Magnetic Resonance and Medical Imaging lect 5

4th year /Medical Physics

Dr . Hanan Abd Ali

Fourier Transformation

- The FID is a plot of MR signal intensity as a function of time (see Figure 1–14). If a mathematical operation called a Fourier transformation (FT) is performed on the FID, the result appears as an NMR spectrum (Figure 1–15).
- Whereas the FID is a graph of signal intensity versus time, the NMR spectrum is a graph of signal intensity versus inverse time (s^{-1}), or hertz (Hz). Therefore the NMR spectrum is signal
- intensity versus frequency. Each of the peaks in the NMR spectrum represents one characteristic of the tissue under investigation.

How is an image obtained from an NMR spectrum?

The following is a simplistic explanation . Figure 1–16 presents a transverse cross section through the trunk of the body. The patient lies in a uniform B_0, and two pixels are highlighted. If both pixels contain the same tissue, the peak in the NMR spectrum represents both pixels. One can tell by looking at the spectrum what is in both pixels but cannot determine how much of the signal comes from each location.

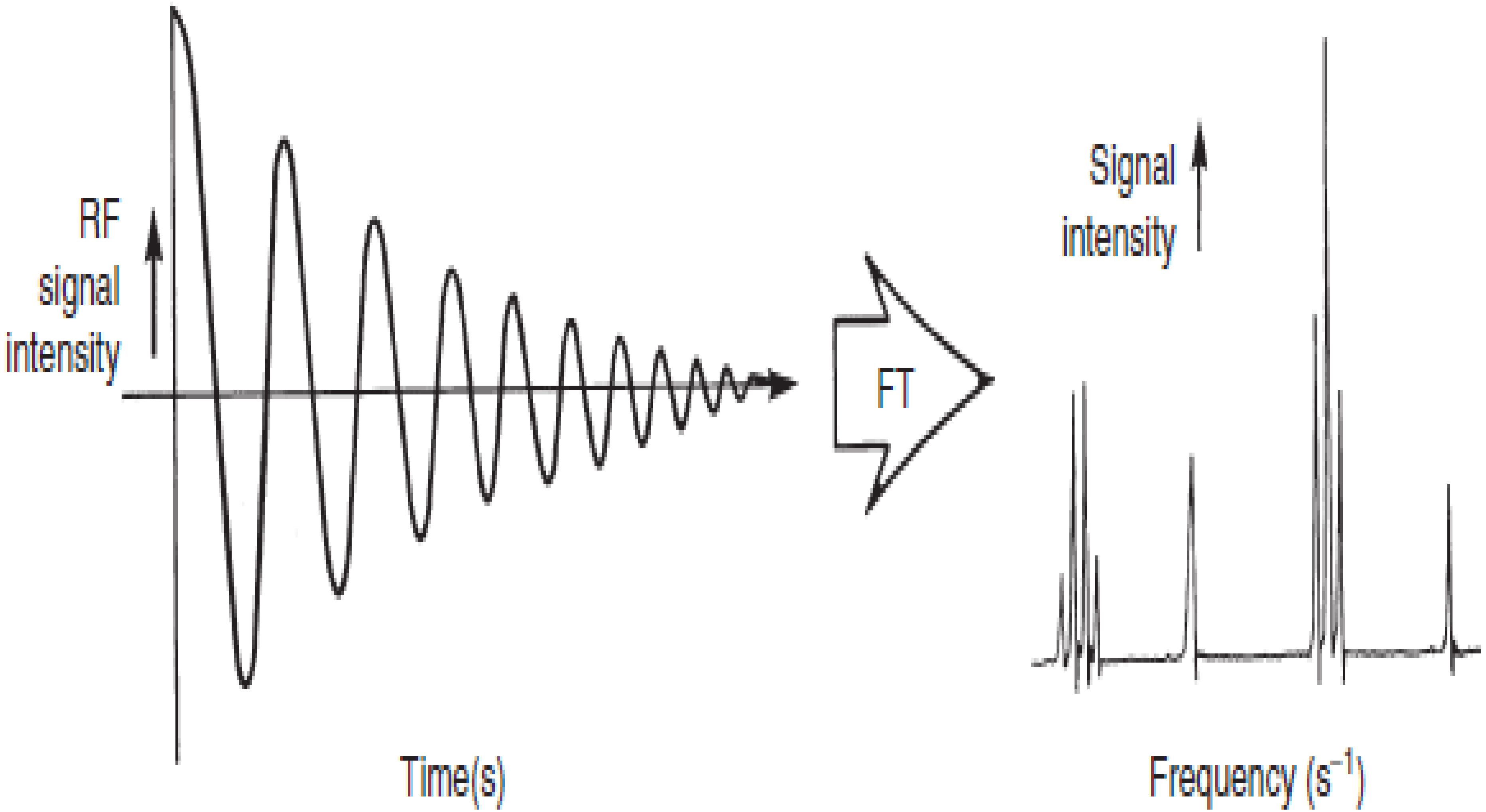

FIGURE 1-15 When a Fourier transformation *(FT)* is performed on the free induction decay, a nuclear magnetic resonance spectrum results.

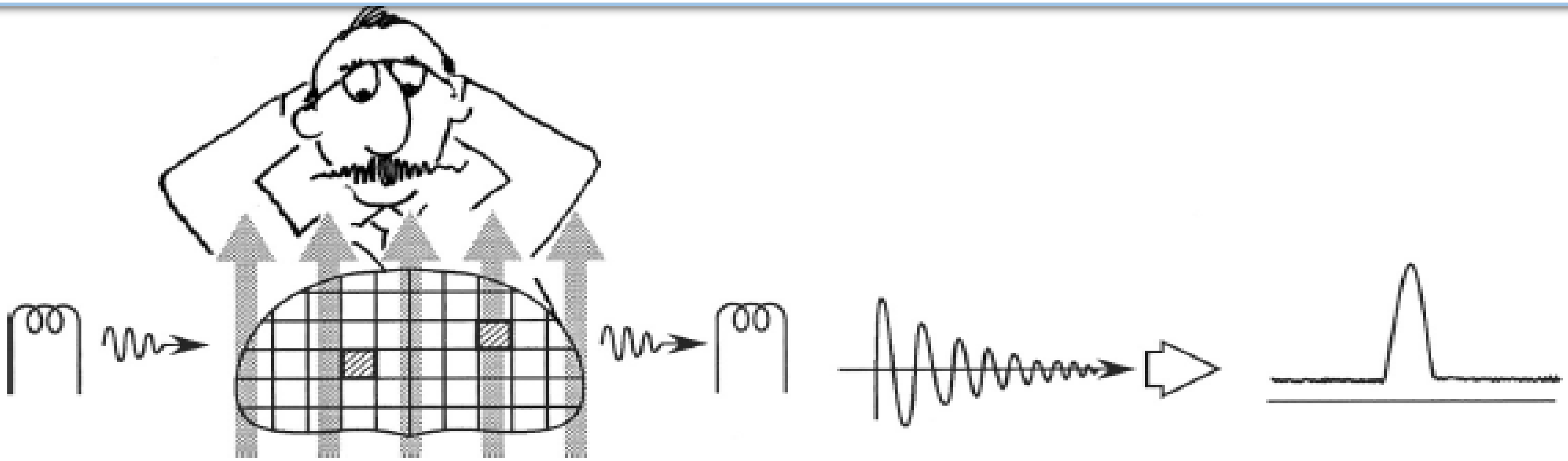

FIGURE 1-16 If the same tissue were in the two highlighted pixels, both pixels would be represented by the same peak in the nuclear magnetic resonance spectrum.

