

## Field-Cycling Magnetic Resonance Imaging

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

The first use of FFC-MRI was in conjunction with Proton-Electron Double-Resonance Imaging (PEDRI) to image the distribution of free radicals in biological samples, making use of 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 [2,3,4].

Relaxometric FFC-MRI aims to obtain spatially-resolved  $T_1$ -dispersion data, by collecting images at a variety of evolution field strengths [1,5,6,7]. We have demonstrated methods for implementing relaxometry from localised regions defined on a pilot image [8]. 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 [1,9]. This relies on  $^{14}\text{N}$ - $^1\text{H}$  cross-relaxation phenomena, also known as “quadrupole dips” in the  $T_1$ -dispersion plot [10]. These reductions in  $T_1$ , occurring at water proton Larmor frequencies equal to the  $^{14}\text{N}$  nuclear quadrupole resonances, reveal information about the concentration and conformation of immobilised protein molecules. In recent work, we have demonstrated the potential of FFC NMR and MRI for the detection of changes in cartilage due to osteoarthritis [11].

FFC-MRI relaxometry is inherently relatively slow, since image data must be collected at a range of evolution magnetic field strengths. We have been investigating a combination of FFC with rapid MR imaging methods such as turbo spin-echo, and have succeeded in speeding up data acquisition significantly, with minimal reduction in image quality or the fidelity of  $T_1$ -dispersion data [12].

Developments in FFC-MRI have demonstrated this technique’s ability to extract extra information that is not obtainable from conventional, fixed-field techniques. In addition to bio-medical applications, field-cycling magnetic resonance may have applications in the characterisation and monitoring of industrial processes, for example in the preparation of foodstuffs.

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