ST 6: Medical Imaging Technologies

Time: Wednesday 15:00–16:15 Location: PC 203

ST 6.1 Wed 15:00 PC 203

Piezo-Optic Power Calibration of Nonlinear and Shocked Ultrasound in Real Time — •Milan Fritsche, Johannes Köppl, Luis Guillermo, and Florian Steinmeyer — Technische Hochschule Nürnberg Georg Simon Ohm, Deutschland

Calibration of ultrasound transducers - used in medical diagnostics and therapies like lithotripsy or thermal ablation - is cumbersome: Standard is a radiation-force-balance calibration with time resolution of 1s-2s, where a target is irradiated off-focus to avoid damage. Hydrophones measure acoustic pressure over hours. They are easily destroyed by cavitation, suffer from reflections and exhibit resonances in the frequency response.

The piezo-optic effect is the change of the refractive index under pressure. A Schlieren imaging system consists of a LED with a collimator illuminating the acoustic wavefield in water, a focussing "Schlieren lens", a knife-edge at the lens focus (blocking parts of the Fourier plane) and a camera. Light is refracted proportional to pressure gradients integrated along the light path. The camera records the wavefield in a real image. It is very sensitive to the precise knife edge position, thus not useful for calibration.

In our procedure a CMOS sensor replacing the knife edge records intensity over the full Fourier plane. The intensity variance displays a linear dependence on acoustic power - so far over more than two orders of magnitude (0,5W-150W). This allows for robust calibration of acoustic power even of shock waves with real time resolution of sub-milliseconds.

ST 6.2 Wed 15:15 PC 203

Seeing Sound: Real-Time Schlieren Imaging of Ultrasound Wavefields — Milan Fritsche, Adrian Dittmaier, Maximilian Jahrsdörfer, and •Florian Steinmeyer — Technische Hochschule Nürnberg Georg Simon Ohm

In 1864 August Toepler visualised acoustic waves by Schlieren imaging. Modern components as aspherical lenses, LEDs, CMOS-sensors expand the method to short timescales and a broad range of amplitudes. We demonstrate a number of novel applications.

The piezo-optic effect is the sensitivity of the refractive index to pressure. Our in-line Schlieren setup consists of a LED illuminating the acoustic wavefield of a transducer in water through a collimating lens. Light is refracted proportional to the pressure gradient integrated along the light path. Downstream, a "Schlieren lens" condenses light onto a knife-edge at the lens focus (blocking unrefracted light, yielding a dark field image of the waves). Eventually, a digital camera reconstructs a real image.

By illuminating stroboscopically (frequency 0.5-8 MHz, acoustic power 50mW-150W) a propagating wave appears frozen, images are very sharp. It is shown that the projection of a radially-symmetric ultrasound field is converted into a tomogram of a central symmetry plane. While wave intensity is hard to quantify, field geometry can be evaluated, e.g. wavelength, phase, focal position, distortion by shocks, propagating or standing waves, reflection, cavitation. As a means of quality assurance beam steering in array transducers and/or manufacturing errors can be detected - down to sub-millisecond shutter speed.

ST 6.3 Wed 15:30 PC 203

NeuroMap: Human magnetic particle imaging scanner for brain perfusion — •Liana Mirzojan[1,2], Jan-Philipp Scheel[1,2], Florian Sevecke[1,2], Eric Aderhold[1], Egor Kretov[1], Pascal Stagge[1], Mandy Ahlborg[1], and Matthias Graeser[1,2] — [1]Fraunhofer Research Institution for Individualized and Cell-Based Medical Engineering IMTE, Lübeck — [2]Institute of Medical Engineering, University of Lübeck, Lübeck

In the ever-evolving landscape of medical imaging Magnetic Particle Imaging (MPI) emerges as a new imaging modality that harnesses the unique properties of superparamagnetic nanoparticles, offering high contrast and high sensitivity, with an absence of ionizing radiation. Despite its advantages the development of robust human applications has proven to be a challenge, therefore MPI is still mostly pre-clinical. There are several challenges in scaling a pre-clinical scanner to human size, especially in the most crucial parts, which are the drive and the selection field generators. Main reason for this challenge is the rising power dissipation when scaling to human size. Currently there is a lack of bedside imaging equipment in intensive care units for stroke patients. The aim of the NeuroMap project is to close this gap with a low-field magnetic particle imaging bed-side system. In this work a novel human MPI scanner for stroke monitoring will be demonstrated. Both the drive field and selection field have been optimized with a focus on a clinical application with high patient safety and a performance-efficient design.

