Introduction to Quantum Field Theory

Programme: PhD (Physics) Year: 1/2 Semester : 1/2
Course : Elective Credits : 4 Hours : 60+0+0

Course Overview:
Quantum Field theory (QFT) is the basic framework for tackling most of the advanced and current topics in (theoretical) physics be it the physics of subatomic particles or the physics of condensed matter systems or statistical physics systems. It provides computational tools as well as conceptual tools to understand the various experimental results in these various fields.

This first course on QFT will introduce the students to the bare minimum of this vast subject that is needed to do calculations in particle physics, for instance, that require the use of QFT techniques and to understand the modern physics literature.

Prerequisite Courses:
Familiarity with Lagrangian and Hamiltonian mechanics, Special relativity, Maxwell equations and the potential formulation of electrodynamics, basic results of quantum mechanics.

On completion of this course
CO1: Students will have an understanding of the difficulties with the idea of quantizing a single relativistic particle and will have an appreciation for the need for QFT.
CO2: Students will understand the importance of Green's function as used in QFT.
CO3: Students will be able to use basic calculational technique of Feynman diagrams using which (s)he should be able to do simple computations in scalar field theory and quantum electrodynamics.
CO4: Students will acquire a basic knowledge of the concept of renormalization.

Course Topics:

Topics	Contact Hours
Single particle relativistic wave equations like the Klein-Gordon equation and the Dirac equation and difficulties with their quantization.	2
Elements of classical field theory: The Klein-Grodon field, Lagrangian and Hamiltonian field theory, continuous symmetries and Noether's theorem, discrete symmetries.	6
Canonical Quantization of the free Klein-Gordon field. Green's functions and Feynman propagator.	5
Quantization of the interacting scalar field: Green's function, Wick's theorem, Feynman diagrams and Feynman rules for scalar field theory, scattering amplitudes, Cross-section calculation, Connected diagrams.	10
Dirac field and its quantization. Discrete symmetries of the Dirac theory. Feynman rules for fermions	8
Quantum Electrodynamics: Maxwell's equations and gauge symmetry, Quantization of Maxwell field, Coupling to scalars and fermions, Feynman rules for charged scalars, Feynman rules for Quantum Electrodynamics QED). Elementary processes in QED.	7
Preliminary introduction to renormalization	2

Text Books:

1. M.E. Peskin and D.V. Schroeder, An Introduction to Quantum Field Theory (Levant Books; 2005).
2. L.H. Ryder, Quantum Field Theory (Cambridge University Press; 2008).

Additional References:

1. A. Lahiri and P.B. Pal, A First Book in Quantum Field Theory (Narosa; 2007).

Additional Resources (NPTEL, MIT Video Lectures, Web resources etc.):

1. Online lectures by David Tong at http://www.damtp.cam.ac.uk/user/tong/qft/qft.pdf

Evaluation Method:

Item	**Weightage**
Assignments and/or presentations	50
Midterm	20
Endterm	30

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