Holographic Methods and Applications

Monday 18 August 2014 - Friday 22 August 2014

Reykjavík, Askja, room N-132

Talk titles

Timo Alho: Thermodynamics of holographic models for QCD in the Veneziano limit

We have studied the thermodynamics of a class of holographic bottom-up models for QCD in the limit where both N_c and N_f go to infinity such that their ratio is finite. These Veneziano QCD -models incorporate a gravity-dilaton system to model the glue dynamics and a scalar tachyon for the fermion degrees of freedom. We have solved the system with full backreaction at finite temperature and finite chemical potential, allowing a determination of the chiral and deconfining transitions. I will also discuss ongoing work in modeling the low-temperature hadron gas phase.

Alejandra Castro: The cone, the anyon and the ribbon

In this talk, I'll discuss entanglement entropy in two-dimensional conformal field theories with a gravitational anomaly. This anomaly is holographically represented by a gravitational Chern-Simons term in the bulk action. The anomaly broadens the Ryu-Takayanagi minimal worldline into a ribbon, and the anomalous contribution to the CFT entanglement entropy is given by the twist in this ribbon. The entanglement functional may also be interpreted as the worldline action for a spinning particle -- that is, an anyon -- in three-dimensional curved spacetime. Several simple examples will be discussed.

Miguel Costa: Thermodynamics of the BMN matrix model at strong coupling

We construct the black hole geometry dual to the deconfined phase of the BMN matrix model at strong ’t Hooft coupling. We approach this solution from the limit of large temperature where it is approximately that of the non-extremal D0-brane geometry with a spherical S8 horizon. This geometry preserves the SO(9) symmetry of the matrix model trivial vacuum. As the temperature decreases the horizon becomes deformed and breaks the SO(9) to the SO(6) × SO(3) symmetry of the matrix model. When the black hole free energy crosses zero the system undergoes a phase transition to the confined phase described by a Lin-Maldacena geometry. We determine this critical temperature, whose computation is also within reach of Monte Carlo simulations of the matrix model. The scaling behaviour of the free energy, entropy and horizon size earlier derived in the literature follows from a simple scaling symmetry of the gravity action. We also determine the asymptotic gravity data in terms of normalizable modes near the boundary.

Ben Craps: AdS (in)stability, secular term resummation and the renormalization group

Using weakly nonlinear perturbation theory, we study the (in)stability of anti-de Sitter spacetime under small scalar field perturbations. We show how to resum secular terms using renormalization group techniques. A majority of secular terms that could be present on general grounds given the spectrum of frequencies of linear AdS perturbations, do not in fact arise.

Aristomenis Donos: The thermoelectric properties of inhomogeneous holographic lattices

We consider inhomogeneous, periodic, holographic lattices of D = 4 Einstein-Maxwell theory. We show that the DC thermoelectric conductivity matrix can be expressed analytically in terms of horizon data of the black hole. We numerically construct such black holes associated with various lattices and examine some of the their properties along with properties of the optical conductivity.

Johanna Erdmenger: A holographic Kondo model at strong coupling and conference summary

A holographic RG flow is obtained for a strongly coupled system which interacts with a magnetic inpurity. This is dual to a large N field theory in which a bilinear operator involving an electron and a slave fermion condenses. The resistivity has a power-law dependence on the temperature with real exponent, similarly to a Luttinger liquid. We also find a holographic dual of the phase shift present in field theory Kondo models.

At the end of my talk, I will give a brief summary of the conference and an outlook to further directions.

Nick Evans: Dynamic AdS/QCD and the spectra of gauge theories

Dynamic AdS/QCD is an improved holographic description of QCD that inputs the dynamics through the running of the anomalous dimension of the quark condensate. I will motivate it from rigorous D3/D7 models of chiral symmetry breaking. The model allows the study of the behaviour of the meson spectrum as one changes Nf Nc and even the representation of the quarks. I will compare to lattice data and display behaviours of walking theories and those that lie in the conformal window.

