كلية المأمون الجامعة
قســـــم تقنيات الأشـــعة

1st Semester

المرحلة الثالثة

Equipment Techniques of Magnetic Resonance Imaging

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Lecture (1) Magnetic Susceptibility

Magnetic Susceptibility *is a measure of how a material reacts to an external magnetic field? In other words, it shows how the material responds to magnetic force when it is in a magnetic field. It is measured by how much the material becomes magnetized when placed in a magnetic field.*

Explanation: When a material is placed in a magnetic field, it interacts with the magnetic field based on the material's composition and properties.

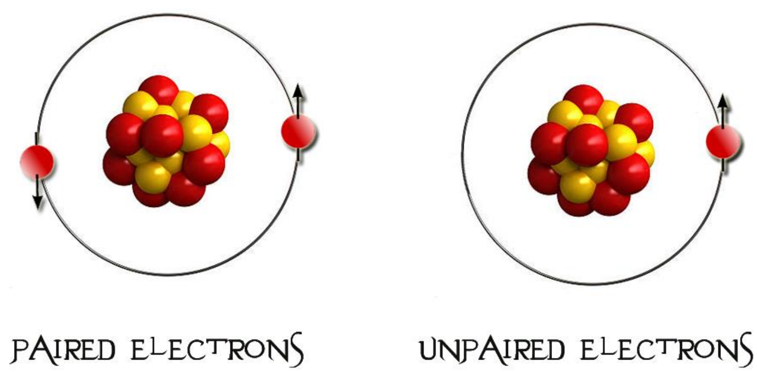
The relationship between Magnetic Susceptibility and electrons is based on how the external magnetic field affects the movement and arrangement of electrons inside the material. The material's response to the magnetic field depends mainly on the electrons and how they are arranged and move inside the atoms and molecules.

Paired and Unpaired Electrons Concept:

Atoms have electrons that move around the nucleus in different orbitals. These electrons have a property called magnetic moment, which comes from the electron's spin and its movement around the nucleus.

In some atoms, the electrons are paired, which means that each electron in an orbital has another electron spinning in the opposite direction. This cancels out the magnetic moment of the atom.

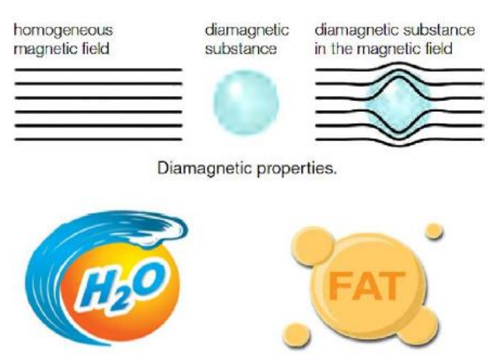
In other atoms, there are unpaired electrons, which means the magnetic moment of the atom is not balanced. This leads to a different response to the magnetic field.



Materials respond to the magnetic field in different ways, and they can be divided into three main types:

1- Diamagnetic Materials:

These materials are not naturally magnetic, and they have a negative magnetic susceptibility.When put in a magnetic field, they are weakly repelled by the field. This means the magnetic field creates a weak magnetic field in the material that is opposite to the external magnetic field.



Examples: Water, copper, glass.

Applications: In Magnetic Resonance Imaging (MRI), water and soft tissues in the body show negative magnetic susceptibility. This helps them interact with the magnetic fields used in MRI.

Physical Chemistry: *In these materials, all the electrons are paired, which means their magnetic moments cancel each other.*

When a diamagnetic material is placed in a magnetic field, the paired electrons respond to the magnetic field in the opposite direction. This creates a weak magnetic moment in the opposite direction.

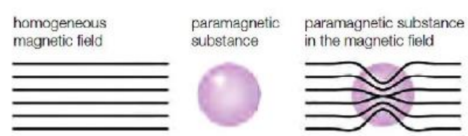
This weak magnetic moment makes the material slightly repel the magnetic field, which is why diamagnetic materials have negative magnetic susceptibility.

*2-*Paramagnetic Materials*:*

These materials have weak positive magnetic susceptibility.

When placed in a magnetic field, they become weakly magnetic, but they lose their magnetism quickly when the magnetic field is removed.

Examples: Aluminum, liquid oxygen, some molecules in the body like oxygenated hemoglobin.



Paramagnetic properties.

Applications: In MRI, paramagnetic materials are used as contrast agents to improve the quality of images.

Physical Chemistry: *In these materials, some of the electrons are unpaired, so the atoms have a net magnetic moment.*

When a paramagnetic material is placed in a magnetic field, the magnetic moments of the unpaired electrons align with the magnetic field.

This causes the material to be weakly attracted to the magnetic field, which is why paramagnetic materials have weak positive magnetic susceptibility. However, when the field is removed, the material loses its magnetism quickly.

3- Ferromagnetic Materials:

These materials have very strong positive magnetic susceptibility.

They become strongly magnetized when exposed to a magnetic field and keep their magnetism even after the magnetic field is removed.

Examples: Iron, nickel, cobalt.

Applications: These materials are used in magnetic storage devices and in strong MRI magnets. However, they are not safe to use with MRI machines because they strongly react to the magnetic field.

Ferromagnetic properties.

***Physical Chemistry**: These materials have a large number of unpaired electrons, which creates a strong magnetic moment.*

In these materials, the magnetic moments of the unpaired electrons interact with each other and align in the same direction, even without an external magnetic field. This makes the material permanently magnetic.

When a ferromagnetic material is placed in a magnetic field, the unpaired electrons greatly enhance the magnetic moment, causing a strong attraction to the magnetic field. This is why ferromagnetic materials have strong positive magnetic susceptibility and keep their magnetism even after the magnetic field is removed.

Relationship with MRI:

In MRI, magnetic susceptibility is used to tell different tissues apart by how they respond to the magnetic field. Different tissues have different levels of magnetic susceptibility, which helps doctors see detailed images of soft tissues, the brain, and other parts of the body.

Diamagnetic materials like water give weak signals because they have a negative response to the magnetic field.

Paramagnetic materials like some contrast agents are used to improve the contrast in MRI images, making details in the body clearer.