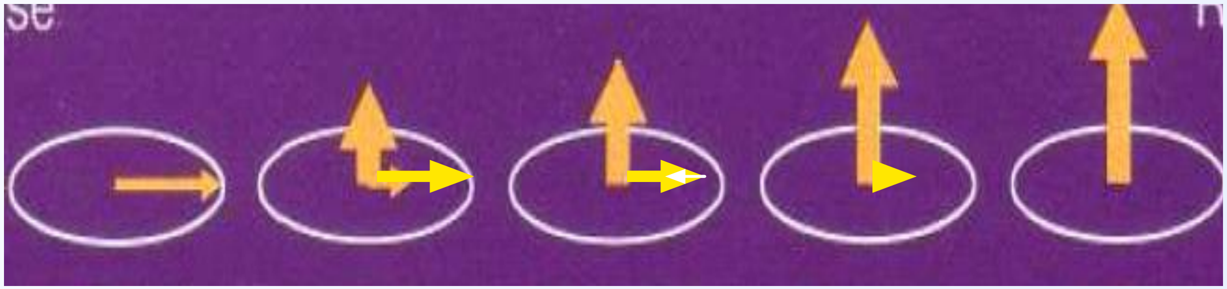
Lesson 4 (A): T2 relaxation time

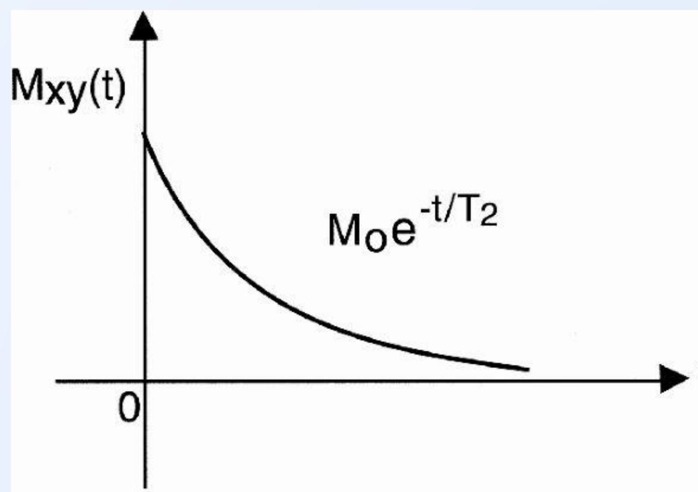
Aims

- Learning the following topics about T2 relaxation time:
- Definition
- Dephasing and rephasing
- Spin-spin interaction
- External magnetic field inhomogeneity

Decay of transverse magnetization

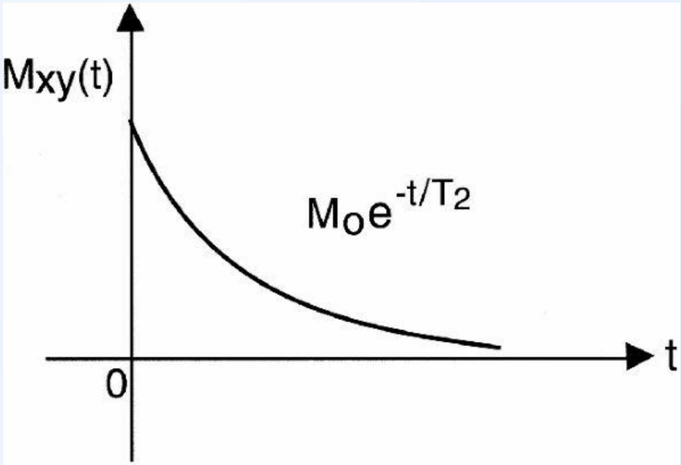


- As the longitudinal magnetization vector Mz recovers, the transverse vector Mxy decays at a rate characterized by T2
- $Mxy (t) = M0\ e-t/T2$