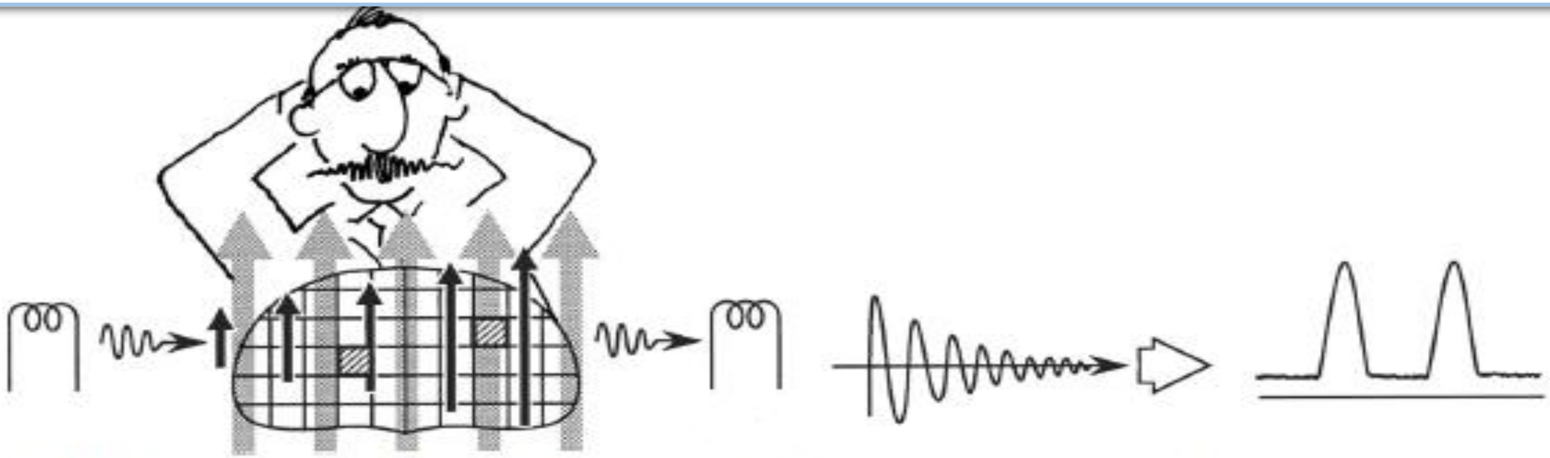

FIGURE 1-17 In the presence of a gradient magnetic field, B_X, the nuclear magnetic resonance spectrum provides information on pixel location.

- If in addition to the uniform (B_0) magnetic, a gradient magnetic field (B_x) is superimposed across the patient that varies in field strength, spatial localization is possible (Figure 1-17). The magnetic field will then change with the x-position, B total $= B_0 + B_x \cdot$

- X. The position where x = 0 is called the isocenter of the magnet, and here the gradient will be zero. However, as the position is moved away from isocenter, the magnetic field will be increased or diminished by an amount equal to $\pm B_x \cdot x$. As a result, even though they represent the same tissue, the tissue in the pixel at the lower magnetic field strength has a lower Larmor frequency than the one located at the higher magnetic field.

- The FID in this situation is considerably more complex. After FT, this spectrum has two peaks instead of one. These two peaks carry spatial information. One represents the pixel at the lower magnetic field; the other represents the pixel at the higher magnetic field.

A uniform magnetic field is required for NMR spectroscopy; gradient magnetic fields are required for MRI.

FIGURE 1-18 Projections can be obtained by rotating the gradient magnetic field around a patient. An image can be reconstructed from these projections by backprojection.

Multiple projections can be obtained in MRI by electronically rotating the gradient magnetic fields around the patient to produce a set of projections (Figure 1-18). The projections are Fourier transformed and then back projection reconstruction can be used to produce an image as in CT.

Paul Lauterbur's early MR images were created in this manner. MR images are reconstructed differently now. The spatial information still comes from the application of gradient magnetic fields superimposed on the B0

- **; however, the reconstruction of an image occurs through a process called two - dimensional Fourier transformation (2DFT) or three-dimensional Fourier transformation (3DFT).**

- **This is a special application of higher mathematics that will be developed conceptually later**.