

Basics of MRI

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Outline

1 MRI System Overview

2 MRI - Breaking down the acronym

- Magnetic
- Resonance
- Imaging

3 Contrast

- Basic tissue contrast
- BOLD contrast
- Other contrasts

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MRI system block diagram

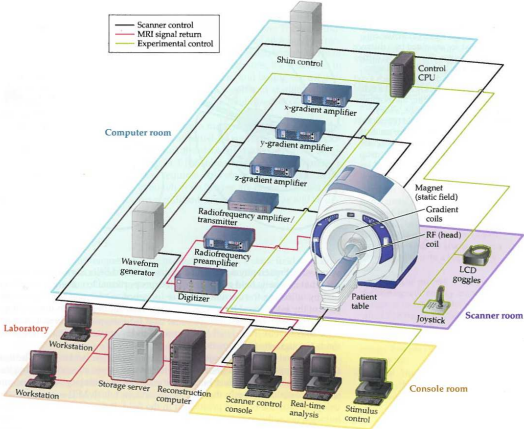


Figure 2.2 Schematic organization of the fMRI scanner and computer control systems. Two systems are important for fMRI studies. The first is the hardware used for image acquisition. In addition to the scanner itself, this hardware consists of a series of amplifiers and transmitters responsible for creating the gradients and pulse sequences (shown in black), and recorders of the MR signal from the head coil (shown in red). The second system is responsible for controlling the experiment in which the subject participates, and for recording behavioral and physiological data (shown in green).

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Magnetic

Magnetic

- Certain nuclei (odd number of protons and/or neutrons) have magnetic properties (i.e. magnetic moment - 1952 Nobel Prize in Physics, to Bloch and Purcell).

Magnetic

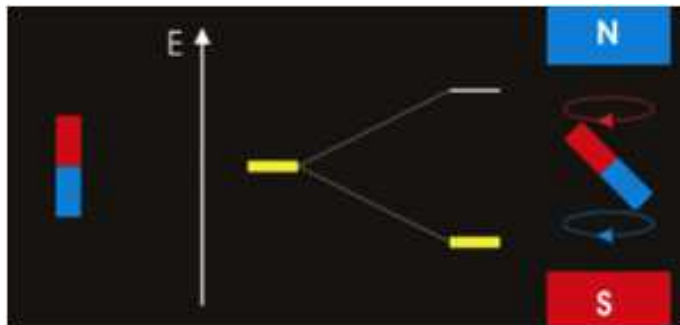
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- Includes ^{13}C , ^{23}Na , ^{31}P , ^{129}Xe , and ...

Magnetic

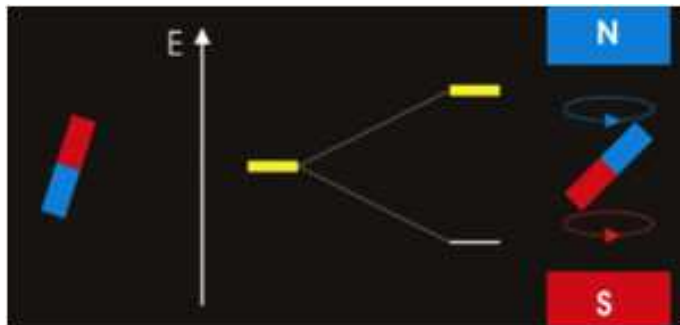
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- ^1H !

