REGPOT kick-off meeting
Heraklion, 7 September 2013

The CRETE QFT group and its implication in CM problems

Elias Kiritsis

Crete Center for Theoretical Physics University of Crete QCN

The Crete Center for Theoretical Physics

• The underlying unit is the section of the Crete Physics Department associated to high energy physics (initial and official name :"particle and nuclear physics")

• Faculty in order of arrival date:

Nikos Papanicolaou (PhD NYU, 1975) currently working on spin models, high T_c superconductivity, topological defects in condensed matter etc.

Theodore Tomaras (PhD Harvard, 1980), currently working on gravity and cosmology

Elias Kiritsis (PhD Caltech, 1988) currently working on string phenomenology, cosmology, AdS/CFT and applications to QCD and condensed matter physics.

Nikos Tsamis (PhD Harvard, 1983) currently working on quantum effects in gravity and inflation.

and

Dimitris Christodoulou (PhD Princeton, 1971), Distinguished Professor of Physics, working on mathematical aspects of general relativity.

- Affiliated members (frequent visitors/collaborators, other disciplines)

Petros Rakintzis (Atomic Physics, Physics Department, Crete)

Christos Panagopoulos (Condensed matter, Physics Department, Crete)

Ioannis Bakas (Mathematical Physics, Athens Polytechnic School)

Costas Skenderis (University of Southampton)

Marika Taylor (University of Southampton)

Nicolas Toumbas (U of Cyprus, recently elected associate professor in the Physics department)

Richard Woodard (U. of Florida)

Xenophon Zotos (Condensed Matter, Physics Department, Crete)

• Postdoctoral fellows are eight currently:

Dylan Albrecht (American, PhD William and Mary College, USA)

Fransesco Aprile (Italian, PhD Barcelona U.)

Daniel Fernandez (Spanish, PhD Barcelona U.)

Takaaki Ishii (Japanese, PhD Osaka U.)

Matti Jarvinnen (Finnish, PhD Helsinki U.)

Fransisco Peña-Benitez (Venezuelan, PhD Madrid U.)

Jie Ren (Chinese, PhD Princeton U.)

Christopher Rosen (American, PhD Colorado U.)

and a senior researcher,

Vasilis Niarchos (Greek, PhD Chicago U.)

• There have been 26 young researchers in the last 12 years.

• There are currently 2 PhD students (I. Constantinou and M. Romania), and on the average 3-5 master's students.

• The profile of the research done at CCTP is strongly international. In the last 3 years (2010-2012) 70% of the publications of CCTP members are collaborations with groups outside Greece.

There are 42 distinct institutions in that list:

- There are 20 European institutions
- 4 from Russia,
- 9 from the US and Canada
- 9 from China, Japan, Korea and India
- 1 from South America

♠ The recent research at ICTP has had some distinctions.

External Advisory/Evaluation Committee

- The role is to advise us on science and science policy and to evaluate us.

- Last evaluation round was in July 2012 and the evaluation is public and positive.

Members are highly distinguished physicists.

- **Curtis G. Callan Jr** is since 1995 James S. McDonnell Distinguished University Professor of Physics at Princeton University, founding director of the Princeton Center for Theoretical Physics (2005-2008), has been chairman of the Physics Department and is currently vice president of APS. He is the recipient of the Sakurai prize for physics (2000) and the 2004 Dirac Medal.

- **John Iliopoulos** is directeur de Recherche au CNRS, (classe exceptionnelle) at the Laboratoire de Physique Théorique, Ecole Normale Supérieure and a member of the French Académie des Sciences. He is the recipient of the Sakurai prize in Physics (1987), the Dirac Medal (2007) and the EPS HEP prize (2011).

- **Gabriele Veneziano**, was a senior staff member at the CERN theory group and holds the chair of particle physics and cosmology at the College de France since 2004. He is the recipient of the I. Ya. Pomeranchuk prize (1999), the Enrico Fermi Prize (2005) and the Danny Heinemann prize (2004).

Overview of the Physics in CCTP

- **Research Direction 1**: Gravity and Cosmology.
  - 1A: High-energy gravitational scattering.
  - 1B: Gravitational backreaction and quantum effects in inflation.
  - 1C: Black holes and blackfolds
  - 1D: Modified theorries of gravity, (related to 3A).
  - 1E String theoretic models of cosmology.
- **Research Direction 2**: Beyond the Standard Model Physics and String Phenomenology
  - 2A: Embedding the Higgs sector in strongly coupled gauge theories
  - 2B: Embedding the SM In string theory

- **Research Direction 3**: The physics of Lorentz violation.
  - 3A: Gravity theories of the Hořava-Lifshitz type.
  - 3B: LV in strongly coupled QFTs.
- **Research Direction 4**: AdS/CFT correspondence (or gauge theory/(string theory+gravity correspondence or holographic correspondence) and applications.
  - 1A: Applications to QCD and Heavy-Ion physics experiments at RHIC and LHC.
  - 1B: Applications to BSM and the naturalness problem.
  - 1C: AdS_4/CFT_3
  - 1D: Finite density and condensed matter applications.
- **Research Direction 5**: Spin systems and strongly correlated materials

Mini-Workshop on application of AdS/CFT to condensed matter problems

The Theoretical High Energy and Cosmology group at the University of Crete, the Low-Temperature Condens Matter at the University of Crete and the Institute of Electronic Structure and Lasers are jointly organizing mini-workshop whose goal is to discuss and assess the potential of (relativistic and non-relativistic) AdS/CFT a: tool to address important problems in condensed matter physics. Such problems include prominently high-superconductivity, but other problems involving strong correlations, as well as disorder may be relevant.

