

Department of Physics, IIT-Kanpur

PHY642: Condensed Matter Phenomena in Low-dimensional Systems

Instructor: Tarun Kanti Ghosh

Prerequisite: None but good knowledge in quantum mechanics, statistical mechanics and solid state physics would help.

Objectives: This course is divided into 28 lectures and systematically developed from basic principles to an advanced level. We will introduce the essential theoretical formalism at an accessible level with illustrations of experimental results. This course will be useful for PG as well as advanced UG students

Course Contents:

1) **Semiconductor Heterojunctions:** Two-dimensional and one-dimensional charged systems, quantum Hall effect, Shubnikov de-Haas (sDH) and dHvA oscillations, role of Berry phase in transport coefficients, transport and optical properties of quantum dots and wires.

2) **Spin-Orbit Coupled Systems:** Low-dimensional electron/hole with spin-orbit interaction, beating pattern in magnetotransport measurements, spin-field effect transistor, spin Hall effect, spin Hanle effect.

3) **Two-Dimensional Dirac Materials:** Graphene monolayer and bilayer, charge and optical conductivity, anomalous quantum Hall effect, existence and role of zero-energy states, graphene nano ribbons, graphene based quantum dots, scattering properties of Dirac electrons, basic properties of silicene, molybdenum disulphide and phosphorous. Topological insulators.

References:

- 1) Tarun Kanti Ghosh, *Exotic properties of low-dimensional quantum systems* (lecture note)
- 2) Thomas Ihn, *Semiconductor Nanostructures: Quantum states and Electronic transport* (Oxford University Press)
- 3) M. I. Katsnelson, *Graphene: Carbon in Two-Dimensions* (Cambridge University Press)
- 4) Shun-Quing Shen, *Topological Insulators* (Springer series)

