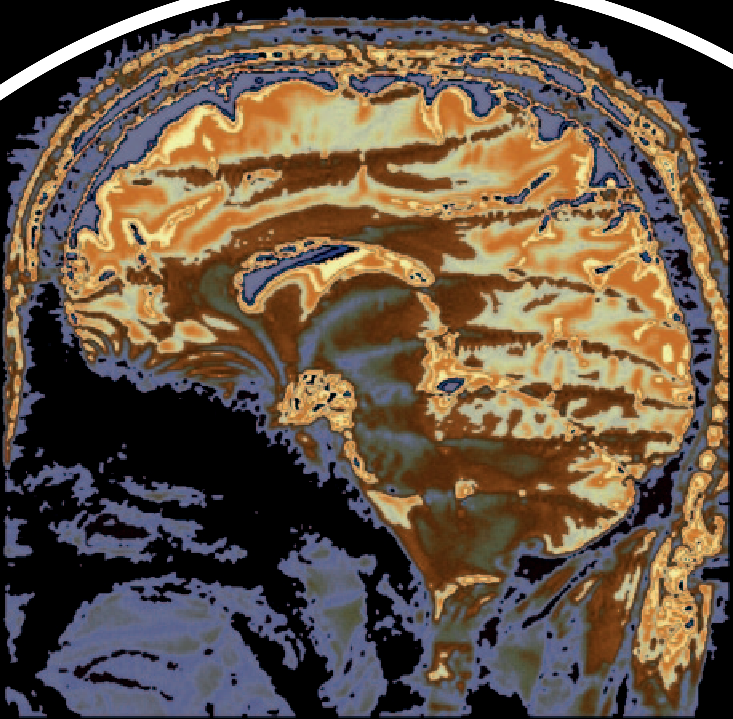
ESMRMB
European Society for Magnetic Resonance in Medicine and Biology



Lectures on MR 2015

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

RF simulation for MR systems: Coil design and safety
February 10–13, Heidelberg/DE

Simultaneous multi-slice/ multiband imaging
March 19–21, Essen/DE

Inverse imaging, sparse sampling, compressed sensing, and more
March 23–25, Freiburg/DE

RF coils: Design, build and characterise your own
June 23–25, BerlinDE

MRI simulation for sequence development, protocol optimisation, and education
June 29 – July 1, Copenhagen/DK

Resting state fMRI - basic concepts, methods & applications
September 2–4, Berlin/DE

Diffusion: What it means and how to measure it
September 28–30, Edinburgh/UK

www.esmrmb.org

ESMRMB 2015
OCTOBER 1–3
EDINBURGH/UK

ESMRMB
European Society for Magnetic Resonance in Medicine and Biology

32ND ANNUAL SCIENTIFIC MEETING

Abstract submission deadline:
April 30, 2015

Early registration deadline:
July 16, 2015

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

Content

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Vienna, November 2014
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Cover Image:
Courtesy of Philipp Ehses and Klaus Scheffler,
Max-Planck-Institute for Biological Cybernetics
Tübingen, Germany

Scientific images kindly provided by the organisation committee 2015.

General Information

Course Information

- All courses are held in English language.
- The duration of the course is 2 to 3 days.
- The detailed programme of each course and the exact time schedule are available at 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 coil design course in Berlin/DE which is limited to 25). 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.

Accreditation

The **Lectures on Magnetic Resonance** programme is accredited by the **European Federation of Organisations for Medical Physics (EFOMP).** A certificate of attendance will be available online for the participants of the entire course.

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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 request to provide these kind of courses that are dedicated towards 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 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.

The course on 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
- Use of principle of reciprocity in MRI
- Generation of appropriate numerical models
- Interpretation of numerical results
- Validation methods for numerical results
- Principles of RF coil design and coil characterisation
- 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
- Numerical assessment of the human RF exposure and RF safety of implants

The course on **Simultaneous multi-slice/multiband imaging** will provide participants with a solid grounding in one of the most exciting developments of recent years: The ability to vastly accelerate data acquisition by the simultaneous acquisition of multiple slices. The course will cover the basic concepts of simultaneous excitation, refocusing and inversion for conventional and adiabatic radio frequency pulses. It will show how the application of these pulses can be limited by both peak RF-voltage and power deposition, and describe strategies for circumventing both of these limitations. The limitations of combined simultaneous multi-slice imaging and in-plane acceleration will be presented. The value of incorporating (blipped) CAIPRIHANA will be explored. Different methods of data reconstruction will be described, and the implications for the acquisition of reference data shown. Finally examples of current and potential future applications will be examined.

The course on will focus on:
- Basic radiofrequency pulse design
- Strategies for reducing peak voltage
- Strategies for reducing pulse power
- Extensions to adiabatic pulse forms
- Basis of reconstruction methods
- Advanced reconstruction methods
- CAIPRIHANA and blipped CAIPRIHANA technique
- Slice cross-talk
- Practical implementations: pulse sequence modifications, acquiring reference data, adjusting B0/B1 and additional sensitivity to motion.
- Where is the concrete benefit and why?
- Examples from neuroimaging and clinical application

Inverse imaging, sparse sampling, compressed sensing, and more are buzzwords which are currently used abundantly (and often interchangeably) to describe methods for image formation based on its formulation as an inverse problem. The course will focus on the introduction of the basic concepts behind the various algorithms and methods, present and discuss different approaches to solve the image equation and give a 'how to…'-introduction into practical implementations. It should be emphasised, that the course is not just a repetition of the previous course held in 2013, but has been somewhat modified. Although basic concepts will still be described, more emphasis will be put on implementations and applications. The exercises will be much more extensive with practical exercises taking place at the computer lab of the University's IT Center. The course will be therefore well-suited for repeat participants as well as for newbies.

The course will cover:
- Introduction of basic concepts of treating image formation as an inverse problem
- Formulation of the forward problem: Non-uniform Fourier Transformation (NUFFT) and other tricks
- Different approaches for regularisation: Basics and discussion of pros and cons
- Implementation issues, parallel processing and GPUs
- Practical implementations: Where to use which approach

The course on **RF coils: Design, build and characterise your own** provides an overview of the basic theory of designing, constructing and testing RF coils for both animal and human scanners. Introduction into software tools for simulations of electromagnetic fields and for safety evaluation will be included.

Practical sessions will cover approximately ~50% of the course, in which participants will learn to build surface coils and volume resonators of their particular interests. Characterisation of RF coils including B1-mapping, measurement of E and H fields and assessment of Parallel Imaging performance will be also part of the course. The course is designed for basic scientists and engineers but also invites clinicians, radiographers, application specialists, (under)graduate students and other MR users interested in gaining a better insight into RF coil technology.

The course on **RF coils** will enable you to

- Understand the behaviour of circuit elements at high frequency
- Understand the concepts of resonance and resonant circuits
- Design impedance matching networks
- Construct baluns and cable traps
- See the range of test equipment used in RF coil design
- Design and build a surface coil
- Understand the theory of volume resonators
- See the operation of different software packages for RF simulations
- Understand the different designs for multiple-frequency RF probes
- Design a birdcage coil
- Build your own coil

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 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.

