International Workshop on Condensed Matter Physics AdS/CFT

Abstracts

Monday 25 May 2015:

GAUNTLETT, Jerome (Imperial College)

Title: Holographic Lattices

We review progress in understanding of black hole solutions that are dual to conformal field theories that have been deformed by operators that break translation invariance. The UV deformation provides a mechanism by which momentum can be dissipated and we discuss how the thermoelectric DC conductivity can be obtained in terms of black hole horizon data. The black holes also provide a framework for finding novel ground states, both metallic and insulating as well as transition between them.

SEBASTIAN, Suchitra (Univ. of Cambridge)

Title: Quantum oscillations in strongly correlated electron systems

Abstract: TBA

HARTNOLL, Sean (Stanford Univ.)

Title: Holographically inspired thoughts on high temperature superconductors and other bad metals

Bad metals are a class of materials whose transport properties cannot be understood within a weakly interacting quasiparticle description.

Away from weak interactions, the natural objects to characterize are the conserved charge and heat current operators. This talk concerns two aspects of these operators. Firstly, many bad metals exhibit unexpectedly similar transport behavior. We suggest that this could be explained by a certain universal bound on charge and heat diffusivities. Secondly, the cuprate high temperature superconductors are especially important examples of bad metals. Transport in the most puzzling part of the cuprate phase diagram is characterized by multiple scaling laws.

I will show that at least five of these scaling laws can be understood from only two nontrivial critical exponents. One of these is an anomalous dimension for the charge density operator.

OOGURI, Hirosi (Kavli IPMU & Caltech)

Title: Entanglement Inequalities

Abstract: TBA

Tuesday 26 May 2015:

KIRITSIS, Elias (Univ. of Crete and APC, Paris)

Title: Tales in the realm of Holographic Conductivity

We present several investigations on holographic conductivity:

1) Based on an analysis of DC conductivities in holographic EMD theories we present saddle points that are insulators with a gap and a discrete spectrum as well as superconductors with momentum dissipation and a discrete spectrum resembling supersolids.

2) Based on the analysis of the AC conductivity of a holographic non-fermi-liquid saddle point, we develop a theory for scaling tales of AC conductivity. We test this theory in diverse holographic scaling solutions and draw a simple condition for the appearence of such scaling tails in generic holographic scaling geometries.

PHILLIPS, Philip (Univ. of Illinois at Urbana-Champaign)

Title: Optical Conductivity as a Window into Mottness in the Cuprates

In the undoped state, the cuprates exhibit an optical conductivity that is featureless at frequencies less than 1eV. By contrast the doped state exhibits low-energy and mid-infrared features whose integrated intensity exceeds the number of dopant carriers as would be anticipated for doping a semiconductor. This excess intensity can only be understood if one invokes an effective high-low-energy mixing and hence the number of low-energy degrees of freedom is dictated by the high-energy scale. I will review how such mixing is expected from doping the Hubbard model and the modern attempts to understand the mid-infrared power law based on holography and a scale-invariant sector termed unparticles. I will show that within holography, no power-law scaling of the optical conductivity obtains in the mid-infrared regime. Within an unparticle construction, I show how such power laws can be produced. The key feature here is a large anomalous dimension. I will discuss how such large anomalous dimensions arise from UV-IR mixing.

ERDMENGER, Johanna (Max Planck Institute for Physics)
Title: Magnetic impurities and universality in AdS/CMT

For a recently established holographic model of a magnetic impurity coupled to a strongly interacting system, we consider quantum quenches as well as the entanglement entropy. Both provide information about the size and formation of the Kondo cloud which screens the impurity.

Moreover, I will present recent results on universal behaviour in a family of holographic s-wave superconductors obtained by adding a scalar field to translation-breaking gravity backgrounds with Bianchi VII symmetry.

LING, Yi (Institute of High Energy Physics, CAS)
Title: Metal-insulator transition by holography

We will review recent progress in understanding Metal-Insulator Transitions (MIT) from a holographic point of view. Our special interests will focus on the building of holographic dual models for charge density waves and Mott-like insulators. The holographic entanglement entropy close to quantum critical points will be discussed as well.

