

QUANTUM FIELD THEORY IN CURVED SPACETIME

Physics 7683

Fall 2009

Instructor: Prof. Éanna Flanagan, 606 Space Sciences or 320 Newman Lab.
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Lectures: 01:25 - 02:40 Tuesdays and Thursdays, Rockefeller 105.

Office Hours: 3pm-5pm Tuesdays in 320 Newman lab or after lectures.

TA: This course does not have a TA or a grader.

Web Page: Information relevant to the course (handouts, problem sets, etc.) can be found on the web page
<http://www.astro.cornell.edu/~flanagan/ph7683/>
which can be accessed by following links from the physics department homepage.

Summary: Quantum field theory in curved spacetime deals with physical phenomena where both quantum mechanics and gravity are important. The main applications are in the area of black hole physics and early universe cosmology. This course will cover some subset of the following topics (depending on time constraints): quantization of fields on curved backgrounds; particle creation; Unruh effect; Hawking effect; black hole thermodynamics; trans-Planckian issues; black hole information loss paradox; quantum origin of primordial perturbations in the early universe; renormalization of the expected value of the stress energy tensor; Casimir effect; negative energies; backreaction and limitations of semiclassical gravity theory.

Grading: This is a special topics course which is being offered for the first time. It will be graded Satisfactory/Unsatisfactory for all registered students. There will be no final exam, but to aid your assimilation of the material covered there will be homework sets every two weeks. These will be handed out on Thursdays, and will be due two weeks later on Thursday. You are expected to abide by the Cornell University Code of Academic Integrity.

Prerequisites: I will assume that you have taken courses in general relativity and quantum field theory. On the general relativity side, you will need to be familiar with the things like the action principle formulation and black hole and cosmological solutions. On the quantum field theory side, not too much will be needed, since we will not be using Feynman diagrams or renormalization. Our starting point will be mode expansions of free fields. Exposure to the background field method would be helpful but not necessary. Familiarity with some concepts from quantum optics (coherent states, squeezed states) would also be helpful but not necessary.

Textbook: The required textbook is *Quantum Fields in Curved Space*, by N.D. Birrell and P.C.W. Davies, published by Cambridge University Press, Cambridge (1984). This is quite a good book, and covers most of the topics that we will be interested in. The main exception is in applications to cosmology, for which other books will be more useful. See a separate handout for a review of other useful books.