The course **MRI simulation for sequence development, protocol optimisation, and education** will focus on

- Theory of classical MR: Applicability and limitations of the physical models
- Computer simulation of classical NMR and MRI experiments
- Implementation of optimised code for high performance simulation of MR physics
- Design and simulation of basic and advanced MRI sequences
- Simulation of MRI artifacts related to basic physics, off-resonance effects, motion and flow
- MR simulation under realistic physiological conditions including diffusion and perfusion
- Interfacing simulated MR-data into image reconstruction and post-processing software
- MR simulations as an educational tool and for visualisation of basic phenomena
- MR simulations in research: Protocol optimisation, pulse design, model verification

The course on **Resting state fMRI - basic concepts, methods & applications** focuses on methodology and applications of this rapidly growing field. An overview will be provided on the major analysis strategies, applications, including those in clinical populations, and special emphasis will be put on the importance of physiological and other confounding factors, and the impact of different acquisition strategies. The course will be complemented by ample hands-on training, which will provide participants a good overview of the major software suites used by the field to analyse resting state data.

The course on **Resting state fMRI** will provide you with

- Insights into the sources of correlated resting state activity
- Knowledge on the most important analysis strategies
- Methods to control physiological noise contributions
- Techniques to quantify local resting state behaviour
- Proficiency to perform network analysis
- Deeper understanding of the meaning of abnormal resting states
- Practical guidelines for resting state acquisitions
- An overview on critical aspects and limitations
- A perspective on future directions in this field of research

The course **Diffusion: What it means and how to measure it** is an in-depth overview of MR measurements of diffusion, providing a solid background in this rapidly expanding research field. Fundamental physics of molecular diffusion serves as a basis for the presentation of main experimental methods. This course focuses on the question how to use diffusion MRI for probing microscopic sample structure that is much finer than the imaging resolution. The course is designed for basic scientists who already have experience in MRI and wish to extend their knowledge of the physics of diffusion-weighted imaging.

Attendance of the course on **Diffusion: what it means and how to measure it** will provide you with a fundamental knowledge of

- Diffusion metrics and their behaviour in heterogeneous media
- Relation between diffusion-weighted signal and diffusion metrics
- Pulse sequences and acquisition strategies
- Practical sequence design and parameter optimization
- Artefacts: Symptoms, mechanisms and remediation
- How tissue microstructure is represented by diffusion metrics
- Strategies of biophysical modelling in diffusion MR
- Available methods for probing microstructure using diffusion MR

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European Society for Magnetic Resonance in Medicine and Biology

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SOCIETY JOURNAL MAGMA (PRINTED JOURNAL) € 50

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www.esmrmb.org

More information at www.esmrmb.org

Educational Levels

The **Lectures on Magnetic Resonance** are dedicated to 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 RF exposure or who already have basic to intermediate experience in RF simulation.

Simultaneous multi-slice/multiband imaging

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 simultaneous multi-slice / multiband imaging with a view to implementing or applying it.

Inverse imaging, sparse sampling, compressed sensing, and more

This course is intended for MR physicists, other scientists and PhD students who are familiar with the basic concepts of standard imaging techniques and who wish to get knowledgeable about the currently 'hot topic' of accelerated imaging based on undersampled data. The course will present the mathematical principles but also implementation issues with practical examples such that attendees will be able to use these methods and techniques in their own work.

RF coils: Design, build and characterise your own

This course runs from introductory to advanced levels. It is primarily intended for scientists and engineers who have a basic knowledge of mathematics and simple electrical circuits. However, the course also reaches out to clinicians, experienced radiographers, application specialists and other MR users interested in gaining a better insight into the traits of RF coil technology. Attendees should have a working knowledge of magnetic resonance basics. The course balance lectures with practical sessions including RF coil design, simulation of electromagnetic fields, building your own coils, safety evaluation and coil characterisation.

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.

Resting State fMRI - basic concepts, methods & applications

The intended audience should be familiar with the basic concepts of functional MRI studies, including standard analysis strategies for task-based approaches. The course therefore is suitable for PhD students and post-doctoral scientists in psychology, neuroscience or MR physics. A basic understanding of BOLD physiology, MR physics, and brain anatomy is expected. The focus on analysis strategies will provide greatest benefit for those planning or starting data acquisition or analysis, or for researchers wanting to get a good overview of the potential of this method.

Diffusion: What it means and how to measure it

This course is intended for MR physicists, other scientists and PhD students who already have experience in basic MR methods and knowledge of MR excitation and acquisition principles, and who wish to extend their knowledge on diffusion-weighted imaging. This advanced course provides a detailed introduction into the field of diffusion measurements, which covers the physical principles of diffusion in heterogeneous media, measurement techniques and applications to investigation of the cellular structure of living tissues.

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Check out the
ESMRMB Event Calendar

Use our new online tool to find MR-related courses, workshops and congresses.
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RF simulation for MR systems: Coil design and safety

February 10–13, 2015
German Cancer Research Center (DKFZ)
Heidelberg, Germany

Course and local organisers:

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

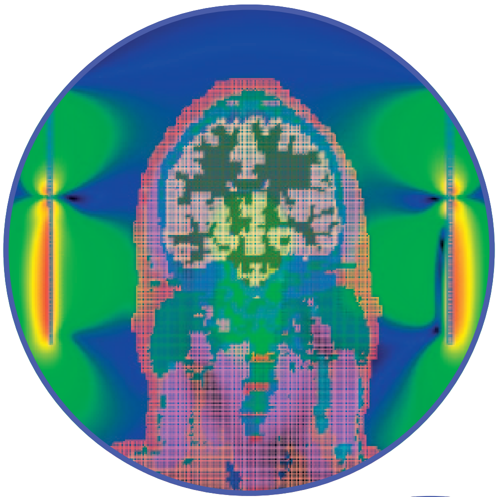
Nico van den Berg
University Medical Center Utrecht
Utrecht/NL

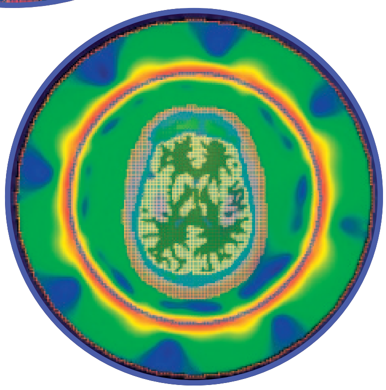
Local organiser:

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

Preliminary faculty:

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





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 deepen the subject matter of the lectures individually by solving fundamental problems. Under guidance of the faculty, the application of numerical methods and the adjustment of important simulation parameters with respect to the chosen method will be explained. 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

- Field quantities
- Material properties, biological tissue
- Maxwell's equations
- Conservation of energy – power balance
- Quasi-static approximation (Biot-Savart law)
- Wave propagation
- Polarisation

Numerical methods

- Basics of the solution in time and frequency domain
- Introduction to local methods
  - Finite-difference method/Finite integration method in time domain
  - Finite element method
- Overview of
  - Integral equation methods
  - Hybrid methods
- Application examples