Wednesday 27 May 2015:

RYU, Shinsei (Univ. of Illinois at Urbana-Champaign)
Title: Symmetry-protected topological phases and quantum entanglement

The importance of quantum entanglement in understanding phases of matter as well as quantum phase transitions has been more recognized recently. In particular, for those states of matter which cannot be described by the symmetry-breaking paradigm of Landau-Ginzburg-Wilson, quantum entanglement, as quantified by various entanglement measures, may provide us a way to characterize and detect such states. While directly measuring entanglement in experiments is often challenging, entanglement-based approaches have already established their status as a powerful numerical tool, and are still rapidly growing. In this talk, by using selected examples such as symmetry-protected topological phases in one and two spatial dimensions, I will illustrate the use of quantum entanglement in understanding topological phases of matter with symmetries.

TAKAYANAGI, Tadashi (YITP, Kyoto Univ.)
Title: Emergence of Holographic Spacetime from Quantum Entanglement

In the first half part I will review recent progresses on (holographic) entanglement entropy and its connection to emergence of gravitational spacetime e.g. in the context of tensor networks. In the latter half part, by developing these interesting ideas, I will introduce our recent proposal of ``surface/state correspondence'' (arXiv:1503.03542), which offers us a natural generalization of the standard holographic principle.

Thursday 28 May 2015:

TRIVEDI, Sandip (Tata Institute)
Title: Entanglement Entropy in Gauge Theories

We propose a definition for the entanglement entropy of a gauge theory on a spatial lattice. Our definition is valid for both Abelian and Non-Abelian gauge theories. We also argue that our definition agrees with the entanglement entropy calculated using the replica trick. This definition, however, does not agree with some standard ways to measure entanglement, like the number of Bell pairs which can be produced by entanglement distillation.

FANG, Zhong (Institute of Physics, CAS)
Title: Topological Semimetals

Topological semimetals, characterized by Weyl/Dirac nodes in the bulk and Fermi arcs on the surfaces, are new states of three-dimensional (3D) quantum matters, different from topological insulators. Weyl nodes are stable topological objects, and can be viewed as effective magnetic monopoles in the 3D momentum space. Its time-reversal invariant version ---- 3D Dirac node, however, consists of two copies of distinct Weyl nodes with opposite chirality, and requires additional symmetry protection, such as the crystal symmetry. Novel properties, such as negative magneto-resistance and non-local transport, can be expected for such semimetals, due to the presence of chiral anomaly. Recently, several Dirac semimetal (Na3Bi and Cd3As2) and Weyl semimetal (HgCr2Se4 and TaAs) compounds have been predicted and experimentally verified. In this talk, I will review the theoretical progress with focus on the predictive roles of first-principles calculations in this field. Some recent experimental progress will be also addressed.

SASA, Shin-ichi (Kyoto Univ.)

Title: A fresh look at hydrodynamics from fluctuation formulas

The hydrodynamic equations that describe macroscopic dynamical behavior of simple fluids were established in the nineteenth century, and microscopic understanding of such non equilibrium dynamics had been developed over the twentieth century. For the last two decades, fluctuation formulas have been found in systems out of equilibrium. With them, we are now freshly looking at hydrodynamics. In my presentation, I start with the simplest example of hydrodynamics - Stokes' law. Analyzing this example with fluctuation formulas, I review large deviation theory, symmetry properties in large deviation functions, and an associated variatiomal principle. As a result of these modern concepts, we can re-derive Stokes' law, without the hydrodynamic equations, but by formulating the connection between long-range correlated fluctuations at the surface and simple fluctuations in the bulk. This work was done in collaboration with Masato Itami.

DAS, Sumit (Univ. of Kentucky)

Title: Smooth and instantaneous quenches in field theory and holography

In recent years, holographic methods have thrown valuable light on universal scaling behavior in quantum quench involving critical points. In particular, holography has led to new scaling laws for fast but smooth quench. This talk will discuss these results and show that scaling in fast smooth quench is a universal feature of all quantum field theories irrespective of holography. We will also discuss how these results relate to those in sudden quench.

