How to build a new imaging modality … and make it work

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Abstract: Magnetic Particle Imaging (MPI) is an emerging tomographic imaging modality that offers high sensitivity, high temporal resolution, and quantitative capabilities without ionizing radiation. Since its first demonstration in 2005, MPI has evolved into a versatile platform for imaging magnetic nanoparticle distributions in vivo, with growing relevance for preclinical imaging, diagnostics, and theranostics [1,2].
This talk aims to provide a comprehensive overview of MPI tailored for physicists interested in the intersection of magnetism, instrumentation, and biomedical applications.
Beginning by demystifying the physical principles underlying MPI, including the nonlinear magnetization response of superparamagnetic nanoparticles and the generation of spatial encoding fields. A comparative look at different scanner geometries – such as field-free point (FFP) and field-free line (FFL) configurations – will shed light on how spatial resolution and acquisition speed can be optimized.
On the hardware side, several key components are required for building an MPI system, including gradient and drive-field coils, receive chains, and analog-digital converter.
After digitization, there are multiple strategies for image reconstruction, nanoparticle characterization, and calibration techniques that enable accurate and quantitative imaging.
Emphasis will also be placed on the fingerprinting of nanoparticles and how these can be used to distinguish between particle types, states, or functionalization.
Finally, the talk will highlight recent advances and promising near-future applications of MPI, such as real-time vascular imaging, cell tracking, hyperthermia applications, and functional imaging.

Fig. 1: From the idea behind Magnetic Particle Imaging to the application in the clinical environment.

Whether you're a physicist curious about novel imaging technologies or a researcher considering MPI for your own applications, this session will equip you with the fundamental understanding and practical perspective needed to engage with this rapidly evolving field.

References: [1] A. Davida, B. Basari, J.Appl.Phys. 136:220701 (2024). [2] C. Billings et al, Int.J.Mol.Sci. 22:7651 (2021).