Physics 686 – Gauge Theories (and Supersymmetry) – Spring 2004

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office hours: Whenever you can find me. (Thursday afternoons are unlikely.)

Home page: http://zippy.physics.niu.edu/phys686.html

Class meetings: Tuesdays 3:00-4:50, Wednesdays 12:30-1:30

Graduate Catalog Description: Gauge principles, spontaneous symmetry breaking, Higgs mechanism, standard model of particle physics, application to electroweak interactions and quantum chromodynamics. [We will also cover supersymmetry for 3/4 of the course.]

Textbook: There is no official textbook for this course. I will hand out lectures notes, consisting of an updated version of my article "A supersymmetry primer". You probably do not want to make your own copy of the version on the WWW, as that will be obsolete very soon. Some good books on non-supersymmetric gauge theories (NOT required):

- *An Introduction to Quantum Field Theory* by M.E. Peskin and D.V. Schroeder.
- *Gauge Theory of elementary particle physics* by T.-P. Cheng, L.-F. Li.

Grading: Homework sets assigned about once per week account for 100% of your course grade. Neatness counts! Late penalty policy: 5% off for each day after the due date, up to 1 week; 90% off after 1 week. You are encouraged to consult with each other and/or with outside sources on the homework. However, do not turn in anything that you have simply copied, or anything that you do not truly understand.

I strongly urge you to take notes in class, even though I will hand out lecture notes. Please feel free to ask questions in or out of class, including by email.

Topics to be covered: We will cover topics at the frontier of the Standard Model. This includes gauge theories of the strong and electroweak interaction, and especially supersymmetry as a candidate theory of the TeV scale.

- Review of Quantum Field Theory
  - Fields, Lagrangians, and Feynman rules
  - Cross sections and decay rates
  - Quantum Electro-Dynamics (QED)
  - Global symmetries and Gauge symmetries
  - Spontaneous symmetry breaking
- The Standard Model
  - Quantum Chromo-Dynamics (QCD)
  - Chiral symmetry breaking
  - The Standard Electroweak Theory
  - The Higgs boson
  - Two-component fermion notation
- The Hierarchy Problem

- Quadratic divergences and the Higgs mass
- The problem with fundamental scalar fields
- An alternative: Technicolor

- Basics of Supersymmetry
  - Fermion/boson symmetry
  - Supermultiplets
  - Particle content of Minimal Supersymmetry
- Supersymmetric Lagrangians
  - The simplest supersymmetric model: a free, massless chiral supermultiplet (the Wess-Zumino model)
  - Masses and interactions
  - Lagrangians for gauge supermultiplets
  - Supersymmetric gauge interactions
  - Summary: How to build a supersymmetric model
- Soft supersymmetry breaking
- The Minimal Supersymmetric Standard Model (MSSM)
  - The superpotential and supersymmetric interactions
  - R-parity and its implications
  - Soft supersymmetry breaking in the MSSM
  - Hints of an organizing principle
- Origins of supersymmetry breaking
  - General considerations
  - The goldstino and the gravitino
  - Planck-scale mediated supersymmetry breaking
  - Gauge-mediated supersymmetry breaking
  - Other trendy ideas
- The mass spectrum of the MSSM
  - The Higgs bosons
  - Neutralinos and charginos
  - The gluino
  - Squarks and sleptons
- Experimental signatures for supersymmetry
  - Superpartner decays
  - Signals at hadron colliders
  - Signals at e^+e^- colliders
  - Dark matter detection