



Department of Physics, Indian Institute of Technology Kanpur

PHY615: Non-Equilibrium Statistical Mechanics

Instructor-in-charge: Sagar Chakraborty

(Prerequisite: PHY412 or equivalent)

Course Content:

Introduction to non-equilibrium processes (NESS etc.); Zwanzig model; Kac model; Jargon of Probability & Stochastic Process, Random walk & Markov Chain: Stationary, Limiting and Equilibrium Distributions; Brownian process; Langevin equation; Ito & Stratenovich SDEs, Ito SDE to Fokker-Planck equation; Ito-Stranovich dilemma; Chapman-Kolmogorov equation; Master Equation; Krammer-Moyal Expansion; Correlation formula and delta-integrals; Fokker-Planck equation (FPE) to Langevin equation; OU Process: SDE & FPE solutions of moments and correlations; Multi-variable SDE & FPE; Homogeneous solutions; Potential solution; Detailed Balance; Kramer's Equation; Kubo formula; Linear response theory: Fluctuation dissipation theorem and Onsager regression relation; Irreversible thermodynamics; Onsager reciprocity relations; Prigogine's Theorem; Phase order Kinetics: Coarsening and Nucleation, Glauber and Kawasaki transition rates; Glauber model and critical slowing down: Mean field and 1D; Backward Master & FPE; Adjointness and equivalence; Boundary Conditions; First passage time (FPT) and Arrhenius formula; Nucleation; Probability of exit through particular end; Birth-Death Process, Fixation Probability; Kimura's neutral selection theory; TASEP with periodic and open BC; mean field approximation; Phase transitions.

Reference Books:

1. *"Non-equilibrium Statistical Physics: A Modern Perspective"*, by Livi and Politi (Cambridge University Press, 2017).
2. *"Simple Brownian Diffusion"*, by Gillespie and Seitaridou (Oxford University Press, 2013).
3. *"A Kinetic View of Statistical Physics"*, by Krapivsky, Redner and Ben-Naim (Cambridge University Press, 2010).
4. *"An introduction to chaos in non-equilibrium statistical mechanics"*, by Dorfman (Cambridge University Press, 2009).
5. *"Stochastic Processes in Physics and Chemistry"*, by van Kampen (Elsevier, 2007).
6. *"Stochastic Methods"*, by Gardiner (Spinger, 2009).
7. *"The Fokker—Planck equation"*, by Risken (Spinger, 1989).
8. *"Non-equilibrium Statistical Mechanics"*, by Zwanzig (Oxford university Press, 2001).

Brief Course Policy (tentative):

Attendance mandatory. Marks distribution: Homeworks (20%), Quizzes (20%), Mid-sem exam (25%) and End-sem exam (35%).