

McBride Brain Institute field trip is Tuesday March 22
Meet at MBI at 5:10 pm sharp!



Magnetic Resonance Imaging

Components of an MRI system

The Static Magnet

- The permanent magnet.
- Resistive Electromagnet
- Superconducting Electromagnet

RF System

- The Transmitter is made up of an RF synthesizer, power amplifier, and transmitting coil. *May be the same*
- The receiver consists of a pick-up coil, amplifier, and signal processing system.

The Magnet Gradients

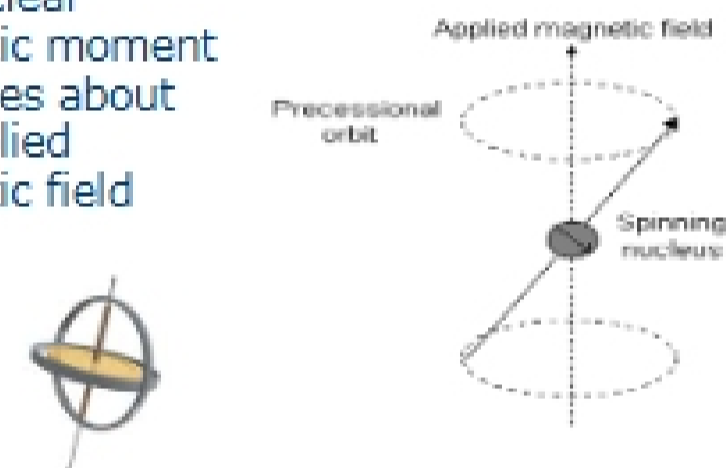
- Magnet gradients are produced by coils which are not parallel.
- Coils are resistive magnets.
- Produce gradients from 20 mT/m to 100 mT/m.

Some Nuclei Commonly Used in NMR

Nuclei	Unpaired Protons	Unpaired Neutrons	Net Spin	g (MHz/T)
^1H	1	0	$\frac{1}{2}$	42.58
^2H	1	1	1	6.54
^{31}P	1	0	$\frac{1}{2}$	17.25
^{23}Na	1	2	$\frac{3}{2}$	11.27
^{14}N	1	1	1	3.08
^{13}C	0	1	$\frac{1}{2}$	10.71
^{19}F	1	0	$\frac{1}{2}$	40.08

Spin in a Magnetic Field

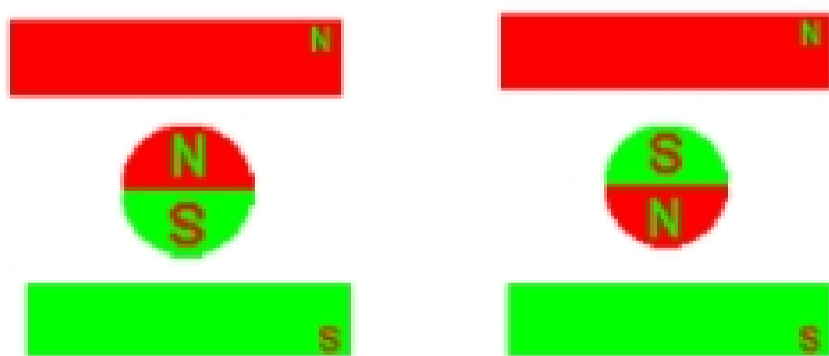
- The nuclear magnetic moment precesses about the applied magnetic field



