Off-Mainstream Techniques/ “Applications of SQUID Detected MRI”, Michelle Espy espy@lanl.gov
Highlights:

- It is possible and sometimes advantageous to perform MRI at very weak magnetic (μT) fields
- At ultra-low (ULF) fields one can combine MRI with magnetoencephalography (MEG) or explore new methods for functional brain imaging (e.g. resonant MREIT, Direct Neural Current Imaging)
- Contrast between certain tissues/materials is improved
- Novel pulse sequences are possible, susceptibility artifacts are removed
- Imaging in the presence of metal is simplified
- The requirement for large and homogeneous magnetic fields are relaxed
- Portable or inexpensive systems are possible
- Pre-polarization methods, similar to field-cycling MRI, and ultra-sensitive detection (i.e. the superconducting quantum interference device, SQUID) can help improve SNR
- The challenges are low signal, long imaging times, shortening relaxation times, and increased influence of concomitant gradients and external magnetic fields
- Advantages, challenges, and potential applications are discussed

Title: “Applications of SQUID Detected MRI”
Target audience: MR scientists seeking new challenges, Ph.D. students in the advanced phase of their projects thinking of future directions and clinicians looking for new diagnostic modalities and treatment options. The attendees are expected to be familiar with the basic MRI techniques and hardware.

OUTCOME/Objectives: Recognize new trends in imaging technology development related to MRI; Explain the physical principles of the alternative imaging modalities and approaches; Identify the challenges associated with the new technological developments; Evaluate applicability of the new imaging approaches to particular medical areas; Join the development effort or apply these techniques.

PURPOSE: While the overwhelming technological trend in MRI is to fields > 1 T to achieve high SNR, there are applications where ultra-low fields (ULF, μT) can bring benefits outweighing the challenges.

METHODS: There is significant loss in signal from polarization and performance of Faraday detection at these low fields. To mitigate this, recent approaches to ULF MRI have included polarization enhancement (primarily from pre-polarization methods) and sensitive detection by SQUIDs.

RESULTS: Several compelling demonstrations of ULF MRI have been made: MEG and MRI together [1] which is not possible in traditional MRI; The potential for novel functional brain imaging approaches based on the interaction of the spins with currents (neural or applied); J-coupling spectroscopy exploiting the narrow line-widths achievable at ULF [2]; Improved T_1 contrast; Imaging near metal is simplified and applications where high fields cannot be tolerated are enabled [3]. However, images remain far from clinical relevance due to low SNR, and imaging times are quite long. Improved pulse sequences and use of parallel imaging methods will likely offer some improvement.

DISCUSSION: There is significant opportunity, and need, for improvement in ULF methods. It is important to have clear understanding of when the benefits outweigh the challenges.

CONCLUSION: ULF MRI appears to be an exciting area of research for specific applications.

REFERENCES: [1] V. Zotev et al, J. Mag. Reson. (2008) v194(1): 115-20, [2] R. McDermott et al., Science (2002) v295(5563): 2247-2249; [3] J. Clarke et al., Ann. Rev. Biomed. Eng. (2007) v9: 389-413