Quantum Condensed Matter Field Theory

Programme: Ph.D. (Physics) Year: First Semester : First
Course : Core Course Credits : 4 Hours : 52

Course Context and Overview:
The course is intended to prepare the Ph.D. students with using quantum field theory techniques to study various quantum condensed matter systems in view of the related experimental findings.

Prerequisits:
Quantum Mechanics, Electrodynamics, Statistical Mechanics and Condensed Matter Physics

On completion of this course		**Bloom's Level**
CO1	Students will have technical expertise of using quantum field theory methods in certain condensed matter systems.	3
CO2	Students will understand aspects of Broken symmetry and collective phenomena.	2
CO3	Students will be able to use basic calculational technique of various response functions mesaured in related experiments.	3
CO4	Students will acquire a basic understanding of renormalization in condensed matter systems.	2

Course Topics and contact hours allotment:

Topics	**Contact Hours**
From particles to fields: A case study with classical harmonic chain: phonons, Extension to quantum harmonic chain.	6
Second quantization: Introduction to second quantization, Applications of second quantization.	6
Feynman path integral: The path integral: general formalism, Construction of the path integral, Applications of the Feynman path integral.	6
Functional field integral: Construction of the many-body path integral, Field integral for the quantum partition function, Field theoretical bosonization: a case study.	6
Perturbation theory: General structures and low-order expansions, Ground state energy of the interacting electron gas, Infinite-order expansions.	6

Broken symmetry and collective phenomena: Mean-field theory, Plasma theory of the interacting electron gas, Bose–Einstein condensation and superfluidity, Superconductivity.	8
Response functions: Aspects of modern experimental techniques, Linear response theory, Analytic structure of correlation functions, Electromagnetic linear response.	7
The renormalization group: Ising model, Renormalization group: general theory, RG analysis of the ferromagnetic transition, RG analysis of the nonlinear σ-model, Berezinskii–Kosterlitz–Thouless transition.	7

Textbooks and references:

Text Books:

1. Condensed Matter Field Theory: Alexander Altland and Ben Simons, Cambridge University Press

Reference Books:

1. Methods of Quantum Field Theory in Statistical Physics: A. A. Abrikosov, L. P. Gorkov, I. E. Dzyaloshinski, Dovar Publications

2. Many-Particle Physics, 3rd Edition (Physics of Solids and Liquids) by Gerald D. Mahan , Springer

Evaluation Methods:

Item	Weightage
Class Presentations	30
Mid Term	20
End Term	50

CO and PO Correlation Matrix

COs	PO1	PO2	PO3	PO4	PSO1	PSO2	PSO3
CO1	3	2		2			
CO2	3	2					
CO3	3			3			
CO4	3			3			

S- Strong; M-Medium; L-Low

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