Ministry of Higher Education and Scientific Research
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3rd

Radiology Techniques Department

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M.SC. Theoretical Physics

Course Two

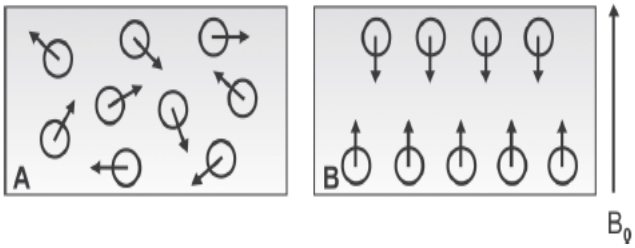
Lecture 11: Magnet and Resonance

2020/2021

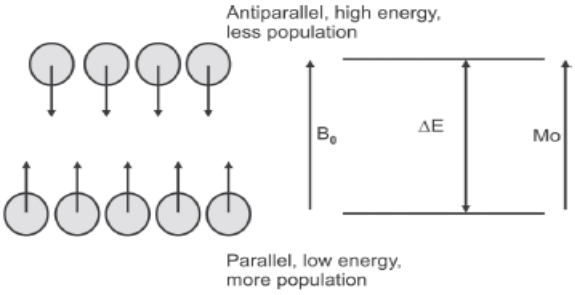
Hydrogen makes up 80% of all atoms found in the human body, making hydrogen extremely useful for MRI. Because hydrogen is a single-charged spinning nucleon

- This proton is electrically positive charged and it rotates around (spin) its axis.
- Their spin and charge distribution gives magnetic properties.
- Hydrogen protons in the body thus act like many tiny magnets. The nucleus is said to be a magnetic dipole

- Under normal circumstances, these magnetic dipoles (each has a north and south magnetic pole) are randomly distributed in space. Consequently, if the net magnetic field of a patient were measured، it would be zero because all of the individual magnetic dipole moments cancel. Net magnetization is symbolized by M
- The number of excess proton is about 3 spins per million at 1.0 Tesla magnetic field strength

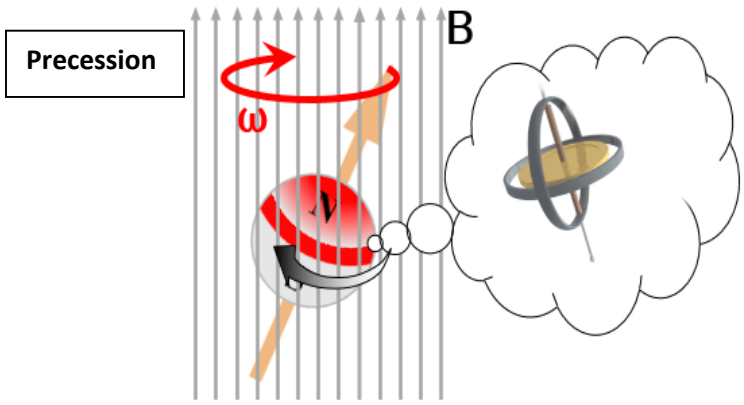


When the patient is placed in the presence of a strong external magnetic field, some of the individual nuclear magnetic moments align with the external magnetic field.



Precession

- External magnetic field exerts a force on the proton that undergoes precession.
- The direction of the spin axis tilts and rotates around the external magnetic field, with fixed frequency



The Larmor Equation

This precession occurs at an angular frequency (ω) that is proportional to magnetic field strength (Bo).

- The fundamental equation for MRI, the Larmor equation

$\omega = \gamma B$

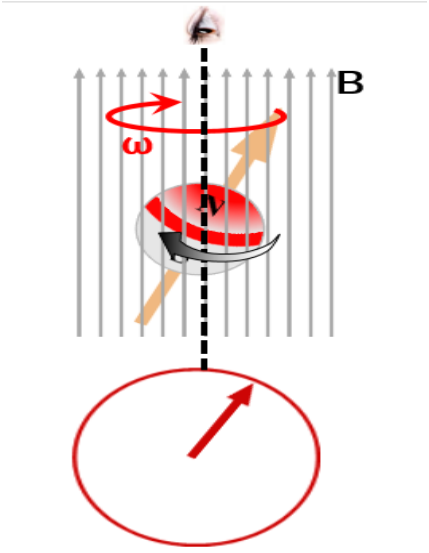
where ω is the frequency of precession (or resonant frequency) and γ is the gyromagnetic ratio (for hydrogen is **42.6**).

✓ if the magnetic resonance imaging system 1.5 Tesla then Larmor frequency or precessional is:

42.57 × 1.5 = 63.855 MHz

Radiofrequency and Resonance

If a radiofrequency (RF) pulse having frequency equal to Larmor frequency of tissue is applied perpendicular to the magnetic field, then it is absorb by the proton nuclei and resonance occurs.



