Scuola Superiore di Catania

Corso Specialistico

Classe delle Scienze Umanistiche e Sociali

Ambito Scienze e Tecnologie

a.a. 2022-2023

Aspetti delle teorie di gauge

Aspects of gauge theories

Language italian/english

Prerequisites

Quantum mechanics, Quantum Field Theory 1,2

Course content

The course will provide a general introduction to the physics of gauge theories, starting from essential notions and covering various aspects of the subject, ranging from the main properties of quantum electrodynamics to the more complex Yang-Mills theories. The general aim is to provide the students with the fundamental theoretical elements necessary to achieve a basic understanding of, at least, some of the many contexts where gauge theories play a central role, such as the electroweak and/or strong interactions, or even the gravitational interactions.

Part I:
Basics of gauge theories
Path Integral quantization;
Yang-Mills theories quantization, gauge fixing and Faddeev-Popov ghosts;
Quantum electrodynamics (QED) and Ward identities,
Renormalization of QED;
Yang-Mills BRST symmetry and Slavnov-Taylor identities;
Beta function, Landau pole of QED, asymptotic freedom of Yang- Mills theory.
Part II: Quantization of Gauge Theories within the canonical approach
Reminder about Lorentz and Translational Invariance in Field Theory
The canonical energy-momentum and angular momentum densities
The canonical momentum and angular momentum
Angular momentum in a relativistic theory
Lorentz transformation properties of the gauge field $A\mu(x)$ and its consequences
Quantization of a gauge theory

Problems in the quantization procedure in Gauge Theories
Gauge invariance vs. gauge independence
The Dirac method for constrained systems
Dirac method and Dirac bracket
First class vs second class constraints
Particle moving on a sphere
Relativistic particle
Dirac Field Theory
Maxwell Field Theory
Part III:
Heat Kernel Methods for Gauge Theory
Introduction to Heat Kernel Expansion
Calculation of Heat Kernel coefficients used in Yang-Mills and Gravity
Divergencies and Heat Kernel coefficients (t'Hooft formula)
Divergencies and Beta function of Yang-Mills and QCD via Heat Kernel methods
Non-local Heat kernel and lowest order finite part of the Effective Action for Yang-Mills

The teaching consists of frontal lectures, which contain a part of exercise.

Final exam

The final exam consists of an oral scrutiny with questions covering the whole subject treated in the lectures.