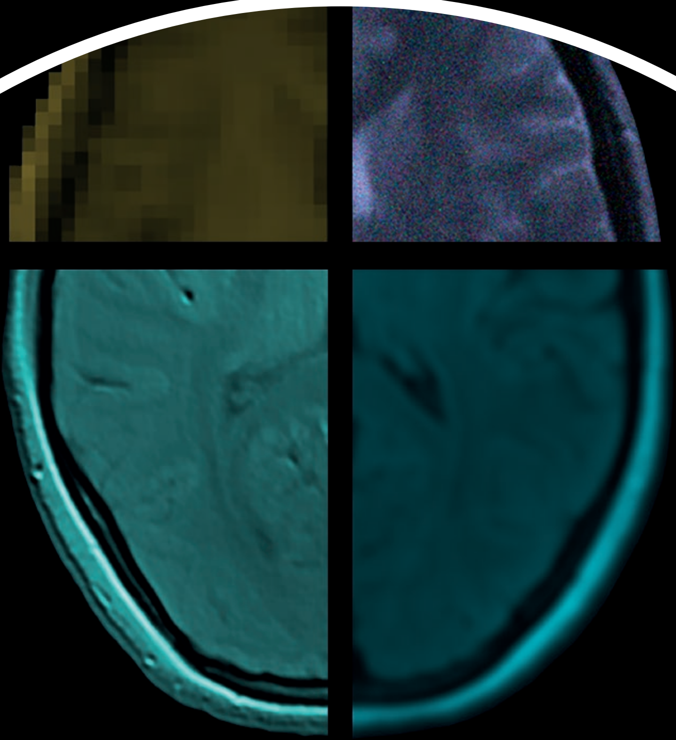
ESMRMB

European Society for Magnetic Resonance in Medicine and Biology



Lectures on MR 2017

Educational courses, exercises, and practical demonstrations on MR physics and engineering

RF simulation for MR systems: Coil design and safety
February 22–24, Utrecht/NL

RF-Coils: Design and build your own
June 20–22, L'Aquila/IT

Measurement of perfusion and capillary exchange
June 21–23, Bremen/DE

MRI simulation for sequence development, protocol optimisation and education
June 28–30, Eindhoven/NL

Parallel imaging: Basic and advanced reconstruction concepts
July 20–22, Göttingen/DE

Small animal MR imaging
October 17–18, Barcelona/ES

Susceptibility weighted imaging and quantitative susceptibility mapping
November 6–8, Graz/AT

www.esmrmb.org

ESMRMB 2017
OCT. 19 – OCT. 21
BARCELONA / ES

ESMRMB
European Society for Magnetic Resonance in Medicine and Biology

34TH ANNUAL SCIENTIFIC MEETING

The European Forum for MR research
and clinical practice
www.esmrmb.org

Content

ESMRMB
European Society for Magnetic Resonance in Medicine and Biology

Join the European Forum for MR Research and Clinical Practice

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ESMRMB Office: Neutorgasse 9, AT-1010 Vienna
www.esmrmb.org

More information at www.esmrmb.org

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General Information and Registration

Course Information

- All courses are held in the English language.
- The duration of the courses is 2 to 3 days.
- A detailed programme of each course and the exact time schedule is available on the ESMRMB website.
- About 40% of the total teaching time is used for repetitions, exercises and practical demonstrations to practice and intensify the learning experience.
- A maximum of 50 places per course are available (except for the RF simulation course in Utrecht/NL, which is limited to 30, and the RF coils course in L'Aquila/IT, which is limited to 20). Early registration is recommended.
- If less than 20 participants register, the ESMRMB reserves the right to cancel a course at the latest 4 weeks prior to its beginning.
- The ESMRMB ensures the evaluation and certification of all courses, and guarantees didactically and scientifically experienced teachers.

Registration

To register for your desired course(s), please visit our website at **www.esmrmb.org**.

Please note that your registration becomes valid only after payment is received and confirmed by the ESMRMB Office. The confirmation will be available for download in the online 'MyUserArea'.

Information on registration fees and our cancellation policy can be found online at www.esmrmb.org.

Sponsoring

The Lectures on MR programme 2017 is kindly supported by

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Cover Image:
Research Center Magnetic Resonance Bavaria (MRB)

Scientific images kindly provided by the organisation committee 2017

Goals of the Courses

With the **Lectures on Magnetic Resonance** the ESMRMB continues to offer new teaching courses that are especially designed to provide the physical fundamentals of MR imaging, diffusion, perfusion, spectroscopy and RF engineering, as well as aspects of applications of these techniques in clinical and biochemical research and development. The ESMRMB and its Education and Workshop Committee is convinced that there is a strong need and demand to provide these kinds of courses that are geared to the needs of MR physicists and other basic scientists working in a clinical or research environment.

The course **RF simulation for MR systems: Coil design and safety** is designed to give an in-depth introduction to the numerical computation of radio-frequency (RF) fields in magnetic resonance (MR) systems with the main focus on the application to RF coil design and patient RF safety. The course programme includes modules with theoretical lectures, practical exercises as well as hands-on training on commercial simulation platforms. The goal of the course is to enable the participants to solve typical MR-related field problems with suitable numerical models and to implement post-processing procedures to characterise multi-channel RF coils and to assess the RF exposure of patients/volunteers.

This course will focus on
- Commonly used numerical methods (e.g. FDTD/FIT, FEM)
- Characteristics of the solution in the time and frequency domain
- Basics of electromagnetic theory
- Basic RF engineering principles
- Practical simulation aspects
- Interpretation of numerical results
- Validation methods for numerical results
- Implementation of post-processing procedures for coil characterisation
- Numerical assessment of the RF exposure of the human body
- Learning through practical exercises with application of different numerical methods to fundamental MR-related problems

The course on **RF coils: Design and build your own** provides an overview of the basic principles of designing, constructing and testing of RF coils for both animal and human scanners. Practical sessions will cover approximately 50% of the course, in which participants will learn to build surface and volume RF coils relevant to their particular interests. Characterization of RF coils including S-parameters, Q-measurements and optimization, B_1 calibration and mapping, measurement of E field and assessment of parallel imaging performance will be also part of the course. The course is designed for basic scientists and engineers but also has been attended in the past by clinicians, radiographers, applications specialists and other MR users interested in gaining a better insight into RF coil technology.

This course will enable you to
- Understand the behaviour of circuit elements used to construct RF coils
- Understand the concepts of resonant circuits, quality factor and the effects of sample loading
- Design impedance matching networks
- Construct baluns and cable traps
- Get first-hand experience with test equipment used in RF coil design
- Design and build a single-tuned surface RF coil
- Understand the theory of volume resonators
- Design a single-tuned birdcage RF coil
- Understand the effect of RF shields
- Understand the different designs for multiple-tuned RF probes
- See the principles of software packages for RF simulations

The course on **Measurement of perfusion and capillary exchange** provides an overview of modern technologies for perfusion imaging with a focus on MRI modalities. The variety of methods that have been developed in the past is presented and analysed critically. The course is aimed at providing the participants with criteria for deliberate selection of methods in their studies. The in-depth analysis is based on the underlying physics of perfusion encoding, the theory of contrast agent effects on the MR signal and the mathematics of data processing. The course will provide practical tips and tricks for your next perfusion studies.

