Current Themes in Holography: Exact results, applications, extensions and fundamentals

HoloGrav Network

Monday 25 April 2016 - Friday 29 April 2016

Niels Bohr Insitute

Scientific Programme

Benjamin Basso

Title: "Hexagons and Three-Point Functions"

Abstract: I will present a framework for computing correlators of three single trace operators in planar N=4 SYM theory that uses hexagonal patches as building blocks. This approach allows one to exploit the integrability of the theory and derive all loop predictions for its structure constants. After presenting the main ideas and results, I will discuss recent perturbative tests and open problems.

Niklas Beisert

Title: "Yangian Symmetry of Planar N=4 SYM"

Abstract: This talk is about integrability of Planar N=4 super Yang-Mills theory. We present a concrete notion of the corresponding Yangian symmetry in this model, show that it holds true, and discuss the (perturbative) implications for correlation functions and Wilson loops.

Matteo Bertolini

Title: "A goldstino at the bottom of the cascade"

Abstract: We discuss the holographic description of supersymmetry breaking vacua in N=1 quiver gauge theories arising from D-branes at CY singularities, focusing on the conifold theory as a protoype. There exists a two-parameter family of supersymmetry breaking solutions with the asymptotic of the supersymmetric Klebanov-Strassler background. Within this family, we show that those (and only those) solutions related to antiD-branes at the tip of the conifold correspond to dual field theory vacua where a goldstino mode is present and supercurrent Ward identities hold. Our findings do not depend on the IR singularity of the dual backgrounds, nor on its resolution, and constitute a check for the existence of supersymmetry breaking vacua in the conifold cascading gauge theory, and in a large class of N=1 quiver gauge theories.

Francesco Bigazzi

Title: "Theta Dependence in Holographic QCD"

Abstract: Effects of the theta parameter - the coefficient of the CP-breaking topological term - are studied in Witten-Sakai-Sugimoto's model of holographic QCD. I will first consider the unflavored version of the model and discuss the theta-dependence of various observables. The holographic results, which qualitatively agree with available lattice data at small theta, provide a benchmark for further corrections. I will then consider the inclusion of massive quarks and present the holographic computation of the neutron electric dipole moment.

Agnese Bissi

Title: "Analytic bootstrap for higher spin operators"

Abstract: In this talk I will present how to use crossing symmetry in weakly coupled

gauge invariant conformal field theories to constrain analytically the anomalous dimension and the three point function of higher spin operators, to all loops in perturbation theory.

Frederic Bruenner

Title: "Glueball Decay in the Witten-Sakai-Sugimoto Model"

Abstract: I present recent results on glueball decay rates in the Witten-Sakai-Sugimoto model. I will discuss the predictions for the decay of a scalar glueball into pseudoscalar mesons, with an emphasis on the role of the inclusion of finite quark masses. Furthermore, I will discuss new results on the pseudoscalar glueball.

Alejandra Castro

Title: "Warped conformal field theories"

Abstract: Warped conformal field theories (WCFTs) are a novel class of non-relativistic theories in two dimensions, which are interesting in both holography and QFT. In this talk I will show how to derive general properties of the spectrum and modular properties of partition functions of WCFTs. A simple, yet non-trivial, example of such theory is a massive Weyl fermion in $(1+1)$-dimensions, which we will use as a guideline to illustrate the charm behind WCFTs.

Geoffey Compère

Title: "BMS holography"

Abstract: I will first review the BMS algebra and its relationship to the memory effect in general relativity. I will then argue that asymptotic symmetries are extended into the bulk spacetime. I will then show how this leads to gravitational vacua encoding permanent memories, and black holes with BMS supertranslation field and superrotation charges which encodes part of the history of collapse and evolution of the black hole. I will argue that there is a relationship source-vev between the supertranslation field and superrotation field, which is a characteristic feature of BMS holography.

Miguel Costa

Title: "Soft Pomeron on holographic QCD"

Abstract: We study the graviton Regge trajectory in holographic QCD as a model for high energy scattering processes dominated by soft-Pomeron exchange. This is done by considering spin J fields from the closed string sector that are dual to glueball states of even spin and parity. In particular, we construct a model that governs the analytic continuation of the spin J field equation to

the region of real J<2, which includes the scattering domain of the negative Maldelstam variable t. The model leads to approximately linear Regge trajectories and is compatible with the measured values of 1.08 for the intercept and 0.25GeV−2 for the slope of the soft Pomeron. The intercept of the secondary Pomeron trajectory is in the same region of the subleading trajectories, made of mesons, proposed by Donnachie and Landshoff, and should therefore be taken into account.

