PHYS 5500, Section 2
Black Hole Clinic
One-credit course

Syllabus - Fall 2017

Instructors

Maria J. Rodriguez, SER 236, maria.rodriguez@usu.edu

Course description

Black holes, objects so dense that not even light can escape their gravitational pull, are some of the most fascinating objects in the sky. The extreme conditions created by black holes make them extraordinary laboratories for studying quantum effects in gravitational systems.

In this course we will provide a practical approach to the construction and analysis of black hole solutions and will study some of their implications for our theories of classical and quantum gravity, including General Relativity and String Theory.

Approach

The course will be based on a *Physics Clinic*[1] that will provide students with hands-on physics experience under the direct supervision of the Faculty who are not only great researchers and experts in the field but also trained in individually educating and mentoring students.

Besides daily white board talks each class will include `hands-on activities'. By hands-on activities it is meant reproducing a computation from a research paper or the resolution of practical problems on the computer. Wolfram *Mathematica* (no campus license needed) will be used for that purpose, which is currently considered a computing standard in college education and physics research.

Goals

Through their participation in the Black Hole Clinic, students gain a wide range of skills, including:

- learning about black holes in the most modern setups
- conducting physics writing and research
- investigating and analyzing facts about black holes
- drafting research papers
- developing programming skills

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[1] Similar to the law school clinics, which are law school programs that provide students with hands-on-legal experience under the supervision of attorneys

- collaborating with other students and senior researchers

Topics covered

A number of topics in classical and quantum gravity will be covered under the overarching theme of black hole solutions to the Einstein equations of general relativity, and its supergravity extensions.

Black hole solutions

- Introduction to Einstein equations
- Construction of black hole solutions
- Thermodynamic analysis of black holes

Black hole physics as a window into quantum gravity

- The Kerr black hole and its near horizon geometry
- Asymptotically Anti-de Sitter black holes
- The Kerr/CFT correspondence
- The AdS/CFT correspondence

Supergravity black holes

- Basics of string theory
- Basics of supergravity
- Supergravity black holes

Prerequisites

Classical field theory and Modern Physics (Phys 2710 or 3710) at undergraduate level is desirable but not necessary. No prior knowledge of Wolfram Mathematica programming is required.

Text

The course will be based on the instructors' own lecture notes based on the following textbooks:

- S. Hawking and M. Perry *The Large Scale Structure of Space-Time* (Cambridge University Press)
- D. Freedman and A. van Proeyen, *Supergravity* (Cambridge University Press)

Grading

Grades will be based on a final project.