

Lectures/Tutorials „Modern Applied Mathematics in Bioelectromagnetism“

In WS2026/2027 and SS2027, Veranstaltungsnr.: 106371, lectures of 2 hours per semester in combination with the tutorials of 1 hour per semester in WS2026-2027 and SS2027.

Bachelor/Mathematics; Master/Mathematics; Medizin. Wissenschaften; Dr rer med/Medizin. Wiss.; Staatsexamen – Medizin; interdisciplinary Master's programme in Cognitive Neuroscience (iKoN)

Abstract:

Nowadays devices and tools are available for analyzing and monitoring the human brain at a high level of detail. These details are necessary, e.g., for successful surgery or, more generally, for basic brain research. Rapid advances were achieved in the fields of structural and functional imaging modalities such as Magnetic Resonance Imaging (MRI), ElectroEncephaloGraphy (EEG) and MagnetoEncephaloGraphy (MEG). Since the functional modalities EEG and MEG each have their strengths and weaknesses, they complement each other and synergetic effects are expected from their integration. Non-invasive computational methods are often used in the field of neurosciences. The field of EEG/MEG source analysis is a representative of such methods. Non-invasive tools are of course preferable to invasive methods which may be of high risk to patients. In fundamental brain research, most often there is no other choice besides computational methods. Furthermore, in recent years, new methodologies were developed for manipulating the human brain using brain stimulation methods such as Transcranial Electric Stimulation (TES) and Transcranial Magnetic Stimulation (TMS).

This lecture will focus on mathematical methods for the analysis of EEG, MEG, MRI, TES and TMS. We will study registration and segmentation methods for the structural modalities T1-weighted MRI, T2-weighted MRI and Diffusion Tensor MRI (DT-MRI) and signal analysis, Maxwell equations, Helmholtz' reciprocity law, existence and uniqueness of solutions, boundary and finite element forward methods, inverse approaches such as current density reconstruction, beamforming and Bayesian inversion as well as optimization approaches for multi-sensor brain stimulation modalities such as TES and TMS. Finally, we will apply the new methodologies for reconstructing and manipulating neuronal networks in the human brain in neuroscientific applications and in clinical fields of neurology and psychiatry.

The students should have basic knowledge of analysis, linear algebra and numerical mathematics. Some knowledge on functionalanalysis, numerical mathematics of partial differential equations, inverse problems and optimization is helpful, but we will also de-rive the most important concepts in the lectures.

The first lecture will be on Oct. 13 from 16:00-17:30 in the seminar room of the Institute for Biomagnetism and Biosignalanalysis, Malmedyweg 15, 48149 Münster (wooden house behind the ENT-clinic). It is also possible to follow the lecture per zoom:

<https://uni-ms.zoom-x.de/j/65351170951?pwd=bFTbjbteVo0XtbjQvryga4OwmynfL1.1>

Meeting-ID: 653 5117 0951

Kenncode: 200596

A following bachelor or master thesis in the topics of the lecture/tutorial might be possible and also welcome. If there is the need, the lectures will be given in english, otherwise in german.