TFY4340 Mesoscopic Physics
Spring 2010

Updated: May 7, 2010.

Brief course summary.

- 11.01: First meeting with (some of) the students.
- 12.01: Introduction. Covered by Chapter 1 in Heinzel or Datta.
- 19.01, 25.01, 26.01, 01.02: Solid State Physics update, including the band structure of graphene. Partly covered by Chapter 2 in Heinzel, and most introductory textbooks on Solid State Physics.
- 08.02, 15.02: Surfaces, Interfaces. Covered by Chapter 3 in Heinzel.
- 22.02, 01.03: 2DEG in GaAs/AlGaAs HEMT. Covered by Chapter 3 in Heinzel.
- 01.03: Transport theory. Drude model. Boltzmann equation. Chapter 2 in Heinzel.
- 08.03: Einstein relations. Landauer formula. Chapter 7 in Heinzel, Chapter 2 in Datta.
- 15.03: Quantized conductance. (Heinzel Ch 7, Datta Ch 2) Magnetotransport. (Heinzel Ch 6, Datta Ch 1)
- 22.03: Büttiker–Landauer formalism. (Heinzel Ch 7, Datta Ch 2) Quantum Hall Effect, Edge states, Shubnikov de Haas oscillations. (Heinzel Ch 6, Datta Ch 4)
- 12.04: Quantum Interference Effects: Aharonov–Bohm effect, Weak localization, Universal conductance fluctuations. (Heinzel Ch 8, Datta Ch 3+5)
- 19.04: Single Electron Tunneling, Single electron transistor. (Heinzel Ch 9, Datta Ch 6)
- 26.04: Spintronics. Tunneling magnetoresistance (TMR), Giant magnetoresistance (GMR). (Heinzel Ch 12). (Spintronics will not be a topic on the exam in 2010.)

Exercises.

- Exercise 1, 25.01: Crystal structure. Reciprocal lattice. Brillouin zone. Density of states.
- Exercise 2, 02.02: Band structure. Tight–binding model. Graphene. 2D and 3D plotting with Matlab. *Paper*: P. R. Wallace, *Phys Rev* **71**, 622 (1947).
- Exercise 3, 09.02: Effective mass. Properties of graphene.
- Exercise 4, 16.02: Surface states.
- Exercise 5, 23.02: Linear potential at AlGaAs–GaAs interface. Variational and numerical approach to the Schrödinger equation. (Matlab.)
- Exercise 6, 02.03: Boltzmann equation vs Drude model.
- Exercise 7, 16.03: 2DEG in uniform magnetic field and harmonic confining potential. Landau levels.
- Exercise 8, 13.04: 4–terminal device. Büttiker–Landauer formalism. Onsager symmetry relations. Hall resistance.
- Exercise 9, 20.04: 4–terminal device with narrow constriction. Edge states. Longitudinal resistance. *Paper*: H. van Houten et al, *Phys Rev B* **37**, 8534 (1988).
- Exercise 10, 20.04: Single electron transistor.

Other relevant papers.

- B. J. van Wees et al, *Phys Rev Lett* **60**, 848 (1988).
- D. A. Wharam et al, *J Phys C* **21**, L209 (1988).
- K. von Klitzing et al, *Phys Rev Lett* **45**, 494 (1980).
- Chambers, *Phys Rev Lett* **5**, 3 (1960).
- Tonomura et al, *Phys Rev Lett* **48**, 1443 (1982).
- Webb et al, *Phys Rev Lett* **54**, 2696 (1985).
- Timp et al, *Phys Rev Lett* **58**, 2814 (1987).
- McCann et al, *Phys Rev Lett* **97**, 146805 (2006).
- Gorbachev et al, *Phys Rev Lett* **98**, 176805 (2007).
- Skocpol et al, *Phys Rev Lett* **56**, 2865 (1986).
- P. A. Lee, *Physica* **140A**, 169 (1986).
- Thornton et al, *Phys Rev B* **36**, 4514 (1987).
- Giæver and Zeller, *Phys Rev Lett* **20**, 1504 (1968).

Department of physics, May 7, 2010.
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