Department of Physics
Indian Institute of Technology Kanpur

Course Title: Novel Phases of Quantum Matter

Course Number: PHY675A

Course Units: 3-0-0-0 (9)

Course Instructor: Adhip Agarwala

Course Timings: (timings will be decided after discussions)

Prerequisites: Master's level of Condensed Matter Physics and Statistical Mechanics (PHY543/PHY412)

First Lecture: Will be declared later.

Course Objective:

Ideas in topology, entanglement, and non-perturbative interactions have fundamentally transformed the way we classify phases of quantum matter. In particular, the appearance of fractionalized excitations, non-trivial band topology and long-range entanglement requires us to revisit quantum many-body physics and its toolkit to investigate and diagnose new phases of matter. These ideas, developed over the last four decades, are here to stay and need to be acquainted with in order to understand the fast developing subject. This graduate level course therefore aims at bringing these ideas to graduate students for meaningful engagement and to further explore the novel phases of quantum condensed matter systems.

Syllabus:

Lectures	Topics
12	Topological phases of matter: Free fermionic models and symmetry classification (2). Integer Quantum Hall effect (2). Graphene. Haldane Model. Kane-Mele Model (2) . BHZ Model. Three Dimensional Topological Insulators(2). Bipartite entanglement Entropy (2). Topological invariants and physical observables (2).
8	One Dimensional Systems: Jordan Wigner Transformation. Transverse Field Ising Chain (2). Haldane Chain. Su-Schrieffer-Heeger Chain (3). Lieb-Shultz-Mattis theorem (1). Boundary theories (2).
14	Topologically Ordered Phases: Fractional Quantum Hall Effect (3). Toric Code (2). Kitaev's honeycomb spin model(2). Topological Entanglement Entropy (1). Quantum Spin Liquids (2). Chern Simons theories and Gauge theories (3). Further special topics (1).
6	Experimental Overview: Graphene (2), frustrated spin systems (4)

References:
(i) Topological Insulators by S. Q. Shen (ii) Quantum field theory of many body systems by X.G. Wen. (iii) Quantum phase transitions by Subir Sachdev.

Grading scheme:
Quiz (20%), Mid-Sem Examination (20%),
Final Examination (30%), Assignments (20%),
Readings and discussions (10%).
Grading will be relative.

Assignment Submission Policy:
Will be in hard-copy. Please respect deadlines.

Assignment/Exam Policy:
In Assignments: Participants are welcome to discuss among each other and refer to literature. Due credit should be provided in terms of references/people discussed with, when submitting the assignment.

Copying an assignment from a colleague – will be penalized. Students may be asked to present their answers to assignment questions to the rest of the class, therefore please ensure you stand by your submitted scripts.

In exams, any kind of mal-practice will be severely penalized. Present examiner's discretion will be final in such instances.

Attendance policy:
An attendance record will be maintained. Exams/surprise quizzes (if any) will not be repeated for absentees. Frequent casual absences/vegetative participation may be penalized, and/or sustained attendance with active participation may be rewarded. Instructor discretion will be final.

Absence due to medical/emergencies will be duly considered, even for re-examination, if informed with necessary documents and in time.