The workshop will take place **8-12 May (arrival day is May 7, departure days is May 13)** in the premises FORTH.

The structure of the workshop will be based on a few targeted talks that will introduce several key subjects a ample time for discussions.

Researchers interested in participating should contact one of the organizers, Profs **Christos Panagopoulos Elias Kiritsis**.

The meeting is supported by a **European Union Excellence Grant** (MEXT-CT-2006-039047), a **European You Investigator Award** and a **European Union Grant** FP7-REGPOT-2008-1-CreteHEPCosmo-228644.

J. Analytis (Stanford)

A. Auerbach (Haifa)

M. Cubrovic (Leiden)

T. Fiol (Barcelona)

U. Gursoy (Utrecht)

C. Herzog (Princeton)

P. Horava (Berkeley)

B. S. Kim (Berkeley)

E. Kiritsis (Crete)

G. Kofinas (Crete)

X. Liu (Perimeter Institute)

D. Mansi (Crete)

A. Mauri (Crete)

L. Mazzanti (Paris)

R. Meyer (Munich)

V. Niarchos (Paris)

M. Lippert (Haifa)

C. Panagopoulos (Crete)

I. Papadimitriou (Swansea)

L. Papantonopoulos (Athens)

T. Petkou (Crete)

D. Sadri (Leiden)

K. Schalm (Amsterdam)

J. Spalek (Krakow)

T. Tomaras (Crete)

N. Toumbas (Cyprus)

D. Yamada (Jerushalem)

J. Zaanen (Leiden)

X. Zotos (Crete)

Quantum Field theory, String Theory and Condensed Matter Physics

Home | Program | Information | Participants | Travel | The region

1-7 September 2014

(31 August is arrival day, 8 August is Departure day)

International Organizing Committee	Local Organizing Committee
• Costas Bachas (Paris) • Koenraad Schalm (Leiden) • David Tong (Cambridge) • Jan Zaanen (Leiden)	• Elias Kiritsis (UoC) • Vassilis Niarchos (UoC) • Christos Panagopoulos (UoC) • Giorgos Tsironis (UoC)

Key Participants

- Alan Adams (MIT)
- Joe Bhaseen (Cambridge)
- John Cardy (Oxford University)
- Letitia Cugliandolo (Universite Paris 6)*
- Jan De Boer (University of Amsterdam)
- Benoit Doucot (Universite Pierre et Marie Curie)
- Johanna Erdmenger (Max Planck Institute, Munich)*
- Antonio Garcia-Garcia (Cambridge)
- Jerome Gauntlett (Imperial College London)
- Andrew Greene, (University College London)
- Pierre LeDoussal (ENS, Paris)
- Sung Sik Lee (McMaster University and Perimeter Institute)
- Robert Leigh (University of Illinois, Urbana)
- Gilad Lifshytz (Technion and University of Haifa)
- Hong Liu (MIT)
- Andy Mackenzie (University of St Andrews and MPI Dresden)
- Marc Mezard (ENS, Paris)
- Robert Myers (Perimeter Institute)
- Yaron Oz (Tel Aviv University)
- Olivier Parcollet, (IPhT, Saclay)*
- John Preskill (Caltech)*
- Steven Gubser (Princeton University)*
- Sean Hartnoll (Stanford University)
- Gary Horowitz (UC Santa Barbara)
- Thierry Jolicoeur (Universite d'Orsay)
- Shamit Kachru (Stanford University)
- Andreas Karch (University of Washington)*
- Alexei Kitaev (Caltech)*
- Per Kraus (UCLA)
- Jorge Kurchan (ESPC, Paris)^*
- Philip Phillips (University of Illinois, Urbana)
- Shinsei Ryu (University of Illinois, Urbana)
- Subir Sachdev (Harvard University)*
- Gordon Semenoff (University of British Columbia)
- Dam Son (University of Chicago)*
- Adi Stern (Weizmann Institute)
- Henk Stoof (Utrecht University)
- Tadashi Takayanagi (Yukawa Institute, Kyoto)*
- Sandip Trivedi (Tata Insitute)

