FAST FIELD-CYCLING MRI: T1-DISPERSION FOR ENHANCED MEDICAL DIAGNOSIS

David J. Lurie, Lionel M. Broche, Gareth R. Davies, Nicholas R. Payne, P. James Ross and Vasileios Zampetoulas

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

Fast Field-Cycling Magnetic Resonance Imaging (FFC-MRI) exploits the variation of T_1 with magnetic field strength (T_1-dispersion), with the aim of increasing the diagnostic potential of MRI [1].

NMR relaxometry is often implemented using FFC, by switching the magnetic field rapidly between levels during 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-MRI aims to obtain spatially-resolved T_1-dispersion data, by collecting images at a range of evolution field strengths [1-3]. We have 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 shown 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 and improved pulse sequences and algorithms [7,8].

In our lab we have built a range of FFC-MRI equipment, including two whole-body human sized scanners, operating at detection fields of 0.06 T [9] and 0.2 T [10]. 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. The recently-completed 0.2 T FFC-MRI system uses a single resistive magnet (albeit composed of three coaxial coils) [10]. This has the advantage of increased flexibility in B_0 programming, at the expense of poorer field stability during the detection period, necessitating a higher degree of instrumental complexity.

This presentation will cover the main techniques used in FFC-MRI and will summarise current and potential bio-medical applications of the methods.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 668119 (project "IDentIFY").

[1] Lurie D.J., Aime S., *et al.*, Comptes Rendus Physique **11**, 136-148 (2010).
[2] Carlson J.W., Goldhaber D.M., *et al.*, Radiology **184**, 635-639 (1992).
[3] Lurie D.J., 1st Symposium on Field-Cycling NMR Relaxometry, Berlin, p5, (1998).
[4] Pine K.J., Davies G.R. and Lurie D.J., Magn.Reson.Med. **63**, 1698–1702 (2010).
[5] Broche L.M., Ismail S.R., *et al.*, Magn.Reson.Med. **67**, 1453-1457 (2012).
[6] Broche L.M., Ashcroft G.P and Lurie D.J., Magn.Reson.Med. **68**, 358-362 (2012).
[7] Ross, P.J., Broche, L.M., and Lurie, D.J., Magn. Reson. Med. **73**, 1120-1124 (2015).
[8] Broche, L.M., Ross, P.J., Pine, K.J. and Lurie, D.J., J. Magn. Reson., **238**, 44-51 (2014).
[9] Lurie D.J., Foster M.A., *et al.*, Phys.Med.Biol. **43**, 1877-1886 (1998).
[10] Ross P.J., Broche L.M., *et al.*, Proc. 25th ISMRM, Hawaii, p2677 (2017).