Massachusetts Institute of Technology

Physics 8.513 Physics Department Fall 08

COHERENT AND COLLECTIVE PHENOMENA IN QUANTUM TRANSPORT

This course will introduce and discuss the main types of physical systems in which various phenomena of quantum transport are investigated, taking a general point of view with an emphasis on the behavior of quantum systems driven out of equilibrium. A number of concrete examples will be discussed, such as two-dimensional electron gases, carbon nanotubes, graphene, quantum dots and quantum circuits, showing how these systems help to investigate the phenomena of quantum statistics, interactions, and correlations in many-particle systems. We shall try to emphasize the physical and visualizable aspects of the subject. While the course is intended for students with a wide range of interests, many examples will be drawn from condensed matter physics and atomic physics.

Tentative course topics:

- Quantum-coherent electron transport, scattering matrix approach
- Electron resonances, tunneling, quantum dots, Coulomb blockade;
- Quantum charge fluctuations, spin fluctuations, Kondo effect, Dicke effect;
- Quantum kinetic equation, transport in the presence of disorder;
- Transport in graphene;
- Quantized Hall effects;
- Electrons in one dimension, hydrodynamics, fermi-edge singularity, Luttinger liquids, fractional charge, conductance quantization, chiral edge states in quantum Hall systems;
- Quantum mechanics in the presence of noise and dissipation, phase dynamics of Josephson junctions, tunneling with dissipation, decay of supercurrent in Josephson junctions;
- Superconducting quantum bits;
- Quantum noise, temporal correlation and coherence, photodetection and electric noise, shot noise, Hunbury-Brown and Twiss effect, counting statistics;

Lectures: Tu, Thr, 1:00-2:30, in Rm. 2-151, by Prof Leonid Levitov
Prerequisite: introductory Statistical Mechanics and Quantum Mechanics

Instead of textbook: We shall use primarily lecture notes and reading material, which will be made available on course webpage

`http://www.mit.edu/~levitov/8513`