Magnetic Resonance Imaging

Spin

atomic nucleus has its own magnetic field

External magnetic field ($B$)

$\uparrow$ aligns spins

$B$

$\uparrow$ parallel (more stable, $<E$)

$\downarrow$ antiparallel (less stable, $>E$)

Radio wave

$hf = E_{ap} - E_p$
Spin
B

parallel

anti parallel

precession

Magnetization (M)

frequency (Larmor frequency)

THE SAME AS the f of the absorbed radio wave

M = sum of all spins magnetic momenta

parallel

anti parallel

add spins →
Steps of MRI

1. Place body in a strong magn. field

Magnetic field aligns spins

MRI: nucleus used = proton (H nucleus)
2. Sending radio frequency (RF) wave to body

1. Magnetization rotates

\[
\begin{align*}
M & \rightarrow \text{projection of } M \text{ on axis of } B \\
M_z & \rightarrow \text{speed of return, } T_1 \text{ (relaxation time)}
\end{align*}
\]

2. Spins are synchronized from above

\[
\begin{align*}
\text{not in phase} & \rightarrow \text{in phase}
\end{align*}
\]

3. Switching off RF wave

\[
\begin{align*}
\text{spins return to “out-of-sync”} & \rightarrow \text{relaxation time } T_2
\end{align*}
\]
MRI image types

1) Proton density
   ~ Concentration of protons in a given point
   ~ Water content

2) T1 image
   ~ T1 relax. time

3) T2 image
   ~ T2 relax. time
How we measure PD, T1, T2

Spins emit radio waves:

- Not in phase

\[ \text{destructor interference} \rightarrow \text{zero} \]

- In phase

\[ \text{radio wave emitted by spins of the body} \rightarrow \text{detected by coils} \]

Spins are desynchronized

RF wave
Localization

$\nabla \mathbf{B}$

$f \sim \mathbf{B}$

different $f$ at different points