Possible nuclear spin states

- High Energy

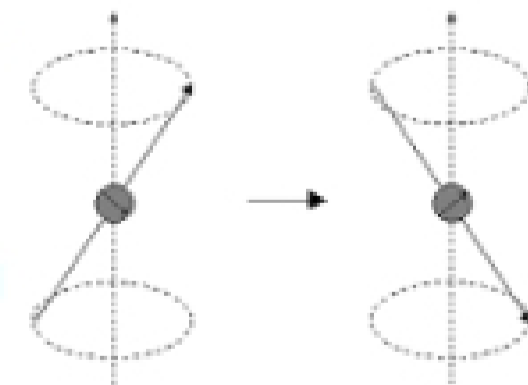
- Low Energy

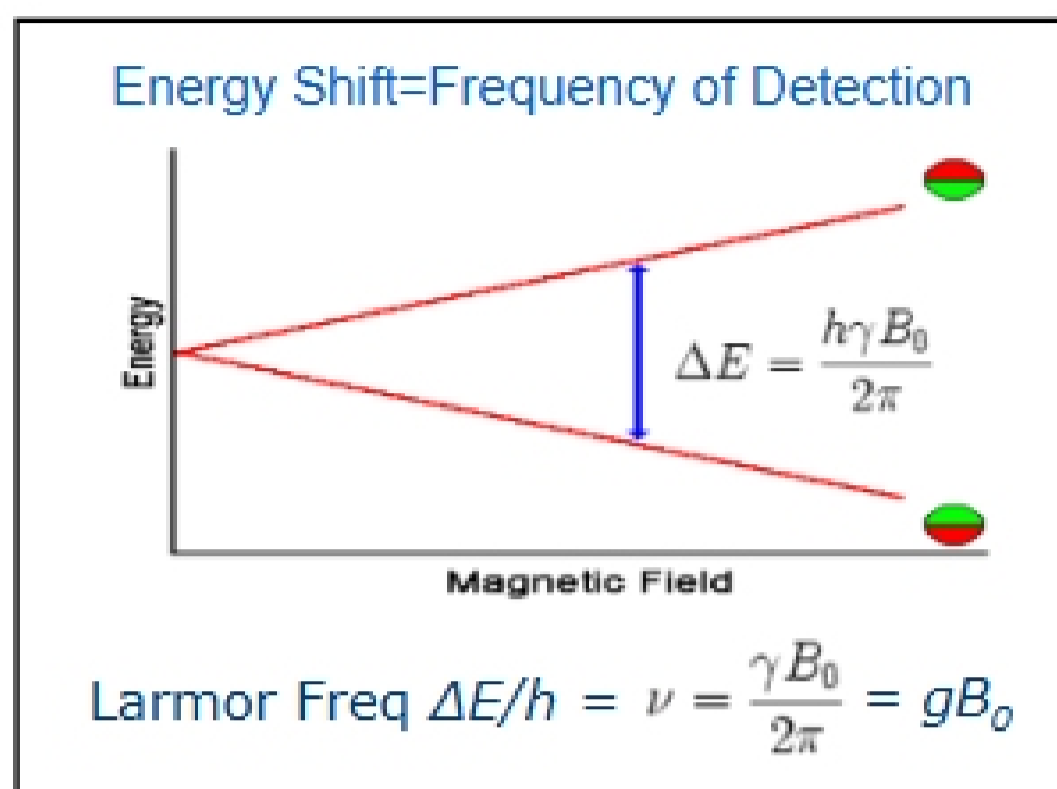


Photon Absorption

- Transition from low energy state to high energy state absorbs a photon

The energy needed to make the transition depends on the magnetic moment of the nucleus and the strength of the applied magnetic field





Some Nuclei Commonly Used in

$$\text{NMR} \quad \nu = \frac{\gamma B_0}{2\pi} = gB_0$$

Nuclei	Unpaired Protons	Unpaired Neutrons	Net Spin	g (MHz/T)
^1H	1	0	$\frac{1}{2}$	42.58
^2H	1	1	1	6.54
^{31}P	1	0	$\frac{1}{2}$	17.25
^{23}Na	1	2	$\frac{3}{2}$	11.27
^{14}N	1	1	1	3.08
^{13}C	0	1	$\frac{1}{2}$	10.71
^{19}F	1	0	$\frac{1}{2}$	40.08

What did the Quantum Mechanic say when asked "What's New?"

- ▲ A. Small World
- ▲ B. Pussy Cat
- ▲ C. Isaac Newton
- ▲ D. E over h
- ▲ E. The cat may be dead; it's uncertain

r.f. Resonance

When a steady magnetic field is applied to a sample of material, the majority of nuclei are in the high energy state.

