Studies of MRI contrast agents by resolution-enhanced NMR in resistive high-field magnets

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Strong magnetic fields are an extremely powerful tool for investigating, modifying and controlling different states of matter on microscopic and macroscopic length scales. Whereas commercial superconducting magnets reach magnetic fields up to 30.6 T, stronger fields are currently only available at specialized large-scale facilities. There, resistive magnets made of copper alloys and their combination with superconducting magnets (hybrid magnets) generate continuous magnetic fields up to 45 T. Due to very high acquisition and operating costs, such facilities currently only exist in a few places in the world (Europe, USA, China and Japan).

Among the numerous experimental techniques used in such strong magnetic fields, nuclear magnetic resonance (NMR) is a preferred microscopic investigation method that is particularly well-suited for research in solid-state physics, which very often also requires extremely low temperatures. Areas of application include the study of high-temperature superconductors, heavy-fermion systems, quantum magnetism, and other systems with correlated electrons.

Recently, the scope of NMR applications using resistive magnets at the LNCMI in Grenoble has been expanded to include areas of chemistry and materials science that require enhanced resolution. In this presentation, we show the potential of this technique in such magnets for the nuclear magnetic relaxation dispersion (NMRD) studies of protons (^{1}H) in water with dissolved paramagnetic compounds up to 33 T, i.e., 1.4 GHz ^{1}H Larmor frequency. In addition to basic research issues, the latter activity serves the development of future contrast agents for magnetic resonance imaging in high magnetic fields [1,2].

However, due to limitations regarding the field homogeneity and stability of resistive magnets, their use in resolution-enhanced NMR requires tailored methods to overcome these drawbacks, which are discussed. These include broadband NMR probes operating at frequencies above 1 GHz, sample volumes in the microliter range to overcome field inhomogeneities, multi-pulse NMR sequences to eliminate the effects of magnetic field fluctuations, and reference deconvolution analyses to improve the signal-to-noise ratio [3].

References:

[1] G. Guthausen et al., *Dalton Trans.* **44**, 5032 (2015)
[2] M. Ibrahim et al., *Dalton Trans.* **48**, 15597 (2019)
[3] R. Nasser Din et al., *Molecules* **29**, 4956 (2024)