Johanna Erdmenger

Title: "Magnetic impurities and universality in AdS/CMT"

Abstract: I will present recent results on applications of gauge/gravity duality to condensed matter physics. First I will present a holographic model of a magnetic impurity interacting with a strongly coupled electron system, similar to the Kondo model. For this model we have calculated the entanglement and impurity entropies, which may be compared to field theory results. We have also studied quenches in this model. Second, I will discuss universality in the context of gauge/gravity duality models with broken translation invariance.

Nick Evans

Title: "Holographic Nambu Jona-Lasinio Interactions"

Abstract: NJL interactions are introduced into the D3/ probe D7 system using Witten's double trace operator prescription which includes the operator as a classical term in the effective potential. In the supersymmetric system they do not induce chiral symmetry breaking which we attribute to the flat effective potential with quark mass in the supersymmetric theory. If additional supersymmetry breaking is introduced then standard NJL behaviour is realized. In examples where chiral symmetry breaking is not preferred such as with a B field plus an IR cut off chiral condensation is triggered by the NJL interaction at a second order transition after a finite critical coupling. If the model already contains chiral symmetry breaking, for example in the B field case with no IR cut off, then the NJL interaction enhances the quark mass at all values of the NJL coupling. We also consider the system at finite temperature: the temperature discourages condensation but when combined with a magnetic field we find regions of parameter space where the NJL interaction triggers a first order chiral transition above a critical coupling. Finally we begin to explore holograms of a dynamically generated top quark mass such as in top condensation or extended technicolour.

Jerome Gauntlett

Title: "DC Conductivity in Holography and Stokes Equations"

Abstract: In seeking applications of holography to real materials the thermoelectric conductivity is an important observable to study. Like the entropy we show that, universally, the DC conductivity can be obtained in terms of the behaviour of black hole spacetimes purely at the horizon. More precisely, we show that the DC conductivity can be obtained by solving a generalised set of Stokes equations for a charged incompressible fluid on the black hole horizon. Unlike other connections between fluids and black holes, this is an exact result. For certain classes of black holes the Stokes equations can be solved explicitly. We derive a generalised Wiedemann-Franz Law that holds universally within holography in the case of weak momentum dissipation. We also discuss the holographic framework for finding dual descriptions of both 'coherent' and “incoherent' metals,

insulators as well as transition between them.

Blaise Goutéraux

Title: "Hydrodynamic theory of quantum-fluctuating superconductivity"

Abstract: Superfluidity, and the corresponding infinite DC conductivity, arises when the phase of a complex order parameter takes a globally defined value. Equivalently, the supercurrent is conserved. A hydrodynamic theory of transport in quantum mechanically phase-disordered superconductors is possible when supercurrent relaxation can be treated as a slow process. We obtain general results for the frequency-dependent conductivity of such a regime. With time reversal, the conductivity is characterized by a Drude-like peak, with width given by the supercurrent relaxation rate. Using the memory matrix formalism, we obtain a formula

for this width (and hence also the dc resistivity) when the supercurrent is relaxed by short range Coulomb interactions. This leads to a new effective field theoretic and fully quantum derivation of a classic result on the resistance contributed by a flow of vortices. We also consider the effects of breaking time reversal. Our work gives a controlled framework for low temperature metallic phases arising from phase-disordered superconductivity.

Daniel Grumiller

Title: "Rindler holography"

Abstract: We consider three-dimensional Einstein gravity with near horizon boundary

conditions. Our near horizon symmetry algebra is surprisingly simple, namely the Heisenberg algebra for "soft hair". We calculate the Rindler entropy in the near horizon field theory and find that the soft hair does not contribute to the Bekenstein-Hawking entropy. We relate near horizon symmetries with asymptotic symmetries and find that the 'natural' variables for the asymptotic observer differ appreciably from the ones of the near horizon observer, even though both describe the same physics. Our results apply to non-extremal black hole and cosmological horizons.