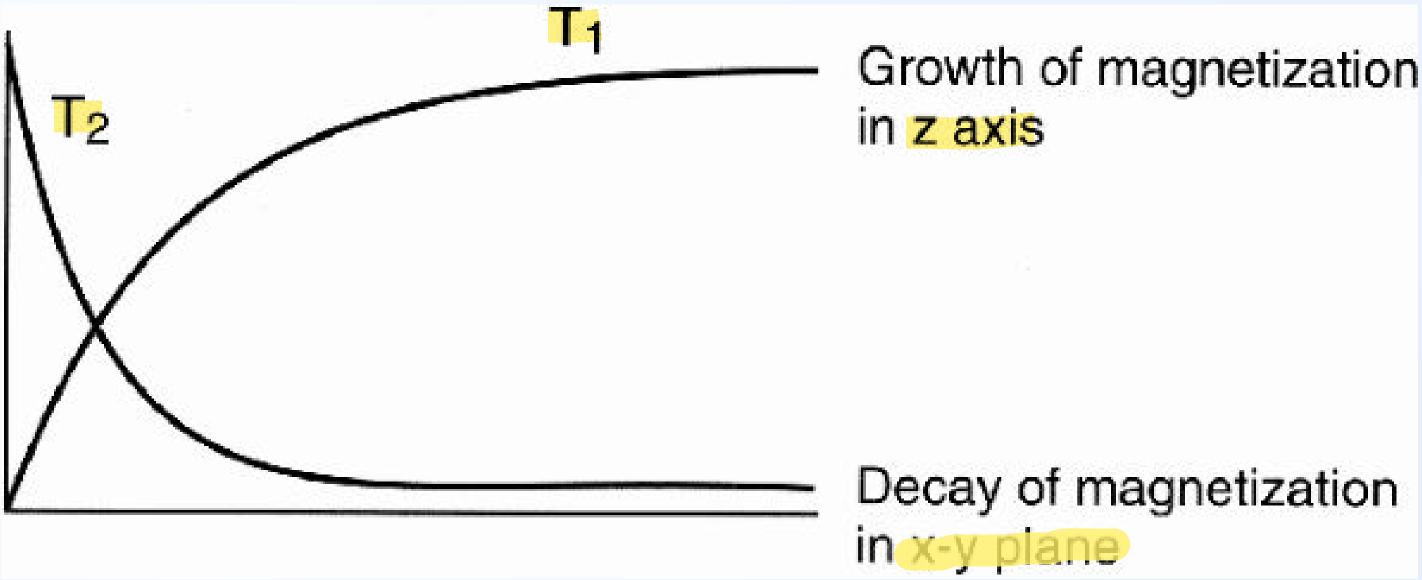


T2 relaxation time

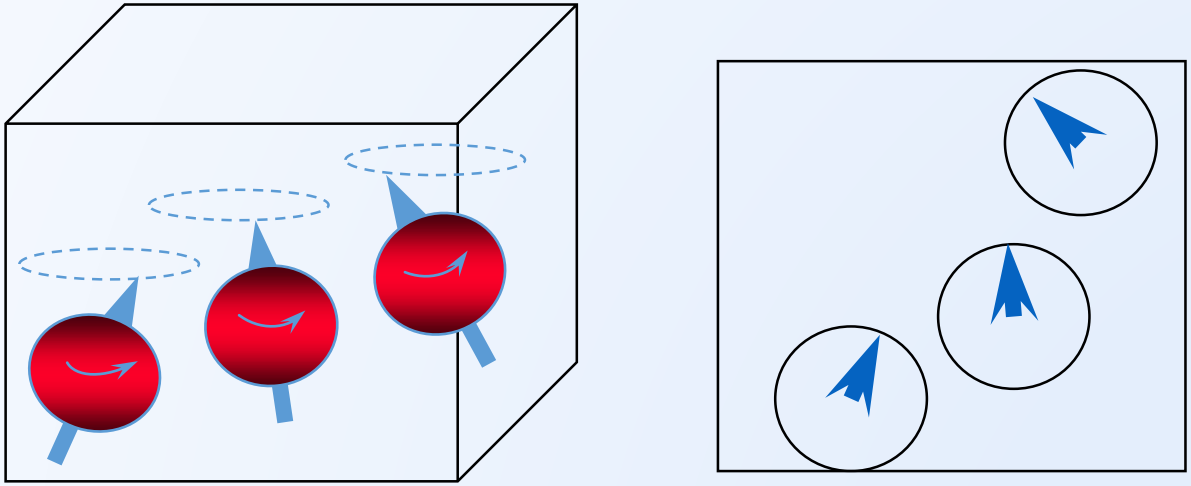
- T2 is defined as the time it takes for the spins to dephase to 37% of the original value.



