1st Semester

كلية المأمون الجامعة

قســـــم تقنيات الأشـــــعة

المرحلة الثالثة

Physics of Magnetic Resonance

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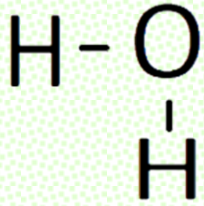
MSc Medical Imaging / MRI Applications

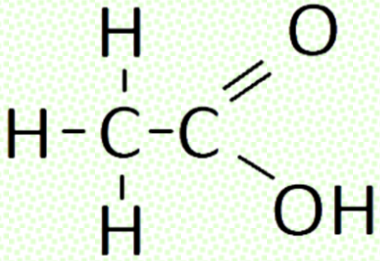
Lecture (1)

All things are made of atoms. Atoms are organized into molecules, which are two or more atoms joined together. The most common atom in the human body is hydrogen, but there are also other elements like oxygen, carbon, and nitrogen. Hydrogen is usually found in water molecules (where two hydrogen atoms are joined with one oxygen atom; H_2O) and in fat (where hydrogen atoms are joined with carbon and oxygen atoms).



Water

→ *The atom consists of a central nucleus and electrons that orbit around it. The nucleus is very small, making up a tiny part of the total volume of the atom. Most of the mass of the atom comes from particles called* ***nucleons****, which are divided into protons and neutrons.*



FAT

Triglycerides

→ *The atomic number is the number of protons in the nucleus. This number gives the atom its chemical identity. Usually, the number of neutrons and protons in the nucleus is balanced.*

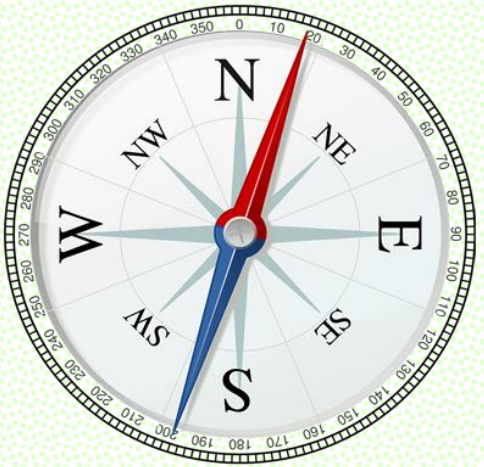
→ *In some atoms, there are slightly more or fewer neutrons than protons. Atoms with the same number of protons but different numbers of neutrons are called* ***isotopes****.*

→ *Electrons are particles that orbit around the nucleus. Traditionally, this was thought to be like planets orbiting the sun, with electrons moving in specific shells. However, according to quantum theory, the position of an electron is not exact and depends on the energy of the electron at any moment in time. This is called* ***Heisenberg's Uncertainty Principle****.*

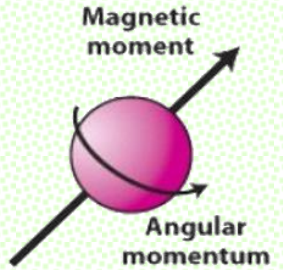
→ *Some particles in the atom have an electrical charge. Protons have a positive electrical charge, neutrons have no charge, and electrons have a negative charge. The atom is electrically stable if the number of negatively charged electrons equals the number of positively charged protons.*

→ *This balance can change when energy is applied to remove electrons from the atom. This creates a lack of electrons compared to protons, causing electrical instability. Atoms where this happens are called ions, and the process of removing electrons is called* ***ionization****.*

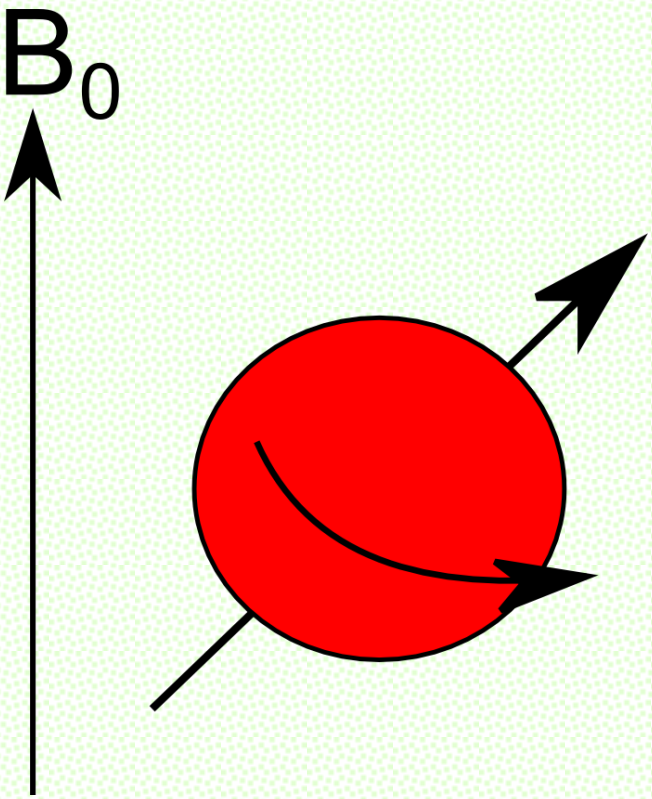
→ *The proton is a subatomic particle that carries a positive charge, and like any particle that has an electric charge and spins around itself, it creates a magnetic effect, which is known as the* ***magnetic moment***



