The interaction between electromagnetic fields and neurons in mesoscopic scale

Supervisors: Prof. Knösche, Dr. Weise

Non-invasive brain stimulation using Transcranial Magnetic Stimulation (TMS) and transcranial Direct Current Stimulation (tDCS) is a useful tool to study the human brain. The induced electric field is capable to depolarize neural structures, which results in the generation of action potentials. However, the exact mechanisms behind the activation function are still unknown. The activation function in turn represents the input variable of the subsequent neuron model for the simulation of for example motor-evoked potentials. The complexity and high number of neurons and cell assemblies in the cortex inhibit detailed models on a macroscopic scale. Instead, a mesoscopic model, which renders a small portion of the cortex is useful to study the activation function of neurons. It is the goal of the thesis to develop a mesoscopic FEM model to investigate the interaction between TMS and tDCS induced electric fields and neurons and to derive the corresponding activation function in dependence of the direction and magnitude of the induced electric field. An FEM model of this complexity is very time consuming to compute, and thus not very suitable in more complex modeling chains. For that reason, it will be approximated by a simplified polynomial representation using the generalized polynomial chaos method (gPC). The accuracy of the derived meta model will be analyzed and most influencing parameters are going to be identified. For this task, already implemented gPC algorithms at the MPI-CBS Leipzig can be used.

The thesis will be conducted in cooperation with the MPI-CBS in Leipzig and can be written in German or English language.

Tasks:
- Getting familiar with previous work on geometric models of grey matter, which were developed at the MPI-CBS in Leipzig.
- Preparation of the FEM model (e.g. meshing, physics, boundary conditions, solver)
- Solve FEM model and run parametric studies
- Uncertainty- and sensitivity analysis of the FEM model to derive a computationally efficient meta model and to identify the most influencing parameters using existing algorithms developed at the MPI-CBS in Leipzig

Contact:
Prof. Dr.-Ing. habil. Thomas Knösche
Max-Planck-Institut für Kognition- und Neurowissenschaften Leipzig
Telefon: 0341-9940-2619
Email: knoesche@cbs.mpg.de

Dr.-Ing Konstantin Weise
Max-Planck-Institut für Kognition- und Neurowissenschaften Leipzig
Telefon: 0341-9940-2580
Email: kweise@cbs.mpg.de