Lesson 3 (B): T1 relaxation time

Aims

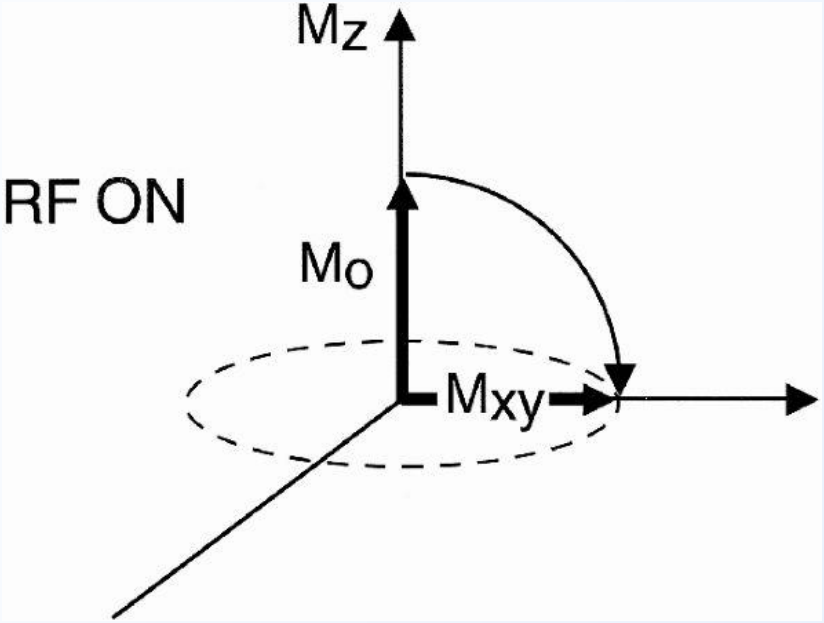
- To explain the following topics:
- Definition of relaxation
- Thermodynamics principle
- Definition of T1 relaxation time
- T1 curve
- Other names

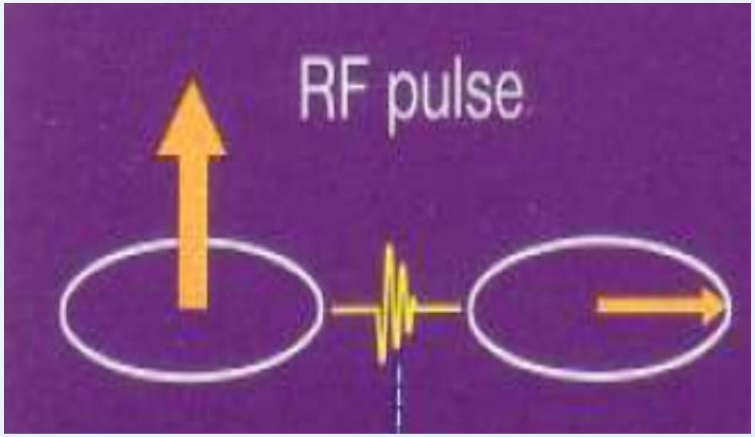
Relaxation

- The term relaxation means that the spins are relaxing back into their lowest energy state or back to the equilibrium state.
- Equilibrium by definition is the lowest energy state possible.

- Relaxation times:
- T1, T2, T2*

RF pulse on





Thermodynamics principle

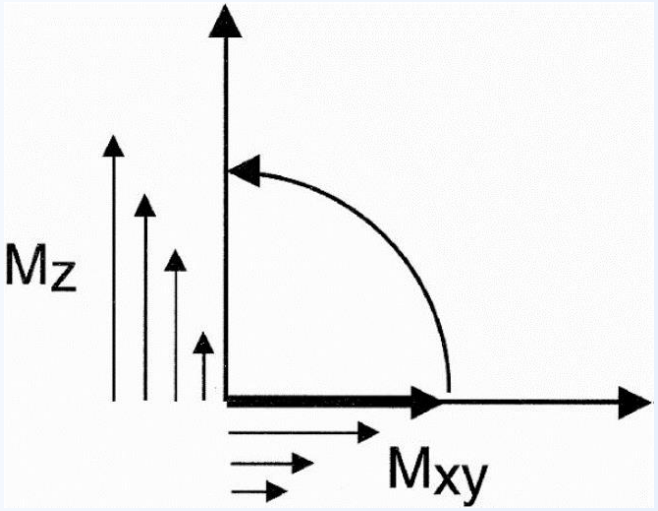
- A general principle of thermodynamics is that every system tends to its lowest energy level.
- Therefore, after the RF pulse is turned off, two things will occur:
- 1) The spins will go back to the lowest energy state.
- 2) The spins will get out of phase with each other.