ST 6.4 Wed 15:45 PC 203

Imaging local diffusion in microstructures using NV-based pulsed field gradient NMR — Fleming Bruckmaier[1], •Robin D. Allert[1], Nick R. Neuling[1], Philipp Amrein[2], Sebastian Lettin[2], Karl D. Briegel[1], Maxim Zaitsev[2], and Dominik Bucher[1] — [1]Department of Chemistry, Technical University of Munich, 85748 Garching, Germany — [2]Division of Medical Physics, University of Freiburg, Freiburg, Germany

Investigating diffusion phenomena within microstructures holds significant importance across scientific domains such as neuroscience, cancer research, and energy research. While magnetic resonance methods are widely employed for quantitative diffusion measurements, their sensitivity in resolving and measuring molecular diffusion within individual microstructures remains limited. This research introduces an innovative tool for exploring diffusion at a microscopic scale by utilizing nitrogen-vacancy (NV) center-based nuclear magnetic resonance imaging (MRI). Our experimental framework integrates pulsed gradient spin echo (PGSE) with optically detected NV-NMR spectroscopy, enabling precise quantification of molecular diffusion and flow within nano-to-picoliter sample volumes. Through correlated optical imaging with spatially resolved PGSE NV-NMR experiments, we showcase the potential of this methodology to investigate local anisotropic water diffusion within a representative microstructure. This approach expands current capabilities in exploring diffusion processes to the microscopic scale, thereby facilitating investigations into single cells, tissue microstructures, and ion mobility in thin film materials.

ST 6.5 Wed 16:00 PC 203

Bildgebung statt Biopsie — •Mona Pistel — Universitätsklinikum Erlangen, Radiologisches Institut

Um auffällige Läsionen im Brustkrebs-Screening weiter klassifizieren zu können, führen Ärzte häufig eine Brustbiopsie durch. Biopsien bringen sowohl eine körperliche wie auch psychische Belastung für die betroffenen Frauen mit. In bis zu 50 % aller Biopsien erweist sich die untersuchte Läsion als gutartig. Dies verdeutlicht den großen Bedarf an einem präziseren und bestenfalls nicht invasiven Tool in der Brustkrebsdiagnose. Die diffusionsgewichtete MRT (DWI) ist ein solches Verfahren, mit dem nicht-invasiv und zudem ohne Verwendung von Kontrastmittel zwischen gutartigen und bösartigen Brustläsionen differenziert werden kann. DWI misst die durch thermische Energie zustande kommende Brownsche Molekularbewegung im Körper. Da bösartige Läsionen eine höhere Zelldichte haben als gutartige, ist die Diffusion der Moleküle in bösartigen Läsionen eingeschränkter als in gutartigen. Neben der Klassifizierung der Läsionen wurde die DWI in dieser Studie auch für die Untersuchung molekularer Eigenschaften von Brustkrebs genutzt. Diese molekularen Eigenschaften können wichtige Hinweise auf den Verlauf der Erkrankung sowie die Wahl der richten Therapie geben. Standardmäßig werden die molekularen Eigenschaften durch eine Biopsie gewonnen. Durch die Heterogenität der Läsionen kommt es jedoch in bis zu 20% der Fälle zu Unterschieden zwischen den Ergebnissen der Biopsieprobe und der postoperativen Probe. Durch die holistische Betrachtung kann DWI hier einen Mehrwert liefern.