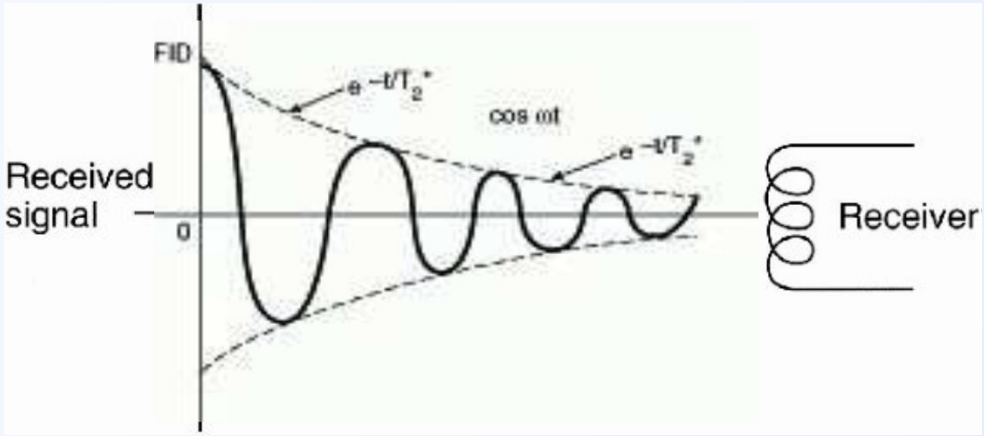
Lesson 4 (B): Free induction decay – T2*

Aims

- Learning the following topics about free induction decay (FID) and T2*:
- Received signal
- FID
- T2*
- Differences between T2 and T2*

Received Signal

- The signal is received by RF coil.
- The received signal is an oscillating, decaying signal. It is called a free induction decay (FID).

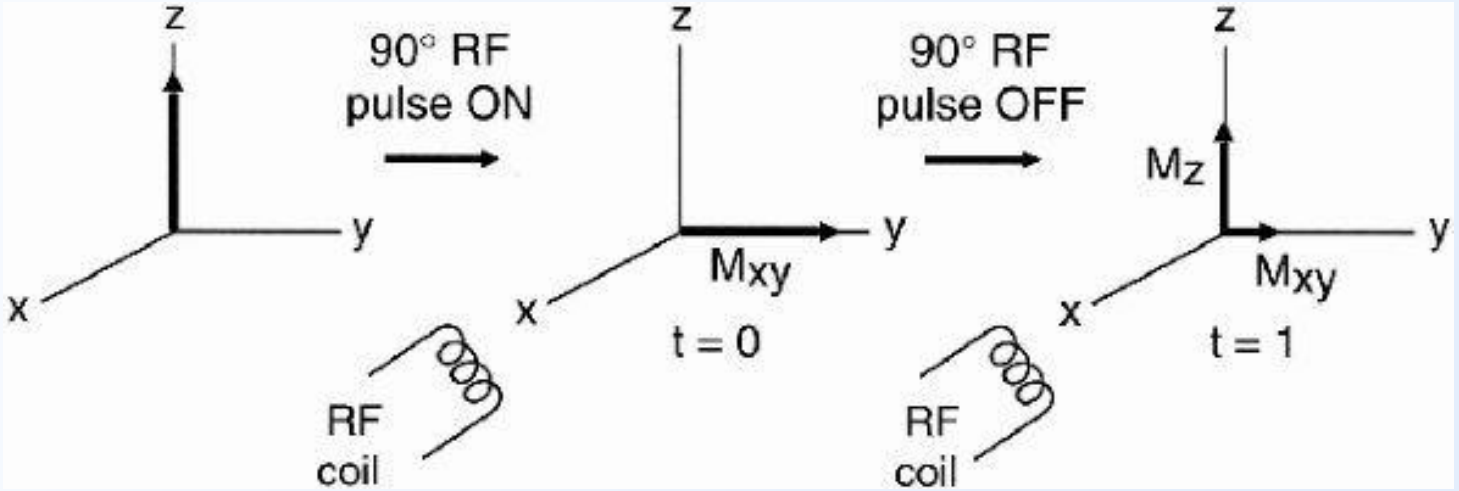


Free induction decay (FID)

- It is called a free induction decay (FID) because, after we turn off the RF pulse:
- Free: The spins begin to precess freely.
- Induction: The spins induce a current in the receiver coil.
- Decay: The signal starts to decay with time.

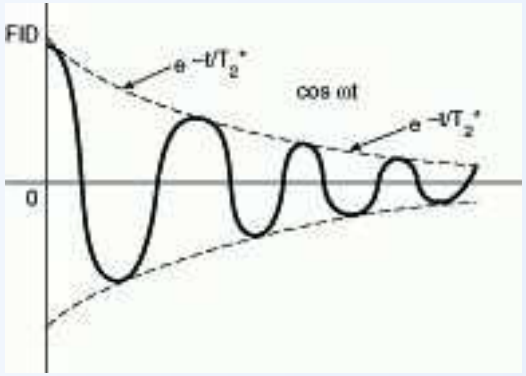
FID

- The received signal can be detected only along the x axis, i.e., along the direction of the RF transmitter/receiver coil.