Validation methods

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

RF coil design and characterisation

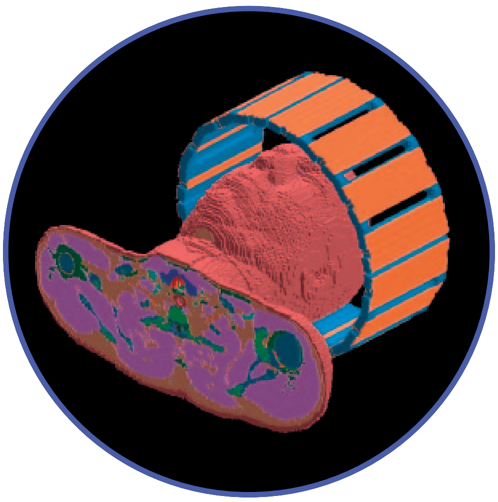
- Basic designs
  - Birdcage
  - Loop elements
  - Stripline-based elements
  - Dipoles
- Matching and tuning
- Multi-channel transmit arrays
  - B_1^+ manipulation
- Characterisation
  - Transmission mode: B_1^+ efficiency, SAR
  - Receive mode: SNR, g factor/g maps

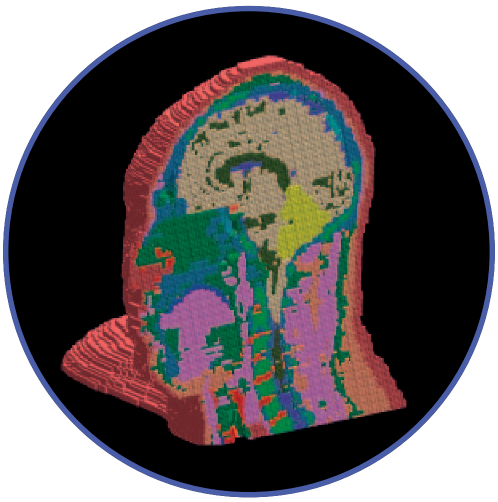
RF safety and guidelines

- Exposure aspects and corresponding SAR and temperature limits
- SAR evaluation and monitoring for multi-channel transmit
- RF safety of implants

Exercises

- Modelling options with selected numerical methods
- Network co-simulation
- Modelling options for birdcage coils
- RF coil arrays
  - Matching, tuning, decoupling
- Correlation between measurement and simulation
- Implementation of post-processing procedures
  - Coil characterisation
  - RF exposure
- Thermal simulation





Simultaneous multi–slice/ multiband imaging

March 19–21, 2015
Erwin L. Hahn Institute
Essen, Germany

Course and local organiser:

David Norris
Erwin L. Hahn Institute Essen/DE
Donders Institute Nijmegen/NL

Preliminary faculty:

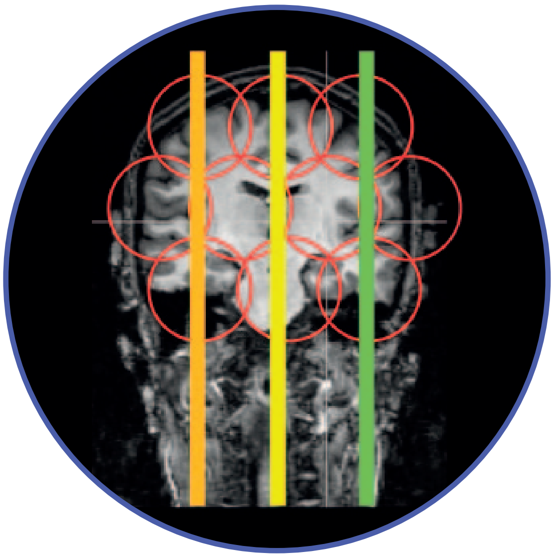
F. Breuer, P. Koopmans, D. Norris, B. Poser

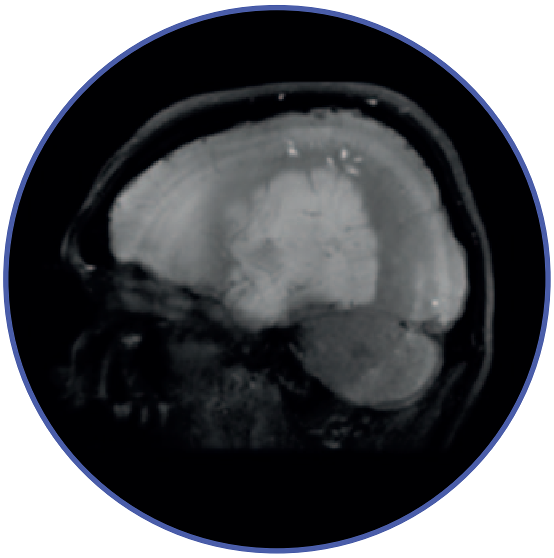
Course description

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 simultaneous multi-slice/multiband imaging with a view to implementing or applying it.

The primary teaching method will be lectures with problem solving classes and discussions. All participants will be expected to know essential MR physics. A working knowledge of image acquisition methods and k-space is essential.

The course will cover RF pulse design approaches; reconstruction techniques, practical implementation and areas of application.





Learning objectives

RF pulse design

- Understand the methods of generating multiband RF pulses
- Know the limitations of peak voltage and power, and methods for avoiding these

Reconstruction methods

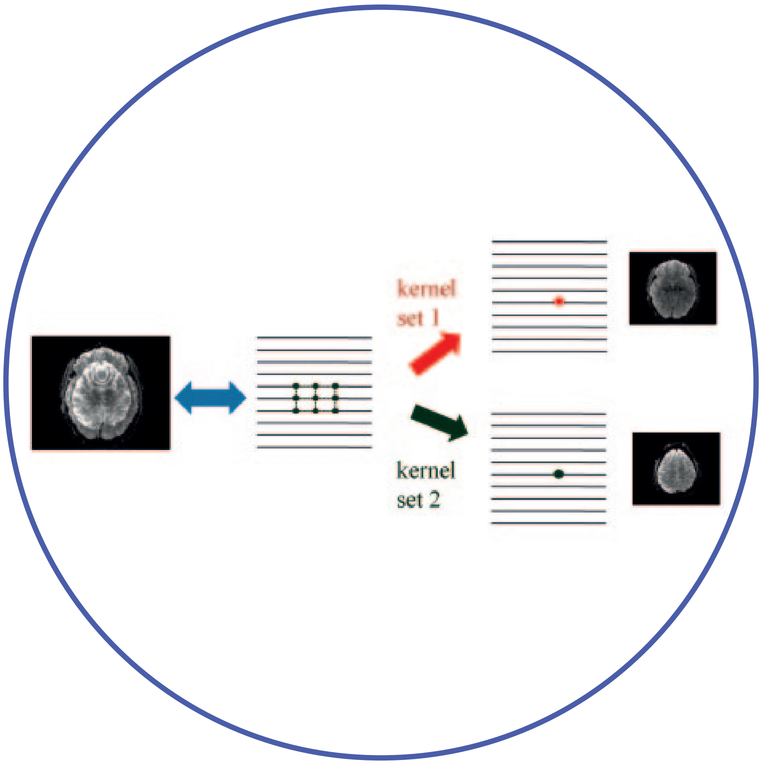
- Understand basic parallel imaging reconstruction methods and how they can be extended to simultaneous multi-slice reconstruction
- Be familiar with the main methods available and their limitations