The course will include lectures on
- Relevant basics of physiology and vascular anatomy
- Theoretical Aspects of ASL, DSC and DCE
- Tracer kinetics, quantification, pharmacokinetic modelling, compartment modelling
- Basic principles of arterial spin labelling (ASL)
- Advanced ASL techniques
- Dynamic susceptibility contrast perfusion imaging (DSC-MRI)
- Dynamic contrast enhanced MRI (DCE-MRI)
- Advanced contrast-based techniques (e.g. multi-echo)

The course **MRI simulation for sequence development, protocol optimisation and education** provides insight into practical implementation of MRI computer simulations. It covers the theory of classical MR physics based on the Bloch equations and the necessary steps to simulate and visualize basic MR phenomena as well as basic and advanced imaging sequences. Model-based simulations are helpful for the basic understanding and education of MR physics, and are necessary for MRI method development and sequence design. The lectures introduce the most important aspects, physical models and computational techniques in order to simulate realistic MR experiments. Special emphasis is given to pictorial design and hands-on-the-keyboard lectures, enabling the attendees to use MR simulations in future research projects.

This course will focus on
- Theory of classical MR: Applicability and limitations of the physical models
- Computer simulation of classical NMR and MRI experiments
- MR simulations as an educational tool and for visualisation
- Design and simulation of basic and advanced sequences
- Simulation pitfalls: avoiding beginners mistakes and the generation of "simulation artifacts"
- Simulation of MRI contrasts and artifacts related to basic physics, off-resonance effects, motion, diffusion and flow
- MR simulations in research: Protocol optimisation, pulse design, model verification
- Interfaces to feed simulated MR signals into existing image reconstruction libraries
- Methods to generate ground-truth in silico MR phantoms for image analysis and post-processing
- Differences between simulations and real life

The course on **Parallel imaging: Basic and advanced reconstruction concepts** is designed to provide a firm conceptual and practical foundation. Attendees will be brought up to date with established techniques and will develop an appreciation of emerging technologies and methods in multi-channel MRI. The three-day course will rely heavily on interactive tutorials using the MATLAB/Python programming environment. Computers and licenses will be provided for the length of the course. At the end of the course, attendees will understand the basic principles and practical implementation of Cartesian and non-Cartesian parallel imaging methods, spatio-temporal undersampling methods and Compressed Sensing. Attendees will also appreciate the role of these methods in established research practice and how such methods may develop and influence MRI research and practise in the future.

This course will focus on
- Image domain pMRI – reconstruction methods
- k-space pMRI – reconstruction methods
- Artifacts & pitfalls in parallel imaging
- Coils and calibration – practical implementation
- Iterative methods & non-Cartesian reconstruction
- Advanced parallel imaging strategies
- Spatio-temporal undersampling and reconstruction
- Compressed Sensing (CS)
- Future directions in multi-channel MRI

Goals of the Courses

The course on **Small animal MR imaging** will address basic technical and practical aspects of MRI with emphasis on demands for small animal application. The lectures will provide basic knowledge about the major aspects of appropriate animal handling, anaesthesia and of monitoring and maintaining a stable physiological state during imaging. Specifically, sensitivity issues and the impact of physiological motion will be addressed. Different strategies to deal with respiratory and heart motion will be introduced. The course will introduce requirements and methods of small animal MR spectroscopy and give an overview of preclinical applications of MRS. MR methods for neuroimaging and functional MRI will be introduced in detail and novel approaches such as optogenetic fMRI will be discussed in detail.

This course will emphasize
- Small animal physiology, gating techniques, tissue processing and preparation
- Basic principles and methods of MRS
- Introduction of advanced neuroimaging MR methods such as BOLD, MEMRI, DWI and DTI
- General overview of preclinical MR applications
- Introduction of optogenetic fMRI and multimodal functional neuroimaging

Progress in **Susceptibility weighted imaging and quantitative mapping** has opened a new window into tissue composition and microstructure. The aim of this 3-day course is to teach participants the fundamentals of this fast growing field. The course will cover the physical basics of magnetic susceptibility, susceptibility weighted pulse sequences, and reconstruction methods to produce qualitative and quantitative susceptibility maps. A special emphasis will also be put on clinical and preclinical applications. This course is dedicated to MR physicists, basic scientists and clinicians who already have a basic background in MRI.

The course will cover
- Theory of magnetic susceptibility
- Formation of bulk susceptibility in biological tissues
- Pulse sequences and implementation issues
- Methods for phase processing and background field removal
- Strategies for solving inverse problems
- Validation of biophysical contributors to magnetic susceptibility
- Clinical and preclinical applications

Educational Levels

The **Lectures on Magnetic Resonance** are geared towards MR physicists and other basic or clinical scientists. The Lectures are certified by the **European Federation of Organisations for Medical Physics (EFOMP).**

RF simulation for MR systems: Coil design and safety

The course is intended for MR physicists, engineers, other scientists and PhD students who either wish to start working in the field of RF coil development and/or RF exposure or who already have basic to intermediate experience in RF simulation.

RF coils: Design and build your own

This course is intended for scientists and engineers who have a basic knowledge of mathematics and simple electrical circuits. Attendees should have a working knowledge of magnetic resonance basics.

Measurement of perfusion and capillary exchange

This course is intended for MR physicists, other scientists and PhD students who already have experience in basic MR methods and knowledge of MR acquisition principles, and who want to get a deeper insight into perfusion imaging and underlying physiological processes and physics.

MRI simulation for sequence development, protocol optimisation and education

This course in intended for MR physicists and scientists with basic knowledge of classical MRI spin physics and sequence design who are interested in improving their knowledge on computer-based modeling of MRI. Attendees should have a working knowledge in Matlab, Python and/or C/C++ in order to work through the hands-on tutorials.

Parallel imaging: Basic and advanced reconstruction concepts

This course is intended for MR physicists, other scientists and PhD students who already have experience in basic MR methods and knowledge of MR acquisition principles, and who wish to extend their knowledge on Parallel imaging principles and techniques. Some knowledge of MATLAB/ Python will be advantageous. All tutorials will be based around pre-existing code prepared for this course. Attendees must have some programming experience and be willing to work with MATLAB/Python.
This course runs from introductory to advanced methods over the three days. At the end of these three days, attendees will take with them the programme code that has been provided and developed by them. This code, in combination with notes taken at the course, will form a package that will enable attendees to implement all the methods discussed during the course.

Small animal MR imaging

The course is intended for scientists and students with a strong interest in small animal imaging. A background in MRI is helpful but not mandatory. The lectures will focus on applications and practical issues. The major aim of the course is to detail the particular requirements for small animal MRI and MRS, including maintaining stable physiological conditions and advanced MRI and MRS techniques for preclinical imaging. The course will further introduce multimodal neuroimaging including optogenentics.

Susceptibility weighted imaging and quantitative mapping

This course is intended for MR physicists, basic scientists and clinicians who have a working knowledge of magnetic resonance basics and who wish to expand their knowledge of qualitative and quantitative susceptibility mapping. To improve students' understanding of susceptibility mapping related problems, specific examinations will be done with MATLAB. The status quo and challenges for clinical applications will be discussed. This course also includes an excursion to a SQUID magnetometer.

