Center for Magnetic Resonance
Department of Electrical Engineering

PhD Thesis:
A novel MR contrast agent for angiography and perfusion: Hyperpolarized water

Kasper Wigh Lipsø

Abstract

Magnetic resonance imaging (MRI) is an important tool for medical diagnosis, and is widely used for its high resolution images and low safety concerns. However, the technique has its limitations due to the inherent low sensitivity. By hyperpolarization, the available signal can be enhanced by several orders of magnitude.

In this project, it is demonstrated how water, hyperpolarized by dissolution dynamic nuclear polarization (dissolution-DNP), can be applied as an MRI contrast agent, to overcome some of the unresolved challenges in modern MRI.

The first part of the project focuses on development of a protocol for production of large samples of hyperpolarized water. The samples are polarized and dissolved in a fluid path compatible with clinical polarizers. The solid state polarization is optimized by frequency modulation and characterized by nuclear magnetic resonance (NMR), and the dissolution process is refined by introduction of a fluorinated solvent to accelerate the transition from solid to liquid state, to yield final liquid state polarization of 13% in samples of 16 mL, suitable for large animal experiments.

A novel method for fluid path sample filling is developed. The method features a 1.5 m long tube of 0.5 mm outer diameter, through which the water sample can be placed in the vial for polarization, and allows for reuse of expensive and not readily accessible fluid paths. The technique is modified for [1-^{13}C]pyruvate samples to fit the demands of modern DNP research in a separate study.

In the second part of the project, hyperpolarized tracers are applied for angiographic imaging and perfusion measurements. First, MRI sequences are investigated with an exogenous ^{13}C-labelled hyperpolarized tracer for cerebral angiography in the rat. Next, the protocol for hyperpolarization of water is translated to a clinical setup and applied for renal angiography and perfusion measurements in the pig. The obtained perfusion measures are compared to conventional Gd-T_1-DCE analysis. Lastly, the method is applied to obtain coronary angiographies in the pig.