Magnetic

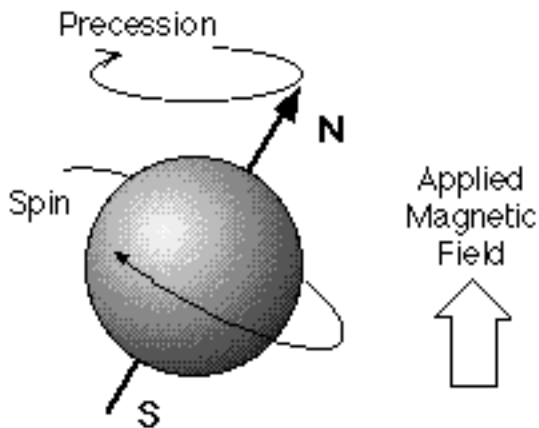
Magnetic



Magnetic



Magnetic



Planck and Larmor Equations

$$E = h\nu = hf_0$$

$$2\pi f_0 = \omega_0 = \gamma B_0$$

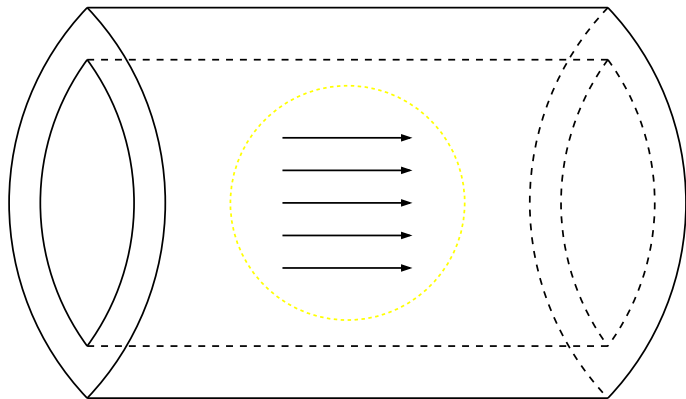
<https://www.youtube.com/playlist?list=PLAE12114468910462>

(Tyler Moore - Videos for MR Tutorial)

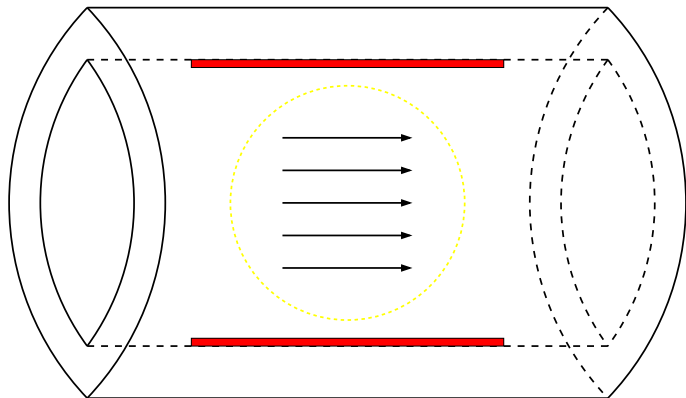
- Precession
- Resonance and excitation

Imaging (location encoding with gradients)

