

**Special Topic : String Theory, Field Theory and Cosmology
(10920PHYS597002)**
Holographic Duality: with applications in condensed matter physics

Outline of Lectures

Instructor: Professor Chong-Sun Chu, GB II.P519.
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Time and Location: Monday, 10:00 - 12:40 (with one 5 minutes break); Lecture room 521, General Building II.

Office Hour: By appointment by email

Resources:

- Holographic Duality in Condensed Matter Physics 1st Edition by Jan Zaanen, Yan Liu, Ya-Wen Sun, Koenraad Schalm, Cambridge University Press
- AdS/CFT Correspondence in Condensed Matter by Antonio Sergio, Teixeira Pires IOP science

Course Outline by Topical Areas: The following topics will be covered in the course:

- Basic introduction to AdS/CFT
 - motivations to the principle of holography
 - conformal symmetry and beta function
 - $N = 4$ supersymmetric Yang-Mills theory
 - D-branes, string theory and supergravity
 - Large N expansion of gauge theory
 - Maldacena AdS/CFT conjecture
 - GKPW rule for correlation functions
- Applications:
 - Finite temperature field theory and black hole in AdS
 - Wilson loop and confinement
 - Holographic description of hydrodynamics;
 - Kubo formula for transport coefficients
 - Quark-gluon plasma and shear viscosity
 - Superconductivity
 - Entanglement entropy and Ryu-Takayanagi formula

Evaluation: Presentation: 50 %, Final report: 50 %. Each person will make a 30 minutes presentation and submit a final report on a topic of choice. Presentation will be on May 31st and June 7th. Please submit your choice of topic by April 5th.

Possible topics are:

1. Hawking radiation as tunneling: Hawking Radiation as Tunneling Maulik K. Parikh, Frank Wilczek, hep-th/9907001

2. Holographic principle: G. 't Hooft, Dimensional Reduction in Quantum Gravity, gr-qc/9310026; L. Susskind, The World as a Hologram, hep-th/9409089.
3. The AdS/CFT conjecture: Juan Maldacena, The Large N limit of superconformal field theories and supergravity, Adv. Theor. Math. Phys. 2:231, 1998 (hep-th/9711200)
4. GKPW rule: Witten, Anti-de Sitter space and holography, Advances in Theoretical and Mathematical Physics 2: 253–291, 1998 (hep-th/9802150)
5. Weyl anomaly from holography: The Holographic Weyl anomaly, Mans Henningson, Kostas Skenderis, arXiv:hep-th/9806087
6. Condensed matter applications of AdS/CFT: a topic of choice from the chapters 8,9,11,12 of the textbook of Jan Zaanen
7. Boundary conformal field theory and holography: Holographic Dual of BCFT Tadashi Takayanagi, arXiv:1105.5165; A New Proposal for Holographic BCFT Rong-Xin Miao, Chong-Sun Chu, Wu-Zhong Guo, arXiv:1701.04275
8. Other topics are possible. Please have a discussion with me.

Week	Main topics (approx.)
(2/22)	Overview of holographic principle: statement, motivation (1,2)
(3/1)	holiday
(3/8)	RG =GR, conformal symmetry, beta function, AdS space (2,3)
(3/15)	Maldacena AdS/CFT conjecture, origin from string theory (4,5)
(3/22)	Large N expansion of gauge theory, SUGRA limit of AdS/CFT (6)
(3/29)	GKPW rule (7)
(4/5)	holiday
(4/12)	QFT in black hole geometry and temperature (8)
(4/19)	AdS black hole and finite temperature effect, Hawking-Page transition (9)
(4/26)	Wilson Loop and confinement (10)
(5/10)	Holographic hydrodynamics, Kubo-formula for transport coefficients (11)
(5/17)	Superconductivity (12)
(5/24)	Entanglement entropy (13)
(5/31)	Presentation
(6/7)	Presentation