SS864 QUANTUM FIELD THEORY 3-1-0-4

Course Objectives:

The main objective of this course is to learn the basic concepts and techniques of quantum field theory, with applications to elementary particle physics, with special emphasis to Quantum Electrodynamics (QED).

UNIT 1: Non-relativistic quantum field theory

Quantum mechanics of many particle systems; second quantisation; Schrodinger equation as a classical field equation and its quantisation; inclusion of inter-particle interactions in the first and second quantised formalism

UNIT 2: Canonical quantization of free fields

Real and complex scalar fields, Dirac field, electromagnetic field, Bilinearcovariants, Projection operators, Charge conjugation and Parity on scalar, Dirac and electromagnetic fields.

UNIT 3:Interacting fields

Interaction picture, Interacting Klein-Gordon field, Covariant perturbation theory, S-matrix and its computation from n-point Green functions, Wick's theorem, Feynman diagrams.

UNIT 4: QED

Feynman rules, Example of actual calculations: Rutherford, Bhabha, Moeller, Compton etc. Decay and scattering kinematics. Mandelstam variables and use of crossing symmetry, coupling Dirac field to electromagnetic field, Feynman rules for computing Green functions, symmetries and Ward identity.

UNIT 5: Higher order corrections and Gauge theories:

One-loop diagrams. Basic idea of regularization and renormalization, Landau pole. Degree of divergence, Calculation of self-energy of scalar in $\varphi 4$ theory using cut-off or dimensional regularization, Path integrals for scalar and fermionic fields.

Gauge theories:Gauge invariance in QED, non-abelian gauge theories(classical theory, quantization), QCD (introduction), Asymptotic freedom, Spontaneous symmetry breaking, Goldstone theorem, Higgs mechanism,Yang-Mills theory.

Reference Books:

1. M. E. Peskin and D. V. Schroeder,*An Introduction to Quantum Field Theory*, Addison-Wesley, New York, 1995.
2. Steven Weinberg, *Quantum Theory of Fields, Vols. I and II*, Cambridge University Press, 1996.
3. I.J.R. Aitchison and A.J.G. Hey, *Gauge Theories in Particle Physics, Vol. 1: From Relativistic Quantum Mechanics to QED*, 3rd Edition, Taylor &Francis, 2002.

4. Lahiri and Pal, *A First Book of Quantum Field Theory*, Narosa, 2007.

5. J.D. Bjorken and S.D. Drell, *Relativistic Quantum Fields*, McGraw-Hill, 1965

Course Outcomes:

After the completion of the course student is expected to:

CO1: Have an understanding of field quantisation and the expansion of the scattering matrix

CO2: Apply Feynman rules to calculate probabilities for basic electromagnetic processes with particles (decay and scattering)

CO3: Understand the basics of quantum electrodynamicsand introduction to QCD

CO4: Familiarity with the concept of Higher order corrections, re-normalization and Gauge theories

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