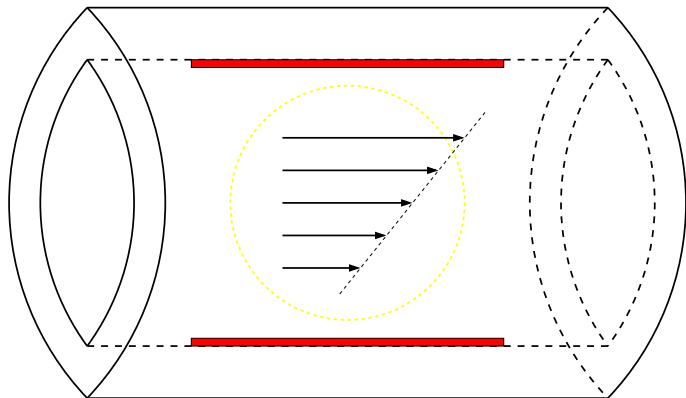
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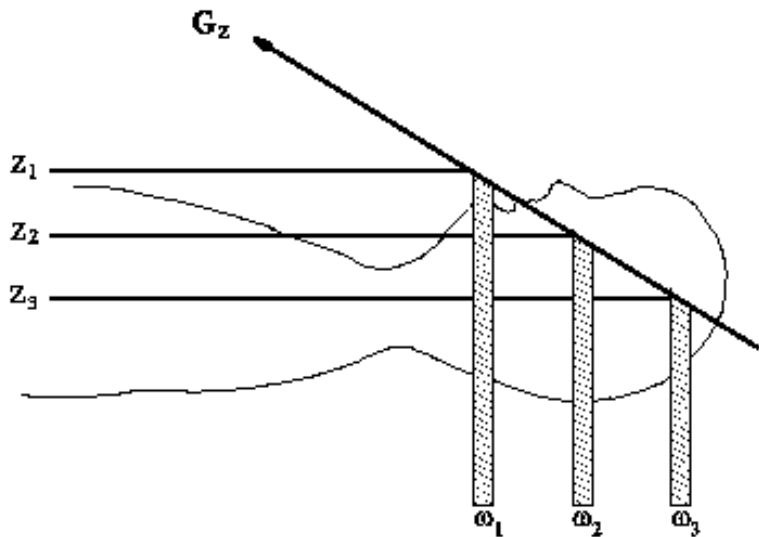
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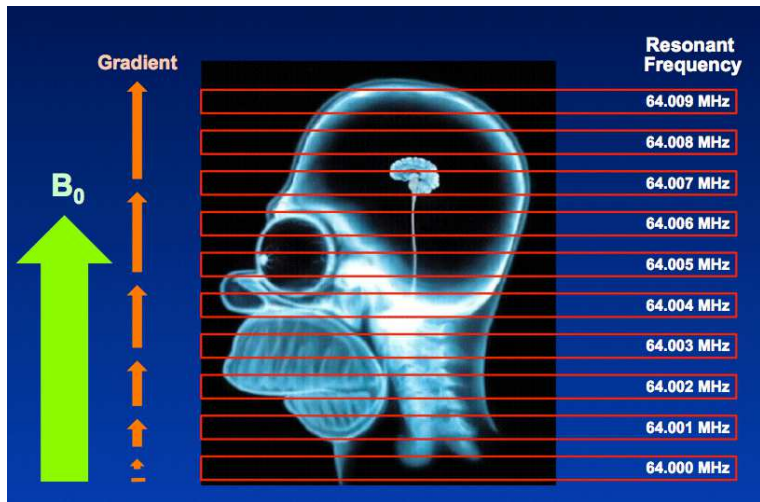
Imaging (location encoding with gradients)