RF simulation for MR systems: Coil design and safety

February 22–24, 2017
University Medical Center Utrecht/NL

Course organisers:

Alexander Raaijmakers
University Medical Center Utrecht/NL

Andreas Bitz
German Cancer Research Center (DKFZ)
Heidelberg/DE

Local organiser:

Alexander Raaijmakers
University Medical Center Utrecht/NL

Preliminary faculty:

A. Bitz, C. Collins, O. Kraff, S. Orzada, A. Raaijmakers, J. Tokaya, N. van den Berg

This course is limited to 30 participants!

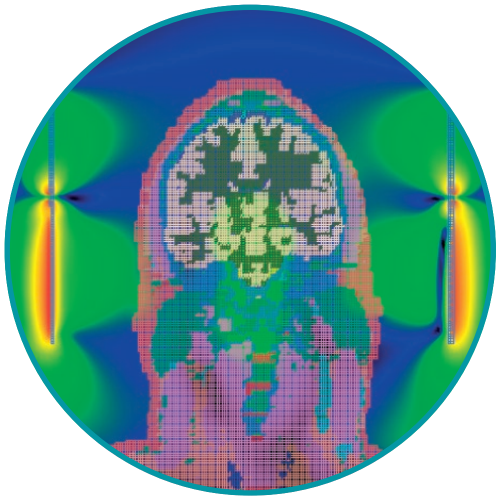
Course description

The aim of the course is to give an in-depth introduction to the numerical computation of radio-frequency (RF) fields in magnetic resonance (MR) systems. Main focus will be the application to RF coil design and patient safety. After the course, participants will be able to solve typical MR-related field problems with suitable numerical methods and corresponding models, to interpret the calculated field distributions and to perform appropriate post-processing procedures to characterise multi-channel RF transmit coils and to assess the RF safety of patients/volunteers under consideration of common exposure scenarios.

The course is intended for MR physicists, engineers, other scientists and PhD students who either wish to start working in the field of RF coil development and/or RF exposure or who already have basic to intermediate experience in RF simulation.

The course programme includes modules with theoretical lectures, practical exercises as well as hands-on training on commercial simulation platforms. Lectures will prepare the fundamentals for successful application of numerical simulation and will start with selected topics of electromagnetic theory followed by an introduction to numerical methods. To derive appropriate numerical models and implementations of post-processing routines, lectures on RF coil design and characterisation as well as on common approaches to assess the RF exposure under consideration of current RF safety guidelines will be given. Further, methods for the validation of the calculated field distributions will be presented. During the practical exercises, the participants will apply the subject matter of the lectures individually by solving basic simulation problems in one of the two supported simulation platforms (CST Studio Suite, CST AG, Darmstadt, Germany or Sim4Life, Zurich MedTech AG, Zurich, Switzerland). Experienced staff members and representatives of the software vendors will ensure that the participants get acquainted with basic and advanced simulation skills, problem solving and the adjustment of important simulation parameters. During the course, software vendors will give an introduction to their simulation software and will present advanced application examples. For the practical exercises and hands-on training, desktop PCs will be provided for the participants.

Learning objectives

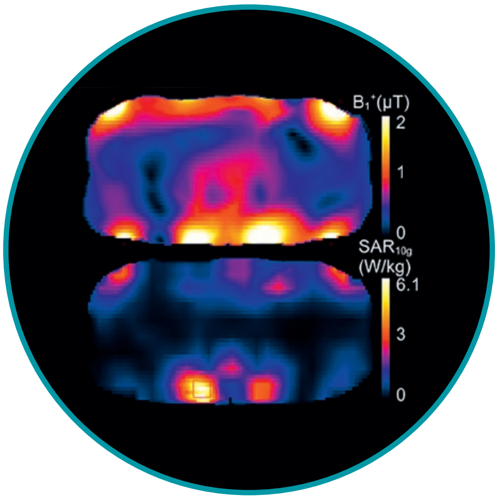


Electromagnetic theory

- Maxwell's equations
- Field characteristics
  in quasi-static and electromagnetic regimes
- Conservation of energy – power balance
- Reciprocity
- Spin excitation and signal reception (B_1^+ / B_1^-)

Numerical methods

- Discretizing Maxwell's equations
- FIT, FDTD, FEM, MoM
- Solution in time and frequency domain
- Hybrid methods



Validation methods

- B_1^+ mapping
- Thermometry
- RF field measurements
- Realistic phantom design and characterisation
- Correlating simulations and measurements

RF coil design and characterisation

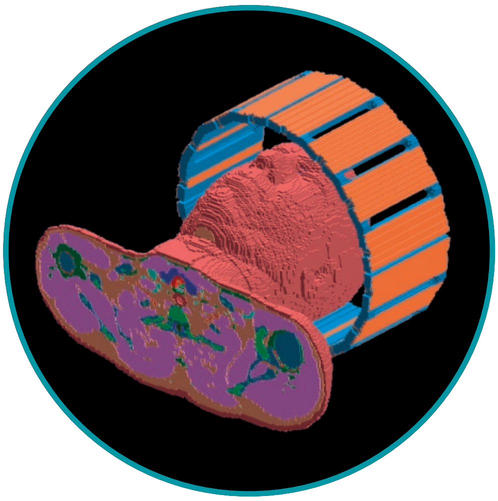
- Basic and advanced designs
  - Loop coil, dipole antenna, birdcage coil
  - Matching, tuning
- Multi-channel transmit and receive arrays
- Characterisation
  - Transmission mode: B_1+-efficiency, SAR
  - Receive mode: SNR, g-factor maps

RF safety and guidelines

- Physiological response to RF absorption
- Exposure assessment based on specific absorption rate
  and tissue temperature
- SAR determination for multi-channel transmit
- RF safety of medical devices

Exercises

- Modelling options with selected numerical methods
- Simulation of birdcage coils
- Network simulation
- RF coil arrays - Matching, tuning, decoupling
- RF coil characterisation
- Determination of RF exposure
- Thermal simulation



RF-Coils:
Design and build your own

June 20–22, 2017
University of L’Aquila/IT

Course organisers:

Marcello Alecci
Molecular Imaging Laboratory
University of L‘Aquila/IT

Andrew Webb
C.J. Gorter Center for High Field MRI
Leiden University Medical Center
Leiden/NL

Local organisers:

Marcello Alecci
Angelo Galante
Assunta Vitacolonna
University of L‘Aquila/IT

Preliminary faculty:

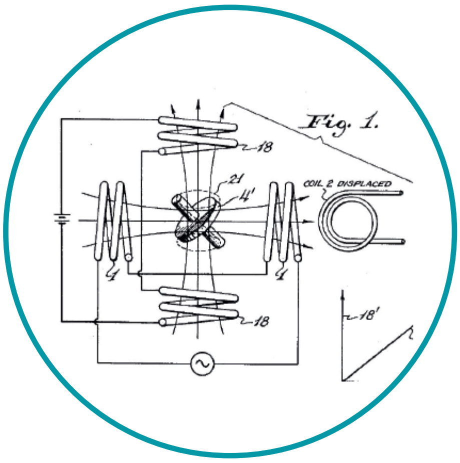
M. Alecci, N. Avdievich, A. Galante, J. Mispelter, A. Monorchio, A. Webb

