Module NMR Spectroscopy and Imaging Methods

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<tr>
<th>Code</th>
<th>72557</th>
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<tbody>
<tr>
<td>Instruction language</td>
<td>English</td>
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<tr>
<td>ECTS credits</td>
<td>6</td>
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<td>Credit hours</td>
<td>6</td>
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<tr>
<td>Duration</td>
<td>1 semester</td>
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<td>Cycle</td>
<td>Each winter semester</td>
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<tr>
<td>Coordinator</td>
<td>Dean of Physics Studies</td>
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<tr>
<td>Lecturer</td>
<td>Prof. Volker Rasche, Prof. Fedor Jelezko</td>
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<td>Allocation to study programmes</td>
<td>Physics M.Sc., elective module, 1st or 2nd semester</td>
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<td>Wirtschaftsphysik M.Sc., elective module, 1st - 3rd semester</td>
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<tr>
<td>Formal prerequisites</td>
<td>None</td>
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<td>Recommended prerequisites</td>
<td>None</td>
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Learning objectives
Students who successfully passed this module:
- know the basic concepts of imaging techniques in medicine and various system architectures
- understand the application of various imaging methods
- understand the fundamentals of magnetic resonance spectroscopy
- are able to handle a magnetic resonance tomography

Syllabus

Imaging methods
The lecture deals with the basic principles of imaging techniques currently used in medicine. Imaging techniques in medicine allow generating image-based information about the anatomy and function of the human body. The methods involved are based on different physical principles such as:
- X-rays (X-classical and computer based tomography (CT)),
- Nuclear Magnetic Resonance imaging (MRI),
- Ultrasound (ultrasound and echocardiography),
- Positron Emission Tomography (PET),
- Single Photon Emission Computed Tomography (SPECT).

The lecture will be divided into four blocks. Each block deals with different physical principles and relative system architecture, advantages and disadvantages of the methods involved as well as their main fields of application in medicine.

Physical principles of magnetic resonance spectroscopy
- Introduction to NMR: QM description of spins, spin operators, density matrix
- Semi-classical description, Bloch equations
- Lineshape of NMR signal
- Spin echoes
- Theory of relaxation: coherence times (T2 and T1), extreme narrowing regime, intensity of NMR signal
Electronic shielding, chemical shift
Spin-Spin coupling, J coupling
Dipolar interactions, averaging by molecular motion
Magic angle spinning
Polarization transfer in NMR: nuclear Overhauser effect, Solomon equations, Hartmann-Hahn resonance, solid effect, optical hyperpolarization
Two dimensional NMR, COSY experiment
New detection methods for NMR: Magnetic resonance force microscopy (MRFM), NV centres in diamond

Practical course

Project work

Literature
- Arnulf Oppelt (Ed), Imaging Systems for Medical Diagnostics, (2005), ISBN: 3895782262

Teaching and learning methods
- Imaging methods in medical technology (lecture, 2 hours per week)
- Physical principles of NMR (lecture and exercise, 2 hours per week)
- Practical course (3 hours per week)
- Project work

Workload
- 45 hours lecture (attendance time)
- 15 hours exercise (attendance time)
- 45 hours practical course
- 30 hours project work
- 45 hours self-study
- Total: 180 hours

Assessment
A prerequisite for the participation in the examination is an ungraded course achievement, which is determined and notified by the lecturer at the beginning of the course. The examination is a graded project work.

Examination
- 13831 NMR Spectroscopy and Imaging Methods
- 13832 NMR Spectroscopy and Imaging Methods (precourse)

Grading procedure
The module grade is the examination grade.

Basis for Research in the fields of Biophysics, condensed matter, quantum optics and medical techniques