Human Relaxometry and MRI using Fast Field-Cycling

David J. Lurie, Lionel Broche, Gareth R. Davies, Kerrin J. Pine and P. James Ross

Aberdeen Biomedical Imaging Centre, University of Aberdeen, AB25 2ZD, Scotland, UK
www.ffc-mri.org

NMR relaxometry refers to the measurement of relaxation times (usually T_1) as a function of magnetic field strength (or Larmor frequency). Usually, relaxometry is accomplished using fast field-cycling (FFC), in which the magnetic field is switched rapidly between levels during the pulse sequence. A key aspect of FFC is that by switching the magnetic field, 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 T_1 over a wide range of magnetic field strengths. FFC-NMR relaxometry of small samples has been in development for several decades, and is now used routinely in many laboratories; commercial FFC-NMR relaxometers are available. In recent years the use of FFC with magnetic resonance imaging (MRI) has been increasing, often using home-built equipment.

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 range of evolution field strengths [1,2,3]. We have recently demonstrated methods for implementing relaxometry on localised regions defined on a pilot image [4]. 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 [5], and we have demonstrated that FFC-MRI can detect changes in human cartilage induced by osteoarthritis [6]. Recent work has focussed on speeding up the collection of FFC-MRI images by incorporating rapid MRI scanning methods [7].

In our lab we have built a range of FFC-MRI equipment, including small-sample scanners operating at a detection field of 0.5 T [8], and two whole-body human sized scanners, operating at detection fields of 0.06 T [9] and 0.2 T. The 0.06 T scanner uses a double magnet, with field-cycling being accomplished by switching on and off a resistive magnet inside the bore of a permanent magnet; this has the benefit of inherently high field stability during the detection period. Our newest scanner (0.2 T) uses a single resistive magnet, giving increased flexibility at the expense of greater complexity and susceptibility to magnetic field fluctuations.

This presentation will cover presently-used techniques of FFC-NMR and FFC-MRI and will summarise potential bio-medical applications of the methods.

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