When the sample is saturated with radio waves (photons) at the resonant (Larmor) frequency, the high and low energy populations become equal ($T = \infty$).

The radio frequency energy (photons) emitted as the sample returns to its initial state can be measured.

At what frequency are the photons emitted when the sample returns to its initial state?

- ▲ A. Larmor frequency
- ▲ B. 2 times Larmor
- ▲ C. It is a broad spectrum of frequencies
- ▲ D. It is random
- ▲ E. Amor frequency

Nobel Prizes related to NMR

Otto Stern, USA: Nobel Prize in Physics 1943 "for his contribution to the development of molecular ray method and his discovery of the magnetic moment of the proton"

Isidor I. Rabi, USA: Nobel Prize in Physics 1944 "for his resonance method for recording the magnetic properties of atomic nuclei"

Felix Bloch, USA and Edward M. Purcell, USA: Nobel Prize in Physics 1952 "for their discovery of new methods for nuclear magnetic precision measurements and discoveries in connection therewith"

Richard R. Ernst, Switzerland: Nobel Prize in Chemistry 1991 "for his contributions to the development of the methodology of high resolution nuclear magnetic resonance (NMR) spectroscopy"

Kurt Wüthrich, Switzerland: Nobel Prize in Chemistry 2002 "for his development of nuclear magnetic resonance spectroscopy for determining the three-dimensional structure of biological macromolecules in solution"

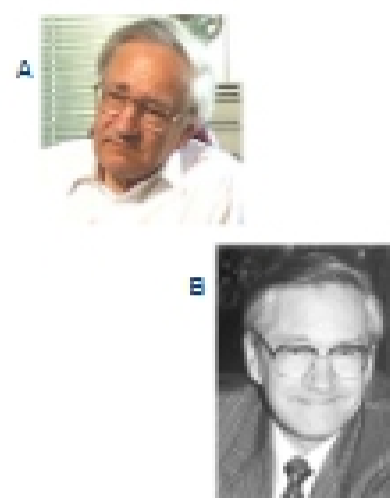
Paul C. Lauterbur, USA and Peter Mansfield, United Kingdom: Nobel Prize in Physiology or Medicine 2003 "for their discoveries concerning magnetic resonance imaging"

http://www2.chemistry.msu.edu/facilities/nmr/900MHz/MCSB_NMR_nobel.html

As energy of photons is raised, their wavelength shortens. Therefore, the resolution of an MRI image—

- A. Decreases as the magnetic field is raised
- B. Increases as the magnetic field is raised
- C. Is not affected by the magnitude of the magnetic field

Pulsed Fast Fourier Transform Spectroscopy

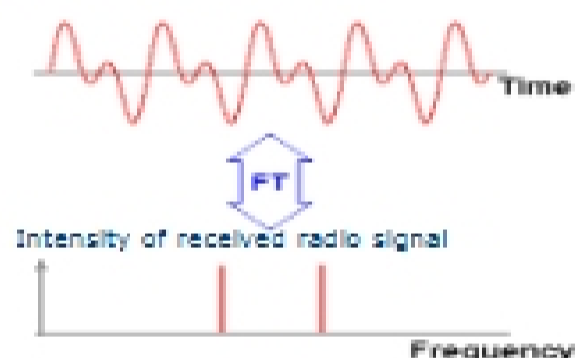


C. Both

- A steady magnetic field is applied and a pulse of radio waves containing a range of frequencies is sent through the sample.
- More efficient—measures response at many frequencies at one time
- Which picture is Richard Ernst, the Nobel Prize winner in Chemistry in 1991?

FT

- A Fourier Transform is used to convert the data from time to the frequency domain.



Big Magnets Rule

- NMR spectroscopy requires very strong magnets (up to 21 Tesla).
- A stronger magnet results in a larger energy level split
 - = higher energy photon
 - = shorter wavelength.