***To be confirmed**

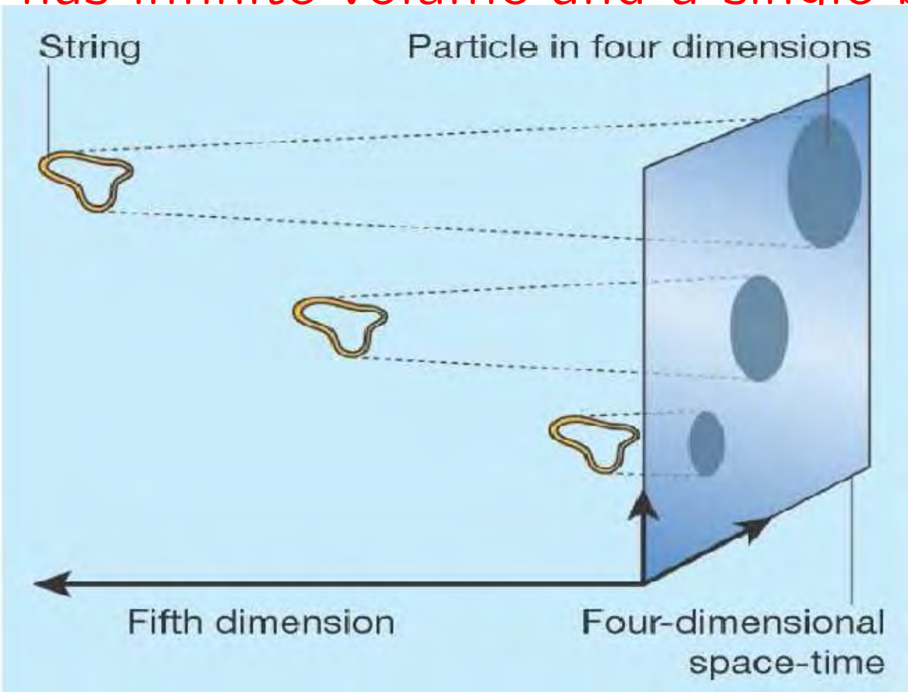
The AdS/CFT correspondence

• The QFT/string theory duality is a generalization of the AdS/CFT correspondence.

• The AdS/CFT Correspondence states that a (3+1)-dimensional (very symmetric, supersymmetric and scale invariant) gauge theory is EQUIVALENT to a (9+1)-dimensional (IIB) superstring theory in a space-time that is $AdS_5 \times S^5$.

Maldacena 1997

• This space (AdS_5) has infinite volume and a single boundary, at $r = 0$.



• Both very different-looking descriptions are describing the SAME THEORY!

• This is a non-perturbative correspondence as: $N_c \to \infty$ and $\lambda \to \infty$, the QFT is strongly coupled (and intractable), but the string theory is weakly coupled and solvable.

Conversely when $\lambda \to 0$, the QFT is perturbatively solvable but the string theory, strongly coupled and strongly curved (intractable).

• The AdS/CFT correspondence is a conjecture: it has passed so many tests that the community assumes it is correct, and moves ahead to use it.

• There is precise one-to-one correspondence between

$$\text{on}-\text{shell} \quad \text{string} \quad \text{states} \quad \Phi(r,x^\mu) \quad \leftrightarrow \quad O(x^\mu) \quad \text{operators} \quad \text{in} \quad \text{QFT}$$

$$\text{classical} \quad \text{solution} \quad \text{for} \quad \Phi(r,x^\mu) \quad \leftrightarrow \quad \text{(semi)classical state} \quad \text{in} \quad \text{QFT} \quad \text{with} \quad \text{coupling} \quad \Phi(0,\text{x}^\mu)$$

• The precise correspondence states that the generating function of QFT correlators of O

$$\langle e^{\int d^4x \ \phi(x) \ O(x)} \rangle \ = \ e^{-S(\phi(x))}$$

Gubser+Klebanov+Polyakov, Witten, 1998

• In the string theory we can compute the "S-matrix" , $S(\phi(x^\mu))$ by studying the response of the system to boundary conditions $\Phi(r=0,x^\mu)=\phi(x^\mu)$.

• The special "thermal state" of a QFT, corresponds to a large black hole solution in the bulk space-time.

The QFT/string theory duality

• The AdS/CFT correspondence can be generalized to the general holographic correspondence:

• *String Theory is the dynamics of Sources of QFT*

E. Kiritsis

• For the correspondence to be useful, the QFT must have large N. What is new here?

• At the gravitational approximation (keeping only a few of the infinite number of string states), one should think of this as a very sophisticated version of dynamical mean field theory, where the metric and other fields as "dynamical mean fields".

• This dynamical gravitational theory, has general relativistic invariance and many other local symmetries: all global symmetries of the QFT (including translation invariance) translate into local symmetries in the dual string theory.

• The gravitational theory is semiclassical (and therefore solvable) when the QFT is strongly coupled. This is why this method is useful.

• For example, coming to superconductivity: BCS assumes that the interactions between electrons are weak, and then one derives an effective field theory for the bound-state Φ

$$E \sim \int d^3x \left[(\nabla\Phi)^2 - \frac{\mu^2}{2}\Phi^2 + g\Phi^4 + \cdots \right]$$

• Holography is applicable if the interactions of "electrons" are strong, but the bound state interactions are weak (suppressed by the large N)

In that case, you can calculate the effective potential and its few first terms are

$$V(\Phi) \sim \int d^3x \left[-\frac{\mu^2}{2}\Phi^2 + g\Phi^{\frac{4}{\Delta}} + \cdots \right]$$

Kiritsis+Niarchos

• Only near the critical point this is enough. Further, solution of the full 5d problem is necessary.

How do we use holography in practice?

• We must decide what the important QFT operators for the relevant dynamics and write their gravitational action.

• Example:

$$g_{\mu\nu} \quad \leftrightarrow \quad T_{\mu\nu} \qquad (\partial^\mu T_{\mu\nu} = 0)$$

$$A_\mu \quad \leftrightarrow \quad J_\mu \qquad (\partial^\mu J_\mu = 0)$$

$$\phi \quad \leftrightarrow \quad O(x)$$

EFFECTIVE HOLOGRPHIC THEORY

$$S = \int d^{d+1}x \ \sqrt{g} \left[R - \frac{1}{2}(\partial\phi)^2 + V(\phi) - \frac{Z(\phi)}{4} F_{\mu\nu}F^{\mu\nu} \right] + \cdots$$

• A classical solution to the EOM, with appropriate b.c. corresponds to a semiclassical state (saddle point) of the QFT.

