Field-Cycling MRI – Techniques and Applications

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In fast field-cycling (FFC) NMR, the magnetic field is switched between levels during the pulse sequence; it has been used for several decades for relaxometry measurements (T_1 as a function of field strength) of small samples. The combination of FFC with magnetic resonance imaging (MRI) remains relatively uncommon, although its prevalence has been increasing in recent years [1].

One application of FFC is 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}N-^{1}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}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].

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