Jerome Gauntlett: Holographic Lattices, Metals and Insulators

Abstract:TBA

Simone Giombi: Higher spin theories and vector models in various dimensions

Higher spin gravity theories in Anti-de Sitter space have been conjectured to be holographically dual to conformal field theories with vector-like matter fields: these include the free CFT's of N-component massless scalars or fermions, but also interacting CFT's such as the Wilson-Fisher fixed point in d=3. I will review recent tests of these dualities in various spacetime dimensions, and also discuss evidence for the existence of non-trivial large N scalar CFT's with O(N) symmetry in 4<d<6.

Blaise Goutéraux: Charge transport with momentum relaxation in holography

Charge can be transported in holography with a finite DC conductivity via various momentum relaxation mechanisms. Focusing on relaxation by massless scalars or helical lattices, I explain how to compute the DC conductivity in terms of horizon data, and investigate the nature of charge transport in effective holographic theories, characterized by at most four scaling exponents. The DC conductivity can be dominated either by pair creation or momentum dissipation, and lead to metallic or insulating phases. Moreover, at low frequencies, the optical conductivity need not scale covariantly as a function of frequency over temperature.

The talk will be based on arXiv:1401.5436 and arXiv:1406.6351.

Andrew Green: Towards a Field Theory over Tensor Network States

Several works have pointed out the similarities between properties of hierarchical tensor network descriptions of critical systems and their gravitational duals. Though the body of circumstantial evidence for this link is compelling, it is difficult to make these notions concrete due to the different language of the two areas. Here, I outline a first step towards bridging this language barrier, by explicitly constructing a field theory over the simplest tensor network states - matrix product states. I develop a functional integral representation of the partition function of a spin chain, where the measure of integration is explicitly over matrix product tensors. I will discuss the potential applications of such a field theory and the challenge presented by extending these ideas to critical systems, to higher dimensions and to hierarchical tensor networks.

Giuseppe Policastro: Semiholographic models of non-Fermi liquids

I will present a class of models that describe strongly-correlated non-Fermi liquid systems emerging from
free fermions coupled to a holographic CFT. The behavior of the system can be analyzed self-consistently in certain regions of the parameter space. I will discuss some predictions for observable quantities and possible comparison to experimental data.

Simon Ross: Multiboundary Wormholes and Holographic Entanglement

I will discuss the relation of entangled states in the
n-fold tensor product of a 1+1 dimensional CFT Hilbert space and black holes with n asymptotically AdS_3 regions connected by a common wormhole. This exhibits an interesting dependence on moduli: In some regions of the moduli space the entanglement is entirely multipartite, but even when the bulk is completely connected, in some regions of the

moduli space the entanglement is almost entirely bipartite:
significant entanglement occurs only between pairs of CFTs.

Koenraad Schalm: Far from equilibrium dynamics in quantum critical systems

We investigate far from equilibrium energy transport in strongly coupled quantum critical systems. Combining results from gauge-gravity duality, relativistic hydrodynamics, and quantum field theory, we argue that long-time energy transport after a local thermal quench occurs via a universal steady-state for any spatial dimensionality. This is described by a boosted thermal state. We determine the transport properties of this emergent steady state, including the average energy flow and its long-time fluctuations.

David Tong: Holography with Large N=4

The holographic dual of string theory on AdS3 x S3 x S3 x S1 has a large N=4 superalgebra and has long been mysterious. I will describe a 2d gauge theory with N=(0,4) supersymmetry and will argue that it flows, in the infra-red, to a theory with large N=4 and the correct central charge.

Erik Tonni: Entanglement negativity in conformal field theory

Entanglement of quantum states and its measures play an important role in many areas of theoretical physics. While the entanglement entropy is a good measure for pure states, the negativity allows to measure entanglement for mixed states. A method to compute negativity in QFT through the replica trick will be described, focussing on 2D CFTs. Analytic results and their numerical checks will be presented for the compactified boson and the Ising model. Also the time evolution of the negativity after a global quantum quench will be discussed.

Stefan Vandoren: Holography with small N=4

We discuss new aspects of holography based on the small N=4 D=2 superconformal algebra with "rho-twists", and the relation to black hole physics.

Balt van Rees: The superconformal bootstrap program

Dmytro Volin: Quantum Spectral curve for AdS/CFT spectrum

I will review recent advancements in computing the spectrum of conformal dimensions in planar N=4 SYM theory. We managed to reduce the task to a simple set of Riemann-Hilbert equations which define the quantum spectral curve for the underlying integrable model.