• There is always a special (fifth) dimension that we call the holographic dimension. It roughly corresponds to the RG scale in QFT. The UV is near the boundary, and the IR on the other side. The evolution of the fields in the holographic direction corresponds to RG flow in QFT.

The first remarkable result

• In any large-N CFT in any dimension (dual to AdS_{d+1}) at finite density, in the IR, there is an emergent scale invariance !

• The IR geometry is $AdS_2 \times R^{d-1}$. Time scales, but space does not!

• The AdS_2 geometry is generically unstable.

• Symmetry breaking (superconductivity) happens!

Three important limits

• Large N limit

• Strong coupling limit

• Low energy limit

The Wilsonian program

• Classification of Scale Invariant/Fixed-point theories (The Wilsonian approach in holography).

• The strategy is to use Effective Holographic Theories (in order to explore all possible QC holographic scale invariant theories with given symmetries.

Charmousis+Gouteraux+Kim+Kiritsis+Meyer

1. To do this we must select the operators expected to be important for the dynamics

2. Write an effective (gravitational) holographic action that captures the (IR) dynamics by parametrizing the IR asymptotics of interactions .

3. Find the scaling solutions describing extremal saddle points, with given symmetries. Built the $T \to 0$ bh solutions around them

4. Study the physics around each acceptable saddle point (thermodynamics, transport, non-linear phenomena).

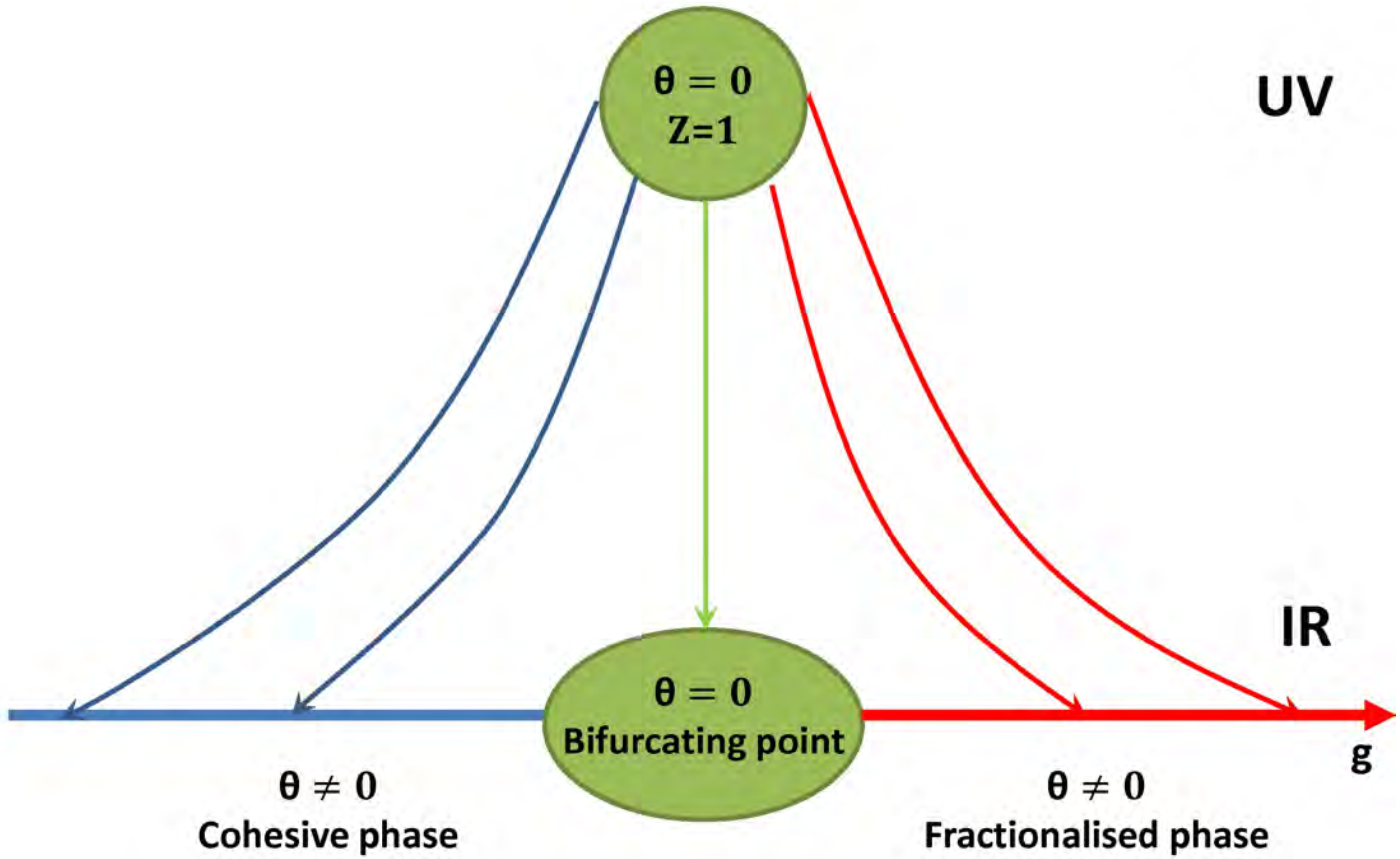
5. Study the scaling region and find universal laws.