→ ***Magnetic moment*** *is a physical quantity that defines the strength and direction of the magnetic field produced by a charged particle, such as a proton or electron, due to its* ***movement or spin****. The greater the charge or speed of the particle's spin, the greater the magnetic moment it generates.*



→ ***Angular momentum*** *is a physical quantity that describes the amount of rotation or circular motion of an object around a specific axis.*



→ ***The gyromagnetic ratio*** *is a physical constant that defines the relationship between the magnetic moment and the angular momentum of a particle, such as a proton or nucleus. In short, it describes the extent to which a*

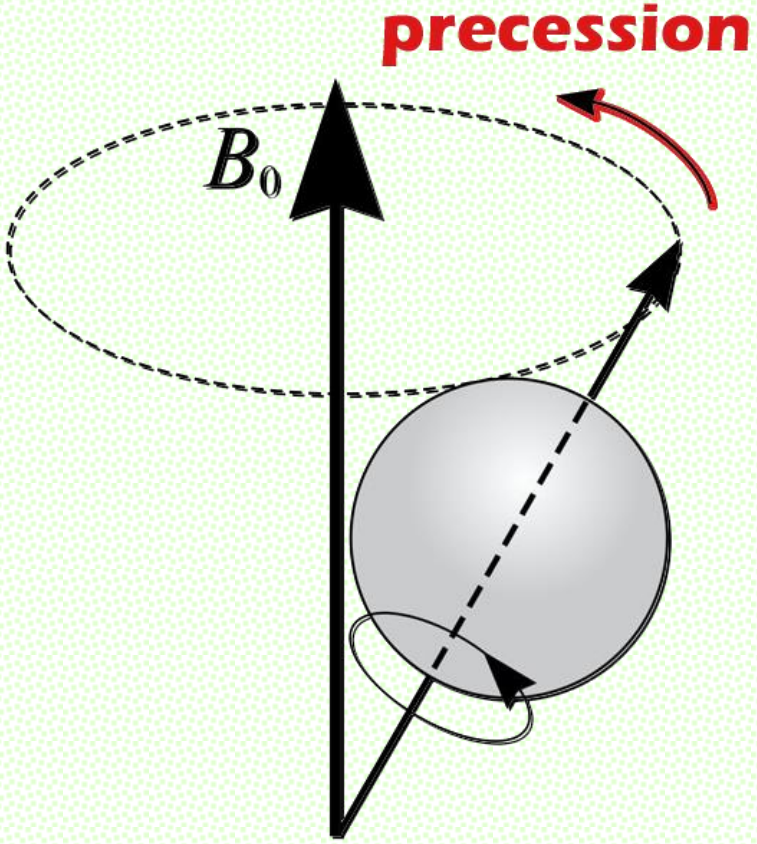
Magnetic particle (like a hydrogen nucleus) interacts with an ***external magnetic field.***

Definition*: The gyromagnetic ratio is the ratio between the magnetic moment of a particle and its associated angular momentum.*

Nucleus or Particle	Gyromagnetic Ratio (γ) in MHz/Tesla
^{1}H	42.58
^{3}He	-32.43
^{13}C	10.71
^{19}F	40.05
^{23}Na	11.26
^{31}P	17.24
electron	-27,204

