HoloGrav Workshop 4-8 March 2013 in Helsinki

1 Summary

The 2013 workshop organised by the ESF network "Holographic methods for strongly coupled systems (HoloGrav)"was organised on 4-8 March 2013 at the Kumpula Campus of the University of Helsinki. The home page of the meeting is http://www.hip.fi/holograv13/

The organising committee of the workshop was K. Kajantie (Helsinki, chair), E. Keski-Vakkuri (Helsinki), M. Panero (Helsinki), K. Rummukainen (Helsinki), K. Tuominen (Jyväskylä), A. Vuorinen (Helsinki), L. Franti (Helsinki).

The meeting was attended by 58 scientists from network member institutes out of whom 23 gave talks. The network support covered their accommodation, coffees between talks and lunch. Partial travel expenses were paid to 7 participants. Local support covered the usual conference infrastructure, lecture hall, internet access, etc.

Out of the participants 12 were accommodated at the University Guest House Töölö Towers, accessible by bus or tram, and 29 at Hotel Ava within a walking distance of about 1 km from the Campus.

2 Scientific content of the event

The content of the meeting is conveyed by the list of talks and their abstracts. All the presentations are linked on the meeting home page.

Alho, Timo (Jyväskylä): Thermodynamics of holographic models for QCD in the Veneziano limit (30')

Abstract: We have studied the thermodynamics of a class of holographic bottom-up models for QCD in the Veneziano limit. We find a rich pattern of stable and metastable phases, depending on the choice of the phenomenological potentials needed to fully define the model. Generically there is a hadronization transition at some temperature, and a chiral symmetry restoring transition which may coincide with the hadronization transition, depending on the choice of potentials. In addition we find a number of more exotic transitions. Computing the full phase diagram in the $(N_f/N_c, T)$ plane and requiring consistency with known features of QCD -like theories, we are able to select among the potentials a preferred candidate for modeling QCD.

Bajnok, Zoltan (Budapest): Review of progress in AdS/CFT integrability (60')

de Boer, Jan (Amsterdam): Quarkyonic phase in holography (60')

Costa, Miguel (Porto): Conformal Regge theory (50')

Abstract: We generalize Regge theory to correlation functions in conformal field theories. This is done by exploring the analogy between Mellin amplitudes in AdS/CFT and S-matrix elements. In the process, we develop the conformal partial wave expansion in Mellin space, elucidating the analytic structure of the partial amplitudes. We apply the new formalism to the case of four point correlation functions between protected scalar operators in N=4 Super Yang Mills, in cases where the Regge limit is controlled by the leading twist operators associated to the pomeron-graviton Regge trajectory. At weak coupling, we are able to predict to arbitrary high order in the 't Hooft coupling the behaviour near J=1 of the OPE

coefficients C_{OOJ} between the external scalars and the spin J leading twist operators. At strong coupling, we use recent results for the anomalous dimension of the leading twist operators to improve current knowledge of the AdS graviton Regge trajectory - in particular, determining the next and next to next leading order corrections to the intercept. Finally, by taking the flat space limit and considering the Virasoro-Shapiro S-matrix element, we compute the strong coupling limit of the OPE coefficient C_{LLJ} between two Lagrangians and the leading twist operators of spin J. (1209.4355)

Craps, Ben (Brussels): Holographic thermalization and energy density fluctuations (60')

Abstract: The sudden injection of energy in a strongly coupled conformal field theory and its subsequent thermalization can be holographically modeled by a shell falling into anti-de Sitter space and forming a black brane. Motivated by event-by-event fluctuations in heavy ion collisions, I will discuss the inclusion of inhomogeneities in such a model. (Blackboard talk)

Djuric, Marko (Porto): Vector Meson Production from AdS/CFT (30')

Abstract: We use gauge/gravity duality to study the production of rho, omega, J/Psi and phi mesons, in the limit of high center of mass energy at fixed momentum transfer, corresponding to the limit of low Bjorken x, where the process is dominated by the exchange of the pomeron. In holography the pomeron is the Regge trajectory in AdS space of the graviton. This is an extension of our previous work on deep inelastic scattering and deeply virtual Compton scattering. We compare our AdS/CFT calculations to data from HERA, both for differential and exclusive cross sections.

