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Beyond Lorentz Invariance
(Advanced Concepts of Symmetry)

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Abstract

Important concepts and mathematical structures – such as the conformal and the supersymmetry algebras, central charges and topological objects – and their role in classical and quantum field theories and solid state physics will be introduced. Special emphasis will be given to topological objects in the framework of gauge theories of the Yang-Mills type and of the Chern-Simons type, and in the framework of gravity theories in three and lower dimensions. The course is divided in three parts:

PART I: Noether charges and Supersymmetry.

The Noether theorem for classical field theories will be presented and discussed in general. Spatiotemporal symmetries from the conformal symmetry to supersymmetry will be introduced. The latter will be achieved via the Haag-Lopuszanski-Sohnius construction of the SUSY algebra.

PART II: Topological objects in gauge theories.

Conservation laws not descending from the Noether theorem will be presented. Important topological objects such as Dirac and 't Hooft-Polyakov monopoles and topological gauge theories, such as the Chern-Simons theory, will be discussed.

PART III: Topological objects in gravity theories.

Three dimensional Einstein gravity will be shown to be equivalent to a gauge theory of the Chern-Simons type. The Chern-Simons gravitational term (conformal gravity) will be presented. Applications to elasticity theory could be outlined.

The lectures will be two hours each and will be followed by a tutorial session to discuss the proposed exercises. Interested students should contact me to arrange for the schedule.