

Techniques and Applications of Field-Cycling MRI

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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].

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, 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].

One aim of FFC-MRI is to obtain spatially-resolved T_1 -dispersion data, by collecting images at a variety of evolution field strengths [1,5,6,7]. We have developed methods for measuring T_1 -dispersion in 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 thrombosis [1,9]. This relies on ^{14}N - ^1H cross-relaxation phenomena, also known as “quadrupole dips” in the T_1 -dispersion plot [10]. These reductions in T_1 , occurring at water proton NMR frequencies equal to the ^{14}N nuclear quadrupole resonance (NQR) frequencies, 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 slow, since in order to measure T_1 -dispersion, image data must be collected at a range of evolution magnetic field strengths. We have recently 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 in 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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†These references are available at www.ffc-mri.org/publications.html