Evans, Nick (Southampton): Probe Brane Systems from Graphene to the Conformal Window (60')

Evans, Nick (Southampton): HoloGrav network: a short description of activities (10')

Hartong, Jelle (Copenhagen): Holographic Models for Theories with Hyperscaling Violation (30')

Abstract: Hyperscaling is the property that the thermal entropy scales with the temperature to the power d/z where d is the number of spatial dimensions and z the critical exponent. Black holes in AdS (z=1) or Lifshitz ($z > 1$) space-times satisfy this property. The entanglement entropy for such space-times scales with the area of the boundary entangling region. Recently, a new class of space-times has been introduced that leads to a violation of hyperscaling in that now thermal entropy scales with temperature to the power (d-theta)/z where theta is a parameter that breaks the scale invariance of metric. For well chosen values of theta one can obtain violations of the area law for entanglement entropy. An example is given by theta=d-1 in which case one observes logarithmic violations. In this talk I will argue that the natural class of Lagrangians for such space-times involves massive vector fields. Then, I will define a natural class of probe Lagrangians (which are not the usual Klein-Gordon particles) that can be used to study correlations functions of the boundary theory and discuss the generalization of the Breitenlohner-Freedman bound. Finally, since the UV properties of metrics with $\theta > 0$ are bad (divergent curvature invariants) I will discuss conditions for the existence of interpolating solutions with a hyperscaling violating IR and an AdS or Lifshitz UV.

Heller, Michal P. (Amsterdam / Warsaw): Holographic thermalization for expanding plasmas (60')

Abstract: I will review the progress in applying holography to thermalization processes in strongly coupled setups motivated by ongoing relativistic heavy ion collision programs at RHIC and LHC.

Jottar, Juan (Amsterdam): (Entanglement) Entropy in three-dimensional higher spin theories (30')

Abstract: A holographic correspondence has been recently developed between higher spin theories in AdS_3 and (1+1)-dimensional CFTs with extended symmetries. In this framework, black hole solutions in the bulk theory are dual to thermal equilibrium states with non-trivial higher spin charges and chemical potentials. We discuss the entropy of higher spin black holes, as computed from an appropriate Euclidean variational principle, and provide a generalization of Cardy's entropy formula for these setups. Additionally, we present a proposal to compute entanglement entropy in the dual CFTs via holography, thus extending the Ryu-Takayanagi prescription to higher spin theories in AdS_3.

Järvinen, Matti (Heraklion): Holographic models for QCD in the Veneziano limit (30')

Abstract: I discuss holographic bottom-up models for QCD in the Veneziano limit (large N_f and N_c with fixed $x = N_f/N_c$). The models are constructed by putting together holographic models of Yang-Mills theory (improved holographic QCD) with Sen-type tachyon actions inspired by brane constructions, and by considering full backreaction. At zero temperature and quark mass the phase diagram, as a function of $x = N_f/N_c$, meets the expectations from QCD. One finds a "conformal phase transition"at $x = x_c$ from a QCD-like regime to the conformal window. The whole spectrum obeys Miransky scaling and the S-parameter approaches a finite positive value as $x \to x_c$ from below.

Keränen, Ville (Stockholm): Real time Wilson loops and AdS/CFT (30')

Abstract: We review calculations of Wilson loops using perturbation theory in N=4 SYM and on the other hand using classical string theory in AdS spacetime. Then we consider Wilson loops at finite temperature states and in certain non-equilibrium states produced by quantum quenches. Finally a qualitative comparison to string theory calculations is made.