Jan Zaanen: Holography and condensed matter experiments: a status report.

The Anti-de-Sitter/Condensed Matter Theory pursuit has been all long energized by the potentiality that the mathematical insights of holography can shed light on the grand mysteries that have been uncovered during the last thirty years in the condensed matter laboratories. Although the interest and sympathy for holography is rising in the condensed matter community, it is still waiting for a killer application. Arguably, the ball is now in the experimentalist's court: holography has delivered a number of sharp and unusual questions, but in order to address these in the lab quite unusual (and expensive) experiments are required. I will review the situation, hopefully inspiring other holographist's to come up with more and better ideas.

Daniel Arean: Dirty Holographic Superconductors

The study of disorder, and in particular the phenomenon of Anderson localization, in interacting many-body systems is a challenging problem in condensed matter physics. By introducing disorder in holographic realizations of superconductivity we can get predictions from the gauge/gravity duality on how strongly coupled superconductors behave in the presence of impurities. It is interesting to see the effect disorder may have on the critical temperature of those systems, and, when studying thin superconducting films, to consider the formation of islands of superconductivity.

Andrey Bagrov: Pairing induced superconductivity in holography

We study pairing induced superconductivity in large N strongly coupled systems at finite density using holography. In the weakly coupled dual gravitational theory the mechanism is conventional BCS theory. An IR hard wall cut-off is included to ensure that we can controllably address the dynamics of a single confined Fermi surface. We address in detail the interplay between the scalar order parameter field and fermion pairing. Adding an explicitly dynamical scalar operator with the same quantum numbers as the fermion-pair, the theory experiences a BCS/BEC crossover controlled by the relative scaling dimensions. We find the novel result that this BCS/BEC crossover exposes resonances in the canonical expectation value of the scalar operator. This occurs not only when the scaling dimension is degenerate with the Cooper pair, but also with that of higher derivative paired operators. We speculate that a proper definition of the order parameter which takes mixing with these operators into account stays finite nevertheless.

Yago Bea Besada: Flavored ABJM with flux and Hall states

We consider an unquenched massless flavored ABJM background and introduce a massive probe flavor brane where an internal gauge field along the compact part is turned on (internal flux). We also include electric field, magnetic field, baryon density and currents, breaking SUSY. It turns out that this set up is an appropriate one to describe the QHE, and constitutes a new example after the

D2-D8' and D3-D7' systems. For a particular relation of these fields N=1/2 SUSY is still preserved, and the solution is analytical. Finally, this can be extended in several directions: unquenched massive background, temperature, etc.

Marko Djuric: Holographic Pomeron and Odderon at Strong Coupling

We discuss conformal Pomeron and Odderon using AdS/CFT, or, equivalently, Pomeron and Odderon in N = 4 SYM, in strong coupling. We explore the relation between the 'Basso-expansion' and the Delta-j curve at strong coupling, and we demonstrate how it can be applied to other Regge intercepts in addition to Pomeron. In particular, we focus on 'Odderons' which are the leading crossing-odd, C = -1, Regge singularities. From the perspective of AdS/CFT, while Pomeron can be identified with a Reggeized Graviton, Odderons correspond to Reggeized anti-symmetric AdS5 Kalb-Ramond tensor-fields. We identify the class of single-trace operators to which the string modes couple to and discuss their anomalous dimension curves. This information is the applied to calculate the Odderon intercept beyond leading order.

Antón Faedo: CFT's at the IR of N=1, d=3 SQCD with backreactiong flavor

We construct the holographic duals to N=1, d=3 Yang-Mills theories with smeared flavor. We work in the Veneziano limit, meaning that we take into account the backreaction of the flavor D6-branes into the geometry of the color D2-branes. In the IR the solution flows to a CFT. We also discuss in detail the internal geometries that have their own interest.

Daniel Fernandez: Collisions of inhomogeneous shockwaves in AdS

Holography has proved to be a useful tool to study strongly coupled plasmas, similar to the quark gluon plasma created in heavy ion collision experiments. Moreover, recently a new approach has shown that it could be used to study the initial stage of these collisions as well. In this regard, it remains to be seen how close the holographic studies will actually be to the experimental observations, since holographic setups do not describe QCD directly. This talk will consist of a review on how a collision of gravitational shockwaves in an AdS spacetime can model a heavy ion collision, together with a sketch of the numerical techniques involved in the calculation. Finally, I will also comment on the introduction of transverse inhomogeneities that may give a more accurate approach to real world collisions.

