Integrated Ph.D

Syllabus for Special Paper (Quantum Dynamics)

Max. Marks: 100 Min Pass Marks: 50

UNIT-I

Postulates of quantum mechanics, qubits, composite quantum systems, Quantum entanglement, Bell Inequality. Density Operator: General properties, Bloch sphere representation, projective measurement, POVM, Schmidt decomposition, reduced density operator. Operator sum representation and its applications. Distance Measures: Norms, Trace Distance and its properties, Fidelity and its properties, relation between Trace Distance and Fidelity. Entanglement measures. Purification: Purification of a density operator, isometric extension of single qubit channels.

UNIT-II

Quantum Maps from First Principle. Lindblad equation from a short time expansion of quantum maps. Lindblad equation via coarse graining. Analytical solution of the spin-boson model for phase damping. Quantum trajectories and unravelling the Lindblad equation. Analytical solution of the general Lindblad equation.

UNIT-III

Non-Equilibrium Dynamics: Keldysh functional integral for driven open systems. From the quantum master equation to the Keldysh functional integral. Various Greens functions. Examples: Single-mode cavity, and some exact properties. Driven-dissipative condensate, Semiclassical limit of the Keldysh action. Some experimental platforms like Cold atoms in an optical cavity, and microcavity arrays.

UNIT-IV

Non-equilibrium stationary states: spin models, Ising spins in a single-mode cavity. Large-spin Holstein-Primakoff representation. Effective Ising spin action for the single-mode cavity. Ising spins in a random multi-mode cavity. Keldysh action and saddle point equations. Quenched and Markovian bath coupling in the Keldysh formalism. Functional Renormalization group: O(n)-model.

References:

1. Quantum Computation and Quantum Information: **M. A. Nielson and I. Chaung** , Cambridge University Press.

2. Field theory of Non-Equilibrium Quantum Systems: **Alex Kamenev**, Cambridge University Press.
3. Keldysh Field Theory for Driven Open Quantum Systems: **L. M. Seiberer et.al**. *Rep. Prog. Phys. 79, 096001 (2016).*