Kiritsis, Elias (Heraklion): Quantum criticality at finite density, hyperscale violation and symmetry breaking (60')

Abstract: All possible scaling IR asymptotics in homogeneous holographic phases preserving or breaking a U(1) symmetry in the IR have been classified. Scale-invariant geometries where the scalar extremizes its effective potential are distinguished from hyperscaling-violating geometries where the scalar runs logarithmically. Both exact solutions as well as leading behaviors can be found. Using them, neutral or charged geometries realizing both fractionalized or cohesive phases are found. The generic global IR picture emerging is that of quantum critical lines, separated by quantum critical points which correspond to the scale invariant solutions with a constant scalar. The surprising outcome is that generically holographic symmetry broken phases have more light degrees of freedom that just Golstone modes, and pseudogaps are generic.

Krssak, Martin (Bielefeld): Energy-momentum tensor correlators in holography and QCD perturbation theory (30')

Abstract: Correlators and spectral functions of energy-momentum tensor in shear and bulk channels in finite temperature SU(Nc) Yang-Mills theory are discussed using two different methods: holography based on the improved holographic model and next-to-leading order QCD perturbation theory. For the bulk channel imaginary time correlator, for which also lattice data exist, lattice data is seen to favor the holographic prediction over the perturbative one over a wide range of temperatures.

Obers, Niels (Copenhagen): Thermal spinning giant gravitons and null waves (60')

Abstract: The blackfold approach is an effective theory describing the long wave length dynamics of black branes revealing fluid and solid properties of black branes. After a short review, I will discuss the use of the blackfold approach, to provide a method to thermalize configurations that are described by DBI/NG in the zero temperature limit. This will be illustrated by considering thermal giant gravitons in the AdS/CFT setup, including the extension of giant gravitons with interal spin. The latter allow for a non-trivial extremal limit describing giant gravitons with null waves.

Pang, Dawei (Munich): On holographic semi-local quantum liquids (30')

Abstract: We study properties of holographic semi-local quantum liquids in arbitrary dimensions. We find that the conductivity from the bulk gauge field fluctuation exhibits a universal behavior, while the conductivity obtained from the drag force calculation varies. We also discuss the holographic entanglement entropy in such backgrounds.

Rebhan, Anton (Vienna): Holographic models of strongly coupled anisotropic plasma (60')

Abstract: Quark-gluon plasma during its initial phase after its production in heavy-ion collisions is expected to have substantial pressure anisotropies. In order to model this situation by a strongly coupled N=4 super-Yang-Mills plasma with fixed anisotropy by means of AdS/CFT duality, two models have

been discussed in the literature. Janik and Witaszczyk have considered a geometry involving a comparatively benign naked singularity, while more recently Mateos and Trancanelli have used a regular geometry involving a nontrivial axion field dual to a parity-odd deformation of the gauge theory by a spatially varying theta parameter. We study the (rather different) implications of these two models on the heavy-quark potential as well as jet quenching and compare their respective predictions with those of weakly coupled anisotropic plasmas.

Rosen, Christopher (Heraklion): Fermi Surfaces in N=4 Super Yang-Mills Theory (30')

Abstract: The study of Fermi surfaces in the context of holography offers an encouraging avenue into the physics of strongly coupled condensed matter systems. While early efforts in AdS/CMT demonstrated that it is possible for a bulk theory with a few simple ingredients to describe Fermi surface physics in the dual gauge theory, they were often unable to provide explicit information about the dynamics of the Fermi surface, or even the dual gauge theory's name. To learn more, it is necessary to investigate the properties of fermionic Green's functions in supergravity theories with known gauge theory duals. After briefly outlining the study of Fermi surface physics in holography, I will discuss the properties of an assortment of Fermi surfaces in N=4 SYM theory, and the "top-down"bulk models which are used to study them.

