

## Lecture “ Magnetism on the nanoscale“ in fall / winter 2011/2012

This aim of this lecture is to give an insight into the exiting research in the field of magnetism and magnetic materials. We will start with an introduction in the basics of magnetism and magnetic materials. This basic knowledge will be used to learn something about important up-to-date measurement techniques, to learn something about magnetic materials which are in the focus of nowadays research and about applications of magnetic materials e.g. in spintronic devices.

### 1. Introduction

- 1.1. Magnetism in nature
- 1.2. Magnetism in history
- 1.3. Magnetic elements
- 1.4. Basic definitions
- 1.5. Generation of magnetic fields - Electromagnetic coils
- 1.6. How to measure magnetic properties?

### 2. Isolated magnetic moments

- 2.1. Matter in magnetic field
- 2.2. Magnetic susceptibility
- 2.3. Diamagnetism
- 2.4. Paramagnetism
- 2.5. Curie law
- 2.6. Magnetic ground states and Hund's rules
- 2.7. Nuclear spins and hyperfine interaction  
Nuclear magnetic resonance (NMR), Mößbauer spectroscopy

### 3. Magnetic interaction

- 3.1. Dipolar interaction
- 3.2. Exchange interaction
- 3.3. Superexchange
- 3.4. Double exchange (Zener)
- 3.5. Colossal magneto-resistance (CMR)

### 4. Magnetic order

- 4.1. Ferromagnetism
- 4.2. Antiferromagnetism
- 4.3. Ferrimagnetism
- 4.4. Hard- and soft magnetic materials
- 4.5. Magnetic domains
- 4.6. How to measure magnetic order  
X-ray absorption spectroscopy (XAS),  $\mu$ SR, Kerr microscopy (MOKE), AFM/MFM

### 5. Spin dependent transport and magneto-resistive effects

- 5.1. Magnetoresistance
- 5.2. Anisotropic magnetoresistance (AMR)
- 5.3. Giant magneto-resistance (GMR)
- 5.4. Tunneling magneto-resistance
- 5.5. Powder magneto-resistance
- 5.6. Exchange bias
- 5.7. Magnetic data storage

### 6. Magnetic materials with respect to state-of-the-art research

- 6.1. Molecular Magnetism
- 6.2. Magnetic oxides (e.g. perovskites)
- 6.3. Materials with 3d electrons (e.g. Heusler compounds)
- 6.4. Magnets with 4f electrons

### 7. Labtour