• As a first step in this program, all general scaling geometries were classified.

Charmousis+Gouteraux+Kim+Kiritsis+Meyer, Gouteraux+Kiritsis

• They generically break hyperscaling invariance and are characterized by two exponents, z, θ.

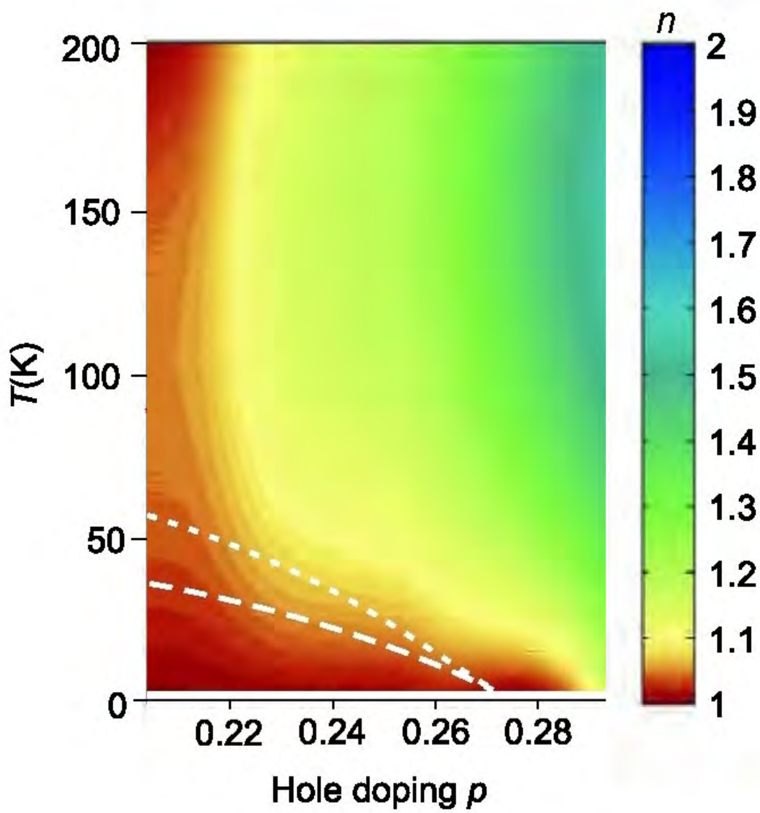
Quantum fractionalisation transitions

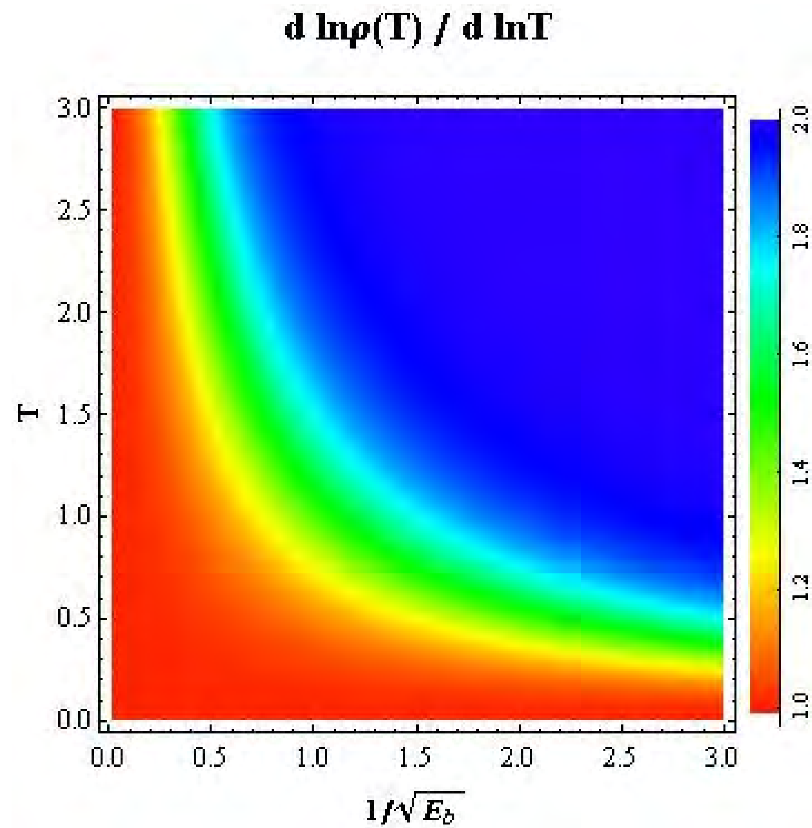


Hartnoll+Huijse'11, Adam+Crampton+Sonner+Withers '12, Goutéraux+Kiritsis '12

Scale invariant fixed point ($\theta = 0$) with a relevant deformation. To reach this point, the flow must be fine tuned. Away from the critical value, the flow picks up the relevant deformation and lands into hyperscaling violation fixed points: a quantum critical line. The line originates from an extra scaling symmetry: $\phi \to \phi + \phi_0$, $Q \to e^{\#\phi_0} Q$