Steinfurt, Stephan (Munich): Supersound diffusion constants from black hole physics (30')

Abstract: We describe the holographic computation of supercharge diffusion constants in theories dual to gravitational theories on the background of AdS black brane solutions (of arbitrary dimension and at vanishing chemical potential for R charges). The computation is performed via the low frequency, low momentum pole of the correlator of supercurrents, which describes the hydrodynamic "phonino"mode, and via the dual transversal gravitino mode using a Kubo formula. Furthermore, the connection to a universal absorption cross section result is drawn analogous to the famous proof of the universality of η/s. Similarities and differences to this result are discussed.

Stricker, Stefan (Vienna): Top down versus bottom up thermalization (30')

Abstract: The precise way, how the quark gluon plasma approaches thermal equilibrium is an interesting and challenging problem. In the limit of weak coupling, the thermalization pattern is of the bottom up type, with the soft excitations reaching thermal equilibrium first. In contrast, holographic studies in the infinite coupling limit have pointed towards top down thermalization, indicating a transition at intermediate coupling between the two behaviours. In a simplified model of holographic thermalization in super Yang-Mills theory it is possible to take string corrections into account and go away from the infinite coupling limit. In this talk I will discuss the finite coupling effects on the thermalization pattern of different constituents of the plasma, where in some cases indeed a shift from top down towards bottom up is visible.

Thorlacius, Larus (Stockholm): Condensed matter applications of holography (60') and Discussion of firewalls (60')

Zingg, Tobias (Utrecht): Holographic de Haas - van Alphen Oscillations

Abstract: An extension on previous 'electron star' models, that is gravity coupled to a fluid of charged spin 1/2 particles, as holographic duals of strongly correlated fermionic systems. In contrast to earlier approaches, the fluid is considered as anisotropic. This novel feature extends the degrees of freedom to contain a spin tensor that allows for a direct coupling to an applied magnetic field. As a result, the backreacted geometry unveils de Haas - van Alphen quantum oscillations which can be seen as direct evidence for the presence of a Fermi surface in the dual theory.

Zoakos, Dimitrios (Porto): Thermodynamics of the brane in Chern-Simons-matter theories with flavor (30')

Abstract: After reviewing the gravity dual of N=6 Chern-Simons-matter theory, we will analyze the addition of backreacted flavors. We will then construct the corresponding flavored black hole and study the thermodynamic properties of brane probes and of the meson melting transition that they undergo at

a certain critical temperature.

3 Results and impact

Holograviy is a method for solving strongly coupled physical systems. At present the field is divided in two sectors, a relativistic field theoretic particle physics-oriented sector and non-relativistic quantum mechanical condensed matter oriented sector. It is remarkable that seemingly so different systems can all be, on some level of approximation, be described by models based on classical gravity in one more dimension.

The talks at the meeting were distributed among these two sectors roughly as follows:

- Particle physics: de Boer, Evans, Costa, Järvinen, Alho, Heller, Craps, Krssak, Zoakos, Djuric, Steinfurt, Stricker, Rebhan. Here the central issues were applications to QCD, which is a perfectly well defined theory but hard to solve. Physical problems were particle spectrum and applications to collisions, in particular to thermalisation in heavy ion collisions. Secondly, holography can be applied to theories close to QCD, perhaps relevant to beyond-the-SM theories like technicolor.
- Condensed matter: Zingg, Obers, Pang, Rosen, Kiritsis, Hartong, Keränen, Jottar. Here a central issue is the behavior of systems close to criticality. Holography can be successfully applied to a study of the scaling properties, one can figure out how the systems behave at large distances without knowing how they behave at small distances, in the ultraviolet. Another concrete and still controversial issue discussed was whether this method can observe the Fermi surface of cold systems.

Actually there is a third important sector of holography presented at this meeting only by a review talk: solving completely N=4 supersymmetric Yang-Mills theory. Finally, the meeting also discussed a recent popular question, the real physical nature of black hole horizons.

In all subfields there is obviously much further work to be done. One definite characteristic is that the problems studied become more and more compicated and often require advanced numerical methods for their study.

4 Final programme of the meeting

This can most simply be found from the home page of the meeting: http://www.hip.fi/holograv13/