



Lecturer

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Professor of Physics

C142A

[email me](#)

Date: Tuesday and Thursday; first lecture on August 26, 2014 (Tuesday)

Time: 10:00 - 11:20 am

Room: P129

Course Description

PHY 552 is a course on the foundations of modern nuclear physics. With the discovery of the “perfect liquid” behavior of quark-gluon plasma at nearby Relativistic Heavy Ion Collider ([RHIC](#)) at [BNL](#) and the Large Hadron Collider ([LHC](#)) at [CERN](#), recent advances in the understanding of Quantum Chromodynamics, and with new theoretical approaches to strongly correlated systems - this is a rapidly evolving field with a broad cross-disciplinary impact.

The goal throughout this course is to develop a deep understanding of the foundations of nuclear physics, to master computations of basic observables (cross sections, correlation functions, etc), and to learn about new theoretical ideas, emerging directions, and the key role of experimental measurements. For the students interested in nuclear and particle physics, the course will provide the knowledge base necessary to begin their research. The students with interests in other fields (condensed matter physics, AMO, ...) will get acquainted with new methods for strongly correlated systems that emerge in nuclear physics.

Outline of the course

- Foundations of quantum mechanics and quantum field theory
- Symmetries, groups and equations of motion
- Gauge invariance and gauge field theories
- Klein-Gordon equation; antiparticles
- Dirac equation and electrodynamics of spin 1/2 fermions
- Perturbation theory; Wick theorem; Feynman diagrams
- Running coupling; renormalization
- Deep-inelastic scattering; Bjorken scaling and the parton model
- Parton saturation
- Quantum anomalies; neutral pion decay
- Dispersion relations and unitarity
- Quantum Chromo-Dynamics: quarks and gluons; symmetries; perturbation theory; evolution equations
- Confinement and chiral symmetry breaking
- Chiral perturbation theory
- Nuclear structure from QCD
- The proton's spin puzzle
- Lattice QCD
- Quark-Gluon Plasma: equation of state; transport properties; signatures
- Phase transitions in the Early Universe

Pre-requisites

Students are expected to have a knowledge of quantum mechanics and relativity, but no previous acquaintance with quantum field theory is presumed.

Recommended texts and sources

1. F. Halzen and A. Martin, “Quarks and Leptons: An Introductory Course in Modern Particle Physics”
2. M. Peskin and D. Schroeder, “An introduction to quantum field theory”
3. J.D. Walecka, “Theoretical Nuclear and Subnuclear Physics”

Several of the topics covered in the course cannot yet be found in any textbook; the references to the original papers will be given.

Requirements

Regular attendance: you are expected to attend all classes

Homework: there will be regular homework assignments; you are expected to complete homework on time.

Office hours

Tuesday, 3:00 - 4:30 pm, C142A

Thursday, 2:30 - 4:00 pm, C142A

You can also contact me by email.

In addition, I will be glad to meet with you at other times; however to make sure that I am available please make a prior appointment.

Grading

Homework - 50%

Mid-term - 25%

Final exam - 25%

Students will be able to access the current status of their grades.

Class attendance will also be considered in the final evaluation.

Web page

Homework, lecture notes, etc will appear at [Blackboard Suite](#):

<https://blackboard.stonybrook.edu>

Special Notes

Any excuses (medical or otherwise) are to be documented, and discussed with the instructor in a timely manner. If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact Disability Support Services at (631) 632-6748 or <http://studentaffairs.stonybrook.edu/dss/>. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential.

Students who require assistance during emergency evacuation are encouraged to discuss their needs with their professors and Disability Support Services. For procedures and information go to the following website: <http://www.sunysb.edu/ehs/fire/disabilities.shtml>