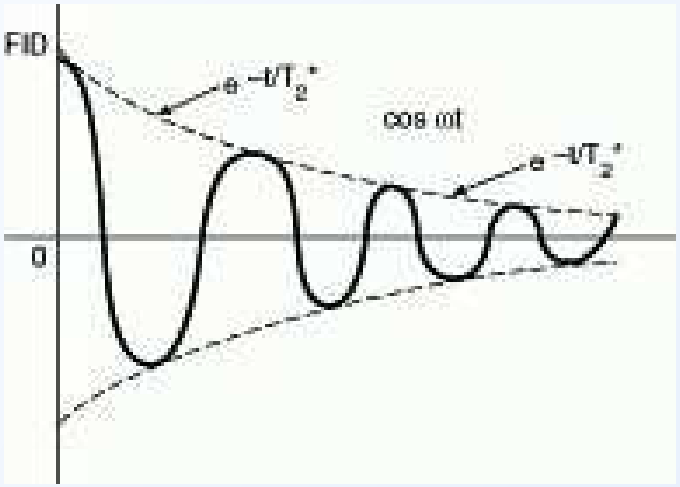


FID

- FID is described mathematically as:
- Mxy (t) = M0 e-t/T2* (cos ω0 t)
- (cos ω0 t): ?
- The formula for an oscillating wave, with a frequency of ω0.
- (e-t/T2*): ?
- Because the signal is decaying, we have to include an exponential function.
- The time constant of this exponential function is given by T2*.



FID



- At time t = 0, the signal is ……
- at a maximum.
- As time goes by, the signal becomes weaker in a sinusoidal manner.
- ?
- because of dephasing

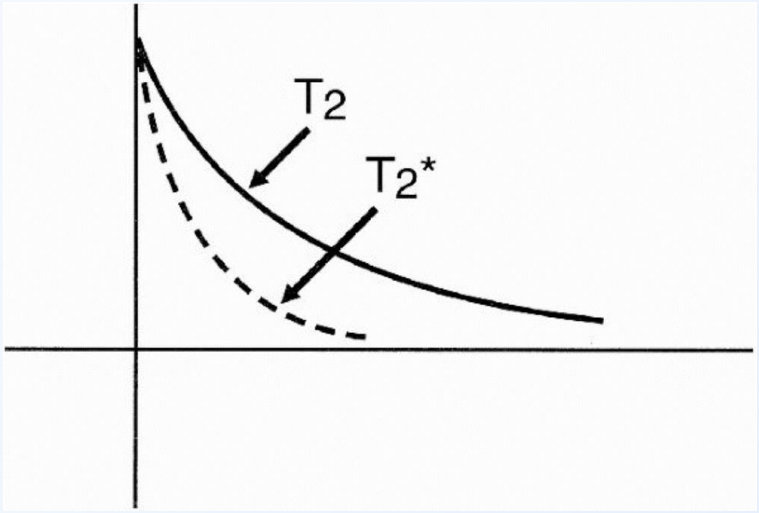
Differences Between T2 and T2*

- T2 decay depends on spin-spin interactions
- T2* decay depends on both:
- Spin-spin interactions
- External magnetic field

Differences Between T2 and T2*

- T2 of a tissue, is fixed.
- ?
- Because it depends only on spin-spin interactions.
- We have no control over T2.
- T2* is not fixed.
- ?
- T2* depends on the homogeneity of the external magnetic field.
- T2* varies depending on how uniform the main magnet is.

T2 and T2* decay curves



- Which one is faster? T2 or T2*

T1, T2 and T2*

- T1: The rate of recovery of the longitudinal magnetization is given by T1.
- T2: The rate of decay of the transverse magnetization is given by T2.
- T2*: The rate of decay of the FID is given by T2*.

T1, T2 and T2*

- Arrange the relaxation times according to how long is each one related time:
- T1 > T2 > T2*
- T1 is 5 to 10 times greater than T2.
- T2* is always less than T2.

Equation

- $\frac{1}{T2*} = \frac{1}{T2} + \gamma\ \Delta B$

- $\frac{1}{T}$: The relaxation rate with unit of 1/sec
- The relaxation rate of $\frac{1}{T2*}$ depends on:
- The relaxation rate of the tissue ($\frac{1}{T2}$)
- The magnetic field inhomogeneity of the external magnet (ΔB)

T2 and T2*

- If we have a perfect magnet that does not introduce any inhomogeneity →
- $\Delta B = 0$ →
- $T2^* = T2$

T2 and T2*

- The newer systems have less magnetic field inhomogeneity, thus making the T2* effects less strong; however, complete homogeneity is not possible. →
- There will always be some T2* effect.

Summary

- FID
- T2*
- Differences between T2 and T2*

Reference

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