# BASICS OF MRI AND RESEARCH ON FAST FIELD-CYCLING MRI

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MRI uses magnetic field gradients to encode spatial information into NMR signals. In frequency-encoding, the NMR signal is recorded while a field gradient is applied. Since the magnetic field varies with position along the gradient direction (e.g. X), Larmor frequency is a function of position, so the detected signal contains a range of frequencies; analysing the frequency content generates a one-dimensional projection of the water-distribution within the patient. Phase-encoding is employed in the second in-plane dimension (e.g. Y); here, the gradient is pulsed on and off prior to measurement of the signal, altering the phase of the NMR signal as a function of position. The image slice is defined using selective-excitation, in which the excitation 90° radiofrequency pulse is shaped (typically a sinc function) and is applied in the presence of a field gradient perpendicular to the slice plane (e.g. along Z for a transaxial X-Y slice). An excellent primer textbook on MRI has been published by McRobbie et al. [1].

During the last decade, our laboratory has focused on the development of Fast Field-Cycling Magnetic Resonance Imaging (FFC-MRI). By switching field strength during an experiment, this technique exploits the variation of $T_1$ with magnetic field ($T_1$-dispersion), with the aim of increasing the diagnostic potential of MRI [2,3]. FFC-MRI aims to obtain spatially-resolved $T_1$-dispersion data, by collecting images at a wide range of evolution field strengths. 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 [4] and 0.2 T [5]. The recently-completed 0.2 T FFC-MRI system uses a single resistive magnet, composed of three coaxial coils.

We have shown that FFC methods can detect changes in human cartilage induced by osteoarthritis [6]. Experiments on resected tissues from breast cancer patients have shown significant differences in the dispersion curves between normal and diseased tissues [7]. We have performed *in vivo* studies on patients with acute ischaemic stroke; FFC-MRI images exhibited increased intensity in stroke-affected regions, with maximum contrast typically at the lowest field used (0.2 mT) [8]. We have also begun studies on patients with brain cancer and patients with breast cancer. All human studies were conducted following approval of the relevant Research Ethics Committees and with informed consent. Work to improve the hardware and software is ongoing, including the implementation of improved RF coils [9].

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