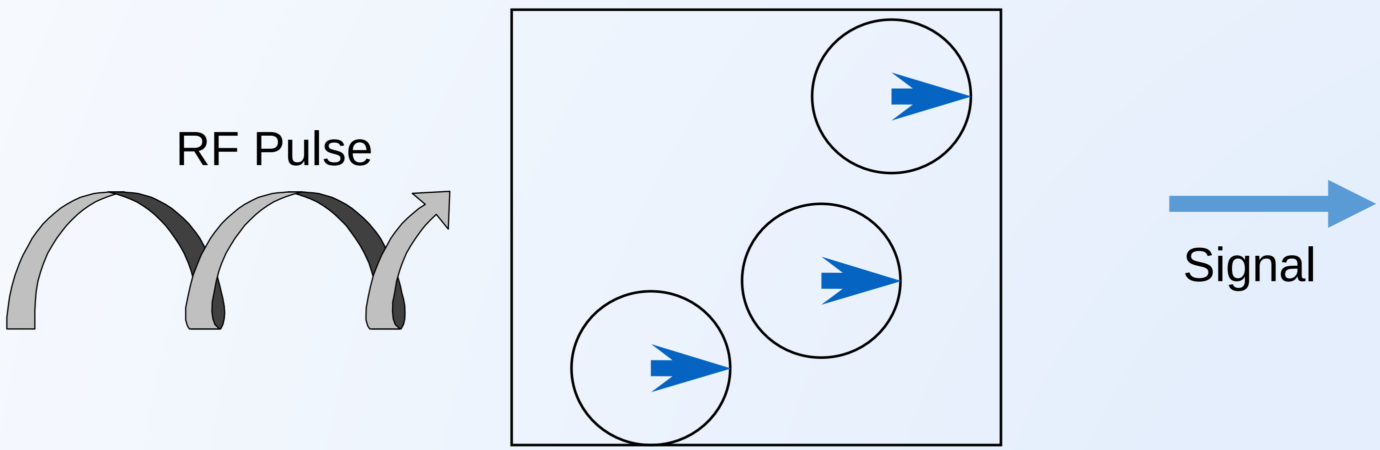
Which relaxation time is longer, T1 or T2?



