PHYS 8800, Advanced Nuclear Physics, Winter 2017

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1 Learning Outcomes

As part of the work associated with this course, the student will be expected to (in no particular order):

1) Aquire an understanding of the basic experiments and theoretical models which led to construction of the Quantum Chromo-Dynamics Lagrangian.

2) Gain a familiarity with quantization of QCD in different gauges using the method of Fadeev and Popov within path integral quantization .

3) Gain a clear understanding of the running of the QCD coupling constant and the physics of asymptotic freedom.

4) Demonstrate the ability to calculate Leading Order expressions for simple processes that involve QCD cross sections.

5) Achieve a through understanding of DGLAP evolution and its effect on parton distribution functions and fragmentation functions.

6) Aquire a qualitative understanding of collinear factorization in hard processes in QCD.

7) Aquire a working knowledge of the BFKL equation, and its extensions at high density.

2 Hours and location:

Tue-Thu, 1pm - 2:15pm, 0185Physics.

Office Hours: Tuesdays 3:00 pm - 5:00 pm or by appointment.

3 Textbooks:

Quantum Field theory and Critical Phenomena J. Zinn-Justin

Other books of interest:

Quantum Field Theory: M. Peskin and D. Schroeder.

Quantum Chromodynamics at High Energy: Y. Kovchegov and E. Levin.

Foundations of Quantum Chromodynamics: T. Muta.

Foundations of Perturbative QCD: J. Collins.

Gauge Theory of elementary particle physics: T. Cheng and L. Li

Quantum Theory of Fields vol I and II: S. Weinberg.

4 Grading (total 400)

Homework: Assigned Bi-weekly, and due every 2 weeks: 40 points each.
(total 5 assignments=200 points)

Final Exam: project, presentation and writeup. 200 points.

5 Course Outline:

1) Particle physics before QCD?

2) The classic experiments: DIS and electron positron annihilation

3) The QCD Lagrangian and Gauge Invariance

4) Quantization and the method of Fadeev and Popov.

5) Higher order calculations, e^+e^- to hadrons

6) Running of the QCD coupling, asymptotic freedom.

7) DGLAP evolution of PDF and FF.

8) Collinear factorization in hard processes.

9) BFKL evolution and QCD at high energies.

6 Homework

About 5 assignments will be handed out during the semester. Each assignment will consist of about 4 to 6 problems. Some of these will be quite difficult. You will have 2 weeks for each homework. Please do not leave these for the last minute. No solutions will be provided. You will be expected to complete as much of the homework as possible. **While consultation with your fellow students and with the instructor is encouraged, copying another student's work is not acceptable. More than one student with similar solutions will be penalized.**

7 Intended Audience (grading for graduate students)

This course is meant for graduate students in nuclear and particle physics only.