Tapestry of Field theory: Classical & Quantum, Equilibrium & Nonequilibrium Perspectives
PHY690Z

Instructor: Mahendra K. Verma, Physics Dept., IITK

Units: 3 lectures, 9 credits

Prerequisite: Quantum Mech, Mathematical Methods, Statistical Physics. Good background in mathematics required.

Course Contents: In this course, we will cover various facets of field theory in a single canvas so as to compare and contrast important paradigms. This course will focus on breadth of field theory. A outline of the course is here:

1. Mathematical Preliminaries: Green's function, Lagrangian and Hamiltonian of fields, Important integrals.

2. Quantum Field Theory 1 (QFT1): Second quantisation, Symmetries, Complex scalar field, Propagators and perturbation theory, Feynman diagrams

3. Statistical Field Theory (SFT): Intro to stat mech, Path integrals and partition function, Landau and Wilson theory of phase transition, Mean field theory, Renormalisation groups (RG), Self-consistent RG.

   Equilibrium and nonequilibrium phenomena, Energy transfers, Fluctuation dissipation theorem.

4. Quantum Field Theory 2: Intro to gauge theory and QED, Mass and charge enormalization, Beta function, Asymptotic freedom. Higgs mechanism

5. Classical Field Theory: Nonequilibrium behaviour, Dynamical critical phenomena, KPZ equation, Time-dependent Ginzburg-Landau equation, Turbulence: Hydrodynamic turbulence, Euler turbulence, Passive scalar turbulence, and MHD turbulence. Contrast these with QFT and SFT

Evaluation: This evaluation in this course will be based on midsem exam, homework, and projects.

Selected References:

(1) T. Lancaster and S. J. Blundell, Quantum Field Theory for the Gifted Amateur

(2) M. V. Peskin and D. E. Schroeder, An Introduction To Quantum Field Theory

(3) M. K. Verma, Energy Transfers in Fluid Flows, Cambridge University Press (2019).

(4) W. D. McComb, Homogeneous, Isotropic Turbulence: Phenomenology, Renormalization and Statistical Closures

(5) Articles, such as Hohenberg and Halperin, Theory of dynamical critical phenomena (RMP, 1977); M. K. Verma, Statistical theory of MHD turbulence (Phys Rep., 2004)