Based on : Sumit.R. Das, Damian. Galante and Robert Myers :
Phys. Rev. Lett. 112 (2014) 171601
JHEP 1501 (2015) 084
arXiv:1505.xxxx (to appear)

CRAPS, Ben (Vrije Universiteit Brussel)

Title: Holographic thermalization and AdS (in)stability

Holography relates black hole formation in Anti-de Sitter spacetime (AdS) to thermalization of a dual field theory. In 2011, numerical studies by Bizon and Rostworowski suggested that spherically symmetric scalar field perturbations of arbitrarily small amplitude could lead to black hole formation in global AdS, often after many reflections from the AdS boundary. They identified secular growth in weakly nonlinear perturbation theory as responsible for the onset of energy transfer to short-wavelength modes. It was later observed, however, that other initial pro files do not lead to collapse and that some explicit finite deformations of AdS make it stable. This seems to imply a complicated interplay of stable and unstable behavior described by a rich topography in the phase space, which we aim to understand better. Using techniques of multiscale analysis, renormalization and averaging we resum the secular terms that invalidate naive perturbation theory, leading to equations describing the energy flow between modes. Results of this analysis include the absence of most secular terms and the construction of three conserved charges of the flow equations.

Friday 29 May 2015:

TAKAHASHI, Yoshiro (Kyoto Univ.)

Title: Exploring quantum many-body physics using ultracold atoms in an optical lattice

Ultracold atoms offer a novel way to study quantum many-body physics because of the high controllability of the system parameters [l]. For example, the behaviors of BEC-BCS crossover is successfully studied by tuning an inter-atomic interaction by a Feahbach resonance technique. In addition, by loading a Bose-Einstein condensate into a three-dimensional optical lattice, which is a periodic potential generated by laser light, a Bose-Hubbard model is successfully implemented, and the quantum phase transition from a superfluid state to a Mott insulating state is intensively investigated by various methods. A Fermi-Hubbard model is also studied, leading to the observation of Mott insulating state and the onset of a magnetic correlation.

In this talk, first I will overview the recent experimental progress on the quantum simulation research of a Hubbard model. Next I will report on our recent experiments using ultracold ytterbium atoms in an optical lattice, especially a non-standard lattice of Lieb lattice which has a novel band structure characterized by a flat band and a Dirac cone. The localization of the atoms in the flat band is successfully observed using Bose-Einstein condensates.

[1]I. Bloch, J. Dalibard, and W. Zwerger, Rev. Mod. Phys. 80, 885 (2008).

VISSER, Matt (Victoria Univ. of Wellington - SMSOR)

Title: Overview of analogue spacetimes

Analogue spacetimes are condensed matter systems that can be given a natural geometrical interpretation in language similar to that of general relativity.

More precisely, analogue spacetimes are condensed matter systems where the propagation of linearized perturbations can be given a natural interpretation in terms of a Lorentzian metric.

This can be done for instance for acoustics in fluids (both non-relativistic and relativistic), for index gradient methods in optics, for (some) meta-materials in transformation optics.

Similarly, defects in a graphene sheet can be given a natural interpretation in terms of Riemann curvature (in fact, Riemann curvature in an ultra-static 2+1 dimensional spacetime), and the Burgers vector associated with lattice edge and screw dislocations has a natural interpretation in terms of the torsion tensor.

I shall present a general overview of what can currently be done along these lines, and what one might hope for in the future.

BHASEEN, Joe (King's College London)

Title: Holographic Approaches to Non-Equilibrium Steady States

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 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.

WITCZAK-KREMPA, William (Perimeter Institute)

Title: Quantum critical dynamics via CFT, Monte Carlo & holography

Conformal field theories (CFTs) describe many experimentally relevant quantum critical phase transitions, such as the ones in the 2+1D Ising and XY models. These theories are generally strongly interacting and lack quasi-particle excitations. I'll discuss dynamical properties of CFTs in 2+1D at finite temperature.

I'll show concrete results stemming from an interdisciplinary approach combining field theory, quantum Monte Carlo simulations, and the AdS/CFT duality. In particular, experimental predictions will be made regarding the charge response near the superfluid–insulator quantum critical transition of bosons on a lattice.

Extensions to many other observables and universality classes will be discussed.

SCHALM, Koenraad (Leiden Univ.)

Title: Condensed matter physics and holography: seductivity and resistance

In real metals the dominant contribution to the resistivity is almost always due to momentum relaxation controlled by translational symmetry breaking in the material. An important question is whether this is also true for strange metals in high Tc superconductors and heavy fermions. This has been a recent theme in the study of holographic duals to strongly coupled electron systems. With a retrospective view towards the results presented at this conference, I will show both how some universal rules (Homes' Law) are manifested, and how the physics underlying the momentum relaxation can be very different from conventional weakly coupled systems.