ST 8: Magnetism and Medicine (MA and ST)

Time: Wednesday 9:30–12:30 Location: H1

Invited Talk ST 8.1 Wed 9:30 H1

Magnetic resonance imaging: an ongoing success story — •Jens Frahm — Biomedizinische NMR Forschungs GmbH, Am Fassberg 11, 37070 Goettingen, Germany

The fascinating development of magnetic resonance imaging (MRI) started more than 35 years ago when Paul Lauterbur published a seminal paper on an imaging method based on nuclear magnetic resonance (NMR). Since then, MRI evolved from a toy for physicists to one of the most important tools in diagnostic imaging, with almost 100 million examinations per year worldwide. In addition, noninvasive MRI studies of experimental animals (e.g., genetically modified mice) play a unique role in translational biomedical research linking advances in molecular biology to studies of human patients. The main driving force behind the large range of diverse MRI methods and applications is the quest for image quality, specificity, and speed. This presentation will illustrate some of these developments by focusing on selected examples. Specific topics include the MRI access to human brain function and the underlying axonal connectivity and fiber architecture. The talk will further address recent progress in real-time MRI yielding movies with up to 40 frames per second. Such techniques exploit non-Cartesian radial encoding schemes and iterative image reconstructions using regularized nonlinear inversion.

Invited Talk ST 8.2 Wed 10:00 H1

Biomedical nanomagnetics: A spin through new possibilities — •Kannan Krishnan — University of Washington, Seattle, USA

Two of the principal challenges in biomedicine are the detection of disease at the earliest possible time prior to its ability to cause damage (diagnostics and imaging) and delivering treatment at the right place, at the right time whilst minimizing unnecessary exposure (targeted therapy with a triggered release). In this context, we have been developing theranostic magnetic nanoprobes (TMN) with tailored properties for high moment or high frequency applications, optimized for localized heating, MRI contrast enhancement and triggered drug release, and individually conjugated for specific functionality. Advantages of these TMNs include (a) the flexibility and precision with which the physical properties of the nanoparticle core – size, size distribution, MRI relaxivity, magnetic relaxation dynamics and pH-sensitivity – can be tailored and optimized. (b) their functionality as ultrasmall and ultrasensitive MRI contrast agents with competitive performance suggesting lower dose and increased penetration. (c) the optimized properties of these TMNs to generate heat locally and the therapeutic potential that this feature implies.(d) their biocompatibility and very low cytotoxicity and (e) their potential for the development of a magnetic particle imaging microscope – an inexpensive, quantitative nanoimaging platform for meaningful dosimetry. Details of our current work in these areas, including translational application, primarily focused on detection and treatment of cancer, will be discussed.

Invited Talk ST 8.3 Wed 10:30 H1

Recent SQUID applications in medicine — •Hans Koch — Physikalisch-Technische Bundesanstalt (PTB), Berlin

An overview will be presented on more recent applications of SQUID sensor systems in medicine, namely in the fields of magnetoencephalography, magnetic nanoparticle probes, and low field magnetic resonance. As a particular aspect the merits of these applications will be highlighted with respect to the grand competition of magnetic resonance imaging.

Invited Talk ST 8.4 Wed 11:00 H1

Biomedical Magnetic Resonance using Hyperpolarized Gases and Liquids — •Laura Schreiber — Section of Medical Physics, University Medical Center, Mainz, Germany

Biomedical magnetic resonance imaging (MRI) is an inherently insensitive methodology since it requires mmoL amounts of the detected nuclei. Therefore, MRI of respiratory gases (O2, CO2, N2) is not feasible in-vivo. Sophisticated hyperpolarization techniques, i.e. optical pumping of nuclear states, increase the nuclear polarization of the noble gases 3He and 129Xe by five orders of magnitude and thus permit a direct imaging of the inhaled gases as they distribute within the lung of a human subject. Therefore, assessment of human lung ventilation becomes feasible. Moreover, techniques have been developed to measure functional lung parameters like intrapulmonary oxygen concentration or the integrity of the alveoli using hyperpolarized gases.

Hyperpolarization of liquids has also become feasible recently using Dynamic Nuclear Polarization (DNP) or Parahydrogen Induced Polarization (PHIP) techniques. This is of particular interest for low sensitivity nuclei like 13C where measurement times are long. Now metabolic studies with DNP- or PHIP-hyperpolarized 13C-labeled substances have become feasible with measurement times on the order of seconds, thus permitting non-invasive assessment of reaction kinetics in-vivo.

Invited Talk ST 8.5 Wed 11:30 H1

Recent Developments in Healthcare Biomagnetics — •Quentin Pankhurst — Director, Davy-Faraday Research Laboratory, The Royal Institution of Great Britain, 21 Albemarle Street, London W1S 4BS

Healthcare biomagnetics - the sensing, moving and heating of magnetic nanoparticles in vitro or in the human body - is a rapidly changing field that is attracting a great deal of interest worldwide. It offers the potential to develop safe and convenient alternatives for a diverse range of therapeutic and diagnostic healthcare applications, using injectable materials of proven safety and reliability. In doing so, it makes use of the three fundamental action-at-a-distance properties of magnetic materials - their ability to act as remote sensors, mechanical actuators, and heat sources. The versatility of the field is leading to the emergence of multi-modal applications, combining two or more of the sensing-moving-heating properties in the same product. Similarly, certain applications are now entering or are close to beginning Phase I/II clinical trials, or in the case of in vitro products, are already entering the marketplace. In this lecture some recent developments in the field will be described and discussed.

Invited Talk ST 8.6 Wed 12:00 H1

SQUIDs for Noninvasive Magnetogastrography — •Alan Bradshaw[1,2], Leo Cheng[3], Andrew Pullan[3], and William Richards[4] — [1]Vanderbilt University, Nashville, TN — [2]Lipscomb University, Nashville, TN — [3]Auckland University, Auckland, NZ — [4]University of South Alabama, Mobile, AL

The magnetogastrogram (MGG) and magnetoenterogram (MENG) have been studied over the past 20 years to assess digestive and motility issues in the stomach and small bowel. While the electrogastrogram (EGG) is capable of measuring frequency dynamics of the stomach's electrical activity, spatiotemporal analyses afforded by multichannel magnetogastrography may prove critical to the assessment of stomach disorders such as gastroparesis. Our recent results from MGG measurements and modeling suggest differences in gastric slow wave propagation between normal controls and diabetic gastroparetics. The electroenterogram (EENG) is not readily recordable in most subjects because of the intervening fat layers, but the MENG is less susceptible to volume conduction effects because of the relative similarity of the magnetic susceptibility of tissue and air. Mesenteric ischemia is a potentially deadly disease characterized by dysrhythmias of the intestinal electrical activity. These dysrhythmias can be detected in the MENG, and our recent studies are investigating the threshold at which effects can be discerned.