Physics MSc of FNS BME
2. semester

THEORY OF MAGNETISM (5 credits)
lecturer: Attila Virosztek

1. **Landau levels in magnetic field**
   Energy eigenvalues of a free electron in magnetic field, Bohr quantization of the quasiclassical orbit, flux quantum, origin of the magnetic oscillations, basics of the quantum Hall effect. (12.1, 12.2.1, lecture notes)

2. **Magnetism of extended electron states**
   Basic notions of magnetism, its quantum mechanical origin, magnetism of conduction electrons, Pauli and Landau susceptibilities. (lecture notes)

3. **Magnetism of atoms and ions**
   Formation of localized magnetic moments, Hund's rules, Curie, Van-Vleck and Larmor susceptibilities. (2.1.1, 2.3.2, 2.4.1, 2.4.2)

4. **Magnetite**
   Filling of the electron shells of iron in its various oxides, magnetic and crystal structure of magnetite as an ionic crystal, possibility of electron movement, charge and spin states, charge ordering. (1.3)

5. **Direct exchange**
   Two electrons in atomic potential on orthogonal orbits, Coulomb and exchange integral, singlet-triplet splitting, 1. Hund's rule, exchange Hamiltonian. (2.2)

6. **Kinetic exchange**
   Non orthogonal orbits, two center problem, Heitler-London approximation, ionized configurations, on-site interaction and hopping integral, effective Hamiltonian of kinetic exchange, comparison of the Heitler-London scheme and the molecular orbit method. (2.5)

7. **Mott transition**
   Metals and insulators, band insulators and Mott insulators, introduction of the Hubbard model, the simplest description of the Mott transition. Atomic limit, Hubbard subbands, Mott-Hubbard transition, ground state phase diagram. (4.1, 4.4.2, 4.7, 4.7.1, 4.8)

8. **Mott insulators**
   The half filled Hubbard model in the limit of large U, spin operators, derivation of the antiferromagnetic Heisenberg model by canonical transformation. (5.1, lecture notes)

9. **Mean field theory of magnetic ordering**
   Ferromagnetism, antiferromagnetism, ferrimagnetism, susceptibilities above the critical temperature. (lecture notes)

10. **The ferromagnetic Heisenberg model**
    Spin wave theory, Holstein-Primakoff transformation, thermal properties. (6.1)

11. **The antiferromagnetic Heisenberg model**
    Ground state and excitation spectrum, spin waves, thermal properties. (6.2)

Literature:

Patrik Fazekas: Lecture Notes on Electron Correlation and Magnetism (World Scientific, Singapore, 1999). The numbers at the end of the above topics refer to the relevant chapters of this book.

Prerequisits: Solid state physics, Statistical physics
Requirement for signature: Attendance of the lectures.
Grade: Based on oral exam.