IIT Mandi
Proposal for a New Course

Course number : **PH 609**
Course Name : **Theory of quantum collision and spectroscopy**
Credit Distribution : 3-0-0-3
Intended for : UG/PG/I-PhD/PhD elective
Prerequisite :PH301/PH513 (Quantum Mechanics), PH524/EP403(Physics of Atoms and Molecules), PH613: Special topics in Quantum Mechanics
Mutual Exclusion : None

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1. Preamble:

The objective of this course is primarily to provide a detailed understanding in the field of collision theory and also to provide an introduction to some advanced topics in many-body theory. It introduces the basic formalism in scattering theory and its applications to a number of cases that are of current research interests. Further it introduces some of the many-body theoretical techniques that play very crucial role in order to understand the electronic and photonic collisions processes.

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2. Course Modules with quantitative lecture hours:

Module 1: Scattering theory-Quantum collisions: Review of Method of Partial wave analysis, and Integral equation of potential scattering; Lippman-Schwinger equation, Born series and approximations, Applications of scattering: Coulomb scattering, Scattering by complex potential Scattering of identical particles, Pseudo-potential and Bethe-Peierls collision theory, Levinson's and Seaton's theorems.

(12 hours)

Module 2: Resonant Scattering-Scattering of partial wave, Resonances in quantum collisions, Breit-Wigner formalism, Fano parameterization of Breit-Wigner formula, correlations induced resonances and shape resonances Broad Vs narrow resonances, Resonance life time, Eisenbud-Wigner-Smith formalism of time-delay in scattering, recent experiments

(8 hours)

Module 3: Many-body formalism

Many-body theory, electron correlations, Second quantization, Many-particle Hamiltonian in occupation number representation, Density fluctuations of electron gas in the Hartree-Fock method, introduction to density functional theory, Bohm-Pines approach to random phase approximation,

(12 hours)

Module4: Relativistic formulation-Foldy-Woutheysen transformations and separation of radial and angular parts of the Dirac equation**,** introduction to relativistic many body theory

(4 hours)

Module 5: Feynman diagrammatic methods-

Schrodinger, Heisenberg and Dirac pictures, Dyson's chronological operator, Gell-Mann-Low Theorem, Rayleigh-Schrodinger perturbation methods and adiabatic switching, Feynman Diagrams, I Order Feynman Diagrams, II and higher order Feynman Diagrams, Linear response of electron correlations

(4 hours)

3. Text books:

1) Physics of Atoms and Molecules, B. H. Bransden & C. J. Joachain (Pearson, 2003)
2) Quantum Theory of Many Particle Systems by A.L.Fetter and J.D.Walecka (Dover, 2003)

4. References:

1) Theory of electron-atom collisions, P. G. Burke and C. J. Joachain (Plenum Press, 1995)
2) Many Electron Theory by Stanley Raimes (Elsevier, 1972)

5. Similarity with the existing courses:

(Similarity content is declared as per the number of lecture hours on similar topics)

S. No.	Course Code	Similarity Content	Approx. % of Content
1.	PH613	4 hrs	10%
2.	PH606	4 hrs	10%

6. Justification of new course proposal if cumulative similarity content is >30%: NA