Fast Field-Cycling Magnetic Resonance Imaging

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Fast field-cycling (FFC) relaxometry of small samples has been in use for several decades, and is now used routinely in many laboratories. The key aspect of FFC is that the magnetic field is switched during the pulse sequence, so that the nuclear spins can "evolve" at a chosen magnetic field strength. Following the evolution period, the magnetic field is switched to the "detection" magnetic field, which is the same for every repetition of the pulse sequence. In this way, a single instrument can be used to measure a sample's NMR parameters (most commonly, T_1) over a wide range of magnetic field strengths. In recent years the use of FFC with magnetic resonance imaging has been increasing, often using home-built equipment.

Field-Cycled PEDRI free radical imaging, developed in our laboratory, 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 carried out at low field (hence relatively low frequency, and low non-resonant absorption), while NMR signal detection and imaging is done at higher field, to preserve SNR. We have constructed two FFC scanners for use with PEDRI, both of which can equally well be used for FFC-MRI [1,2].

Relaxometric MRI is the imaging equivalent of "conventional" field-cycling relaxometry. The aim is to obtain spatially-resolved T_1-dispersion data, by collecting images at a variety of evolution field strengths [3,4]. We have recently demonstrated methods for implementing relaxometry on localised regions defined from a pilot image [5]. 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 [6]. 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 [7]. Magnetisation transfer contrast (MTC) is a standard method in conventional MRI, whereby off-resonance irradiation is used to affect the magnetisation of broad-line macromolecular protons. We have recently demonstrated that MT can be combined with magnetic field cycling in order to negate some of the difficulties inherent with the implementation of MT at low magnetic fields [8].

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*These references are available at *http://www.ffc-mri.org/publications.shtml*