic conductors. In our presentation we will explain about the result and the interpretation.

The holographic Weyl semi-metal

Christian Copetti, Jorge Fernández-Pendás, Karl Landsteiner

Weyl semi-metals are a new exciting class of materials realizing the chiral anomaly in condensed matter physics. I present a holographic model of a Weyl semi-metal and compute the Hall conductivities from the holographic anomalies. An apparent mismatch in the symmetry factor of 1/3 in the triangle diagram is overcome by interpreting the result via the holographic RG flow.

Holographic Subregion Complexity from Kinematic Space

Raimond Abt, Johanna Erdmenger, Marius Gerbershagen, Charles M. Melby-Thompson, Christian Northe

We consider the computation of volumes contained in a spatial slice of AdS3 in terms of observables in a dual CFT. We give an explicit formula for the volume of a general region in the spatial slice as an integral over kinematic space. For the region lying below a geodesic, we show how to write this volume purely in terms of entanglement entropies in the dual CFT. This expression is perhaps most interesting in light of the complexity=volume proposal, which posits that complexity of holographic quantum states is computed by bulk volumes. We further extend many of our results to conical defect and BTZ black hole geometries.

Butterfly Velocity across a Quantum Phase Transition

Bikash Padhi, Matteo Baggioli, Philip W. Phillips, Chandan Setty

We study an anisotropic holographic bottom-up model displaying a quantum phase transition (QPT) between a topologically trivial insulator and a non-trivial Weyl semimetal phase. We analyze the properties of quantum chaos in the quantum critical region. We find a violation of the recently conjectured bound for the butterfly velocity across a QPT. In particular, the butterfly velocity along the anisotropic direction does not display a maximum at the quantum critical point. We observe that instead of the butterfly velocity, it is the dimensionless information screening length that is always maximized at a quantum critical point. We argue that the null-energy condition (NEC) is the underlying reason for the upper bound, which now is just a simple combination of the number of spatial dimensions and the anisotropic scaling parameter.

Membrane flows in anomalous holographic theories

Christian Copetti, Jorge Fernandez Pendas (IFT Madrid)

We study how the presence of ´t Hooft anomalies in the dual field theory description affects the definition of membrane observables (such as the Brown-York stress tensor and the membrane flavour currents) in the gravitational bulk. Once these are correctly defined, the DC contribution to transport coefficients coming from the anomalies can be recovered as horizon fluctuations by matching appropriate conserved fluxes. Some comments are made on the interesting RG dynamics of gravitational Chern-Simons terms that can be extracted through our methods.

Holographic disorder with backreaction

Yiqiang Du

The AdS/CFT correspondence provides a novel tool to analyze strongly coupled and correlated quantum states of matter. Disordering such states may lead to new insights into the physics of many body localized strongly correlated states, possibly in the presence of strong disorder. In AdS/CFT, the probe limit is not suitable for strong disorder, and the backreacted solution needs to be constructed. We are interested in the potential metal-insulator transitions in holographic conductors with disorder. By using the DeTurck method to change the Einstein equations into a set of elliptic PDEs, we are solving the backreacted equations with different strength of disorder. We present results for the backreacted disordered AdS-Soliton, describing a disordered strongly interacting insulator. We will analyze MBL-like phase transitions, new disordered ground states, as well as analyze the thermo-electric conductivities in this setup.

Strongly coupled electron fluids in the Poiseuille regime

Johanna Erdmenger, Ioannis Matthaiakakis, René Meyer, David Rodríguez Fernández

In the context of describing electrons in solids as a fluid in the hydrodynamic regime, we consider a flow of electrons in a channel of finite width, i.e. a Poiseuille flow. The electrons are accelerated by a constant electric field. We develop the appropriate relativistic hydrodynamic formalism in 2+1 dimensions and show that the fluid has a finite DC conductivity due to boundary-induced momentum relaxation, even in the absence of impurities. We use methods involving the AdS/CFT correspondence to examine the system in the strong-coupling regime. We calculate and study velocity profiles across the channel, from which we obtain the differential resistance dV/dI. We find that dV/dI decreases with increasing current I as expected for a Poiseuille flow, also at strong coupling. We also vary the coupling strength by varying eta/s, the ratio of shear viscosity over entropy density. We find that dV/dI decreases when the coupling is increased. Moreover, we find that strongly coupled fluids are more likely to become ultra-relativistic and turbulent. These conclusions are insensitive to the presence of impurities. In particular, we predict that in channels which are clearly in the hydrodynamic regime already at small currents, the DC channel resistance strongly depends on eta/s.

DC transport with external magnetic field for non-relavistic condensed matter systems

Neha Bhatnagar

Recently, considerable interest is seen in investigating real condensed matter systems using holography. The investigation of different phases of strongly coupled systems requires new holographic models. We study the holographic DC conductivities of (2+1) dimensional systems while considering Einstein-Maxwell-Dilaton system with hyperscaling violating geometry in bulk. We also consider axionic fields in bulk to incorporate the momentum relaxation in the system. Applying an external magnetic field, we study the response of the system and obtain analytic expressions for DC conductivities.

Positive gravitational subsystem energies from CFT cone relative entropies

Dominik Neuenfeld, Krishan Saraswat, Mark Van Raamsdonk

The positivity of relative entropy for spatial subsystems in a holographic CFT implies the positivity of certain quantities in the dual gravitational theory. We consider CFT subsystems whose boundaries lie on the lightcone of a point p. We show that the positive gravitational quantity which corresponds to the relative entropy for such a subsystem A is a novel notion of energy associated with a gravitational subsystem bounded by the minimal area extremal surface A˜ associated with A and by the AdS boundary region Aˆ corresponding to the part of the lightcone from p bounded by ∂A. This generalizes the results of arXiv:1605.01075 for ball-shaped regions by making use of the recent results in arXiv:1703.10656 for the vacuum modular Hamiltonian of regions bounded on lightcones. As part of our analysis, we give an analytic expression for the extremal surface in pure AdS associated with any such region A. We note that its form immediately implies the Markov property of the CFT vacuum (saturation of strong subadditivity) for regions bounded on the same lightcone. This gives a holographic proof of the result proven for general CFTs in arXiv:1703.10656. A similar holographic proof shows the Markov property for regions bounded on a lightsheet for non-conformal holographic theories defined by relevant perturbations of a CFT.