



### Updates tracker

- \* August 18, 2010 - first version of the Course web page posted
- \* August 19, 2010 - date, time, location, office hours added

### Lecturer

[Dmitri Kharzeev](#)

Professor of Physics

C109

[email me](#)

Date: Monday and Friday; first lecture on August 30, 2010

Time: 12:50 - 2:10 pm

Room: P117

### Course Description

PHY 557 is an introductory course on elementary particle physics. With the Large Hadron Collider ([LHC](#)) at [CERN](#) pushing the energy frontier to 7 TeV in 2010, the Relativistic Heavy Ion Collider ([RHIC](#)) at nearby [BNL](#) advancing the understanding of Quantum Chromo-Dynamics, and with novel results coming from the Tevatron at [Fermilab](#) and elsewhere - this is a rapidly evolving field at the verge of new discoveries.

The goal throughout this course is to develop a deep understanding of the foundations of particle physics, to master computations of basic observables (cross sections, decay rates, etc), and to learn about new theoretical ideas, emerging directions, and the key role of experimental measurements.

**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
- $e^+ e^-$  annihilation; photon propagator
- Running coupling; renormalization
- Deep-inelastic scattering; Bjorken scaling and the parton model
- Quantum anomalies; neutral pion decay
- Dispersion relations and unitarity
- Quantum Chromo-Dynamics: quarks and gluons; symmetries; perturbation theory; evolution equations; ideas about confinement and chiral symmetry breaking
- Quark-Gluon Plasma: equation of state; transport properties; signatures
- Electroweak interactions; the Weinberg-Salam model and the Higgs mechanism
- Neutrino oscillations
- Quantum field theory at high energies: space-time picture; unitarity; the Pomeron and Regge theory

- Baryon number violation at high energies and temperatures; instantons and sphalerons
- Beyond the Standard Model: supersymmetry; conformal theories and “unparticles”; extra dimensions
- Gauge-gravity duality; AdS/CFT correspondence
- Particle physics and cosmology: phase transitions in the Early Universe; baryogenesis; magnetic helicity; ideas about Dark Energy and Dark Matter

### **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. A concise and comprehensive compilation of current knowledge in particle physics is provided by the [Particle Data Group](#). The latest 2010 edition of the Particle Physics Booklet and the Review of Particle Physics will become available in September and can be ordered [here](#), free of charge. In the meantime you can immediately download it [here](#).
2. F. Halzen and A. Martin, “Quarks and Leptons: An Introductory Course in Modern Particle Physics”, John Wiley & Sons

In addition, the following texts can be consulted:

3. M. Peskin and D. Schroeder, “An introduction to quantum field theory”
4. D. Griffiths, “Introduction to Elementary Particles”

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. In addition to doing course homework, the students will study selected research papers relevant to the topics of the course and make presentations in the class.

### **Office hours**

Monday and Friday, 2:30 - 4:00 pm (three hours a week) at C109.

You can also contact me by email or by phone.

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

### **Grading**

Homework - 50%

Research paper presentation - 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.

### **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>