# Master Laboratory Applied Physics: MR Imaging: Contrasts and Methods (Exp 1)

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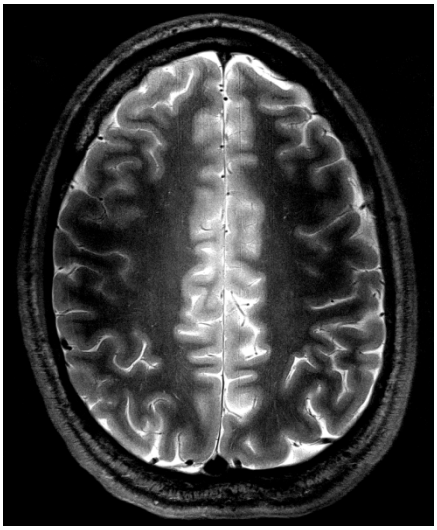
## Introduction

Magnetic resonance imaging provides cross-sectional images of the human anatomy with an excellent soft tissue contrast. Novel MR imaging methods (so called pulse sequences) offer many different image contrasts to optimally visualize the different tissue, for example to differentiate the coronary artery from the surrounding fatty tissue, or to measure the thickness of the grey matter in the brain.



Contrast optimization in a clinically situation can be complex, and requires a precise knowledge of the underlying parameters that determine the image contrast. In particular, contrast is determined by the spin density and the longitudinal (T1) and transverse (T2) relaxation time of the target tissue.

## Preparation before the Experiment

The fundamental physics of MRI is discussed in the lecture on Physics of Medical Imaging, and can be found in several textbooks (e.g., [1,2]). Students need to be able to describe the basics of an MR imaging experiment (pulse sequence), and they must prepare the signal equations for the following for pulse sequences:

1. Spoiled gradient echo (fast low angle shot, FLASH)
2. Balanced steady state free precession (bSSFP or trueFISP)
3. Spin Echo
4. Fast (or Turbo) Spin Echo

The signal equations can be found in [3] - based on these signal equations the experimental parameters will be optimized.

## Experiment

Experiments will be performed over 2 days to (a) measure relaxation times in contrast agent solutions (phantom) and in a volunteer, and the information will then be used to optimize MR imaging parameters (TR, TE, TI) of different pulse sequences to achieve the optimal image contrast for a given target tissue.

### Day 1

Students will receive an introduction into the usage of a whole body MR imaging system (including a safety instruction). Images will be acquired with an existing resolution phantom, establishing the initial parameter settings for the 4 pulse sequences.

A set of phantom vials will be filled with aqueous solutions of a commercial contrast agent (Gd-DTPA) at different concentrations, and the relaxation times will be measured in a series of imaging experiments. The students will analyze the image data, and will program a small evaluation sheet to extract the parameters T1 and T2 using the known signal equations. Based on these experiments, measurement protocols will be prepared for in vivo measurements in a volunteer.

### Day 2

Volunteer experiments will be conducted, in which at first the relaxation times of a target structure (grey against white brain tissue) will be determined. Based on these values, for all pulse sequences optimal values to maximize the tissue contrast will be determined, and then images will be acquired with these parameter sets. From the data, relaxation maps will be calculated by implementing a short analysis program in MatLab.

## Duration: 2 days (1 ECTS point)

## References

[1] Oppelt A: Imaging Systems for Medical Diagnostics. Wiley 2006

[2] Dössel O: Bildgebende Verfahren in der Medizin: Von der Technik zur medizinischen Anwendung. Springer

[3] Bernstein MA, King KF, Zhou XJ. Handbook of MRI pulse sequences. Elsevier