

PHYSICS OF NON-EQUILIBRIUM PHENOMENA

Course Title: PHYSICS OF NON-EQUILIBRIUM PHENOMENA

Course No: PHY 311 3-0-0-9 [3 lectures, 9 credits]

Instructor: Mahendra Verma

Prerequisite: None

Course Contents:

Introduction: examples of non equilibrium phenomena (i) glass transition; (ii) nucleation; (iii) phase separation; experimental probes: dynamics catering; inelastic neutron scattering, theoretical tools: two alternative theoretical approaches (a) Langevin equation dissipation, nonlinearity and noise; illustration with translational Brownian motion; (b) Fokker Planck equation diffusion and drift; illustration with (i) translational Brownian motion, (ii) rotational Brownian motion; master equation loss and gain of probabilities; concept of detailed balance. Meta stability and bi stability: Kramers theory of thermally activated barrier crossing applications in (i) chemical reactions (ii) rock magnetism. Enhancing signals with the help of noise applications of stochastic resonance in (a) nonlinear optics, (b) solid state devices, (c) neuroscience, (d) molecular motors and biological locomotion; Becker Doring theory of homogeneous nucleation and its modern extensions applications in (a) condensation and (b) crystallization. unstable states: Allen Cahn scenario of interfacial dynamics and domain growth applications to domain growth in quenched magnets; Lifshitz Slyozov arguments for phase separation controlled by topological defects: application to liquid crystals; theory of coarsening of cellular patterns applications to soap froths (e.g., shaving foams); non equilibrium steady states in driven system: driven systems of interacting particles applications to vehicular traffic; driven surfaces applications in molecular beam epitaxy (MBE).

I will supplement the above with examples that include

- Instabilities, Bifurcations, and Chaos
- Turbulence and associated enhanced diffusion and drag
- Multiscale phenomena and energy transfers
- Fractals
- Advanced topics like arrow of time and entropy

Textbooks and References:

- (1) S. H. Strogatz, Nonlinear Dynamics And Chaos: With Applications To Physics, Biology, Chemistry, And Engineering, Westview Press (2001).
- (2) R. K. Patharia and P. D. Beale, Statistical Mechanics
- (3) Class notes

Evaluation: Regular examinations, attendance, and mini projects. Detailed weightage to decided later.