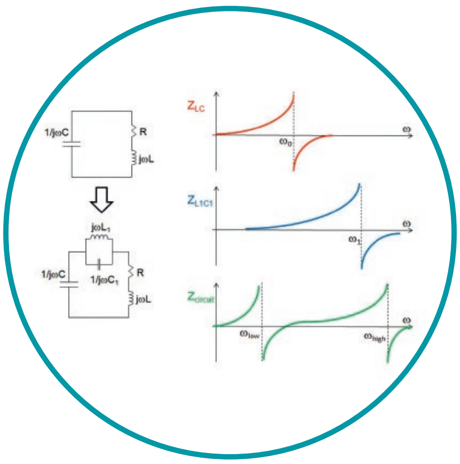
Course description

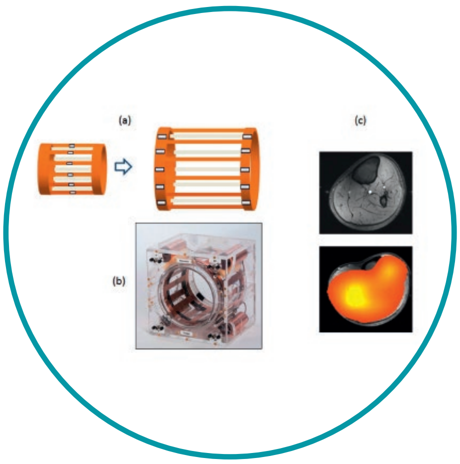
This course is designed to provide a theoretical and practical guide to RF coil design for both animal and human systems. Simple tools for electrical circuit analysis will be introduced, followed by practical design of simple geometries such as surface RF coils. The participants will then design and construct a surface RF coil with their chosen dimensions and frequency of operation. In the second stage, the design of volume birdcage RF coils will be introduced from a theoretical and practical basis. Software for modeling these coils will be discussed, and again the participants can choose which type of RF volume coil to design and construct during the practical sessions.

Finally, advanced topics such as multi-tuned surface and volume RF coils and phased arrays will be introduced, designed and tested on the workbench. Approximately 50% of the course will be spent in the laboratory and the students will be free to take away the RF coils that they have constructed and tested. A high teacher-to-student ratio ensures individual attention at all times.

Since participants will construct their own RF coil this course is limited to a maximum of 20 participants.







Learning objectives

RF circuit design

- Characteristics and use of lumped elements
- Concepts of resonant circuits
- Impedance matching for maximum power transfer
- Baluns and cable traps
- Maximizing experimental SNR by optimizing the coil quality factor
- Concepts in RF coil decoupling
- Multiple-tuned circuits

Hardware for RF testing

- Network analyzer operation
- Quality factor measurements
- Frequency generators
- Resistance bridges, inductance and capacitance meters
- Workbench characterization of RF coil performance

Simulation software

- Principles of EM simulation software packages
- B_1-homogeneity versus B_1-efficiency
- SAR considerations
- High frequency RF effects

Advanced RF coils

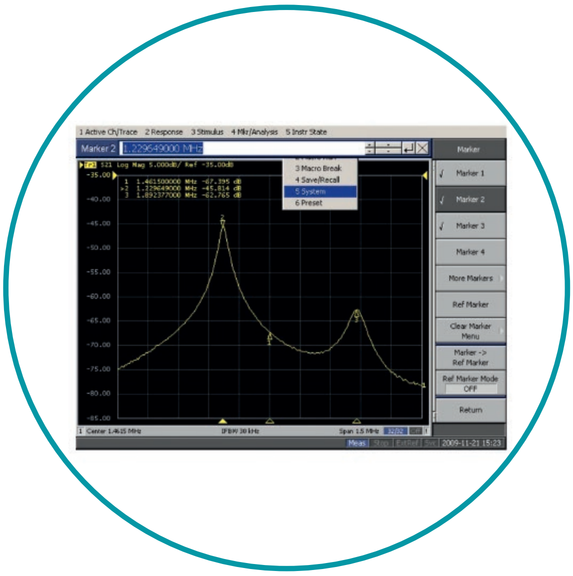
- Birdcage and TEM coils
- Phased arrays
- RF shields and eddy currents
- RF decoupling

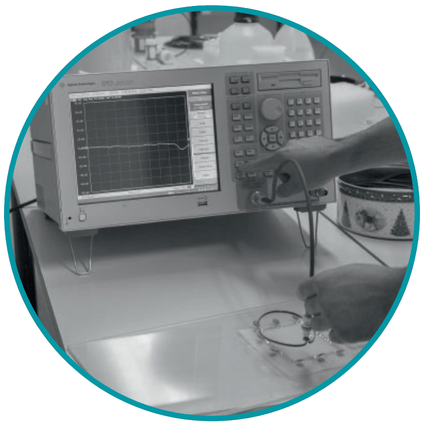
Practical design and construction

- Surface RF coil
- Birdcage volume RF coil
- Double-tuned RF surface coil
- Double-tuned RF birdcage and/or TEM coils
- Phased arrays

RF coil characterization

- Scattering parameters
- RF coil sensitivity profile
- Signal-noise ratio performance
- Parallel imaging performance
- Decoupling and noise correlation
- RF safety





Measurement of perfusion and capillary exchange

June 21–23, 2017
University of Bremen / Fraunhofer MEVIS
Bremen/DE

Course organisers:

Matthias Günther
Fraunhofer MEVIS
Bremen/DE

Steven Sourbron
Leeds Institute of Cardiovascular and Metabolic Medicine
University of Leeds/UK

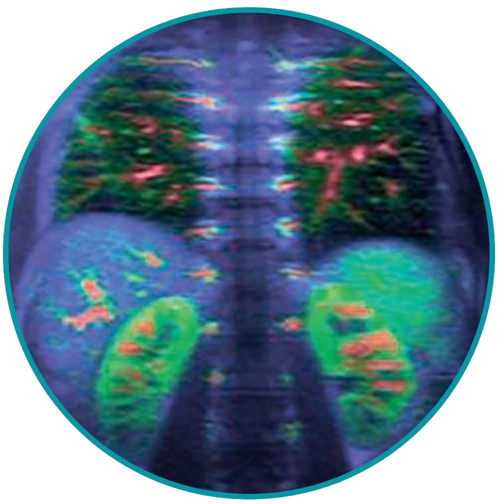
Matthias van Osch
Department of Radiology
Leiden University Medical Center
Leiden/NL

Local organiser:

Matthias Günther
Fraunhofer MEVIS
Bremen/DE

Preliminary faculty:

M. Günther, M. Jerosch-Herold, L. Ostergaard, S. Sourbron, M. van Osch, F. von Samson-Himmelstjerna



Course description

This course is designed to provide deeper insight into the biophysics of perfusion, the consequential requirements to the data acquisition and MR methodology for qualitative and quantitative data evaluation. After an overview of and introduction to the basics of physiology and the clinical role of perfusion imaging, the general theory behind perfusion quantification is explained. An overview of existing perfusion imaging techniques is given.

