PHY 391 – Special Topics

Black Holes, Quantum Gravity and Quantum Information

Prof. Sera Cremonini

Instructor's Contact Information:

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Course Information:

PHY 391, Fall 2025
Time: Tuesday, Thursday 3:00-4:15 pm
Location: Room 511, Physics Building
Website: https://coursesite.lehigh.edu/

Course Description

This course explores advanced topics at the intersection of black hole physics, quantum gravity, and quantum information theory. Students will be introduced to foundational concepts in quantum field theory, the quantum nature of black holes, and key aspects of the holographic gauge/gravity duality. Aspects of quantum entanglement, quantum information and quantum chaos will also be explored, with a focus on the ways in which they can be connected to the physics of black holes.

Required Textbook

There is no required textbook. Useful references will be provided throughout the course.

Grading:

Students will be graded on the basis of class participation and the quality and depth of their in-class presentations.

Grading Scale

A = 88 – 100 B = 75 – 87 C = 62 – 74 D = 50 – 61

Student Assessment Criteria:

- **Reading Assignments:** Students will be assigned relevant readings from the literature to deepen their understanding of course topics. These readings will serve as a basis for class discussions and will help students engage more deeply with the material.

- **In-Class Presentations:** Each student will be expected to explore specific topics in greater depth and give in-class presentations. The presentations are intended to develop skills in organizing and communicating complex material clearly — essential for academic and professional success.

- **Homework Assignments:** Occasionally, ungraded homework problems will be suggested to reinforce key techniques and concepts. While not required, completing these exercises is strongly encouraged, as they offer valuable practice with the calculations and help build a deeper understanding of the underlying methods.

- **Class Participation:** Active participation in discussions is highly encouraged and will be taken into account when evaluating borderline final grades.

Initial competences: Working knowledge of special relativity and quantum mechanics. Familiarity with the basics of string theory and the main properties of black holes.

Final Competences:
The students are expected to:

- Become familiar with major recent developments in quantum gravity, black hole physics and quantum information science
- Learn some of the analytical and technical skills needed to approach simple problems in quantum field theory and general relativity
- Gain an appreciation for the fundamental aspects of the holographic gauge/gravity duality and how they can be applied to strongly interacting quantum systems
- Learn to perform literature searches and present work to a wide audience, by preparing oral presentations.

Accommodations for Students with Disabilities:
Lehigh University is committed to maintaining an equitable and inclusive community and welcomes students with disabilities into all of the University's educational programs. In order to receive consideration for reasonable accommodations, a student with a disability must contact Disability Support Services (DSS), provide documentation, and participate in an interactive review process. If the documentation supports a request for reasonable accommodations, DSS will provide students with a Letter of Accommodations. Students who are approved for accommodations at Lehigh should share this letter and discuss their accommodations and learning needs with instructors as early in the semester as possible. For more information or to request services, please contact Disability Support Services in person in Williams Hall, Suite 301, via phone at 610-758-4152, via email at indss@lehigh.edu, or online at https://studentaffairs.lehigh.edu/disabilities.

The Principles of Our Equitable Community:
Lehigh University endorses The Principles of Our Equitable Community
[http://www.lehigh.edu/~inprv/initiatives/PrinciplesEquity_Sheet_v2_032212.pdf].
We expect each member of this class to acknowledge and practice these Principles. Respect for each other and for differing viewpoints is a vital component of the learning environment inside and outside the classroom.