Slice Encoding/Selection

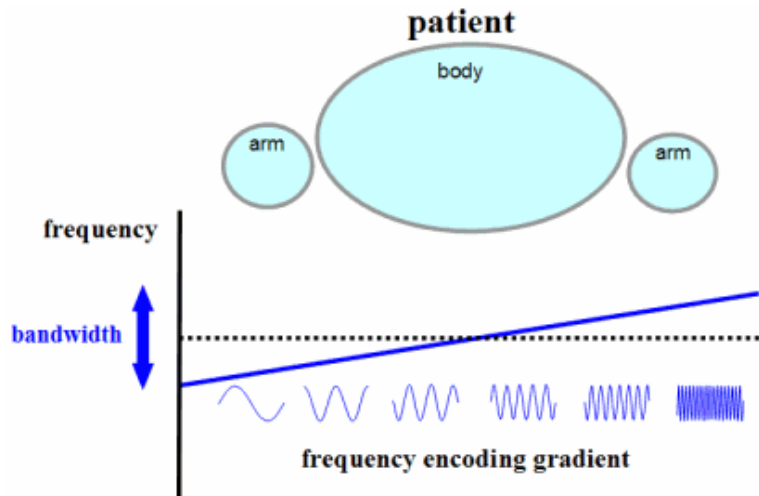


Slice Encoding/Selection



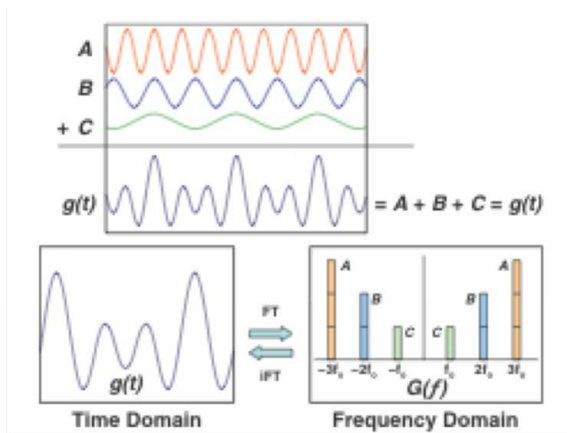
Frequency Encoding

Frequency Encoding



Creating image from signal

Creating image from signal



Creating image from signal

$$s(t) = \int_{\vec{r}} M_{xy}(\vec{r}, 0) e^{-i2\pi\vec{k}(t)\cdot\vec{r}} d\vec{r}$$

Creating image from signal

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- Data acquisition in “Fourier domain” encoded with spatial gradients.

Creating image from signal

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- Fourier transform acquired data to give image.

Creating image from signal

- Data acquisition in “Fourier domain” encoded with spatial gradients.
- Fourier transform acquired data to give image.
- Nobel Prize in Physiology or Medicine in 2003 to Lauterbur and Mansfield.

Creating image from signal

Paper on Fourier Transform in MR: DOI:10.2214/AJR.07.2874

American Journal of Roentgenology, 2008, Vol 5, 1396-1405

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Relaxation times

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(Tyler Moore - Videos for MR Tutorial)

- Transverse (a.k.a T_2) relaxation

Relaxation times

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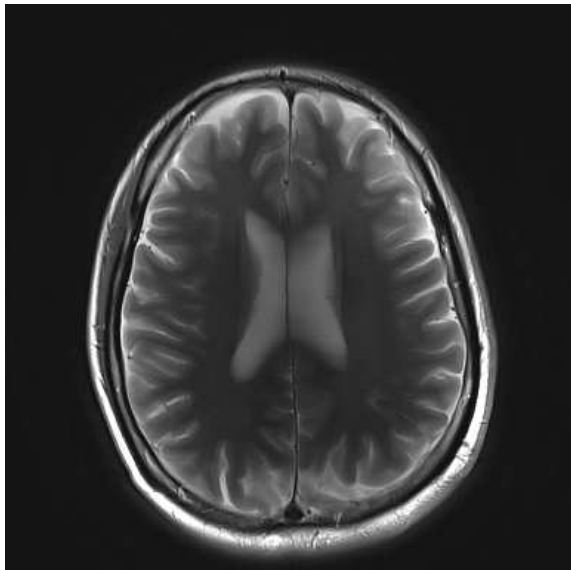
- Transverse (a.k.a T_2) relaxation
- Longitudinal (a.k.a T_1) relaxation

