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Toward neuronal current spectroscopy at Ultra-Low field NMR

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Introduction

The functional significance of different frequency bands of the electroencephalography (EEG), Local Field Potential (LFP) and Multi-Unit-Activity (MUA) is fundamental for the assessment of non-invasive monitoring of the brain activity. The possibility to perform nuclear magnetic resonance (NMR) at Larmor frequencies <2kHz with Ultra-Low field NMR - together with the possibility to modulate the Larmor field during the acquisition of the free-precession decay (FPD) in the range 100Hz-2kHz could open the route toward neuronal current spectroscopy at ULF regimes. This work illustrates our results.

Methods

We used ultra-low field NMR equipment and SQUID detectors. The Larmor frequency was driven by an external signal, monitor of the brain activity. Dipolar phantoms inserted in calibrated medium (σ= 0.33S/m, T_1 and T_2 relaxation times of about 110ms) mimed the neuronal sources while real MUA microelectrode recordings waveforms simulated their timing. Electrodes mounted within the phantom mimed epidural EEG electrodes: their signals were used to tune the Larmor frequency.

Results

We recorded FPDs simultaneously to the simulated EEG data. Their instantaneous Larmor frequencies reflect the spectral content of the MUA waveforms with a temporal delay < 20 ms. We evaluated the SNR and the system's requirements for future in-vivo simultaneous EEG and tuned NMR recordings for the implementation of the resonant mechanism.

Conclusion

It is possible to perform NMR spectroscopy with Larmor frequencies simultaneously matching desired spectral components of the brain activity. This result could open the route to ULF-NMR neuronal current spectroscopy based on the resonant mechanism.