Critical lines vs critical points in Cuprates





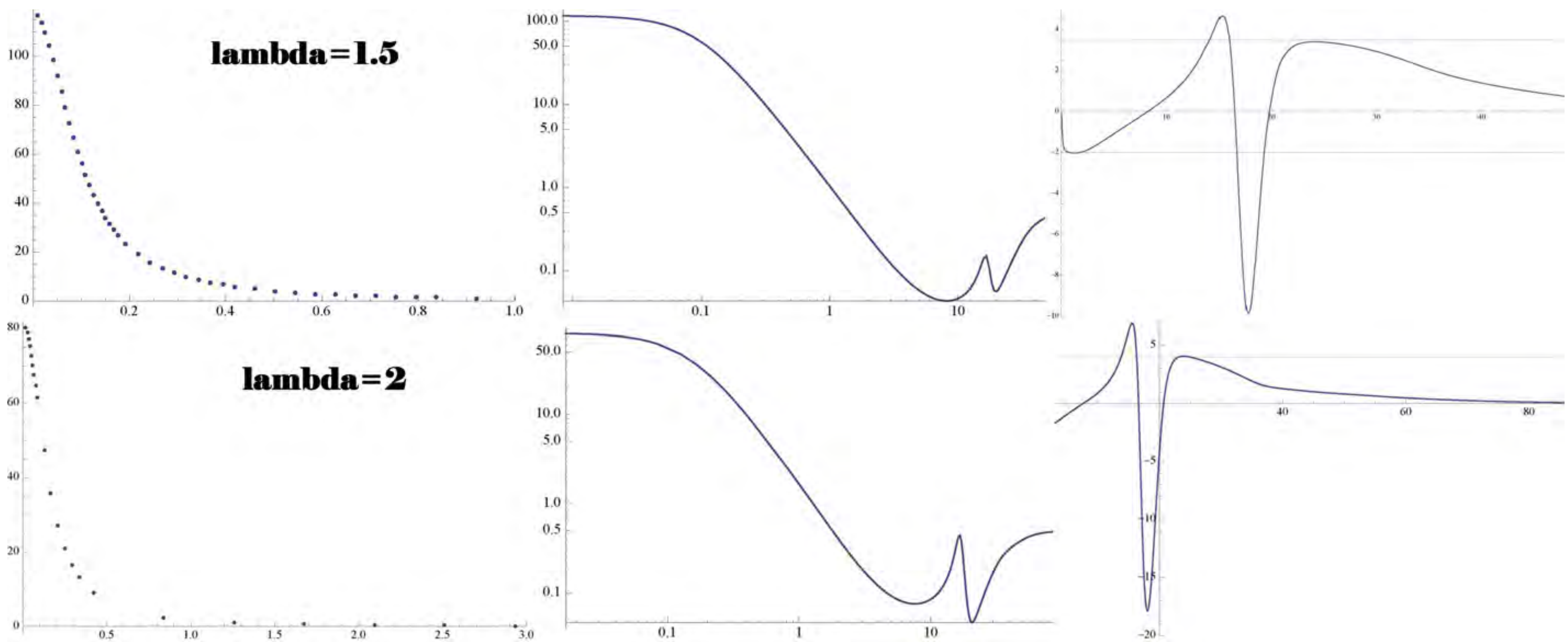
Kim+Kiritsis+Panagopoulos

Anomalous Criticality in the Electrical Resistivity of $La_{2-x}Sr_xCuO_4$.

R.A. Copper et. al. 2009

Breaking translation invariance in holography

- By boundary conditions. Already done in the simplest case (RN). Needs the solution of non-linear PDEs *Horowitz+Santos+Tong*
- Many more cases to be described. Work started with Aristos Donos



- RG flow between AdS and semi-local AdS_2 with $\frac{z}{\theta} = \lambda$.

- Interesting question: what is the resolution of translationally-invariant Mott-like insulators?

Breaking translation invariance: helical breaking

• Use Bianchi VII symmetry: translation in x, accompanied by rotation in y-z plane is a symmetry.

• Novel insulators were found analytically by studying this ansatz.

Donos+Hartnoll

• We have found many more fixed points in EMD, with non-trivial behavior, including a "bad metal" at low temperatures.

ongoing work with Blaise Gouteraux and Aristos Donos

• This goes well beyond studies in this direction, and this context looks like a gold mine for novel behavior in holographic systems.

Breaking translation invariance: The effective approach

• If the charge exchanges momentum with other dynamical ingredients, then momentum conservation is broken. In holography this corresponds to the spacial components of the relevant metric getting a mass.

• This has been used to investigate the conductivity holographically

Vegh, Davidson, Blake+Tong

• The analysis of holographic massive systems, indicates that there is a lot more to study in this context, and the setup studied already is incomplete

Clark+Karch+Aharony, Kiritsis, Kiritis+NIarchos

• A detailed study of these phenomena is in progress using controlled holographic theories

D-wave symmetry breaking

- Attempts to implement this in holography are not trustworthy.

- The simplest method, (and closer to the experimental realization) is by $\ell = 2$ boundary conditions on the stress tensor, at the AdS boundary

- This requires the solution of elliptic non-linear PDES

- The problem looks tractable these days

Computation of the quantum effective action in holography

• This is a theoretical project, that aims at developing the formalism for computing the effective action starting from the holographic bulk action and deriving the holographic RG flow equations.