Basic tissue contrast

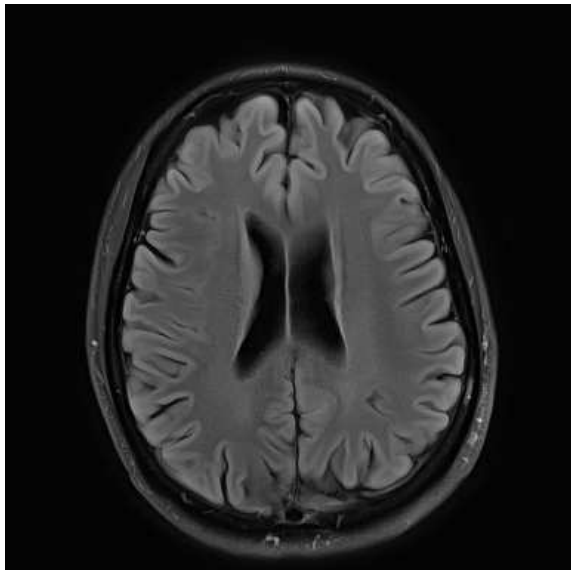
Basic tissue contrast



Basic tissue contrast



Basic tissue contrast

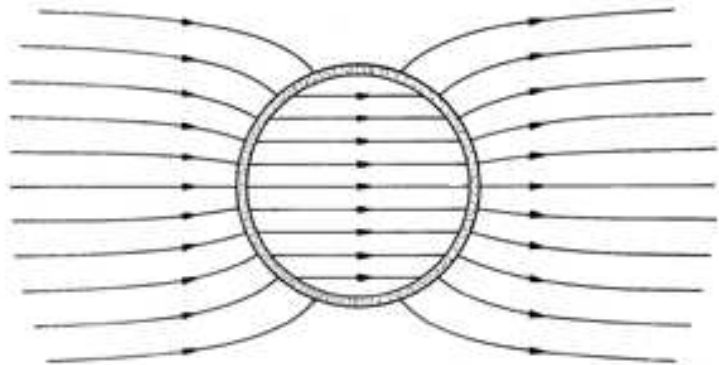


BOLD contrast

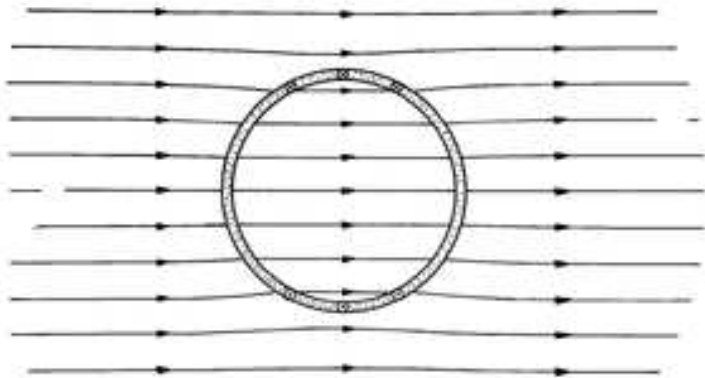
BOLD contrast

- PNAS, 1990 Vol 87(24):9868-9872 - Ogawa *et.al.*
- PNAS, 1992 Vol 89(12):5675-5679 - Kwong *et.al.*
- MRM, 1992 Vol 25:390-397 - Bandettini *et.al.*
- PNAS, 1992 Vol 89(13):5951-5955 - Ogawa *et.al.*

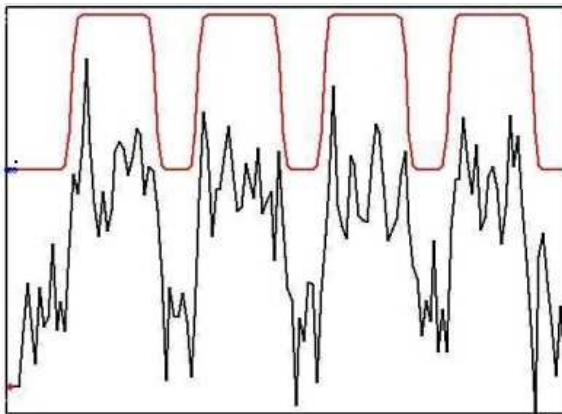
BOLD contrast



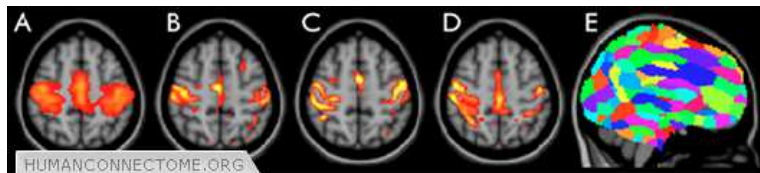
BOLD contrast



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Other types of contrast

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