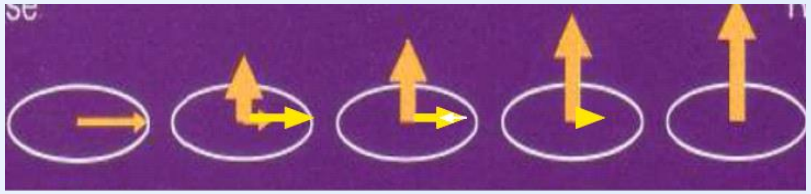
RF pulse off

- After the RF pulse is turned off, two simultaneous but separate processes occur:

1) The Mxy component of the magnetization (transverse magnetization) vector decreases rapidly

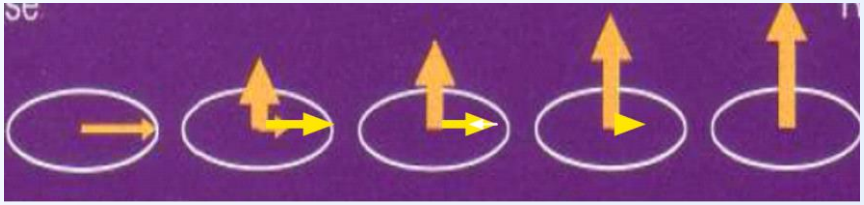
2) The Mz (longitudinal magnetization) component slowly recovers along the z axis.

