

## Fast Field-Cycling Magnetic Resonance Imaging

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While relaxometry of small samples using FFC has been used for several decades, the combination of FFC with magnetic resonance imaging (MRI) remains relatively uncommon, but has been increasing in recent years [1].

One application is in imaging free radicals using Field-Cycled Proton-Electron Double-Resonance Imaging (FC-PEDRI). This uses the Overhauser effect: irradiation of the free radical's ESR causes a transfer of polarisation from electron spins to coupled nuclear spins, resulting in a change in image intensity. 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. We have constructed two FC-PEDRI scanners, both of which can also be used for FFC-MRI [2,3].

Relaxometric MRI is the imaging equivalent of field-cycling relaxometry. The aim is to obtain spatially-resolved  $T_1$ -dispersion data, by collecting images at a variety of evolution field strengths [1,4,5,6]. We have recently demonstrated methods for implementing relaxometry on localised regions defined from a pilot image [7]. 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 [1,8,9]. 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 Larmor frequencies equal to the  $^{14}\text{N}$  nuclear quadrupole resonances, reveal information about the concentration and conformation of immobilised protein molecules. In other recent work we have demonstrated that FFC-MRI can be used with tailored contrast agents which exhibit significantly different relaxivity over the range of field strengths accessible to an FFC-MRI scanner; in this way, the sensitivity of the experiment can be enhanced [11]. Another application of FFC is to study the phenomenon of magnetisation transfer contrast (MTC) as a function of magnetic field at low field [12,13].

In summary, 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 biomedical 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 <http://www.ffc-mri.org/publications.shtml>