FAST FIELD-CYCLING MRI: A NEW IMAGING MODALITY

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The use of Fast Field-Cycling (FFC) in combination with magnetic resonance imaging (MRI) has been increasing in recent years [1].

One of the first uses of FFC-MRI was in conjunction with Proton-Electron Double-Resonance Imaging (PEDRI) to image the distribution of free radicals in biological samples. Irradiating the Electron Spin Resonance (ESR) of a free radical solute enhances the water NMR signal, through the Overhauser effect. Field-cycling allows the ESR irradiation to be applied at low field (hence relatively low frequency, and low non-resonant absorption), while NMR signal detection and imaging is carried out at higher field, to preserve SNR [2].

NMR relaxometry refers to the measurement of relaxation times (usually T_1) as a function of magnetic field strength. It is usually accomplished using FFC, in which the magnetic field is switched rapidly between levels during the pulse sequence. In this way, a single instrument can be used to measure T_1 over a wide range of magnetic field strengths. The aim of FFC-MRI is to obtain spatially-resolved T_1-dispersion data, by collecting images at a range of evolution field strengths [1]. We have recently demonstrated methods for implementing relaxometry on localised regions defined on a pilot image [3]. We have also shown that FFC relaxometry can detect the formation of cross-linked fibrin protein from fibrinogen *in vitro*, in a model of the blood clotting process, via the measurement of ^{14}N-^{1}H cross-relaxation phenomena [4], and we have demonstrated that FFC-MRI can detect changes in human cartilage induced by osteoarthritis [5]. Recent work has focussed on speeding up the collection of FFC-MRI images by incorporating rapid MRI scanning methods and improved pulse sequences and algorithms [6,7].

In our lab we have built a range of FFC-MRI equipment, including two whole-body human sized scanners, operating at detection fields of 0.06 T [8] and 0.2 T. The 0.06 T scanner uses a double magnet, with field-cycling being accomplished by switching on and off a resistive magnet inside the bore of a permanent magnet; this has the benefit of inherently high field stability during the detection period. We have also demonstrated technology for localised field switching within a clinical MRI system [9]. Our newest whole-body human sized scanner (0.2 T) uses a single resistive magnet, giving increased flexibility at the expense of greater complexity and susceptibility to magnetic field fluctuations.

This presentation will cover the main techniques used in FFC-MRI and will summarise current and potential bio-medical applications of the methods.

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