

Seminar Holography and Large- N duality

Sommersemester 2018

Description

CONTENT:

The holographic principle has been identified as one of the cornerstones of a complete theory of quantum gravity. Its most compelling incarnation to date is the celebrated AdS/CFT correspondence, which has taught many important lessons over the past twenty years, and also found numerous applications to understanding the dynamics of strongly coupled quantum systems in geometric terms. Like other dualities that have emerged from string theory, the correspondence is expected to have a deep mathematical counterpart.

The aims of the seminar are two-fold:

1. We will learn the physical motivation behind holography and the basic working of the AdS/CFT correspondence, including its classic tests, hopefully reaching some recent developments by the end of the term.
2. We will study mathematical versions of large- N duality in examples such as the correspondence between Chern-Simons theory on the three-sphere and the topological string on the resolved conifold.

AUDIENCE:

The seminar is aimed at master's students in physics and mathematical physics. Participants should have at least nodding acquaintance with any or all of the following: general relativity; quantum field theory; supersymmetry; string theory; differential geometry; representation theory. We welcome contributions from interested doctoral students and postdocs.

EVALUATION:

This seminar will be listed in the LSF as “Masterpflichtseminar” in Physics and as “Master-Seminar” in Mathematics. To receive credit in the Physics program, you have to prepare a 6–10 page write-up of your talk, and the final grade will be based (in roughly equal amounts) on both the talk and the writeup. The Math program does not require a write-up, though of course you are welcome to provide one.

ORGANIZATION

The seminar will meet on Tuesdays at 13h00 (c.t.) in Mathematikon SR 9. If you were unable to attend the organizational meeting (on February 5) but would like to participate in the seminar, please send us an email.

Organizers and Tutors: Richard Eager, Ingnar Saberi, Johannes Walcher

Talks

INTRODUCTION AND OVERVIEW

Thermodynamics of black holes, entropy bounds and the Holographic Principle; Motivating the correspondence from string theory; statement of the correspondence; brief overview of tests and physical and mathematical applications

References: [MAGOO], [Susskind], [Bousso], [Marino]

Date: April 17

Speaker: J.W.

CLASSICAL GEOMETRY OF ANTI-DE SITTER SPACE

1. From Friedmann-Lemaître-Robertson-Walker to (anti-)de Sitter space, Killing vectors, space(time)s with maximal symmetry, isometries of AdS vs. conformal symmetries of Minkowski space; various models of hyperbolic space and coordinate systems on AdS; geodesics in hyperbolic/AdS-space

2. Conformal compactifications; Penrose diagrams; black holes in flat space and AdS; minimal surfaces in AdS

References: [Carroll, Chapter 8], [O'Neill, Chapter 11], [Kaplan, Chapters 2–3], [Hawking], [Harlow]

Date: April 24

Speaker: Raphael Senghaas, Felipe Müller

Tutor: J.W.

CLASSICAL FIELD THEORY IN ADS

1. The wave equation in anti-de Sitter space, separation of variables; radial equation and boundary conditions; the Breitenlohner–Freedman bound

2. Conformal invariants; Fefferman–Graham expansion; Graham–Lee theorem

References: [Harlow], [Kaplan, Chapters 4–5], [FG], [Freedman], [GL], [Witten 98], [Skenderis]

Date: May 8

Speaker: Martin Bies, Menelaos Zikidis

Tutor: I.S.

CONFORMAL FIELD THEORY

1. The conformal group in various dimensions: Definition, Lie algebra, relation to Poincaré/Euclidean group. Unitary representations of the conformal group.
2. Conformal invariance in quantum field theory: primaries and descendants, conformal correlators, radial quantization and operator-state correspondence, operator product expansion

References: [Mack], [Rychkov], [Simmons], [DMS]

Date: May 15

Speaker: Jannik Fehre, Torben Skrzypek, Oskar Riedler

Tutor: R.E.

 $\mathcal{N} = 4$ SUPER YANG–MILLS

1. Brief review of supersymmetry; maximally supersymmetric Yang–Mills theory and its stringy origin; dimensional reduction.
2. Review of renormalization in Yang–Mills theory; one-loop β -function of $\mathcal{N} = 1, 2, 4$ SYM; proof of conformal invariance; anomalies; supersymmetric operators and breaking of conformal invariance.

References: [DHoker], [Freedman]

Date: May 22

Speaker: Michael Bleher, Fabio Schlindwein

Tutor: R.E.

SUPERGRAVITY, BRANE SOLUTIONS, AND NEAR HORIZON LIMIT

1. Review of supergravity in various dimensions, d’Auria–Fre formalism, rheonomy, supersymmetric solutions of supergravity, Killing spinors and BPS solutions
2. Review of Reissner–Nordström, extremality, p -brane solutions of supergravity and D-branes in string theory: frames and connections on spheres, p -form gauge charges, near horizon limit, thermodynamics, Hawking–Page transition

References: [CdAF], [MAGOO], [Freedman], [BBS]

Date: May 29

Speaker: Johannes Walcher, Ade Adeifeoba

Tutor: J.W.

THE ADS/CFT CORRESPONDENCE

1. Motivating the correspondence, matching of symmetries and decoupling limit.
2. The dictionary: why

$$Z_{\text{AdS}}(\phi) = \left\langle \exp \int \phi \mathcal{O} \right\rangle.$$

References: [Witten 98], [MAGOO], [BDHM], [Joe]

Date: June 5

Speaker: Richard Eager

Tutor: I.S.

TESTS OF THE CORRESPONDENCE

Kaluza-Klein spectroscopy; finite temperature and Hawking-Page transition; anomalies; holographic renormalization and holographic RG; homological algebra

Date: June 12

Speaker: Ingmar Saberi

Tutor: R.E.

CHERN-SIMONS THEORY AT LARGE- N

References: [Witten89], [Witten93], [Marino, Part I], [AK, Chapter 5]

Date: June 19

Speaker: Markus Schreiber, Andreas Schachner

Tutor: T.B.D.

CHERN-SIMONS&TOPOLOGICAL STRINGS

References: [Marino, Part III], [AK, Chapter 6]

Date: June 26

Speaker: Fengjun Xu, Aitor Olivares

Tutor: T.B.D.

DEFORMATIONS OF THE CORRESPONDENCE

1. Polchinski–Strassler; Klebanov–Strassler; quivers
2. Geometric transitions

References: [Joe] and references therein

Date: July 3

Speaker: Sascha Leonhardt, Tobias Witt

Tutor: T.B.D.

HOLOGRAPHY AND PHYSICS

Date: July 10

Speaker: Lukas Hahn

Tutor: TBA

REFERENCES

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