An introduction to arterial spin labeling (ASL) techniques and associated data processing strategies is presented, emphasizing the theory behind quantification approaches. Differences in quantification of continuous and pulsed ASL are discussed, as well as the influence of partial volume effects and prolonged transit time.

Perfusion MRI using contrast agents will concentrate on dynamic susceptibility contrast (DSC) MRI as well as dynamic contrast enhanced (DCE) MRI. The differences in tracer kinetics are explained and demonstrated. The theory of relaxation enhancement induced by the contrast agent is discussed.

As an integral part, the course will also include a substantial amount of time that will be spent on exercises, which are intended to enhance the understanding of basic and advanced topics and will be performed, e.g. by means of simulations under guidance of the lecturers.

The course is designed to provide a compact understanding and a stable foundation for scientists who intend to enhance their knowledge with respect to perfusion-weighted MR imaging or who wish to get involved with method development of perfusion measurements. This course is not focused on a particular organ, although for ASL the brain is still the organ in which it is applied most often.

Learning objectives

Physiology

- Hemodynamics and perfusion regulation
- Characteristics of tissue perfusion
- Clinical importance of perfusion-related parameters

Perfusion modelling

- Theory of perfusion and tracer-kinetics
- Assessment of perfusion using diffusible and non-diffusible tracers
- Imaging modality (SPECT, PET, CT, Ultrasound, MRI)
- Leakage of contrast agent, (extended) Tofts model, other models

Arterial spin labeling (ASL)

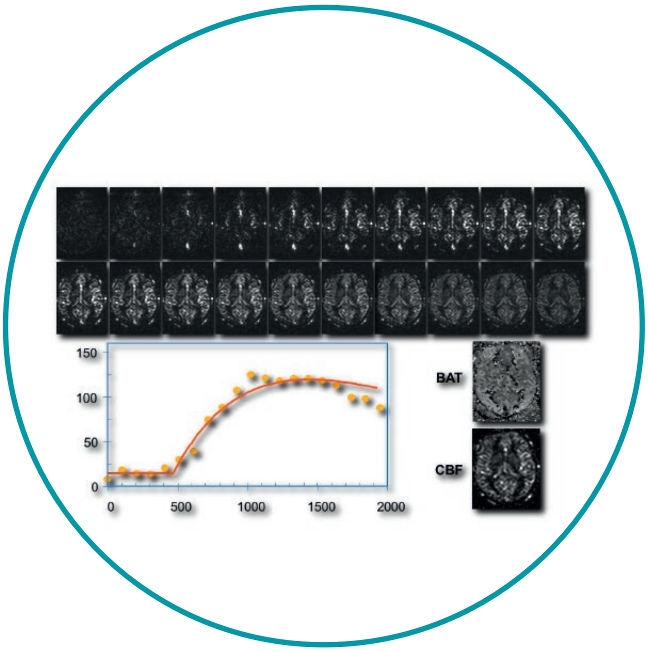
- Basic principles of ASL
- (pseudo-)Continuous versus pulsed ASL
- Implementation and labeling schemes
- Quantification, QUIPSS, transit time, multi-TI, multi-PLD, Hadamard-encoded
- Readout modules, 2D, 3D, multi-slice, background suppression

Dynamic susceptibility contrast perfusion imaging (DSC-MRI) and dynamic contrast enhanced (DCE) imaging

- Types of MR contrast agents and their kinetics in body fluids
- The effect of contrast agent on tissue relaxation: T1, T2 and T2*-relaxivity, the role of water exchange.
- Basic types of imaging sequences in DSC (GE and SE) and DCE (2D and 3D), multi-echo sequences
- DSC and DCE signal theory – relating dynamic signals to concentrations
- Specific methods for specific body areas, incl. clinical applications

Software for ASL, DSC and DCE

- Learn about the capabilities of ASL, DSC and DCE using computer simulations
- Explore dependency on imaging and physiologic parameters
- Learn to process patient data with open source tools



MRI simulation for sequence development, protocol optimisation and education

June 28–30, 2017
Eindhoven University of Technology
Eindhoven/NL

Course organiser:

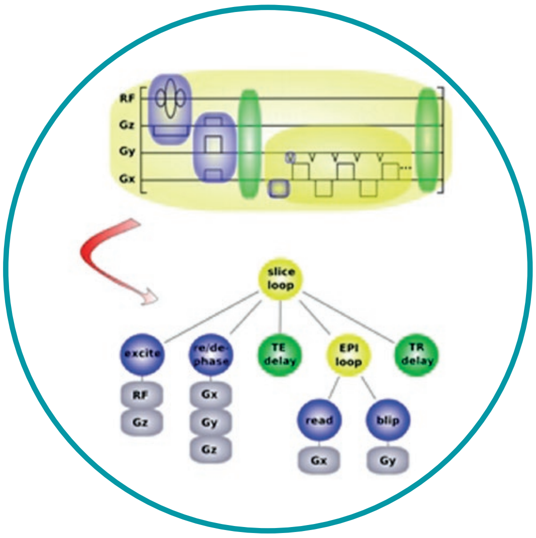
Tony Stöcker
German Center for Neurodegenerative Diseases (DZNE)
Bonn/DE

Local organiser:

Marcel Breeuwer
Medical Image Analysis Department
Faculty of Biomedical Engineering
Eindhoven University of Technology
Eindhoven/NL

Preliminary faculty:

M. Breeuwer, L. G. Hanson, D. Pflugfelder, T. Stöcker, M. Zaitsev



Course description

The course covers theory, application and practical implementation of MRI computer simulations, i.e. the simulation of spin dynamics and their coherent summation in large-scale spin systems under influence of the driving magnetic fields (RF pulses and field gradients). On the one hand, MR simulations based on the Bloch equations are of high educational value. Further, they serve as essential tools in basic MRI method development, sequence design and protocol optimization, and generating ground truth data for image reconstruction and post-processing algorithms.

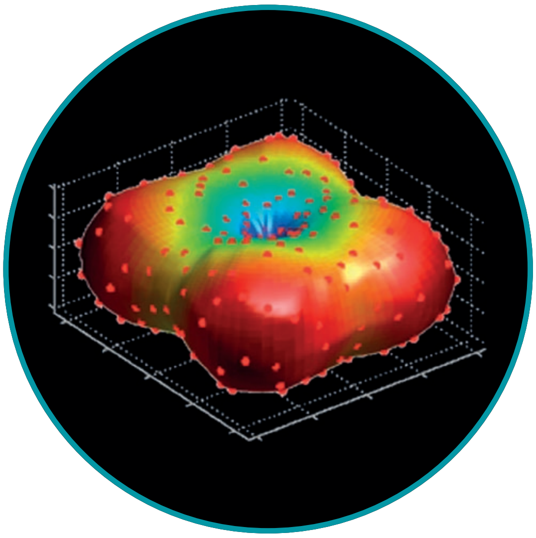
In this three-day course, the students learn the basics of NMR and MRI simulations. The underlying physical models, their field of application and limitations are discussed. Several tools will be introduced and used in accompanying hands-on sessions. The tutorials will concentrate on exercises of educational value and practical relevance in order to improve the understanding of principal effects, such as echo generation and image artifacts. The students learn to simulate basic acquisition schemes, such as gradient echo, spin echo and EPI, as well as non-Cartesian sampling. Magnetization preparation will be simulated and used to tailor measurement protocols for specific applications. By means of pictorial examples, MRI simulations are shown to serve as a valuable tool for MRI methods development and research. It is shown how image analysis and reconstruction algorithms benefit from MR simulations by knowledge of the ground truth. Finally, the differences between MR simulations and real experiments are outlined by a closer look at the hardware components of a MR scanner.

