ACOUSTIC RELAXATION ENHANCEMENT IN MRI

C. Höhl[1], N. Elmiladi[1], F. Jahanbakhsh[1], F. Repp[1], P. Wolf[1], and K. Maier[1]
[1]Helmholtz-Institut für Strahlen- und Kernphysik (HISKP), Rheinische Friedrich-Wilhelms-Universität, Bonn, Germany

Purpose

MRI has become a powerful tool to distinguish between adjacent tissues by taking into account a variety of chemical, physical and biological properties of living tissue. By use of magnetic contrast agents in MRI one can even gain insight into some of the tissue's metabolic functions. Conclusions on the metabolism, however, can only be drawn if (a) the metabolic function in question locally affects the concentration of the contrast agent, and if (b) the contrast agent leads to a clearly observable change of the MRI signal within the region under consideration.

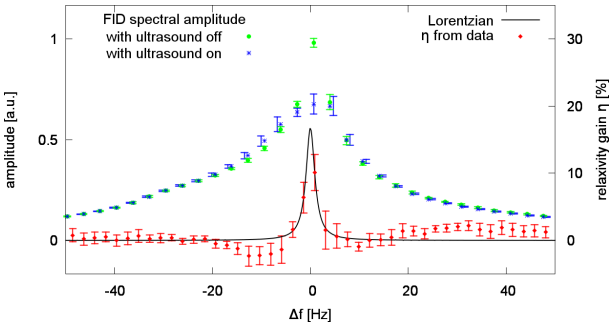
First observations of a contrast mechanism which addresses these limitation have been presented during last ISMRM conference, and a more complete presentation and discussion has been submitted to Phys. Rev. Let. recently. Questions remained open, however, whether the technical requirements for the contrast mechanism may become compatible with *in vivo* measurements in a standard MRI device.

Current research promises to solve the technical difficulties and first observations of the contrast in a low field MRI device are underway.

Method

Contrast agents based on magnetic nanoparticles (MNPs) affect the transverse relaxation times of nuclei of the solvent (e. g. protons) in their vicinity due to their magnetic stray field. MNP also affect the longitudinal relaxation time T_1 if the thermal motion of the MNPs happens to lead to local field fluctuations at nuclei Larmor frequency.

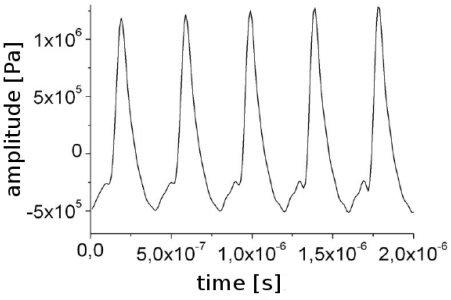
It was shown, that ultrasound at Larmor frequency increased the influence of specially prepared MNPs on T_1 considerably if ultrasound (US) matches Larmor frequency. These experiments were carried out using an NMR spectrometer where shielding of the receiving coils can be realized easily. In an MRI device, however, US radiation at MRI Larmor frequency would lead to disturbance of the MRI device.



Picture: Analysis of the FID following the 90° readout pulse of an inversion recovery sequence (TI = 550 ms, TR = 20 s). The abscissa denotes the frequency difference between the FID spectral components (left ordinate) and the US frequency (f_{US} = 18.25 MHz, $P_{US} = 10^{-2}$ W/cm^2). The result can be interpreted as a gain in relaxivity of the special prepared MNP's (right axis).

Results

The picture[1] presents the pressure evolution over time at a given position in a US wave (f_{US} = 2.5 MHz) in a water sample (measurement with hydrophone with bandwith of 60 MHz). Deviations from the sinusoidal wave-form originate from the strong nonlinear behavior of the water sample. Exploiting frequency doubling effects in tissue not only avoids electromagnetic cross-coupling between the US device and the MRI device, but also provides us with the higher penetration depth of the fundamental wave.



Conclusion

The contrast mechanism allows to distinguish between bound and unbound MNPs independent on their spatial distribution. The strong nonlinearities of tissue exposed to an ultrasonic wave promise this contrast mechanism to become compatible with standard MRI devices.

Experiments exploiting ultrasound frequency doubling to activate the contrast mechanism in a low field MRI device (open tomography system) are underway.

[1] M. Radicke, *Schallstrahlungskontrast in MR-Phasenbildern,* PhD Thesis, Bonn, Germany (2009)