Image formation in MRI

MRI relies on the use of the magnetic field gradient, defined as a linear change in magnetic field strength with position within the bore of the scanner. When current is sent through the x gradient coil (for example), the magnetic field $B_z$ becomes a function of x:

$$B_z(x) = B_0 + x.G_x$$

where $B_0$ is the static field and $G_x$ is the gradient strength, in tesla/m. When a gradient is applied, the NMR resonant frequency also varies linearly with position.

There are three primary methods of spatial discrimination in MRI, all using gradients. These are: selective excitation, used to observe only those spins within a thin slice, by applying a 90° pulse in the presence of  gradient; frequency encoding, where the NMR signal is measured in the presence of a field gradient; and phase encoding where a preparatory pulsed field gradient changes the phase of the magnetisation as a function of position. By combining these methods, images can be reconstructed by 2-D Fourier transformation of the NMR signals.

This lecture will cover the use of field gradients, including the gradient echo, and will introduce the concept of k-space, used to describe and analyse the behaviour of MR pulse sequences.