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Simultaneous Measurement of Magnetic Resonance and Neuronal Signals

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Nuclear magnetic resonance (NMR) and magnetic resonance imaging (MRI) at ultra low magnetic fields (ULF, $\sim$ microT) have advantages over their counterparts at higher magnetic fields, despite the reduction in signal strength. Among these advantages are that the instrumentation uses superconducting quantum interference devices (SQUIDs), and is now compatible with simultaneous measurements of biomagnetic signals, such as magnetoencephalography (MEG). This presents a new opportunity for noninvasive simultaneous functional and anatomical brain imaging. We present here the physical basis and experimental evidence for a variety of ULF-MRI techniques being developed at Los Alamos to enable simultaneous anatomical and functional imaging of the human brain. We conclude by presenting a novel technique, based on the resonant interaction between the magnetic fields such as those that arise from neural activity and the spin population in ULF-MRI experiments, that may enable direct tomographic imaging of the consequences of neural activity.