Mon	12-12:53	P129		
Wed	11-11:53	T.B.A.	**Note time changes!**	Fall 2017
Fri	11-11:53	T.B.A		

PHY680: Introduction to Geometry and Field Theory of Gravity, Supergravity and String Theory

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About this new course:
Modern theoretical physics brings together the well-developed theories of general relativity (GR, of 1915) and the quantum field theory of particle physics (arguably of 1926), but the methods and concepts used in research nowadays are very different from the methods and concepts taught in the usual graduate courses (by me and colleagues). For graduate students this poses a serious problem: they are supposed to know this material, but it is not taught. This course is introduced to try to bridge this gap.

Topics:

1. We shall formulate GR in terms of vielbeins (square roots of the metric) and spin connections for local Lorentz symmetry, instead of metrics and Christoffel connections for diffeomorphism invariance. We use Cartan-Maurer equations to construct solutions. We discuss black holes in Euclidean space, and Dirac fermions in curved space. Also the Gauss-Codazzi equations for the embedding of a hypersurface in curved space.

2. We give an introduction to rigid and local supersymmetry (supergravity), first in quantum mechanics and then in field theory, and we introduce superspace methods. Next, we introduce the concepts of rigid and local conformal and superconformal symmetry, and discuss the corresponding Lie algebras and field theories. Then we discuss boundary terms in field theory in general, and the Gibbons-Hawking boundary term in GR in particular.

3. The theory of induced representations: coset manifolds, covariant Lie derivatives and covariant derivatives. Application: unitary representations of the Lorentz and Poincaré groups, Killing vectors, conformal Killing vectors, and Killing spinors. We discuss ideas of Kaluza-Klein compactifications, and apply them to field theories in 10 and 11 dimensions. We also introduce the Kac-Moody and Virasoro infinite-dimensional Lie algebras of String Theory.

For whom this course is intended, and requirements:
This course is intended for intellectually curious students who like the more formal and fundamental aspects of theoretical physics, not only students who intend to work in string theory.
Students should have seen the basics of scalar field theory and Yang-Mills field theory, the Dirac equation in QED and QCD, the usual tensor calculus of GR, the Einstein equations, and the Schwarzschild solution of GR. However, no knowledge of vielbeins, supersymmetry, supergravity or string theory is assumed. The class will focus on applying the new concepts to concrete problems which students encounter when they start research and which they are supposed to know. So this course could also be called Introduction to Advanced Theoretical Physics, or Mathematical Physics II.

About the teacher:
I have taught regularly the graduate classes in GR, supergravity, string theory (with Herzog, Rastelli, Roček and Siegel), group theory and advanced quantum field theory. I have introduced in the past several new graduate courses: Modern General Relativity, Supergravity, Group Theory and String Theory. I hope that this new course will be equally resourceful.