Acquisition techniques

- Modify pulse sequences for multi-slice acquisition
- Apply CAIPRIHANA techniques and understand their advantages and limitations
- Implement appropriate QA for multiband imaging

Areas of application

- Understand the advantages of the multiband approach
- for fMRI
- Advantages of multiband for diffusion-weighted imaging
- Potential advantages for clinical sequences



Inverse imaging, sparse sampling, compressed sensing, and more

March 23–25, 2015
University Medical Center Freiburg
Germany

Course and local organisers:

Jürgen Hennig
Jakob Assländer
Michael Burdumy
Marco Reisert
Pierre Levan
Rebecca Ramb
Bruno Riemenschneider
Department of Diagnostic Radiology, Medical Physics
University Medical Center Freiburg/DE

Preliminary faculty:

J. Assländer, K.T. Block, J. Hennig, P. Levan, R. Ramb, M. Reisert, M. Uecker

Course description

The course is designed to give an in-depth introduction of the basic concepts behind the various algorithms and methods, present and discuss different approaches to solve the image equation and give a 'how to…'-guide to practical implementations.

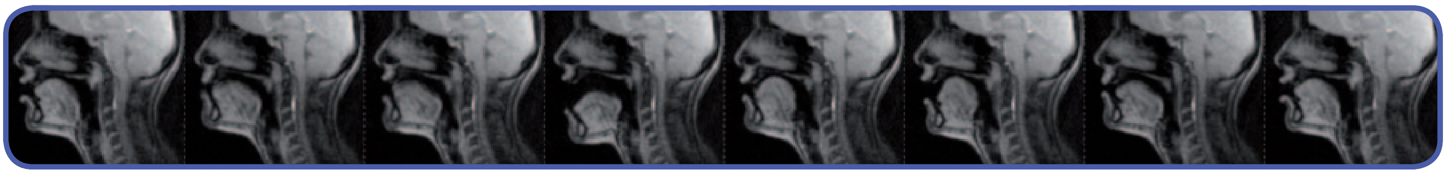
The first part of the course will give an introduction into the concepts of solving inverse problems and present various strategies to formulate the problems. Mathematically, the basic signal equation is a rather simple and linear matrix equation. The challenge lies in the fact that even for moderately sized images the matrix size becomes intractably large.

This course will give insights into various approaches to translate the mathematically straightforward but computationally unfeasible formulation into a practical approach. On one hand this includes means for simplification of the signal equation i.e. by use of non-uniform Fourier Transformation (nuFFT) and/or by separation of the signal encoding matrix into simpler parts.

Methods for solving the signal equation will be presented and discussed. Different implementations for regularization (l1- and l2-norm) in different domains (e.g. wavelets and total variation) will be introduced as well as commonly used algorithms for iterative solution (conjugate gradients etc.).

After the introduction of the principles, the second part will present examples for practical implementation. Possibilities and limits of inverse imaging will be demonstrated for standard applications and realistic data sizes.

The emphasis of this course is placed on the practical exercises, which will be performed in the computer lab of the University's IT Center. The goal is to provide a comprehensive repository of Matlab-routines and give an introduction to open source software like the Berkeley image reconstruction toolbox in order to enable the participants to get hands-on experience with the methods taught in the course.



Learning objectives

The overall goal is to educate participants about the underlying concepts as well as all relevant issue for practical implementation (sequences as well as reconstruction algorithms). This should enable them to apply the principles of inverse imaging to their own work.

Basic principles of inverse imaging

- Introduction to the signal equation
- Sparsity
- Non-uniform Fourier Transform (nuFFT)
- Regularisation
- l_1, l_2,-norm
- Total variation
- Encoding and reconstruction
- Techniques in the k-t-domain/x-f-domain
- Compressed sensing

Solving the matrix equation

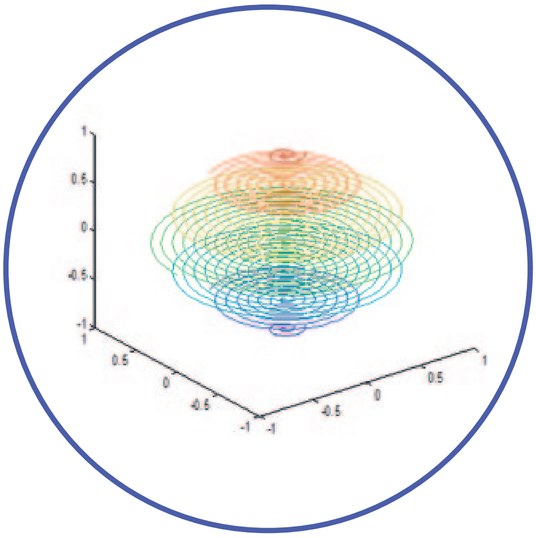
- Linear and nonlinear conjugate gradient methods

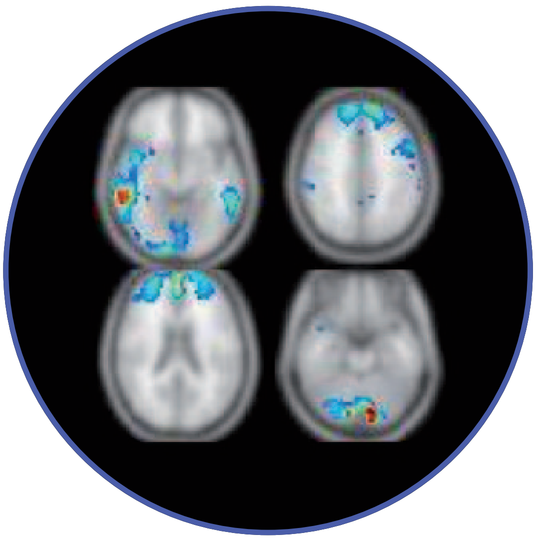
Computational issues

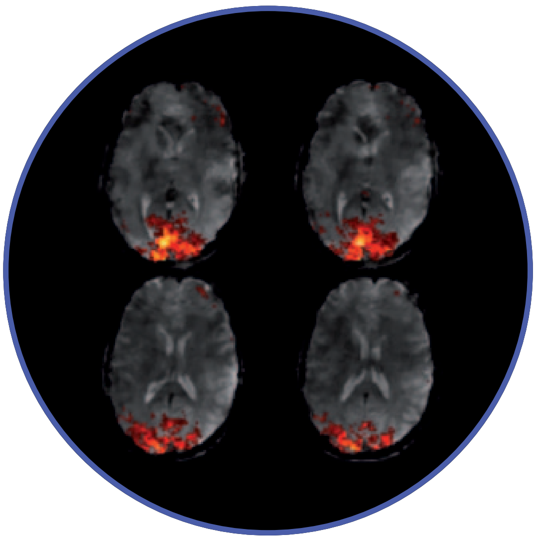
- Parallel processing
- GPUs

Implementations

- Parallel imaging with radial data
- Compressed sensing in clinical imaging







RF coils:
Design, build and characterise your own

June 23–25, 2015
Berlin Ultrahigh Field Facility (B.U.F.F.)
Max-Delbrueck Center for Molecular Medicine
Berlin, Germany