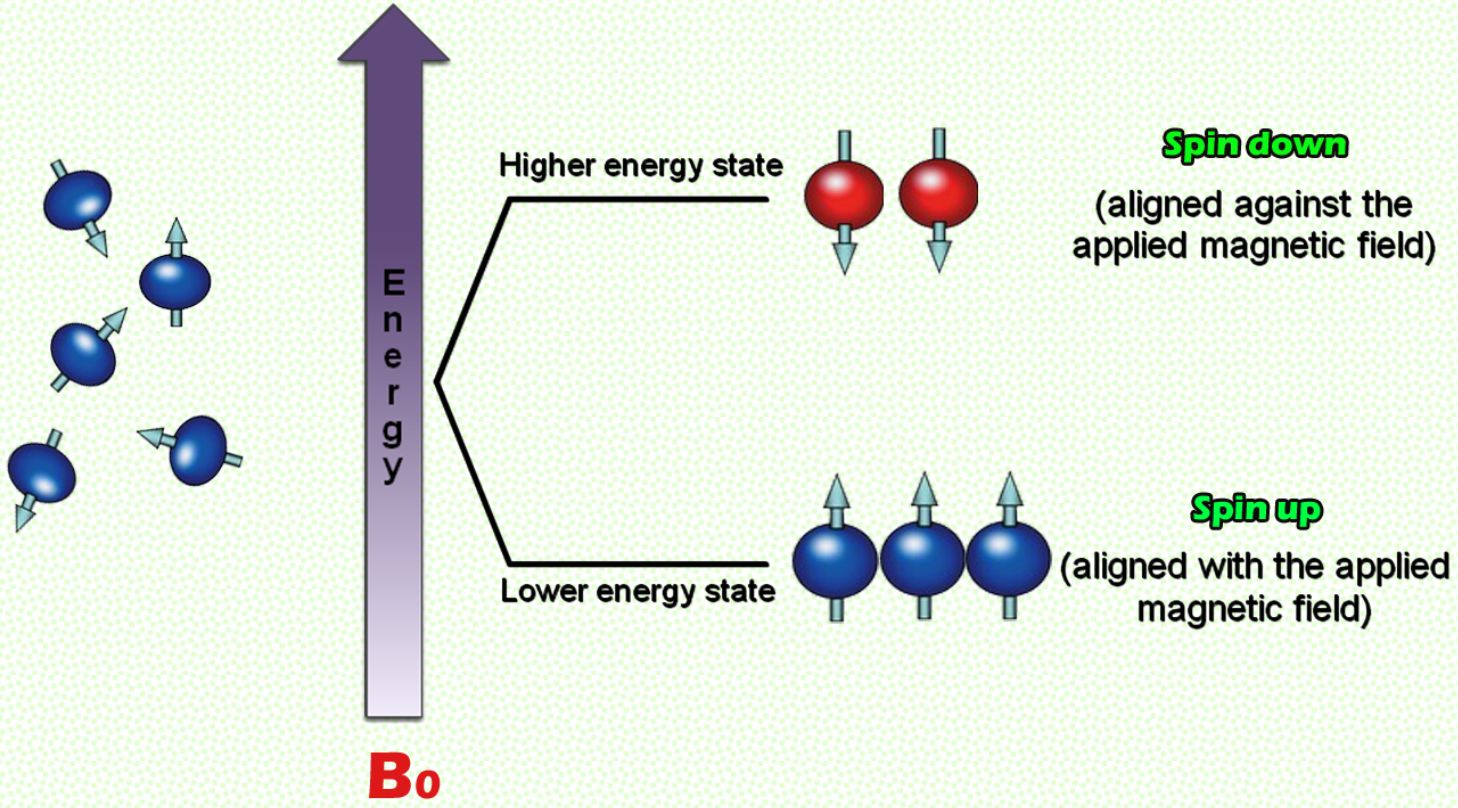
*For the hydrogen nucleus (proton), the gyromagnetic ratio is approximately **42.58** megahertz per tesla (MHz/T). This means that when the hydrogen nucleus is placed in a constant magnetic field, the proton precesses at a frequency of 42.58 MHz.*

→ ***Precession** is the slow, circular movement of the **axis** of a spinning object, such as a proton, under an external force.*



→ ***Nuclear Alignment*** *The protons in the body (especially hydrogen protons) interact with the strong external magnetic field generated by the MRI machine. Each proton possesses a property called spin, which can be in one of two states:*

- ***Low-energy state****: In this state, the proton aligns with the direction of the external magnetic field (B_0).*
- ***High-energy state****: In this state, the proton aligns against the direction of the magnetic field (B_0).*


Energy
Higher energy state
Lower energy state
Spin down
(aligned against the applied magnetic field)
Spin up
(aligned with the applied magnetic field)
B0


Thank
You