Fundamentals of Magnetic Resonance

<table>
<thead>
<tr>
<th>Code No.</th>
<th>Workload</th>
<th>Credit points</th>
<th>Available in semester</th>
<th>Frequency each SuS</th>
<th>Course duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module 12</td>
<td>150 h</td>
<td>5 CP</td>
<td>2</td>
<td></td>
<td>1 semester</td>
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</tbody>
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1. **Teaching Methods**
   - a) Lectures
   - b) Exercises

2. **Hours per week**
   - a) 2 h
   - b) 1 h

3. **Contact time**
   - 45 h

4. **Self-study**
   - 105 h

2. **Learning objectives**
   At the end of the course, students will be able explain the theoretical foundations of nuclear magnetic resonance (NMR) and electron paramagnetic resonance (EPR) spectroscopy. They will understand the general classical description of the magnetic resonance phenomena with Bloch equations, as well as the quantum description of the spin system. They will be able to understand the different parts of the spin Hamiltonian, the time-dependent Schroedinger equation, and the spin density operators. With the Liouville von Neumann equation and the product operator formalism they will be able to calculate the effects of simple pulsed NMR and EPR sequences on the initial density operator.

3. **Soft skills: methodological, self, social competences**
   - Structure, summarize, and revise principal lecture contents, identify and consult relevant literature
   - Develop study strategies, independently assess their effectiveness, and optimize them as needed
   - Learn and work cooperatively, work in teams to overcome scientific challenges

4. **Prerequisite(s)**
   - Admission to the Master Course Program, basics of quantum mechanics, physics.

5. **Evaluation of the learning process**
   - Active participation during lectures, exercises corrected by teaching assistants, hands-on lab experience during exercise hours.

6. **Mode of examination**
   - 45 minutes end-of-term oral examination

7. **Requirements for acquiring credit points**
   - Passing the oral examination

8. **Significance for overall grade**
   - Weighted according to CPs

9. **Module contents**
   - Classic description of the magnetization, Bloch equations in the lab and rotating frames.
   - ON-OFF resonance pulses. NMR spectra, classical experiments.
   - Steady state solution of Bloch equations. Continuous wave (CW) techniques. Scheme of a CW spectrometer.
   - Chemical exchange: McConnell equations.
   - Spin Hamiltonian. Zeeman term.
   - Interaction frame representation.
   - Hyperfine interaction.
   - J coupling. Dipolar coupling.
   - Product operator formalism. Application to some EPR/NMR sequences.

10. **Person in charge / Lecturer(s)**
    - Prof. Dr. Bordignon