INVITED

SQUIDs Applications for Magnetic Resonance Imaging at Ultra-low Magnetic Field

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Nuclear magnetic resonance (NMR) methods are widely used in medicine, chemistry and industry. One NMR application is magnetic resonance imaging or MRI. MRI is among the most effective diagnostic tools in medicine. Conventional MRI instruments use strong magnetic fields for nuclear spin polarization and Faraday coil variants for signal detection. NMR signal strength and frequency is proportional to the strength of the polarizing field. In addition, the sensitivity of Faraday coil based receivers tends to increase with frequency. The common trend in NMR instrumentation is the pursuit of the highest possible field strength associated with the polarizing field. Commercial or nearly commercial efforts have field strengths approaching 7 Tesla. Recently it has become possible and practical to perform NMR and MRI at a small fraction of these enormous field strengths. The now so-called "Ultra-low Field" (ULF) regime requires field strengths only on the order of a few Gauss (1Tesla = 10,000 Gauss). These ultra low field techniques exploit the properties of superconducting quantum interference devices or SQUIDs. SQUID magnetic sensing technology allows for ultra-sensitive detection while a class of strong pulsed pre-polarizing fields greatly enhance signal. SQUID sensing technology is a key component for Biomagnetism instrumentation such as magneto-encephalography (MEG). Modern MEG systems have a few hundred SQUID-based detectors working inside large magnetically shielded rooms. Such SQUID arrays could be used in conjunction with ultra-low field MRI techniques to record MEG signals as well as the anatomical data associated with conventional MRI. The first ever human brain ULF MRI and simultaneous MEG signals were recorded in LANL in 2008. SQUID arrays and the associated gradiometers as a key sensing component for ULF MRI instrumentation, require different approaches to design and construction than SQUIDs for MEG. The SQUID instrumentation enables simultaneous measures of brain anatomy via MRI, and function via magneto-encephalography (MEG). The technology may produce a new generation of light-weight and affordable MRI medical instrumentation for medical, security, and industrial applications. In this presentation I will describe the world first SQUID-based instruments that are capable of performing simultaneous ULF MRI and MEG. Finally, I will present the results from a ULF MRI relaxometer developed and deployed to an airport for inspecting liquids in a check-point for the presence of hazardous materials. Present status and future design trends of this revolutionary new instrumentation will be also discussed.

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