Course organisers:

Thoralf Niendorf
Berlin Ultrahigh Field Facility (B.U.F.F.)
Max-Delbrueck Center for Molecular Medicine
Berlin/DE

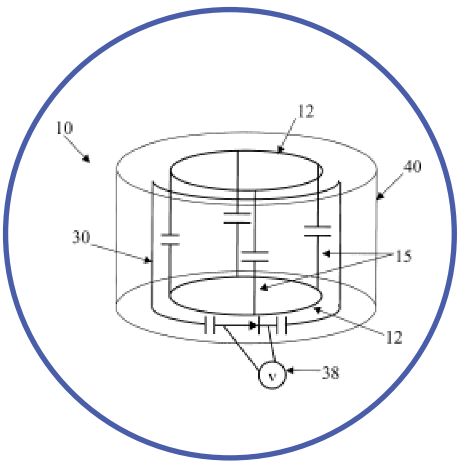
Andrew Webb
C.J. Gorter Center for High Field MRI Leiden
University Medical Center (LUMC)
Leiden/NL

Local organiser:

Thoralf Niendorf
Berlin Ultrahigh Field Facility (B.U.F.F.)
Max-Delbrueck Center for Molecular Medicine
Berlin/DE

Preliminary faculty:

S. Aussenhofer, A. Graessl, S. Gunamony, W. Hoffmann, Y. Ji, A. Kühne, M. del Mar Miñana, T. Niendorf, E. Oberacker, C. Oezerdem, H. Pfeiffer, J. Rieger, D. Santoro, B. Stoeckel, C. Thalhammer, H. Waiczies, P. Waxmann, A. Webb, D. Wenz, F. Wetterling, L. Winter, T. Wittig

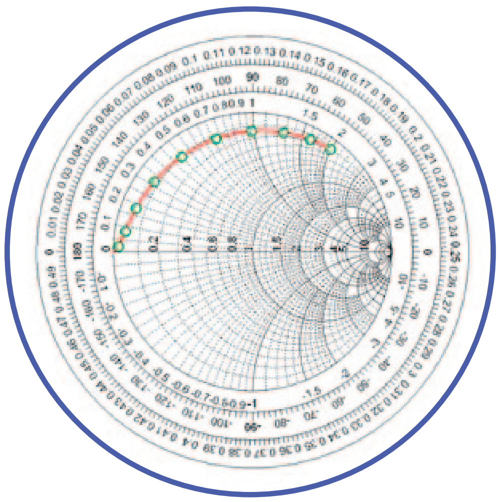


Course description

This course is designed to provide a theoretical and practical guide to RF coil design for animal and human MR systems. Simple tools for electrical circuit analysis will be introduced, followed by practical design of simple geometries such as surface coils. The participants will then design and construct a coil with their chosen dimensions and frequency of operation. In the second stage, the design of volume coils will be introduced from a theoretical basis, software for modelling these coils discussed, and again the participants can choose which type of coil to design during the practical session. Finally, advanced topics such as multi-tuned coils and phased arrays will be introduced, designed and tested.

In addition to the large degree of practical work, 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 in small participant groups under guidance of the lecturers.

Since participants will construct their own coil this course is limited to maximal 25 participants.



Learning objectives

RF circuit design

- High frequency behaviour of lumped elements
- Concepts of resonance and resonant circuits
- Impedance matching for maximum power transfer
- Baluns and cable traps
- Multiple-tuned circuits
- Choice of suitable components
- Concepts for coil decoupling

Hardware for RF testing

- Network analyser operation
- Resistance bridges, frequency generators
- Bench characterisation of coil performance

Simulation software

- Analysis of basic packages
- B1-homogeneity versus B1-efficiency
- SAR considerations
- High frequency RF effects

Advanced coils

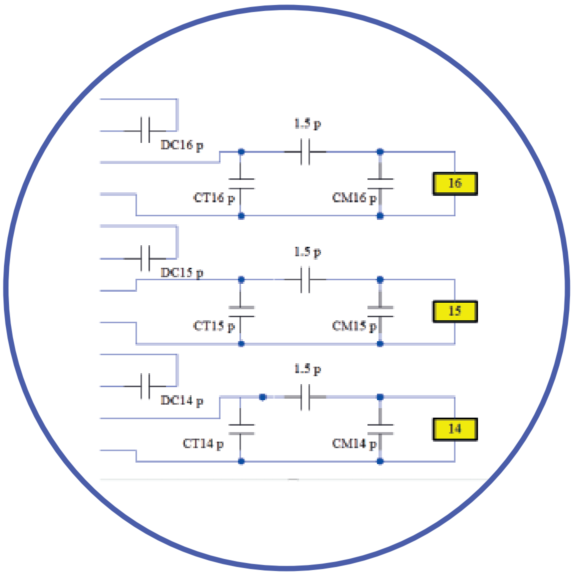
- Birdcage, loop structures, radiative antenna, dipole elements, TEM coils
- Phased arrays

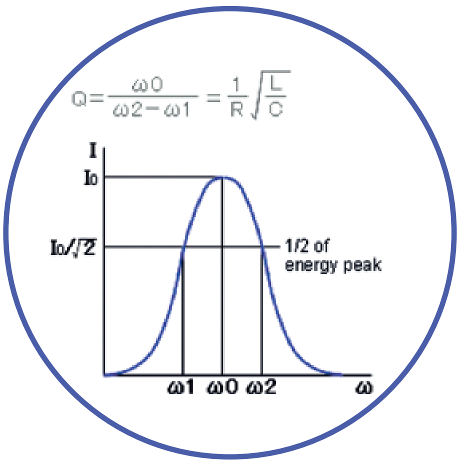
Practical design and construction

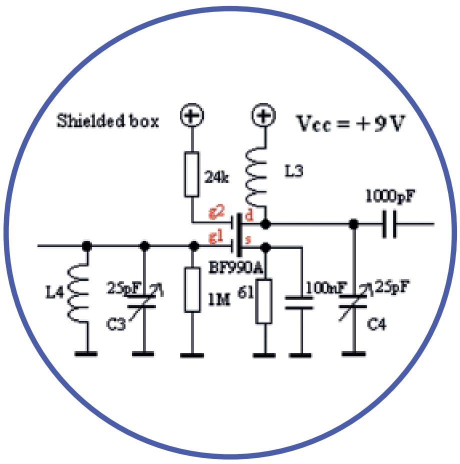
- Surface coil and/or solenoidal coil
- Birdcage volume resonator
- Double-tuned RF coil

