"HIGH-FREQUENCY RELAXATION" WITH CONTRAST AGENTS

C. Hoehl[1], N. Elmiladi[1], J. Mende[1], and K. Maier[1]
[1]Helmholtz-Institut für Strahlen- und Kernphysik (HISKP), Rheinische Friedrich-Wilhelms-Universität, Bonn, Germany

Purpose

MRI provides images with excellent anatomical details based on soft-tissue contrast and functional information in a non-invasive and real-time monitoring manner. MRI has been further advanced by the development of contrast agents such as Gadolinium compounds that enable more specific and clearer images and enlargement of detectable organs and systems.

Magnetic nanometer-sized, colloidal particles (nanoparticles) are well known and extensively used in MRI as contrast agent, too. Due to their influence on the relaxation processes, they offer a possibility to label organic macromolecules. It is interesting to control their effect on MRI by additional parameters, which may be switched on and off externally or may depend on the properties of the surrounding tissue.

We develop such a new contrast method with nanoparticles, by applying ultrasound (US) while performing proton magnetic resonance spectroscopy.

Method

The basic process involved in the relaxation in MRI is coupling between the magnetic moments of the spin and photons with the corresponding larmor frequency - which can lead to stimulated emission or absorbtion. This results in an energy transfer out of the spin system to the lattice (longitudinal relaxation process) or transfer within the spin system (transversal relaxation process).

To gain higher sensitivity with a contrast agent in MRI, the contrast agent has to have a greater effect on the relaxation times. Especially prepared nanoparticles work as a radio frequency transmitter. For this, we are using two completely different kinds of nanoparticles:

a) Superparamagnetic of Iron Oxide (SPIO)

To increase the spectral density of photons with a special frequency, SPIO should work as an antenna. The SPIOs are prepared such that the center of geometry differs from the center of mass. This is done by sedimentation of the SPIOs, so that we can add macromolecules from one side only. Due to the particle velocity in the US-wave, SPIOs are accelerated and due to their asymmetric shape they tilt periodically. This produces additional photons with US-frequency.

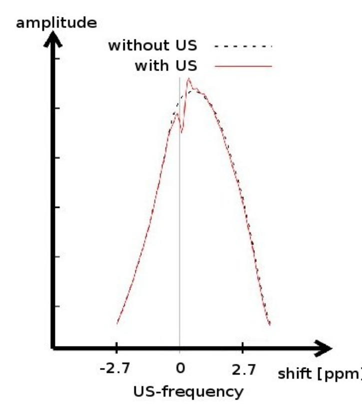
b) Piezoelectric Nanoparticles

Piezoelectric particles have the ability to generate an electric potential in response to applied mechanical stress. In combination with the periodic pressure variation in an US-wave, these particles function as a transmitter (displacement current). To achieve this, a powder consisting of 100nm sized particles is prepared into a colloid in water by coating with PAA.

The HF-fields emitted by nanoparticles are not coherent and therefore unable to rotate the net-magnetization.

Results

Influence of the US on NMR measurements for the SPIO was examined. Early measurements showed a change of the relaxation times T1 and T2* in water when using piezoelectric particles. Furthermore, measurements on SPIO indicates the influence of the US at the resonance frequency. The figure to the right compares the amplitude of the FID after a 90° puls in an inversion recovery sequence with and without US. These measurements were taken before getting the SPIO in the final shape. Sedimentation process of the SPIO have been achieved by applying a combination of centrifugal force and magnetic force.



Conclusion

Using nanoparticles as local antenna in combination with US promises new contrast methods which image properties of the tissue. Even without any special preparation of the nanoparticles, an effect of the US on the MRI-Signal has been seen.