Low Field Nuclear Magnetic Relaxation of Water and Brain Tissue

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In the endeavor to perform in vivo magnetic resonance imaging in very low fields, we developed a dedicated SQUID based NMR/MRI measurement system. The low noise performance of < 30 fT/√Hz above 1 Hz enables the measurement of nuclear magnetic precession at magnetic fields well below 50 µT down to 100 nT. The system is operated inside a heavily magnetically shielding - the Berlin Magnetically Shielded Room BMSR-2.

Each measurement starts with a prepolarization of the sample in a field of up to 5 mT. After this preparation, the free precession decay in the much weaker detection field is measured by the SQUID.

Because ^{1}H of water is the most important nucleus for MRI, we first investigated the nuclear magnetic relaxation of water at very low magnetic fields. We observed a decrease of the relaxation time constant by about 25% at Larmor frequencies below 1 kHz, which is known from earlier studies. Surprisingly, we also found a strong variation of both longitudinal and transversal relaxation time around Larmor frequencies of 100 Hz that has not been observed before, and that is not in line with the standard NMR relaxation theory.

With the knowledge of waters behavior and systems spectral resolution we recorded the ^{1}H line of the human brain tissue. Here we found line widths of about 3 Hz corresponding to T_1 relaxation times of 100 mT. The aim behind these investigations is the measurement of the influence of neuronal currents to this NMR lines. This might open the possibility of a direct recording of neuronal currents by low field NMR. To this end we proposed two possible mechanisms: a DC-mechanism and a resonant mechanism. To localize the source of such neuronal currents one has to combine neuronal current detection with low field magnetic resonance imaging. In this spirit we actually develop low-field MRI below 1 kHz as the prerequisite to fulfill the requirements of the resonant mechanism for neuronal current detection.

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