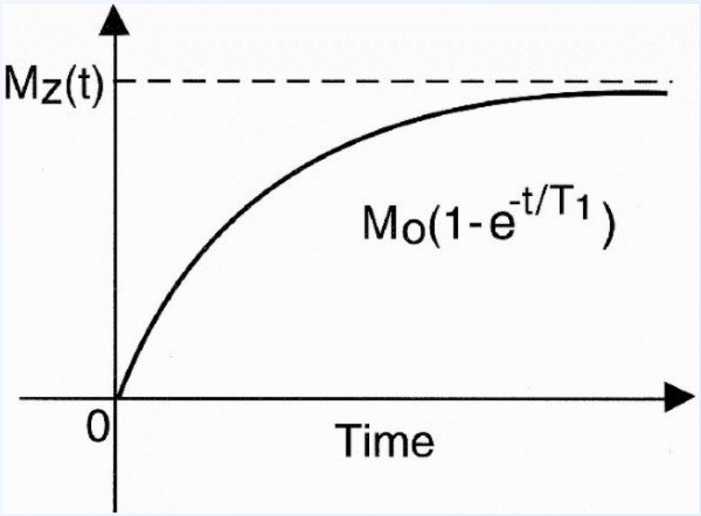




Recovery of longitudinal magnetization

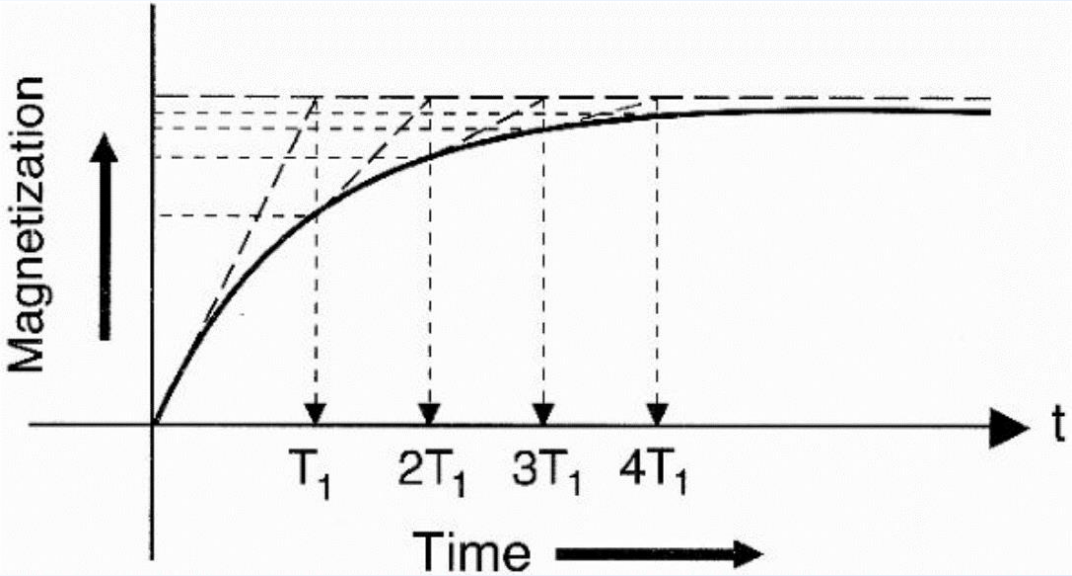
- The growth of longitudinal magnetization M0 occurs with a time constant T1.
- Mz (t) = M0 (1 - e-t/T1)





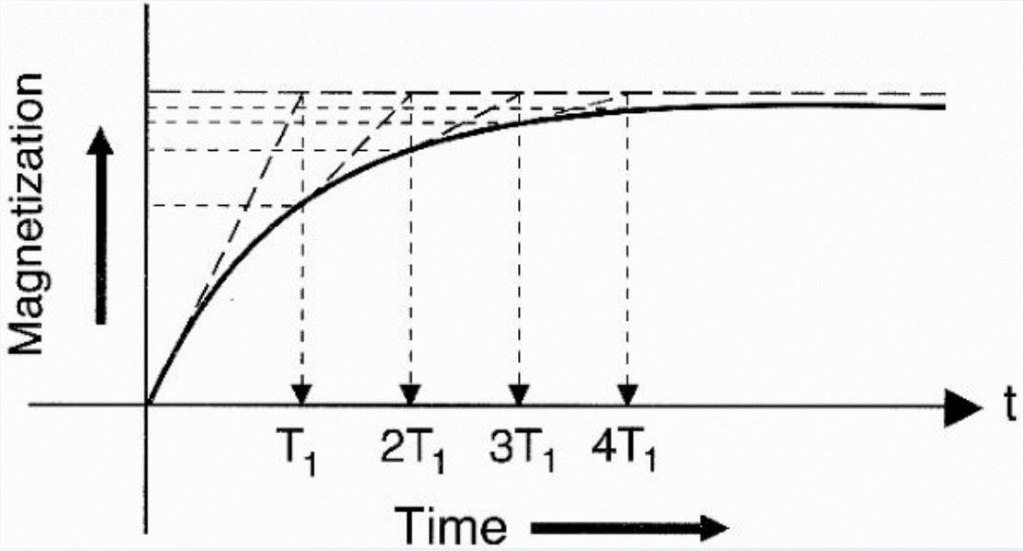
T1 relaxation time

- The time for a tissue to reach 63% of longitudinal magnetization is its T1 time.



T1 curve

- After about four or five T1 times we almost reach the plateau of the exponential growth curve.



T1 relaxation time

- T1 relaxation time depends on:
- The kind of tissue we are imaging
- The strength of the magnet
- If B0 decreases →
- The T1 of the tissue also decreases:
- ↓ B0 → ↓ T1
- For instance, biologic tissues have shorter T1 values at 0.5 T than at 1.5 T.

T1 relaxation time

- T1 = longitudinal relaxation time
- T1 = spin-lattice relaxation time

Longitudinal relaxation time

- T1 is called the longitudinal relaxation time because it refers to the time it takes for the spins to realign along the longitudinal (z) axis.

Spin-lattice relaxation time

- T1 is also called the spin-lattice relaxation time because it refers to the time it takes for the spins to give the energy they obtained from the RF pulse back to the surrounding lattice in order to go back to their equilibrium state.

Summary

- Definition of relaxation
- Thermodynamics principle
- Definition of T1 relaxation time
- T1 curve
- Longitudinal relaxation time
- Spin-lattice relaxation time

Reference

- Hashemi, RH and Brandy, WG. MRI the Basics, Second Edition