RF coil characterisation

- Decoupling and noise correlation
- Coil sensitivity profile, B1-mapping and B1-shimming
- Parallel Imaging performance
- Signal-noise ratio performance







MRI simulation for sequence development, protocol optimisation, and education

June 29 – July 1, 2015
Technical University of Denmark (DTU)
Copenhagen, Denmark

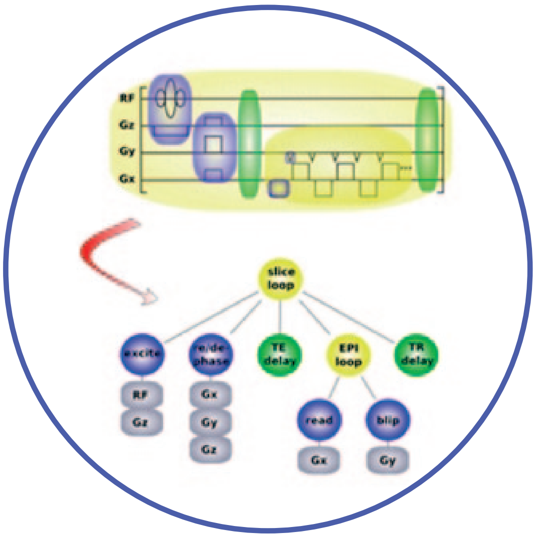
Course & local organisers:

Lars G. Hanson
Technical University of Denmark (DTU) and Danish Research Center for Magnetic Resonance (DRCMR)
Copenhagen/DK

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

Preliminary faculty:

L.G. Hanson, D. Pflugfelder, T. Stöcker, K. Uludağ, K. Vahedipour, 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 optimisation.

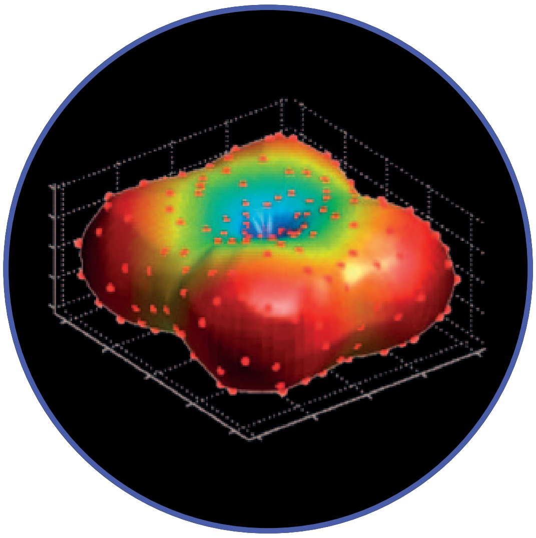
In this three-day course, the students learn the basics of NMR and MRI simulations. The underlying physical models, their field of application and limitations are discussed. As realistic MRI simulations are time-consuming, the course is explicitly aimed at teaching efficient computer implementations and methods for high performance computing such as multi CPU/ GPU environments. 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 schemes such as spiral or twisted radial trajectories. Magnetization preparation will be simulated and used to tailor measurement protocols for specific applications involving basic spin relaxation as well as advanced MR contrast mechanisms such as diffusion, flow, and susceptibility effects. By means of pictorial examples, MRI simulations are shown to serve as a valuable tool for MRI methods development and research.

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 (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
- 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 & diffusion
- Use optimised code for MR physics simulation for integration in own projects
- Generate gold-standard MRI data for post-processing
- Store simulated MR signals using open standard formats (e.g. ISMRM raw files) for interfacing into foreign libraries
- 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
- Use MR simulations as an educational tool
- Explain the advantages, limitations and differences of the physical models on which the MR simulation is based



Resting state fMRI – basic concepts, methods & applications

September 2–4, 2015
Charité Universitätsmedizin Berlin
Germany

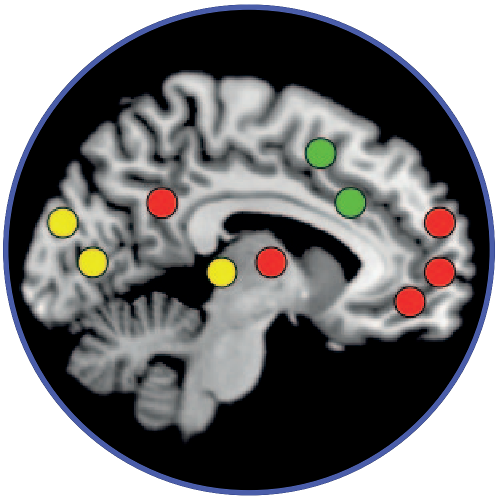
Course and local organisers:

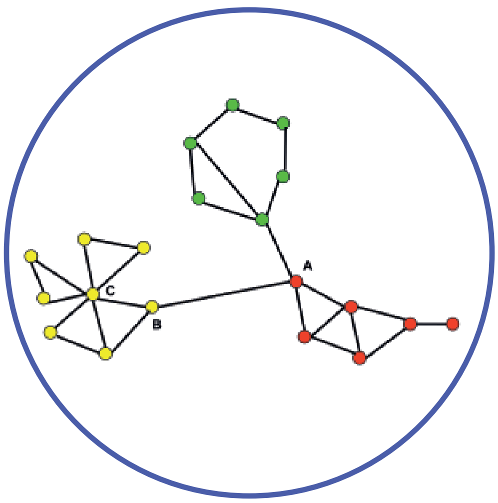
Ilya Veer
Charité Universitätsmedizin Berlin
Berlin/DE

Martin Walter
Leibniz Institute for Neurobiology
Magdeburg/DE

Preliminary faculty:

C. Beckmann, C. Chang, P. Fransson, V. Kiviniemi, S. Sadaghiani, L. Uddin, M. Walter, C. Windischberger, I. Veer



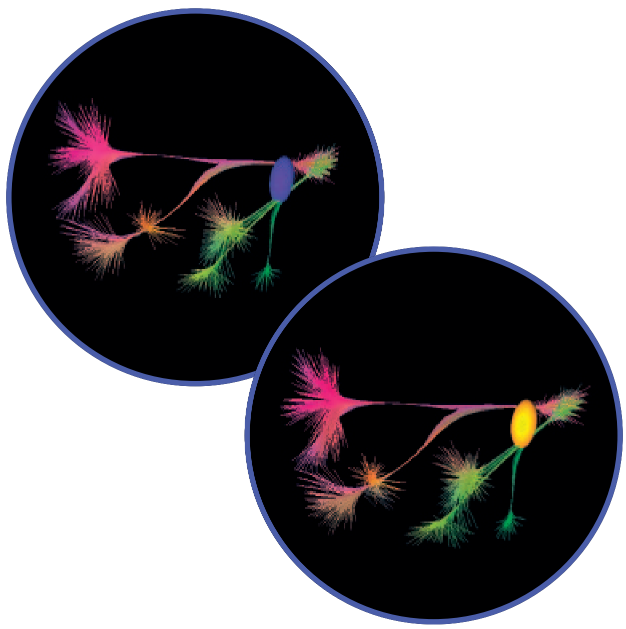


Course description

Resting state fMRI focuses on the temporal characteristics and spatial organisation of spontaneous fluctuations of the BOLD signal. Over the last decade it has received increasingly more interest from the neuroimaging community, and has proven itself an important new research tool for neuroscientists. Not only is resting state fMRI able to provide insights into the fundamental functional organisation of the human brain, the relatively simple experimental setup, compared to task-related fMRI, makes it ideally suitable for large-scale multi-centre investigations. The short duration and low cognitive demand, on the other hand, are favourable aspects for clinical research and applications.

