1000 FIELD STRENGTHS IN ONE SCANNER – FAST FIELD-CYCLING MRI

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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.

Earth's Magnetic Field MRI has been investigated since the early days of MRI. Since the Boltzmann magnetisation at 50 μT is naturally very small, field-cycling is used to boost the initial magnetisation using an inhomogeneous magnet coil, for subsequent detection in the Earth's field. Despite the low frequency, good quality images can be obtained [1].

Pre-Polarised MRI is similar to Earth's field MRI, in that a strong, inhomogeneous magnetic field is pulsed for a time of the order of T_1 in order to boost the initial magnetisation, and hence improve the SNR, with detection at intermediate field [2,3].

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 [4,5]. We have recently demonstrated methods for implementing relaxometry on localised regions defined from a pilot image [6].

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 [7,8].

FFC-MRI is a developing area, which offers significant extra information, compared to conventional fixed-field MRI. Due to the necessity to switch the magnetic field rapidly (in a few tens of milliseconds), it requires special magnets, power supplies, and control hardware and software. All of these present significant technical challenges which are currently being addressed.

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