The course is aimed at post-graduate and post-doctoral MR scientists interested in learning the simulation of general NMR and MRI spin-physics and signal formation based on the Bloch Equations (excluding effects of intra-molecular interactions). A basic background in classical MR spin physics as well as computer programming is required. A working knowledge in MATLAB, Python and/or C/C++ will be helpful. Exercises will primarily be based on the JEMRIS open source MRI simulator distributed for a range of operating systems. Access to a computer cluster will be available. Students are, however, encouraged to bring their own laptop with a pre-installed MATLAB, if possible.

Learning objectives

At the end of the course the student will be able to

- Use several basic tools for classical NMR and MRI simulation
- Visualise basic MR phenomena such as excitation, resonance and relaxation
- Explain the advantages, limitations and differences of the physical models on which the MR simulation is based
- Use MR simulation as an educational tool
- Avoid beginners mistakes in MR simulations such as numerical artifacts
- Simulate fundamental MR sequences for image acquisition and contrast manipulation
- Explain basic MRI artifacts and the procedures to avoid them
- Simulate the influence of eddy currents, nonlinear gradient fields, concomitant fields, chemical shift, susceptibility and any other off-resonance sources
- Simulate the influence of motion, flow and diffusion
- Use optimised code for MR physics simulation for integration in own projects
- Perform rapid prototyping and testing of new acquisition schemes
- Perform multi-channel excitation simulations to test new RF pulses
- Use MR simulations in research, e.g. to validate new diffusion or perfusion models
- Feed simulated MR signals into existing image reconstruction libraries
- Generate ground-truth in silico MR phantoms for image analysis and post-processing
- Understand the differences between MR simulations and real life MR experiments



Parallel imaging:
Basic and advanced reconstruction concepts

July 20–22, 2017
University Medical Center Göttingen/DE

Course organiser:

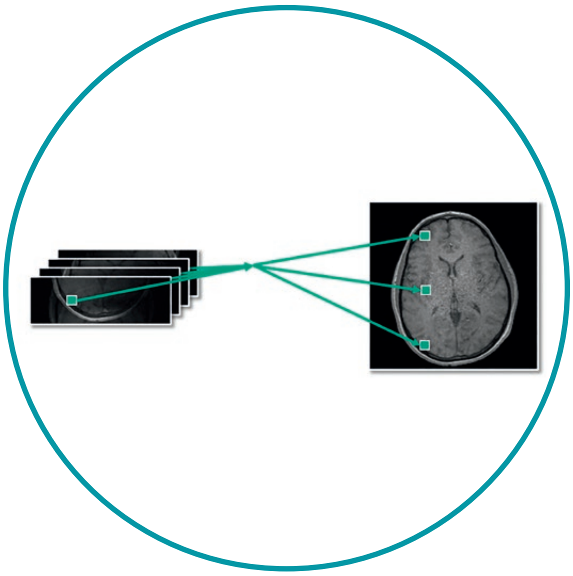
Felix Breuer
Magnetic Resonance Bavaria (MRB)
Würzburg/DE

Local organiser:

Martin Uecker
University Medical Center Göttingen/DE

Preliminary faculty:

M. Blaimer, F. Breuer, M. Doneva, J. Hajnal, F. Knoll, S. Kozerke, K. Prüssmann, N. Seiberlich, M. Uecker



Course description

This course is designed to provide a strong practical foundation in the principles of parallel magnetic resonance imaging. Parallel imaging (PI) is now an integral part of many clinical MRI exams. The concepts and methods of PI are informing research in many disparate aspects of MRI. This course is aimed at PhD students and scientists new to parallel imaging who wish to gain a working knowledge of parallel magnetic resonance to underpin their work. The course will be split in two parts, with approximately half the time spent attending lectures and the other half doing practical MATLAB tutorial exercises. We will provide computers and software licenses for the duration of the course.

The course will cover image reconstruction from multiple coils starting with an image domain view (e.g. SENSE) and moving quickly to a k-space perspective (e.g. GRAPPA). We will then look at more advanced methods; non-Cartesian parallel imaging and many of the mathematical tools used in these reconstruction algorithms. We will look at allied methods, in particular spatio-temporal undersampling and subsequent reconstructions. In addition, an introduction to the Compressed Sensing (CS) concept will be given. Finally we will look to the future and discuss how multi channel MRI may impact future directions in MRI.

An integral part of the course will be the MATLAB/Python tutorials where attendees will be able to work through example code provided for them. These examples will demonstrate and enhance their understanding of the concepts discussed throughout the course. Exercises will be set where attendees will modify this code to develop new examples and functionality. At the end of the course they will be free to take this code away with them.

Some previous exposure to MATLAB/Python is preferable but not mandatory. All participants should have some programming experience. All participants will be expected to know essential MR physics. A working knowledge of image acquisition methods and k-space is essential.

Learning objectives

Image domain parallel imaging

- Define the basic reconstruction problem
- Reconstruct full images from aliased images
- Explore the effects of coil coupling on the reconstruction
- Calculate and measure reconstruction quality

k-space parallel imaging

- Relate image domain and k-space methods
- Assess costs and benefits of image domain and k-space methods
- Calculate and measure reconstruction quality

Coils and calibration

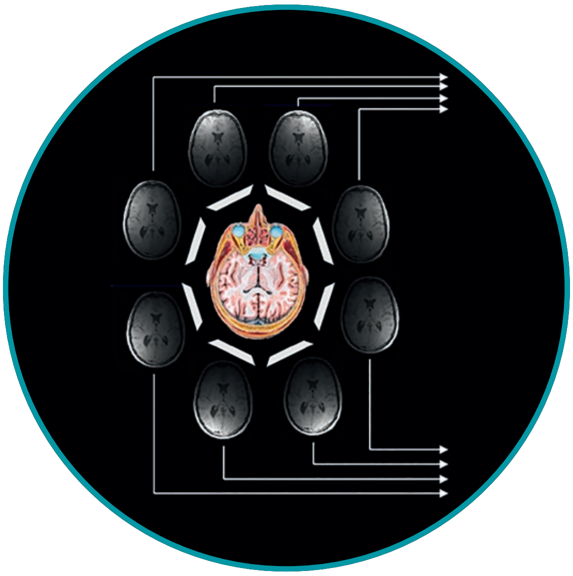
- Understand how coil calibration is achieved
- Compare auto-calibration and pre-calibration approaches
- Establish design criteria for parallel imaging array coils
- Demonstrate how coil calibration errors affect reconstruction

