SUPERSYMMETRY AND SUPERGRAVITY (fall 2015)

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In this class we introduce and discuss field theories with a rigid (constant parameters) Fermi-Bose symmetry ("susy") and with a local (spacetime-dependent parameters) susy; in the latter case Einstein gravity is needed for consistency, and these susy gravity theories are called supergravities ("sugras"). Susy and sugra were discovered in the 1970's (sugra even here at Stony Brook), but they are usually very briefly introduced and then used as essential parts of string theory. Here we shall instead give much more background material to derive and explain their structure. We do not assume any prior knowledge of susy and sugra, but expect that students have had a one-semester course in quantum field theory, and (for the second part) some familiarity with curved space. This class was last taught in the fall of 2013 and is for any interested graduate student, whether or not he/she wishes to go on in string theory. Typed notes will be handed out in the class, and at the end there will be both an oral and a written exam.

CONTENTS:

PART I. We begin in 4 dimensional Minkowski space with the Wess-Zumino (WZ) model and N=1 super Yang-Mills theory (SYM). Then we introduce the N=2 hypermultiplet and N=2 SYM. Finally we construct the celebrated N=4 SYM model.
Next we discuss the group theory underlying these theories: superalgebras and their unitary representations in terms of particle states. No prior knowledge of group theory is needed.
This is followed by a general introduction to the geometry of coset manifolds: vielbeins, connections, Lie derivatives, covariant derivatives, and induced representations. We apply this to construct superspace, first the N=1 case, then the N=2 case. We then reobtain the susy theories we obtained earlier in x-space by integrating over the anticommuting coordinates.
If time permits we end this first part of the course by discussing some important applications:current multiplets and anomaly multiplets, quantization and super Feynman graphs, nonrenormalization theorems, complex geometry and susy nonlinear sigma models.

PART II. In the second part of the course we discuss supergravities. We begin with the N=1 d=4 sugra (simple sugra). Next comes the N=2 sugra (which realizes Einstein's dream of unifying electromagnetism and gravity). Then we mention the N=1 d=11 sugra, and some sugras in d=3,2,1. These sugras are called ordinary or Poincare (or anti de Sitter) sugras, to distinguish them from conformal sugra. We only introduce and discuss N=1 conformal sugra. We couple it to the massless WZ model (which is conformal), and reobtain simple sugra by choosing a suitable conformal gauge.
Then we turn to superspace supergravity. We discuss the geometry of local superspace, the constraints on the supertorsions and supercurvatures, the Bianchi analysis of these constraints, and the solution of the constraints. Here the coset formalism we introduced earlier simplifies the discussion a lot.
INTENDED SCHEDULE: Spring 2016 I intend to teach part 2 of Advanced Quantum Field Theory instead of General Relativity.