Michael Gary: Lifshitz Holography with Isotropic Scale Invariance

Is it possible for an anisotropic Lifshitz critical point to actually exhibit isotropic conformal invariance? We answer this question in the affirmative by constructing a higher spin holographic realization. We provide consistent boundary conditions and determine the associated asymptotic symmetry algebra. Surprisingly, we find that the algebra consists oftwo copies of the W3 extended conformal algebra, which is the extended conformalalgebra of an isotropic critical system.

Moreover, the central charges are the same asin AdS3 holography. We consider the possible geometric interpretation of the theoryin light of the higher spin gauge invariance and remark on the implications of theasymptotic symmetry analysis.

Gianluca Grignani: Holographic bilayers

Two holographic models of a double monolayer Dirac semi-metal are considered. Both models exhibit two phases with chiral symmetry breaking inter-layer and intra-layer exciton condensates. The effect of external magnetic fields and the introduction of charge densities in the monolayers are examined and the phase diagram in terms of layer separation and chemical potential is derived.

Troels Harmark: Spin matrix theory: A quantum mechanical model for the AdS/CFT correspondenc

We introduce a new quantum mechanical theory called Spin Matrix theory (SMT). SMT describes N=4 super-Yang-Mills theory near critical points in the grand canonical phase diagram. Despite being a non-relativistic quantum mechanical theory SMT contains a variety of phases resembling gauge theory and string theory. Its planar limit is a gas of spin chains that depending on the coupling either resembles planar gauge theory operators or strings. Including 1/N effects it is a gas of interacting spin chains. When raising the energy the spin chain gas deconfines due to non-perturbative effects in 1/N. For SU(2) SMT we find a semi-classical description of this deconfined phase for high temperatures at any coupling. This reveals the phase at temperatures way above the Hagedorn temperature.

Jelle Hartong: Lifshitz Space-Times for Schroedinger Holography

I will define for a broad class of models the sources and vevs for asymptotically Lifshitz space-times with critical exponent z in the range (1,2]. It turns out that the sources and vevs transform in representations of the Schroedinger group, with the same critical exponent z, that acts locally on the sources and vevs. The boundary geometry in all cases is described by torsional Newton-Cartan geometry. We use these insights to set up a fluid/gravity correspondence that allows us to study Lifshitz hydrodynamics of the boundary field theory.

Carlos Hoyos Badajoz: Hydrodynamics of Lifshitz fluids and superfluids

Quantum critical points are believed to underlie the exotic properties of heavy fermion compounds and other materials including high Tc superconductors. They are characterized by a non-relativistic Lifshitz' scaling symmetry that has been shown to emerge in many systems with holographic duals, including holographic superconductors,electron' stars and disordered systems. When temperature is introduced a large region of the phase diagram of these systems is dominated by the physics of the quantum critical point. At long wavelengths one can use an effective hydrodynamic description. I discuss the properties and novel transport phenomena that appear in Lifshitz fluids and superfluids from the point of view of effective field theories and holographic models.

Maria Irakleidou: Conformal gravity holography in four dimensions

We formulate four-dimensional conformal gravity with (Anti-)de Sitter boundary conditions that are weaker than Starobinsky boundary conditions, allowing for an asymptotically subleading Rindler term concurrent with a recent model for gravity at large distances. We prove the consistency of the variational principle and derive the holographic response functions. One of them is the conformal gravity version of the Brown-York stress tensor, the other is a `partially massless response'. The on-shell action and response functions are finite and do not require holographic renormalization. Finally, we discuss phenomenologically interesting examples, including the most general spherically symmetric solutions and rotating black hole solutions with partially massless hair.

Matti Jarvinen: Progress in backreacted holographic QCD

I discuss some of the latest developments in holographic bottom-up models for QCD in the Veneziano limit (V-QCD) where the flavor fully backreacts to the glue. Finite quark mass and the axial anomaly can be included in the model in a natural way, and the pion and eta prime masses satisfy the Gell-Mann-Oakes-Renner and Witten-Veneziano relations. I also show how the S-parameter depends on the quark mass and how double trace deformations affect the phase diagram.

