MODELING DIRECT DETECTION OF THE NEUROMAGNETIC FIELD BY MAGNETOENCEPHALOGRAPHY AND MAGNETIC RESONANCE IMAGING

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Two different techniques have been used to directly detect the magnetic field generated by electric current flowing in neurons. When a subset of the currents possesses geometric order and has sufficient strength the resulting field can be detected outside the head using SQUID based detectors. An excellent review of the theory and practice of Magnetoencephalography (MEG) can be found in Hämäläinen et al. [1]. A second technique relies on the fact that a current flowing in any neuronal compartment, e.g., a dendrite, produces a magnetic field that is strongest close to the current. In the presence of an external magnetic field the precession frequency of protons in the immediate neighborhood of the current will be altered, those on one side of the current will speed up and those on the opposite side will slow down. The dephasing that results modifies both the phase and magnitude of the MRI signal, and we obtain some analytic expressions for these quantities. Using a simple model of the neuronal currents with parameters partially constrained by experimental MEG data, we estimate the size of the effect on the MRI signal.

1. M. Hämäläinen et al., "Magnetoencephalography—theory, instrumentation, and applications to noninvasive studies of the working human brain", Revs. Mod. Phys. **65**, 413-497, 1993.