Jelle Hartong

Title: "Non-relativistic Hydrodynamics and Lifshitz Black Branes"

Abstract:Like a relativistic field theory couples to Riemannian geometry, the natural geometry to which a non-relativistic field theory (Galilean, Lifshitz, etc) couples is called torsional Newton-Cartan (TNC) geometry. This is also the geometry that one finds on the boundary of a Lifshitz space-time. I will explain what TNC geometry is and then study fluids on it, mostly at the level of perfect fluids. I will show that one can obtain Lifshitz perfect fluids by a twisted null reduction of scale invariant Galilean (Schroedinger) perfect fluids. In the last part of the talk I will discuss a holographic realization of such a fluid in terms of Lifshitz black branes with momentum in a theory with a broken U(1) symmetry.

Carlos Hoyos

Title: "Neutron stars and speed limits in AdS/CFT"

Abstract: The properties of matter in the interior of neutron stars cannot be described from first principles using perturbation theory or lattice calculations. It is even unknown whether deconfined matter could exist at the core of the star. We examine this question using probe branes in AdS to model the properties of deconfined matter and discuss how constraints on equations of state of holographic models might affect the results

Romuald Janik

Title: "String interactions and integrability"

Abstract: I will first describe the conventional approach to constructing the light cone string field theory vertex and then describe our recent approach using integrability and functional equations.

Kristan Jensen

Title: "Large N limits and chaos in quantum mechanics and AdS2"

Abstract: Since its inception, the AdS2/CFT1 correspondence has remained poorly understood. With the Sachdev-Ye-Kitaev models in mind, I will discuss some progress in unraveling both sides of a putative holographic correspondence for quantum mechanics, with large N limits and thermodynamics playing a key role. I will also discuss some universal results for the butterfly effect in AdS2.

Keun-Young Kim

Title: "Homes' law in holographic superconductors"

Abstract: Homes' law is an empirical universal law for high-temperature and some conventional superconductors. The law states that, for various superconductors, there is a "universal" relation between the superfluid density (\rho_s) at zero temperature and the transition temperature (T_c) multiplied by electric DC conductivity (\sigma_DC) right above the transition temperature. i.e. \rho_s(T=0) = C \sigma DC(T_c)*T_c, where C is a "universal" material independent constant. We study this universal law in holographic superconductor models with momentum relaxation. *

Robert Myers
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*Title: "Entanglement Holography" *
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*Abstract: For general conformal field theories, the entanglement for small perturbations of the vacuum is organized in a novel holographic way. For spherical entangling regions in a constant time slice, perturbations in the entanglement entropy are solutions of a Klein-Gordon equation in an auxiliary de Sitter spacetime. The role of the emergent time-like direction in dS is played by the size of the entangling sphere. For CFTs with extra conserved charges (e.g., higher spin charges), we show that each charge gives rise to a separate dynamical scalar field in dS. *

Carlos Nunez

Title: "Aspects of Gauge-Strings duality"

Abstract: I will discuss some recent advances on the duality between Gauge Fields and Strings. In particular, I will focus the attention on the interplay between holography and non-Abelian T-duality, making the point that we can use gauge theory data to resolve singularities in Supergravity.

Silvia Penati

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*Title: "Wilson loops in ABJ(M): from localization to Bremsstrahlung function through framing" *
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*Abstract: Supersymmetric localization provides exact results for BPS Wilson loops that should match QFT computations in some regularization scheme. The agreement is particularly subtle in three dimensions where complex answers from localization sometimes arise. For the 1/6 BPS Wilson loop in ABJ(M) theory I will discuss the correct interpretation of the imaginary terms in the localization result as originating entirely from a non--trivial framing of the circular contour. Contrary to pure Chern-Simons theory, for ABJ(M) the framing phase is a non--trivial function of the couplings and potentially receives contributions from vertex-like diagrams. I will discuss the intimate link between the exact framing factor and the Bremsstrahlung function of the 1/2-BPS cusp. *

Moshe Rozali

Title: "Particle Production at Strong Coupling"

Abstract: We study the dynamics of a strongly-coupled quantum field theory in a cosmological spacetime using the holographic AdS/CFT correspondence. Specifically we consider a confining gauge theory in an expanding FRW universe and track the evolution of the stress- energy tensor during a period of expansion, varying the initial temperature as well as the rate and amplitude of the expansion. At strong coupling, particle production is inseparable from entropy production. Consequently, we find significant qualitative differences from the weak coupling results: at strong coupling the system rapidly loses memory of its initial state as the amplitude is increased. Furthermore, in the regime where the Hubble parameter is much smaller than the initial temperature, the dynamics is well-modelled as a plasma evolving hydrodynamically.

