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Calculation and Evaluation of Current Densities and Thermal Heating in the Human Body

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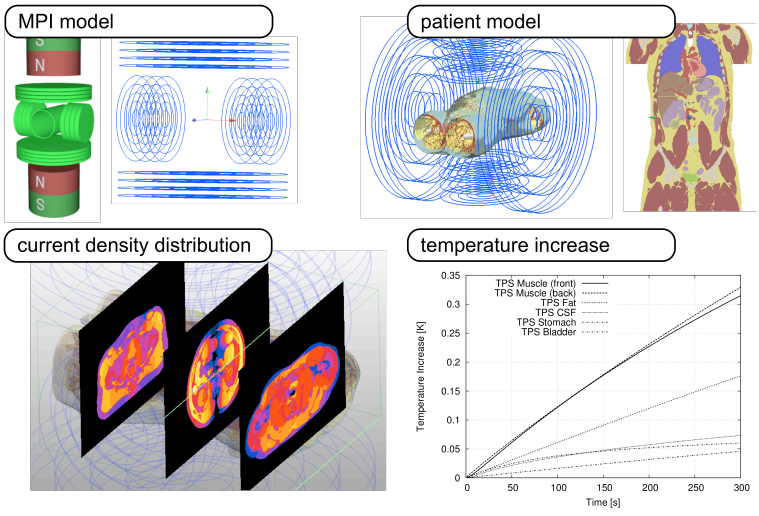
This research project originally was initiated by the Philips laboratory in Hamburg. There, Magnetic Particle Imaging (MPI), a new medical imaging technique, was developed and initially presented in 2005. MPI is able to produce images of high spatial and temporal resolution by measuring the magnetic fields generated by magnetic particles in a tracer. By combining the nonlinear magnetization curve of the small magnetic particles with an inhomogeneous magnetic field, this technique yields high-resolution images. In this work the current densities and possible warming in the human body, generated by the radio-frequency fields, are to be calculated and evaluated, using numerical techniques for field computation. Upper limits for field-gradients, quickly changing in space and time, will be derived from measurements and simulations, especially with respect to the risk of heart arrhythmia induction as well as possible muscle- and nerve-stimulation.

Numerical simulation with whole torso models provide quantitiative field distributions of current densities and Specific Absorption Rates (SAR), from which the temperature increase can be derived with the Pennes' Bio-heat equatiion. Yet, from the current densities distributions one cannot tell whether muscles or nerves are stimulated or not. Thus analytic cell models are consulted to decide whether the current density induced by the magnetic field is strong enough to evoke a transmembrane voltage above stimulation threshold.

In addition experimental work is being carried out in order to investigate stimulation thresholds for magnetic fields in the kHz-range. Therefore, a figure-of-eight coil was built, producing strong magnetic fields at frequencies up to 25 kHz.



Publications

- J. Bohnert et al.. Simulations of current densities and specific absorption rates in realistic magnetic particle imaging drive-field coils. *BMT Proceedings* (55), 2010
- J. Bohnert et al.. Effects of time varying currents and magnetic fields in the frequency range of 1 kHz to 1 MHz to the human body - a simulation study.*IEEE EMBS Proceedings, 6805-6808, 2010*
- J. Bohnert et al.. Calculation and evaluation of current densities and thermal heating in the body during MPI. In *Magnetic Nanoparticles,S. 162-168,* 2010