UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Quantum Gravity

2627-1-F1703Q042

Aims

To introduce the quantum aspects of black holes and the AdS/CFT correspondence: black hole thermodynamics, Hawking radiation, the holographic principle, the holographic dictionary and its tests, entanglement entropy and the Ryu-Takayanagi formula. By the end of the course the student is able to carry out in detail the basic computations of each of these topics.

Contents

1. Black hole thermodynamics.
2. The AdS/CFT correspondence.
3. Black holes, entropy and entanglement in holography.

Detailed program

Part I. Laws of black hole mechanics; Bekenstein entropy and the generalized second law; quantum fields in curved spacetime; Hawking radiation and gray-body factors; the Unruh effect and the thermofield double; the Euclidean approach to gravitational thermodynamics.

Part II. Conformal field theory; anti-de Sitter space; the 't Hooft large-N limit; the holographic principle and the AdS/CFT dictionary; correlation functions and holographic renormalization; holographic anomalies; introduction to strings and D-branes; the Maldacena limit of D3-branes; tests of the correspondence.

Part III. Black holes in AdS and the Hawking-Page transition; fine-grained and coarse-grained entropy, the Page curve and the information problem; black hole entropy as entanglement entropy; the Ryu-Takayanagi formula.

Prerequisites

General Relativity and Quantum Field Theory. No previous exposure to string theory or supersymmetry is assumed.

Teaching form

Lectures (42 hours).

Textbook and teaching resource

Lecture notes by the lecturer, updated during the course: https://nmekareeya.github.io/QG

Further reading:

- E. Witten, Introduction to black hole thermodynamics, arXiv:2412.16795
- A. Zaffaroni, Introduction to the AdS/CFT correspondence
- D. Tong, String theory, arXiv:0908.0333

Semester

Second semester (42 hours, 6 ECTS).

Assessment method

Oral exam based on the material in the lecture notes.

Office hours

By appointment via email: n.mekareeya@gmail.com

Sustainable Development Goals