Koenraad Schalm

Title: "Holographic metals do not Anderson localize"

Abstract: Anderson famously showed that the sufficient presence of random impurities can change normal metals to insulators. I will show that this effect not present in strongly correlated metals that can be described by holography. A key insight will be applicability of a hydrodynamic description of the system. In the holographic dual this is captured by universal horizon physics. Excitingly three recent experiments detect such hydrodynamic flow inside electronic systems. No deep knowledge of condensed matter physics is assumed.

Gordon Semenoff

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*Title: "Quantum Hallography" *
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Abstract: This talk will contain an update on the phenomenon of quantum Hall ferromagnetism in graphene and other Weyl semi-metals and its description using a top-down holographic model.

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Brian Swingle

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*Title: "Measuring Quantum Information Scrambling" *
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*Abstract: This talk is concerned with two ideas: that black holes can be viewed as highly entangled quantum information processing devices and that there exist fundamental bounds on the dynamics of quantum field theories. These two ideas are connected by holographic duality which relates quantum gravity and quantum field theory. I will first review how ideas of quantum entanglement, quantum information scrambling, and computational complexity have contributed to our understanding of black holes. Then I will argue that a natural next step is to begin testing these ideas in the lab using recent advances in the coherent manipulation of quantum many-body systems. Focusing on information scrambling, I will present an experimental proposal, feasible with existing technology, to measure so-called out-of-time-order correlations which probe information scrambling. I will then discuss broadly what we can learn about quantum field theory and quantum gravity using such measurements. *

Marika Taylor

Title: "Entanglement Entropy and the F theorem"

Abstract: Entanglement entropy is a UV divergent quantity. We begin by explaining reasons for defining a renormalized entanglement entropy and then present a systematic renormalization scheme for entanglement entropy, comparing our approach to earlier ad hoc renormalization. We then discuss the relevance of renormalised entanglement entropy to the F theorem for three-dimensional conformal field theories, and present new results concerning the validity of the F theorem for general RG flows.

Larus Thorlacius

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*Title: "A holographic model for black hole complementarity" *
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*Abstract: We present a version of black hole complementarity, where a semiclassical effective field theory provides an approximate description of the evolution of interior infalling degrees of freedom while exterior degrees of freedom evolve according to an exact description of holographic origin.The infalling degrees of freedom have a complementary description in terms of outgoing Hawking radiation and must eventually decohere with respect to the exterior Hamiltonian, leading to a breakdown of the semiclassical description for an infaller. Trace distance is used to quantify the difference between the complementary time evolutions, and to define a decoherence time. In a particular model for the holographic theory, which exhibits fast scrambling, the decoherence time coincides with the scrambling time. We propose a dictionary between the holographic theory and the bulk description where mean field evolution corresponds to the evolution with respect to the bulk effective Hamiltonian. These results support the hypothesis that decoherence of the infalling state is complementary to approaching the curvature singularity. *

Mark van Raamsdonk

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*Title: "Gravitational constraints from entanglement inequalities" *
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Abstract: According to the AdS/CFT correspondence, asymptotically AdS spacetimes arising as states of a consistent gravitational theory should be related to states of a dual conformal field

*theory. The holographic entanglement entropy formula relates the entanglement structure of these CFT states to the spacetime geometry. Through this relation, contraints obeyed by entanglement in all consistent quantum theories can be translated to constraints on the dual spacetime geometries. In this talk, we discuss some of these constraints, focusing on the gravitational implications of positivity and monotonicity of relative entropy in the CFT. *

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Alberto Zaffaroni* *
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*Title: "AdS4 black holes and 3d gauge theories" *
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*Abstract: One of the great success of string theory is the microscopical explanation of the entropy of a class of asymptotically flat black holes. Much less is known about asymptotically AdS black holes. In this talk I explain how to derive the entropy of a class of asymptotically AdS supersymmetric black holes in four dimensions using holography. The counting of black hole micro-states is related to a counting of states in the dual 3d gauge theory which can be explicitly performed using localization. *
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Konstantin Zarembo* *
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Title: "N=2 Holography and Localization"

Abstract: Localization is a powerful probe of holography, and the only non-perturbative tool available in the non-conformal setting. The prime example is the N=2 *mass deformation of N=4 SYM, whose holographic dual is known explicitly. Firm field-theory predictions at strong coupling can then be confronted with holographic calculations with a variety of probes such as fundamental strings and D-branes. An unexpected novel feature of N=2* is an infinite number of quantum phase transitions accumulating towards strong coupling.