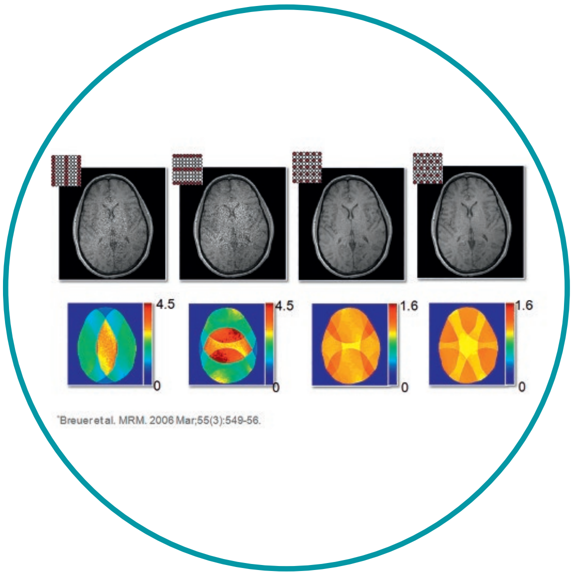
Non-Cartesian parallel imaging

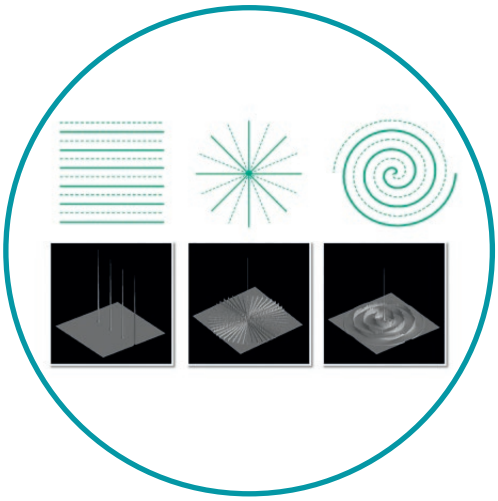
- Define the reconstruction problem
- Review mathematical methods used in reconstruction
- Reconstruct non-uniformly sampled data with iterative methods (CG SENSE)
- Reconstruct non-uniformly sampled data in k-space

Reconstruction with prior knowledge

- Learn about Compressed Sensing
- Understand spatio-temporal undersampling and reconstruction methods
- Calculate and measure reconstruction quality







Small animal MR imaging

October 17–18, 2017
Universitat Autònoma de Barcelona
Cerdanyola del Vallès, Barcelona/ES

Course organisers:

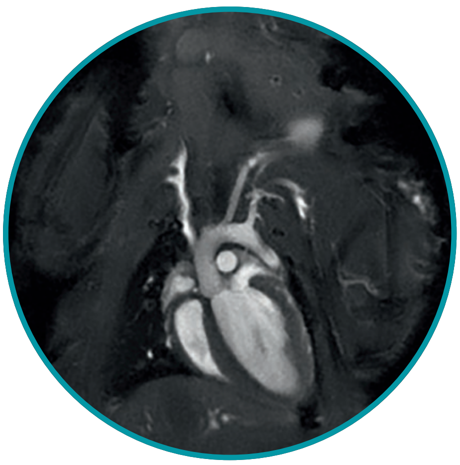
Cornelius Faber
Translational Research Imaging Center
Department of Clinical Radiology
University Hospital Münster/DE

Local organisers:

Ana Paula Candiota
Margarida Julià-Sapé
Centro de Investigación Biomédica en Red
Universitat Autònoma de Barcelona
Cerdanyola del Vallès, Barcelona/ES

Preliminary faculty:

A. P. Candiota, C. Faber, M. Julià-Sapé, N. Just, F. Schmid, L. Wachsmuth



Course description

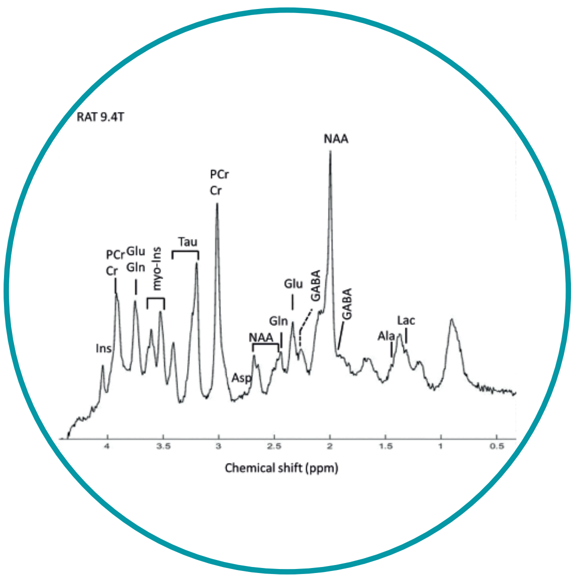
Small Animal MR imaging has come to play a key role in biomedical research for studying experimental rodent models of human diseases. Because of its non-invasiveness and versatility, the non-invasive MR technique complements biochemical and histochemical methods for investigating biological processes under normal and pathological conditions.

The course will address basic technical and practical aspects of MRI/MRS/MRSI with emphasis on demands for small animal application. The major aspects of appropriate animal handling, anaesthesia and of monitoring and maintaining a stable physiological state during imaging will be explained. Specifically, sensitivity issues and the impact of physiological motion will be addressed. Different strategies to deal with respiratory and heart motion will be introduced.

One focus will be the particular requirements and methods for MR spectroscopy in rodents. Selected presentations will provide more detailed information about advanced MR methods and their preclinical applications. Reviews from different fields of neuroimaging will illustrate that MRI and MRS can not only provide qualitative anatomical information but permit reliable measurements of quantitative parameters directly related to the neurophysiological state, to tissue integrity and structure, and even to functional aspects.

Finally, a session on optogenetic fMRI will introduce this novel field and provide practical details on how to perform optical stimulation and recordings in the MR scanner.

The course is intended for students, scientists and clinicians with a strong interest in biomedical applications of small animal imaging. Prior knowledge of basic MR will be helpful although non-specialists in MR are welcome to register.



