Syllabus

Overview

This course covers the phenomenology of particle physics. The underlying theory of particles, called the Standard Model, will be covered, along with numerous applications of current interest.

There will be weekly problem assignments. It is important to keep up with the problem assignments as they illustrate principles covered in class and introduce new ideas. Also, the homework will count for 50% of your grade. The other half of your grade will be a take-home final during finals week.

Success in this 4-credit hour course is based on the expectation that students will spend a minimum of 9 hours of study time per week in preparation for class (readings, papers, discussion sections, preparation for exams, etc.).

I don’t have scheduled office hours but am available anytime I am around, which is most weekdays. You can usually find me in my office (room 323, x62879) or in the High Energy Physics area (Room 27, x62920). You can also reach me by email either to set up an appointment if you are having problems finding me or for any other reason (blocker@brandeis.edu).

Learning Goals

The learning goals for this course are

- Understand the structure of the Standard Model and its historical roots.
- Understand how to calculate lowest-order cross sections and decay rates in the Standard Model.
- Understand the successes and deficiencies of the Standard Model.
- Understand recent and current experimental efforts to precisely test the Standard Model and to search for physics beyond the Standard Model.
Text Book

The text book for this course is *Introduction to Elementary Particles* by David Griffiths, second edition. The first edition is usable, but some of the problems are numbered differently, so you have to be very careful about this. There will be weekly reading assignments, and we will cover most of the book. There are two aspects of Griffiths that differ from the way I will present them:

- Griffiths uses Gaussian units instead of Lorentz-Heaviside (see section on units below).
- Griffiths doesn’t set $\hbar = c = 1$, as I will do.

Course Outline

1. Standard Model (non-rigorous and about 1/2 of course)

2. Experimental tests of Standard Model
   (a) $e^+e^- \rightarrow \mu^+\mu^- , \tau^+\tau^- , e^+e^- , \gamma\gamma , q\bar{q}$
   (b) Static quark model
   (c) Perturbative QCD
   (d) Deep inelastic scattering
   (e) Dynamic quark model
   (f) W and Z production
   (g) Jets
   (h) Top quark
   (i) CP violation and B-meson oscillations
   (j) Higgs boson
   (k) Neutrino oscillations
   (l) Muon g-2

3. Extensions to the Standard Model
   (a) Supersymmetry
   (b) Quantum Gravity
   (c) String Theory
   (d) Compositeness
   (e) Others
Useful Web Sites

Particle Data Group   pdg.lbl.gov
Fermilab             www.fnal.gov
CDF                  www-cdf.fnal.gov
D0                   www-d0.fnal.gov
CERN                 www.cern.ch
Babar                www.slac.stanford.edu:/BF/
Belle                belle.kek.jp
ATLAS                atlas.ch
CMS                  cms.cern.ch

Requirements

It is assumed that you are familiar with the basic concepts of quantum mechanics, classical mechanics, electromagnetism, and special relativity. No knowledge of particle physics or quantum field theory is assumed.

As for mathematics, you need to know calculus and the basics of matrices.

References

In addition to the text, the following books may be useful references:

- *Introduction to High energy Physics*, Don Perkins
- *Gauge Theories and the ‘New Physics’*, Leader and Predazzi
- *An Introduction to Quarks and Partons*, F. E. Close
- *Gauge Theories of the Strong, Weak, and Electromagnetic Interactions*. Chris Quigg