Alexander Krikun: Classical and quantum temperature fluctuations via holography

We study local temperature fluctuations in a CFT on the sphere, dual to a black hole in asymptotically AdS space-time. The fluctuation spectrum is governed by the lowest-lying hydrodynamic modes of the system whose frequency and damping rate determine whether temperature fluctuations are thermal or quantum. We calculate numerically the corresponding quasinormal frequencies of the black hole in global AdS and match the result with the hydrodynamics of the dual CFT at large temperature.

Matthew Lippert: Holographic Anyonic Superfluidity

This talk will be about an unusual type of superfluid, one made up of anyons. I will discuss anyons, their relation to the quantum Hall effect, and how an anyonic superfluid is unlike a typical superfluid. Then I will describe a holographic model of a strongly-coupled anyonic superfluid and the stability of its supercurrents.

Daniele Musso: Comments on finite counter-terms in holography

Finite counter-terms are a ubiquitous and physically relevant feature of holographic systems. I describe briefly three examples, thermo-electric transport in massive gravity, holographic general gauge mediation and AdS/CFT optics. Eventually attempting some general comment.

Dmitry Ponomarev: Holographic computations in higher spin theories

We use recently developed techniques including the split representation of higher spin propagators and Mellin transform to facilitate computations of the bulk higher spin Witten diagrams. By matching them with the CFT result we reconstruct higher spin interactions.

Razieh Pourhasan: A Holographic Quantum Hall Ferromagnet

A detailed numerical study of a recent proposal for exotic states of the D3-probe D5 brane system with charge density and an external magnetic field is presented. The state has a large number of coincident D5 branes blowing up to a D7 brane in the presence of the worldvolume electric and magnetic fields which are necessary to construct the holographic state. Numerical solutions have shown that these states can compete with the the previously known chiral symmetry breaking and maximally symmetric phases of the D3-D5 system. Moreover, at integer filling fractions, they are incompressible with integer quantized Hall conductivities. In the dual superconformal defect field theory, these solutions correspond to states which break the chiral and global flavor symmetries spontaneously. The region of the temperature-density plane where the D7 brane has lower energy than the other known D5 brane solutions is identified. A hypothesis for the structure of states with filling fraction and Hall conductivity greater than one is made and tested by numerical computation. A parallel with the quantum Hall ferromagnetism or magnetic catalysis phenomenon which is observed in graphene is drawn. As well as demonstrating that the phenomenon can exist in a strongly coupled system, this work makes a number of predictions of symmetry breaking patterns and phase transitions for such systems.

Christopher Rosen: Fermi Surface Physics from Gauged Supergravity

Recently, holography has demonstrated its utility as a vehicle for explorations of Fermi surface physics in certain well studied field theories. Previous results in strongly coupled N=4 Super Yang Mills have motivated subsequent investigations into analogous states in 2+1 dimensional ABJM theory. I will overview the application of holography to these systems, introducing new results with interesting features in ABJM theory along the way.

Javier Tarrio: Scaling solutions in SYM theories with fundamental charge density

I will discuss scaling solutions that arise in supergravity in the presence of external stringy sources, that modify the IR behavior of the field theory duals to (intersections) of branes.

Benjamin Withers: Breaking translational symmetry in holography

I will discuss approaches to the construction of bulk geometries dual to holographic phases without translational invariance. In the first example I will discuss an explicit breaking by turning on spatially dependent sources in the dual field theory. Through exploiting a scalar shift symmetry both the bulk geometry and finite DC conductivity may be computed analytically. In the second example I will discuss the numerical construction of inhomogeneous black brane solutions in the absence of sources, where it is found that translational invariance is broken spontaneously via a second order phase transition.

Tobias Zingg: A holographic Dual for logarithmic Field Theories with z = 2 Lifshitz Scaling

A brief compendium about quasinormal modes and two-point correlations functions of a z=2 Lifshitz geometry and its aptitude to exemplify a gravitational dual description for logarithmic field theories with anisotropic scaling invariance.