This three-day course aims to provide all the background knowledge necessary to enter the field of resting state fMRI and plan own experiments and analyses. The attendees will learn about the history, acquisition, and common analysis methods of resting state fMRI. In addition, important limitations and caveats will be discussed, including the treatment of physiological confounds and the global signal. Lastly, a full day hands-on practical training complements the lectures. Attendees will learn to analyse resting state data using freely and commonly available software packages, focusing on the basic analysis steps of seed-based correlations, ICA, and graph analysis.

The course format has been developed as an educational workshop for researchers with basic knowledge on fMRI, including MR physics, brain anatomy, BOLD physiology, as well as standard analysis methods for task-based data. The course is of particular interest to PhD students and post-doctoral scientists in psychology, neuroscience, or MR physics, who are planning acquisition or analysis of resting state fMRI data.



Learning objectives

What is resting state fMRI?

- What are local low frequency spontaneous fluctuations (LFSF)?
- What are (f)ALFF, ReHo or Hurst characteristics?
- Temporal coherence: Seed based versus network based approaches?
- What is the relation between functional and structural connectivity?
- What discerns resting state activity from other types of noise?

How do we process rs-fMRI data?

- How do we acquire the data?
- What is the impact of instructions?
- What are basic analysis strategies for local activity and interregional signal coherency?
- How do we treat physiological noise?
- What are the effects of global mean regression?

What are brain networks?

- What are brain functional connectivity networks?
- How do we use ICA and what is it good for?
- What are other network approaches?
- How do I analyse graph properties during rest?

What is the default mode network?

- What are task positive and task negative networks?
- What are functions of the default mode network?
- How do we assess within and between network activities?

What is ongoing activity?

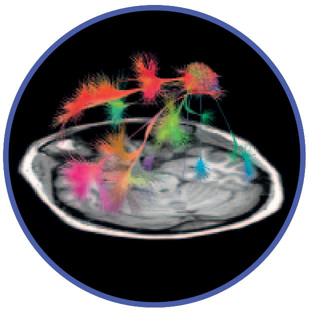
- How are resting state fluctuations and attention related?
- How can we combine resting state and task based fMRI?
- How are EEG characteristics related to rs-fMRI?

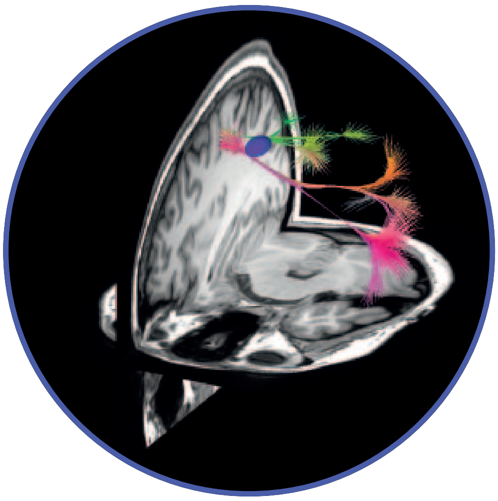
What about inter-individual variability?

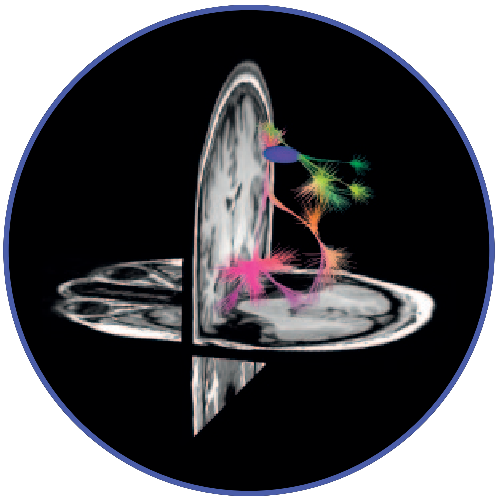
- What is reliable, what is stable, and what changes in rs-fMRI?
- What are dynamic properties of connectivity?
- Which pharmacological effects do we know?
- What impact does development have on resting state measures?

Which clinical aspects can we investigate?

- What are robust findings of abnormal resting state behaviour in patients?
- What is the perfect clinical resting state experiment?
- How can we use rs-fMRI in diagnosis and monitoring of patients?
- What needs to be solved for multi-centre approaches using resting state fMRI?







Diffusion:
What it means and how to measure it

September 28–30, 2015
Clinical Research Imaging Centre (CRIC)
Queen´s Medical Research Institute
Edinburgh, United Kingdom

Course organiser:

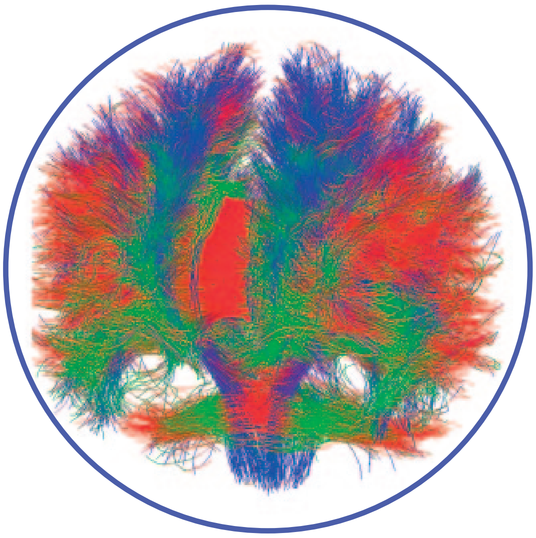
Valerij G. Kiselev
Medical Physics
Department of Diagnostic Radiology
University Medical Center Freiburg/DE

Local organisers:

Neil Roberts
Clair Young
Clinical Research Imaging Centre (CRIC)
Queen´s Medical Research Institute
University of Edinburgh/UK

Preliminary faculty:

E. Fieremans, V.G. Kiselev, D.S. Novikov, R.G. Nunes, M. Weigel



Course description

The basic idea of MR diffusion measurements is easy to explain, but its practical implementations require real know-how. How to design experiments? How to extract diffusion properties from the measured signal? How do these properties reflect the cellular structure of biological tissue? What is the up-to-date diffusion-MR road map? Is there any *Terra incognita?*

This advanced course is designed to provide a solid foundation for those who wish to develop methods of diffusion measurements or apply them in the biomedical context. A significant part of time will be spent on exercises, which will be performed by participants individually under the guidance of the lecturers.

The course will begin with an introduction to the basic concepts of the physics of diffusion, such as the conservation law and the Fick's law, leading to the diffusion equation and providing basic examples along the way. The fundamental quantity, the diffusion propagator, will be introduced.