Learning objectives

MR basics

- Introduction to MRI and MRS
- Contrast mechanisms and MRI techniques (BOLD, Diffusion, MT)
- Contrast agents (T1-, T2* agents)
- Hardware (RF coil design, including array coils and cryo probes)

Small animal imaging

- Rodent physiology and monitoring (animal handling, procedures, anaesthesia)
- Prospective and retrospective gating
- Tissue processing, ex vivo sample preparation

Advanced MR methods

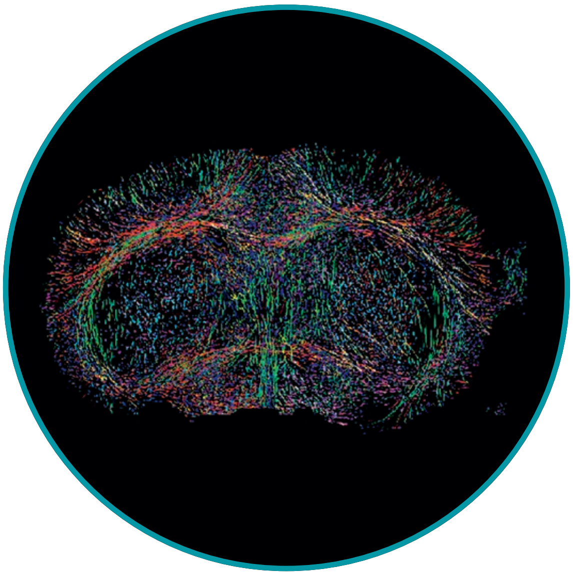
- MEMRI
- BOLD fMRI
- Resting state fMRI
- DWI, DTI
- Single voxel MRS
- Spectroscopic imaging

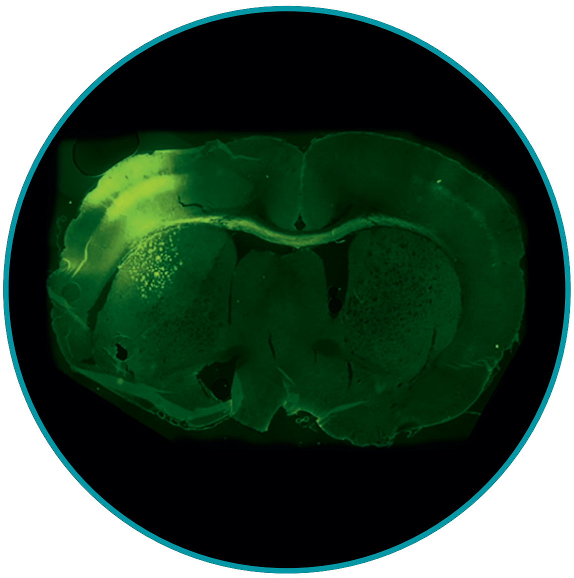
Neuroimaging applications

- Neurodegeneration
- Epilepsy
- Neuroinflammation

Optogenetic fMRI

- Basics of optogenetics
- Neurophysiological recordings in the MR scanner
- Assessment of networks of the brain





Susceptibility weighted imaging and quantitative susceptibility mapping

November 6–8, 2017
Department of Neurology
Medical University of Graz/AT

Course organisers:

Jürgen R. Reichenbach
Jena University Hospital – Friedrich-Schiller-University Jena/DE

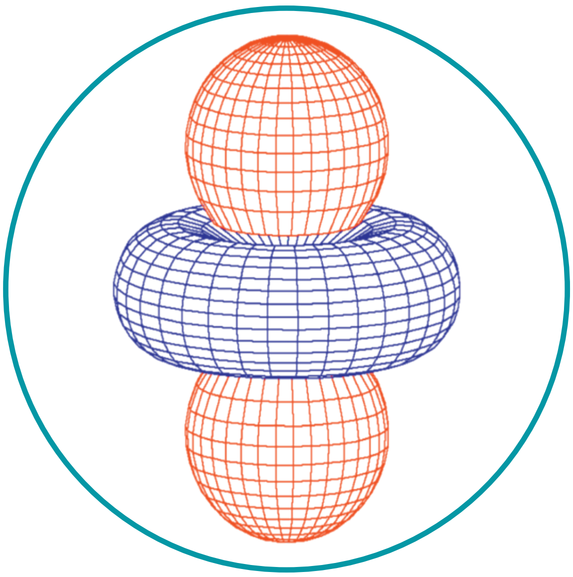
Stefan Ropele
Medical University of Graz/AT

Local organisers:

Stefan Ropele
Christian Langkammer
Medical University of Graz/AT

Preliminary faculty:

R. Bowtell, K. Bredies, A. Deistung, H. Krenn, S. Robinson, A. Rovira



Course description

Magnetic susceptibility is a fundamental physical property which can significantly affect MR image contrast. Susceptibility weighted imaging (SWI), which was one of the first attempts to maximize this contrast, has enabled us to highlight tissue structures and compounds that can hardly be detected by conventional MRI, including iron, calcifications, small veins, blood and bones. In recent years, impressive progress has been made in quantification of tissue susceptibility in vivo by solving the inverse problem (QSM). While first clinical susceptibility mapping studies have focused on the brain, susceptibility mapping outside the brain has become an advancing and rapidly growing field that offers new clinical applications.

This course will enable interested scientists, MR physicists or PhD students to understand the concepts of SWI and QSM and their applications. The course is also suited for clinicians with interest in new clinical applications of susceptibility imaging. However, basic MRI knowledge is a prerequisite to benefit from the entire course program.

The course will address four major topics including the fundamentals of magnetic susceptibility, pulse sequence considerations, reconstruction methods and (pre)clinical applications. The primary teaching method will be lectures with ample room for discussions. In addition to the lectures, specific examinations will be done with MATLAB to provide hands-on experience with the methods taught in the course. Participants are encouraged to bring their own laptop with a pre-installed MATLAB. If this is not possible, please contact the local organizers. The course also includes an excursion to a SQUID magnetometer.

Learning objectives

Magnetic properties of tissue

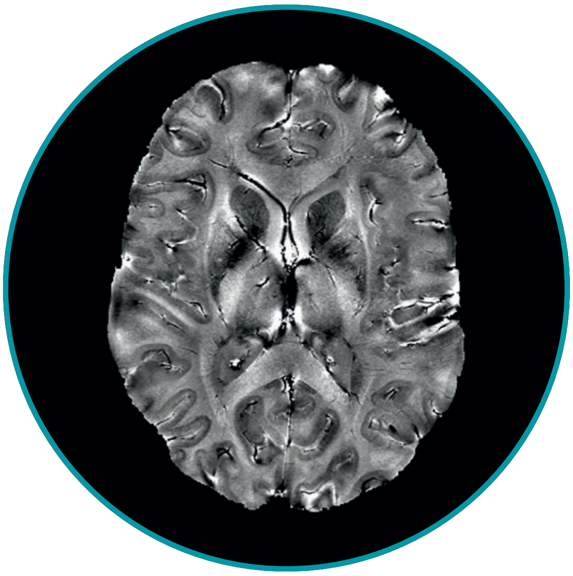
- Be familiar with the magnetic properties of different tissue components and trace elements
- Understanding how bulk susceptibility is affected by tissue composition and microarchitecture
- Characteristics of major tissue constituents (water, iron, myelin)
- Non-MRI methods for assessing susceptibility of tissue

Susceptibility weighted MR sequences

- Pulse sequence considerations
- SNR optimizations
- Impact of image resolution and voxel aspect ratio
- Combining signals from multi-coil arrays
- Effect of B0 gradients and correction schemes
- Non Cartesian sampling schemes

Reconstruction methods

- Phase unwrapping, filtering, background field removal
- Combining phase and magnitude images (SWI)
- Quantitative susceptibility mapping (QSM)
- Inversion algorithms
- Advanced mathematical methods
- Susceptibility tensor imaging



Clinical and preclinical applications

- Detection of microbleeds and calcifications
- Iron mapping in inflammatory and neurodegenerative diseases
- Assessing myelin content
- Tumor imaging
- Ischemia
- Quantification of contrast agent
- Quantitative blood oxygenation venography
- Applications outside the brain

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