Quantum transport and electronic interferences at mesoscopic scales

Part I (R. Deblock)

Introduction: from classical to quantum transport

1. Conductivity and relaxation time, classical diffusion
2. Elastic collisions and microscopic static disorder potential
3. Inelastic collisions (example: electron-phonon interaction)
4. Phase coherence length

I. Conductance of a quantum coherent wire between two reservoirs (conductance and transmission).

1. Case of a 1D wire: conductance quantum, Büttiker-Landauer formulas
2. Beyond 1D: conductance quantization, localization
3. Conductance Fluctuations and quantum interferences
4. Multi terminal measurements

II. Persistent currents and orbital magnetism of an isolated mesoscopic ring.

1. 1D Aharonov Bohm ring: persistent current in a ballistic 1D ring, effect of disorder
2. Beyond 1D: diffusive regime, sign of persistent currents and ensemble average
3. Experiments

III. Response of a mesoscopic ring to an electromotive force: conductance without reservoirs.

1. Bloch Oscillations: role of inelastic scattering
2. Linear response to a time dependent flux
3. Conductance and electromagnetic absorption
4. Experiments

IV. Weak Localisation

1. Quantum corrections after averaging on disorder: weak localisation and coherent back scattering
2. Dimensionality effects
3. Ensemble averaged Aharonov Bohm oscillations, Sharvin and Sharvin experiment
4. Spin Orbit scattering
Part II (T. Kontos)

I. Introduction to electrical transport through an artificial atom

1. Artificial quantum systems and the mesoscopic scale
2. Nanofabrication techniques
3. Examples of quantum dots: energy scales

II. Electrical transport through a single energy level

1. How to treat sequential tunneling: master equation, a heuristic derivation
2. Derivation using the density matrix theory approach
3. Coulomb blockade and Coulomb oscillations
4. Coulomb diamonds and how to measure them.

III. Role of the electronic spin

1. Fundamental mechanisms for coupling the electronic spin and electrical transport
2. A hybrid structure: a quantum dot attached to ferromagnetic contacts
3. Selection rules for electrical transport: the spin blockade

IV. Introduction to the Kondo effect in quantum dots

1. Beyond sequential tunneling
2. The unitary limit
3. The Kondo effect in magnetic alloys versus the Kondo effect in quantum dots.

Bibliography

- [Datta 97] Supriyo Datta Electronic Transport in mesoscopic systems Cambridge (1997)

Lecture notes and slides of previous years (mostly in French):
http://www.equipes.lps.u-psud.fr/spm/spip.php?rubrique4