Next, we show why the diffusion propagator is accessible with a diffusion-weighted NMR measurement. The cumulant expansion will serve as a basis to understand the relation between the genuine diffusion measures and their measurable 'apparent' counterparts. We shall in particular consider the cases of narrow and oscillating diffusion-sensitising gradients, which are most straightforwardly connected to the fundamental diffusion metrics. We will then discuss the implications of theory to the experiment design.

As everything depends on high-quality images, we shall present basic and advanced experimental techniques, discuss their advantages and disadvantages, optimisation, imaging artefacts and remediation.

Concluding the course, we will discuss the biophysical modeling and interpretation of the diffusion-weighted signal and how it helps to respond to current challenges in quantifying tissue microstructure, providing a number of examples and reviewing existing models and paradigms.

This course will take place in Edinburgh right before the ESMRMB 2015 Congress and can serve as an introduction to the field for students and postdocs attending the meeting.

Learning objectives

Diffusion measures and their relation to tissue structure

- Gaussian and non-Gaussian diffusion
- Diffusion propagator
- The cumulant expansion
- Narrow gradient pulses, q-space imaging and diffusion diffraction
- Oscillating gradients
- Double wave vector diffusion weighting
- Effective medium theory

Strategies of biophysical modelling in diffusion MR

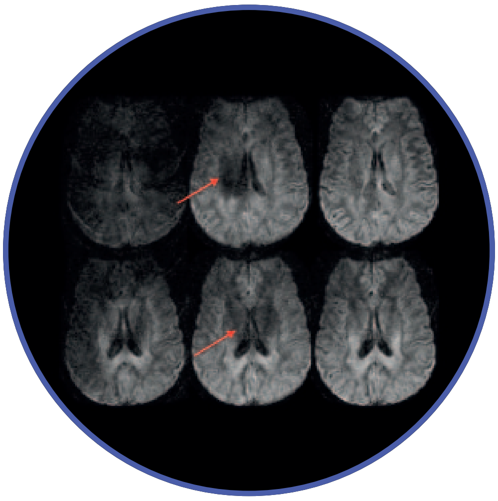
- Manual for model builders: The art to find the dominant contribution
- About model testing
- About Monte Carlo simulations
- Review of existing models

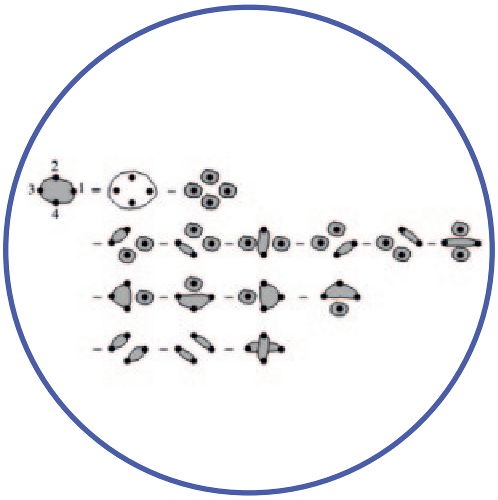
Methods for measurement of diffusion

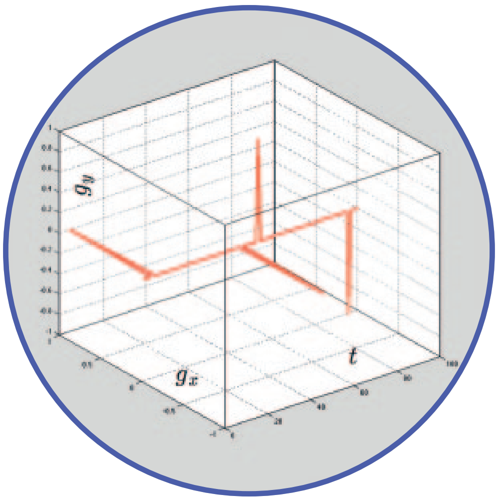
- Diffusion-weighted imaging sequences
- Single shot and multi-shot sequences
- Single shot diffusion-weighted EPI sequence
- Practical sequence design and parameter optimisation
- Potential artefacts and correction
- Alternative diffusion-weighted imaging methods: Multi-band acquisitions, multi-shot EPI, TSE, PROPELLER, SSFP and others
- Challenges of diffusion measurements outside the brain

Post-processing

- Basics of diffusion tensor calculation
- Correction of susceptibility related distortions of EPI
- images
- Correction of eddy currents distortions
- Artefacts of multi-shot/segmented DWI and possible
- Methods of compensation







Registration

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

Please note that your registration becomes valid only upon reception of payment and confirmation by the ESMRMB Office, the latter will be available for download in the online 'MyUser Area'.

Registration

Rates refer to one course. If more than one course is booked at once, a 10% reduction will be granted.

Apply to all ESMRMB Lectures on MR courses in 2015.

The registration fee includes:
- Attendance of the course
- Teaching material for the course (digital syllabus)
- Coffee & Lunch
- Welcome Reception

Participants are responsible for their own travel and hotel arrangements. When making your flight bookings, please make sure that you will be able to stay for the entire course.

Terms of cancellation

In the case of cancellation of registration by the participant:

> 4 weeks before the course date: the registration fee will be refunded less 20% for administrative costs.
< 4 weeks before the course date: no refund will be granted.

If less than 20 participants register, ESMRMB reserves the right to cancel a course 4 weeks prior to its beginning, at the latest.

Registration is possible online at **www.esmrmb.org**

Registration fees

(except RF coil design course)

Early registration fees

(until 8 weeks prior to the course)

	Members**	Non-Members
Basic scientists, physicians, MR technologists/radiographers and others with a professional degree	**€ 490**	**€ 660**
PhD students and physicians in training*	**€ 340**	**€ 435**

Late registration fees

(after 8 weeks prior to the course)

	Members**	Non-Members
Basic scientists, physicians, MR technologists/radiographers and others with a professional degree	**€ 610**	**€ 805**
PhD students and physicians in training*	**€ 410**	**€ 530**

Industry fee

This rate applies for employees/representatives of commercial companies.

€ 990

RF coils: Design, build and characterise your own

Please note that due to special requirements for this course different registration fees apply.

Early registration fees

(until 8 weeks prior to the course)

	Members**	Non-Members
Basic scientists, physicians, MR technologists/radiographers and others with a professional degree	**€ 640**	**€ 810**
PhD students and physicians in training*	**€ 490**	**€ 585**

Late registration fees

(after 8 weeks prior to the course)

	Members**	Non-Members
Basic scientists, physicians, MR technologists/radiographers and others with a professional degree	**€ 740**	**€ 935**
PhD students and physicians in training*	**€ 540**	**€ 660**

Industry fee

This rate applies for employees/representatives of commercial companies.

€ 1,150

* PhD students and physicians in training are requested to provide a signed attestation from the head of the institution/department confirming their student/training status no longer than 10 days after the registration.

** Reduced course fees are available for members in good standing who have paid their 2015 ESMRMB membership fee.

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