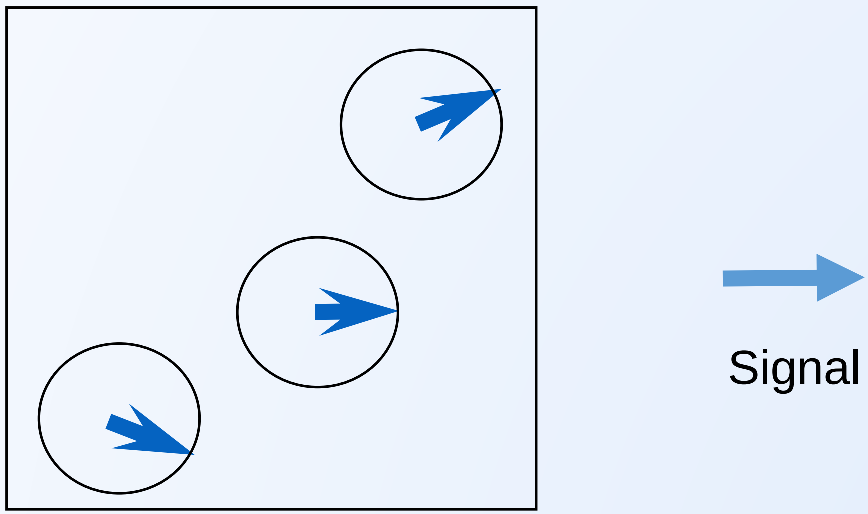
Dephasing



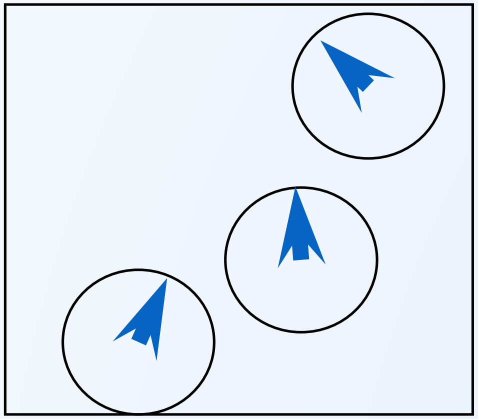
Rephasing



Dephasing



Dephasing



No Signal

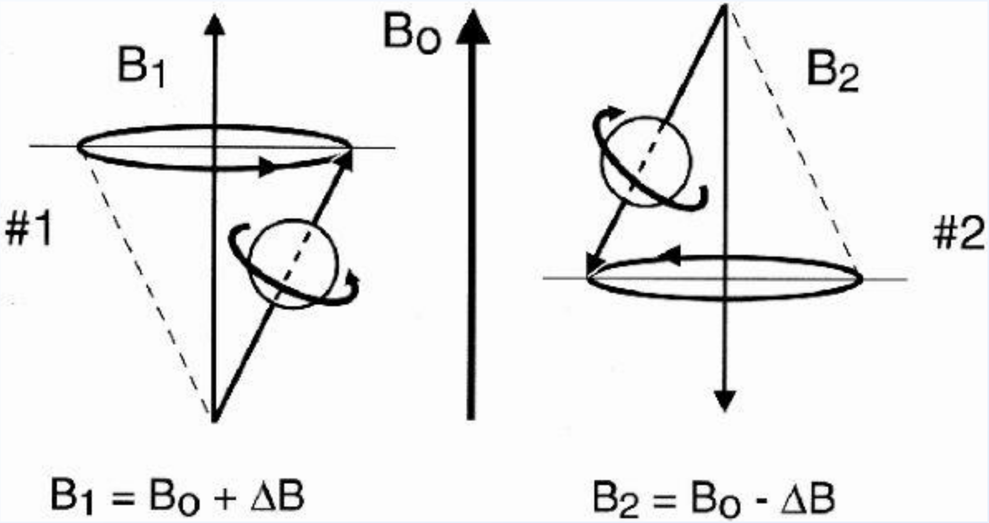
Dephasing

- Two phenomena that make dephasing of the spins:

1) Interactions between spins (internal inhomogeneities)
2) External magnetic field inhomogeneities

- These two phenomena together cause protons to spin at slightly different frequencies.

Interactions Between Individual Spins



- $B1=B0+ \Delta B$ → The precessional frequency of the proton #1 will increase slightly.
- $B2=B0 - \Delta B$ → The precessional frequency of proton #2 will decrease slightly.

Spin-spin interaction

- The difference in the magnetic environment created by these spin-spin interactions may be very small, but it makes a difference in the overall homogeneity of the magnetic field to which the spins are exposed.

Spin-spin interaction

- Spin-spin interaction depends on the proximity of the spins to each other.
- For example, in water (H2O), the protons are separated more widely than they are in a solid tissue. →
- More spin-spin interactions in a solid tissue

Spin-spin interaction

- Spin-spin interaction is an inherent property of every tissue and is measured by T2.

T2 relaxation time

- Transverse relaxation time
- Spin-spin relaxation time

External magnetic field inhomogeneity

- This is the second phenomenon that makes spins get out of phase.
- Some variation in the homogeneity of the magnetic field exists.
- External magnetic field inhomogeneity →
- Protons in different locations precess at different frequencies because each spin is exposed to a slightly different magnetic field strength.

External magnetic field inhomogeneity

- These varying frequencies are very close to each other and very close to the true Larmor frequency; however, these tiny differences in frequency result in spin dephasing.

Dephasing resulted from external magnetic field inhomogeneity

- Imagine three protons of P1, P2 and P3.
- P1 exposed to B0 → it precess at ω0
- P2 exposed to B0+ → it precess at ω0+
- P3 exposed to B0- → it precess at ω0-
- There are slightly differences between the frequencies →
- Spin dephasing

Summary

- T2 relaxation time
- Dephasing and rephasing
- Factors affecting dephasing
- Spin-spin interaction
- External magnetic field inhomogeneity

Reference

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