Departement Physik, Universität Basel
Prof. C. Bruder (Zimmer 4.2, Tel.: 267-3692, Christoph.Bruder@unibas.ch)
PD Dr. Thomas L. Schmidt (Zimmer 4.10, Thomas.Schmidt@unibas.ch)

Theoretical Solid-State Physics, Herbstsemester 2014

I. Introduction
I.1 Electrons in periodic potentials
I.2 Second quantization and lattice models

II. Green's functions
II.1 Time evolution in quantum mechanics
II.2 Single-particle Green's function
II.3 Wick's theorem and Feynman diagrams
II.4 Linear response theory
II.5 Imaginary-time Green's functions
II.6 Self energies and the Dyson equation

III. The electron gas
III.1 The Jellium model
III.2 Non-interacting electrons
III.3 first-order perturbation theory in the electron-electron interaction
III.4 Failure of second-order perturbation theory
III.5 Wigner crystal
III.6 Polarizability and Random-Phase Approximation (RPA)

IV. Phonons, electron-phonon interaction
IV.1 Hamiltonian for electrons and nuclei
IV.2 Optical and acoustic phonons
IV.3 Quantum-mechanical theory
IV.4 Electron-phonon interaction

V. Superconductivity
V.1 Phenomenology of superconductivity
V.2 Cooper pairs
V.3 The Bardeen-Cooper-Schrieffer (BCS) theory

VI. Broken symmetry and collective properties
VI.1 Broken symmetry
VI.2 Goldstone modes

VII. The quantum Hall effect
VII.1 Landau levels
VII.2 Quantized Hall conductance
VII.3 Landau levels in graphene

VIII. Strongly correlated systems
VIII.1 Fermi liquid theory
VIII.2 The Hubbard model
VIII.3 The atomic limit $t/U \to 0$
VIII.4 Ferromagnetic and antiferromagnetic order; low-energy excitations

“The behavior of large and complex aggregations of elementary particles, it turns out, is not to be understood in terms of a simple extrapolation of the properties of a few particles. Instead, at each level of complexity entirely new properties appear, and the understanding of the new behaviors requires research which I think is as fundamental in its nature as any other.”
P. W. Anderson, *More is Different*, Science **177**, 393 (1972).

“Can properties emerge from a more complex system which are not present in the simpler substrate from which the complex system is formed?
The theory of broken symmetry gives an unequivocal ‘yes’ answer to this question: In equilibrium systems containing large number of atoms, new properties – such as rigidity or superconductivity – and new entities or structures – such as quantized vortex lines – can emerge which are not just nonexistent but meaningless on the atomic level.”
P.W. Anderson and D.L. Stein, in *Basic notions of condensed matter physics* (Addison-Wesley, Reading, 1984)