• The strategy is to rewrite the second order gravity equations as first order flow equations in terms of auxiliary functions that in supergravity are known as the superpotentials.

• This has been achieved for the effective potential at finite temperature and density, and for the action for all two derivative terms in a Einstein-Dilaton theory (at T=0) so far

Kiritsis+Niarchos, Kiritsis+Li+Nitti

• It is extremely useful for (a) analytical study of phase transitions, (b) the numerical study of non-linear dynamics, like quenches, (c) the analytical study of symmetry breaking.

Interacting Large-N QFTs and "layered systems"

• This is a framework of networks of large-N QFTs coupled together with multitrace interactions. Such interactions are "weak" and solvable at large-N.

Kiritsis+Niarchos

• For example an infinite chain of (2+1)-dimensional QFTs could describe the layers of a High-T_c superconductor along the easy-axis.

• Preliminary studies have been made, and several phenomena were found:

Kiritsis+Niarchos

(a) relativistic generalizations of the Gross-Pitaevski equation were found

(b) Such a framework can be generalized to finite temperature

(c) Solitons and chaotic behavior have been found

(d) Simple Josephson junctions can be made.

• Lifshitz transitions can be predicted for two layered systems. The general problem of criticality induced in multi-interaction systems is an interesting and open question.

• The "Designer" approach can be applied because the framework is modular, and it may describe various "nano-scale conglomerates".

• The holographic framework for all of the above is massive multigravity.

• Many other questions remain to be answered in this framework that is very flexible

Non-equilibrium phenomena

• Holography is ideal for describing non-equilibrium phenomena, like quenches, thermalization, turbulence etc.

• Both analytical and numerical techniques are efficient in answering related questions.

• In QFT perturbation theory all of these questions are very hard to answer.

• Thermalization in particular is the formation of a (black-hole) horizon in holography.

• For several problems in this class, the hyperbolic non-linear PDEs must be solved. There is progress in this direction in the last 3-5 years.

• The study of non-equilibrium steady states that seem ubiquitous in holographic strongly coupled plasmas

• An interesting class of problems that has experimental backing recently is phase transitions induced by external forcing the system.

• Example 1: The Laser (second order) phase transition induced by optical pumping an appropriate atomic system.

Graham+Haken

• Recent experiments that see important rise of the critical temperature in Cuprates when they are excited with light in special frequencies.

Fausti et al.

• Setting up holographic models for such phenomena is an important and interesting task.

• In such cases the spatio-temporal correlations seem to play a crucial role.

Experiment

• Despite all this theory, we are very eager to see new experimental results and to try to explain them.

• For this we need contact with the experimentalists, and other theorists.

• We hope that this REGPOT will contribute in this effort and we are very eager to learn what our partners are doing.

.

THANK YOU

The Physics Department

• The Physics Department of the University of Crete was founded in 1978.

• It has 29 faculty members, 5 emeriti, 1 Distinguished professor,12 technical and administrative personnel, 14+34=48 postdoctoral research fellows, 33 Master's students and 29 PhD students.

• It has close ties and collaboration with the nearby Foundation for Research and Technology Hellas (FO.R.T.H) (A European Laser Facility).

• The Physics Department is the top of its kind in Greece. It was the first in Greece (1984) to have organized graduate studies (all other universities followed suit in the late nineties following pressure from the EU), a curriculum on a par with modern standards, and to cultivate high-quality experimental research (a subject from difficult to impossible in countries like Greece).

• the research areas that are represented involve

♠ High Energy Physics and Cosmology (theoretical)

♠ Astrophysics (theoretical and observational)

♠ Condensed matter physics (Theoretical and experimental)

♠ Applied physics and material science (Mostly experimental)

♠ Atomic physics and Lasers (theoretical and experimental)

♠ Others (atmospheric physics,plasma physics,accelerator physics etc)

Previous Researchers

Foreign researchers

Matthew Lippert (American, PhD UC Santa Barbara, now at Amsterdam U.)

Rene Meyer (German, PhD LMU Munich, now in IPMU Tokyo)

Tassos Taliotis (Cypriot, PhD Ohio State U., now at Vrije Universitat Brussels)

Hong Bao Zhang (Chinese, PhD Beijing University, Vrije Universitat Brussels)

Bom Soo Kim (Korean, PhD Berkeley, now at Tel Aviv University)

Daisuke Yamada (Japanese, PhD University of Washington, Seattle, now on a carrier break)

Takeshi Morita (Japanese, PhD Kyoto University, now at KEK, Japan)

Pavel Spirin (Russian, PhD Moscow State University, currently researcher at Moscow State University)

Vakif Onemli (Turkish, PhD University of Florida, now faculty at Koch U., Istanbul)

Andrea Mauri (Italian, PhD University of Milano, now senior researcher at the University of Milano)

Diego Mansi (Italian, PhD University of Milano, now senior researcher at the University of Milano)

Mirian Tsulaia (Ukrainian, PhD JINR Dubna, now Professor at Ilia State University, Tbilisi, Georgia)

Alexei Koshelev (Russian, PhD ITEP MOscow, now long term research fellow at Vrije Universitet Brussels)

Dominic Clancy (British, PhD Sussex University, now at the Spitzer Space Telescope project, JPL, California)

C. Sochichiu (Moldovan, PhD JINR Dubna, now faculty at Sung-Kyung-Kwan U., Suwon, South Korea)

Raf Guedens (Belgian, PhD Cambridge University, now researcher at U. of Maryland)

Amin Hammou (Algerian, PhD ICTP Trieste, now faculty at Oran Science and Technology U.)