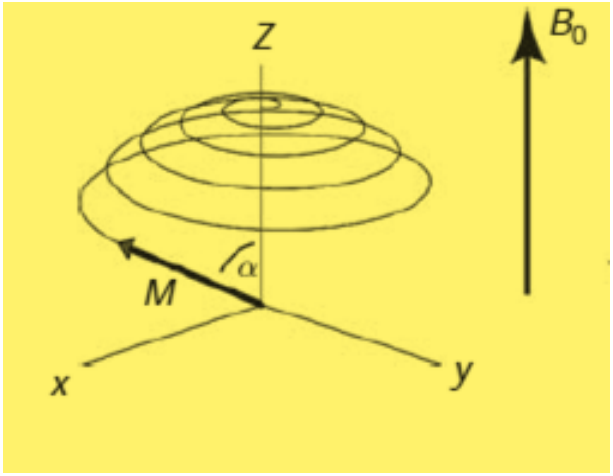
Net Magnetization

The direction of the Bo field is commonly designated as the z-axis.

- The net magnetization vector (M) has three components, namely, (i) longitudinal (M_Z), (ii) equilibrium (M_O), and (iii) transverse (M_{XY}).
- The M_Z is the component of the magnetic moment parallel to the applied magnetic field.
- M_{xy} is the component of the magnetic moment perpendicular to the applied magnetic field

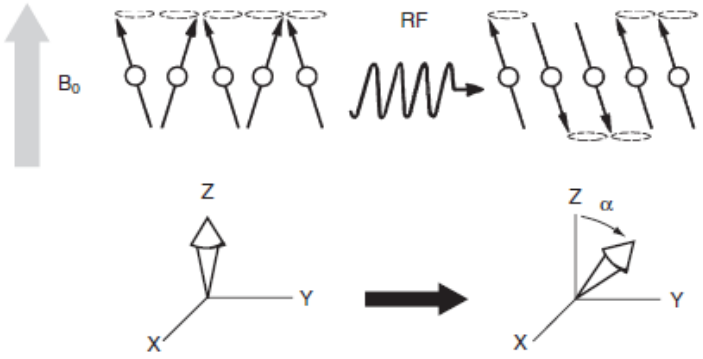
Flip angle

Flip angle, also called tip angle, is the amount of rotation the net magnetization (M) experiences during application of a radiofrequency (RF) pulse.



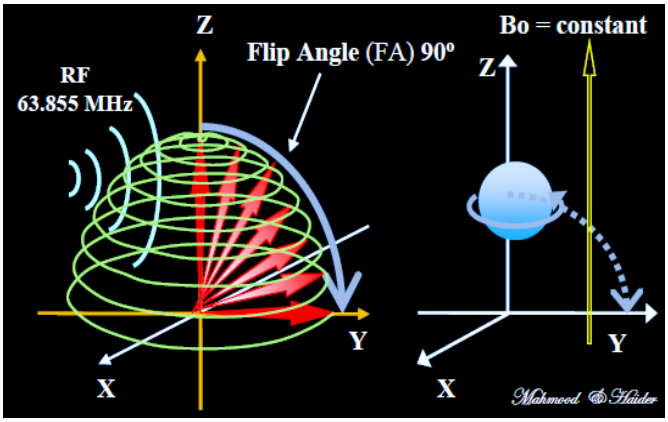
$M_{XY} = 0$

$M_Z = M_0$



Excitation

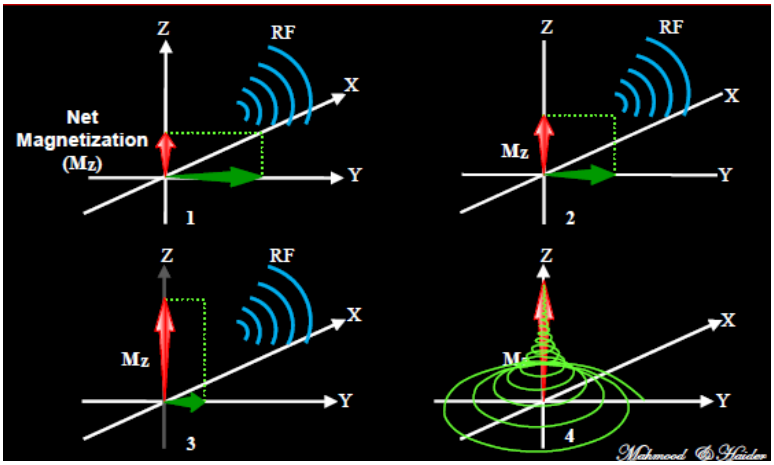
If the net magnetization rotated 90 degrees in x-y plane and this means the same thing if we say that the protons raised to a **higher energy state**. This occurs because the protons absorbed energy from the **RF pulse**



- by sending an RF pulse at the **Larmor Frequency**, with certain strength (amplitude) and for a certain period of time it is possible to rotate the **net magnetization** into a plane perpendicular to the Z-axis, in this case the X-Y plane

Relaxation

When the RF pulse is switch OFF, the magnetization vector returns to equilibrium position and the spins undergo loss of phase coherence. As a result



- The relaxation process can be divided into two parts: **T1** and **T2 relaxation**.