Special/Select Topics in the Theory of Atomic Collisions and Spectroscopy - Video course

COURSE OUTLINE

This course builds on the previous NPTEL course 'Special/Select Topics in Atomic Physics' given by Dr. P.C.Deshmukh and aims at preparing senior students for graduate research in some key areas of theoretical atomic physics. The course is covered in 7 Modules. The focus of this course is set on providing the tools that are necessary to study, and engage in, some frontier research areas of theoretical atomic physics. Methods of quantum collision theory, partial waves phase shift analysis, ingoing and outgoing boundary conditions, time-reversal symmetry etc. are introduced. The student is then taken through the methods of second quantization and approximation methods in addressing many-electron correlations, with a special emphasis on the random phase approximation. Feynman diagrammatic methods are introduced. An introduction to the quantum defect theory is provided and some applications of these techniques are summarized.

COURSE DETAIL

Module No:	Lecture No:	Topic
Module 0 Introductory Lecture	01	Introduction to the STiTACS course
Module 1: Quantum Collisions	02	Quantum Theory of collisions
	03	Quantum Theory of collisions: optical Theorem
	04	Quantum Theory of collisions: optical Theorem
	05	Quantum Theory of collisions: Differential scattering cross section
	06	Quantum Theory of collisions: Differential scattering cross section, Partial wave analysis
	07	Quantum Theory of collisions: Optical Theorem – Unitarity of the Scattering Operator
	08	Quantum Theory of collisions: Reciprocity Theorem, Phase shift analysis
	09	Quantum Theory of collisions: More on Phase shift analysis
	10	Quantum Theory of collisions: resonant condition in the l^{th} partial wave.
	11	Quantum Theory of collisions:

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http://nptel.ac.in

Physics

Additional Reading:

'Relativistic Quantum Theory of Atoms and Molecules: Theory and Computation (Springer Series on Atomic, Optical, and Plasma Physics)' by Ian P. Grant (Springer, 2007)

Hyperlinks:

1. https://www.physics.iitm.ac.in/~labs/amp/
2. https://www.youtube.com/watch?v=2sP5C7Eh8HY
3. http://nptel.ac.in/courses/115106057/
4. http://www3.nd.edu/~johnson/
5. http://www.phy-astr.gsu.edu/manson/

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		Levinson's theorem
	12	Quantum Theory of collisions: Levinson's theorem
Module 2: Second Quantization	13	Many body theory, electron correlations
	14	Second Quantization Creation, Destruction and Number operators
	15	Many-particle Hamiltonian & Schrodinger Equation in 2^{nd} Quantization formalism
Module 3: Electron Gas in the Hartree-Fock and the Random Phase Approximation	16	Many-electron problem in quantum mechanics
	17	Hartree-Fock Self-Consistent-Field
	18	Exchange, Statistical, Fermi-Dirac correlations
	19	Limitations of the Hartree-Fock Self-Consistent-Field formalism
	20	Many-Body formalism, II Quantization
	21	Density fluctuations in an electron gas
	22	Bohm-Pines approach to Random Phase Approximation
	23	Bohm-Pines approach to Random Phase Approximation
	24	Bohm-Pines approach to Random Phase Approximation
Module 4: Feynman Diagrammatic Methods	25	Schrodinger, Heisenberg and Dirac "pictures" of QM
	26	Dyson's chronological operator
	27	Gell-Mann-Low Theorem
	28	Reyleigh-Schrodinger perturbation methods and adiabatic switching
	29	Feynman Diagrams
	30	I Order Feynman Diagrams

	31	II and higher order Feynman Diagrams.
	32	Linear response of electron correlations
Module 5: More on Quantum Collisions	33	Lippman Schwinger equation of potential scattering
	34	Born Approximation
	35	Coulomb scattering
Module 6:Resonances in Quantum Scattering	36	Scattering of partial waves
	37	Scattering at high energy
	38	Resonances in Quantum Collisions
	39	Breit-Wigner Resonances
Module 7: Fano Analysis of Resonances	40	Fano parameterization of Breit-Wigner formula
	41	Discrete state embedded in the continuum
	42	Resonance life times
	43	Wigner-Eisenbud formalism of time-delay in scattering
Module 8:Guest Lectures by Professor S.T.Manson	44	Photoionization and Photoelectron Angular Distributions
	45	Ionization and Excitation of Atoms by Fast Charged Particles
	46	Photo-absorption by Free and Confined Atoms and Ions: Recent Developments

References:

1. Quantum Collisions Theory by C.J.Joachain (Elsevier, 1979)
2. Quantum Theory of Many Particle Systems by A.L.Fetter and J.D.Walecka (Dover, 2003)
3. Many Electron Theory by Stanley Raimes (Elsevier, 1972)
4. Atomic Collisions and Spectra by U.Fano and A.R.P.Rau (Academic Press, 1986)
5. Atomic Structure Theory: Lectures on Atomic Physics by Walter R. Johnson (Springer; 2007)