Axel Krause (German, PhD Humbolt University, now faculty at Ludwig-Maximilians U., Munich)

Ciprian Acatrinei (Romanian, PhD SISSA Trieste, currently faculty at IFIN-HH, Bucharest)

Greek Researchers

Leandros Perivolaropoulos (PhD Brown University, now full professor at Ioannina University)

Ioannis Gialas (PhD DESY, now full professor at the Aegean University)

Costas Anagnostopoulos (PhD Syracuse University, now associate professor at National Technical U. of Athens)

Nikos Tetradis (PhD Stanford University, now full professor at National U. of Athens)

Nikos Irges (PhD University of Florida, now assistant professor at the Technical University of Athens)

Aggelos Fotopoulos (PhD NorthEastern University, now working in industry)

George Kofinas (PhD University of Athens, now assistant professor at Aegean University)

Collaborating institutions 2010-2012

Europe

- Amsterdam University, The Netherlands
- APC, Paris, France
- Barcelona University, Spain
- Cambridge U. , UK
- CERN, Switzerland
- CP3 Origins, Denmark
- Ecole Polytechnique, France
- Edinburg University, UK
- Frankfurt University, Germany
- Haifa University, Israel
- Helsinki Institute of Physics, Finland
- Milano University, Italy
- Niels Bohr Institute, Copenhagen, Denmark
- Nordita, Stokholm, Sweden
- Orsay University, Paris, France
- Oxford University, UK
- Santiago de Compostela U., Spain
- Southern Denmark University, Denmark
- Technion, Israel
- Utrecht University, The Netherlands

Russia

- ITEP. Moscow, Russia
- JINR, Dubna, Russia
- Lebedev Institute, Moscow, Russia
- Moscow State University, Russia

USA and Canada

- Florida University, USA
- Illinois University, Urbana, USA
- Kansas State University, USA
- Montreal University, Canada
- Perimeter Institute, Canada
- UCLA, USA
- Victoria University, Canada,
- Virginia Tech, USA
- Washington University, Seattle, USA

China, India, Japan, Korea

- Beijing, Academy of Mathematics and Syst. Sci., China
- Beijing Institute of Theoretical Physics, China
- Beijing Normal University, China
- Beijing, GUCAS, China
- Nachang University, China
- RIKEN, Tokyo, Japan
- Tata Institute, Mumbai, India
- Yonsei, University, Korea

South America

- CECS, Valdivia, Chile

Recent Distinctions

• Distinguished Professor D. Christodoulou was awarded the Shaw prize for the Mathematical Sciences, shared with Prof. R. S. Hamilton. The prize was given for their highly innovative works on nonlinear partial differential equations in Lorentzian and Riemannian geometry and their applications to general relativity and topology.

• CCTP Postdoctoral researcher T. Morita, was awarded the "Young Scientist Award of the Physical Society of Japan" for his work on the phase structure of compactified YM.

• The paper Int.J.Mod.Phys. D20 (2011) 2847-2851 by Tsamis+Woodard received an honorable mention from the Gravity Research Foundation.

• The paper arXiv:1204.2029 [hep-th] by Zhang+Wu+Tiang, received an honorable mention from the Gravity Research Foundation.

• The paper Class.Quant.Grav.26:105006,2009 by Tsamis+Woodard has been highlighted in 2009 by the Journal of Classical and Quantum Gravity

• The paper Nucl.Phys.B821:467-480,2009 by Kiritsis+Kofinas was among the 50 most cited papers in 2009. Today it has 267 citations in SPIRES.

• The papers Phys.Rev.Lett.101:181601,2008 and Nucl.Phys.B820:148-177,2009 by Gursoy+Kiritsis+Mazzanti+Nitti were highlighted in Physical Review Focus on the occasion of a recent high-precision lattice calculation in Large N gauge theory.

Detailed plan of the presentation

- Title page 0 minutes
- The Crete Center for Theoretical Physics 7 minutes
- Advisory/Evaluation Committee 9 minutes
- Physics at CCTP 12 minutes
- The AdS/CFT correspondence 16 minutes
- The QFT/string theory correspondence 18 minutes
- How do we use holography in practise 20 minutes
- The Wilsonian Program 22 minutes
- Quantum Fractionalisation transitions 24 minutes
- Critical lines vs critical points 26 minutes
- Breaking translation invariance in holography 28 minutes
- Breaking translation invariance: helical breaking 29 minutes
- Breaking translation invariance: The effective approach 31 minutes
- D-wave symmetry breaking 32 minutes
- Computation of the quantum effective action in holography 34 minutes
- Interacting Large-N QFTs and "layered systems" 37 minutes
- Non-equilibrium phenomena 39 minutes
- Experiment 40 minutes

- The physics department 41 minutes
- Past researchers 42 minutes
- Collaborating Institutions, 2010-2012 43 minutes
- Recent CCTP Distinctions in Research 47 minutes