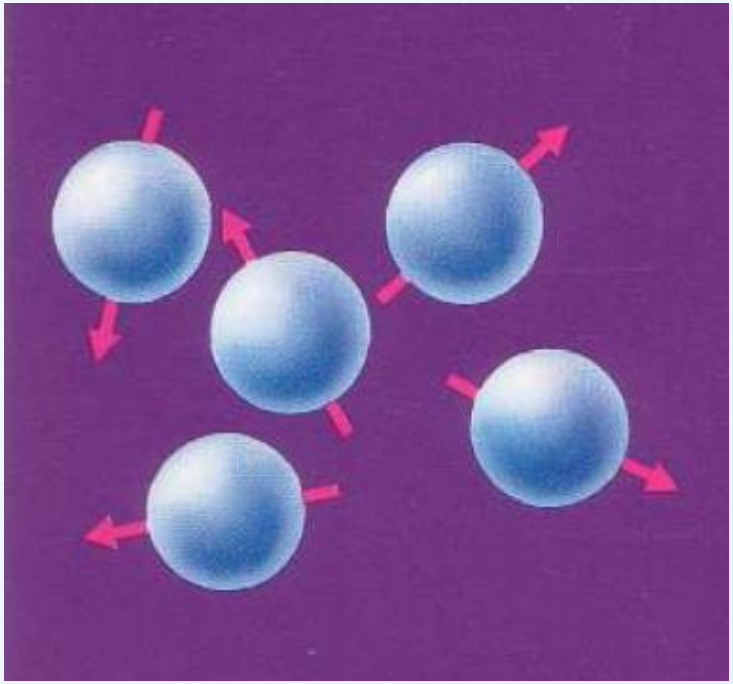
Lesson 2: Role of RF pulse

Aims

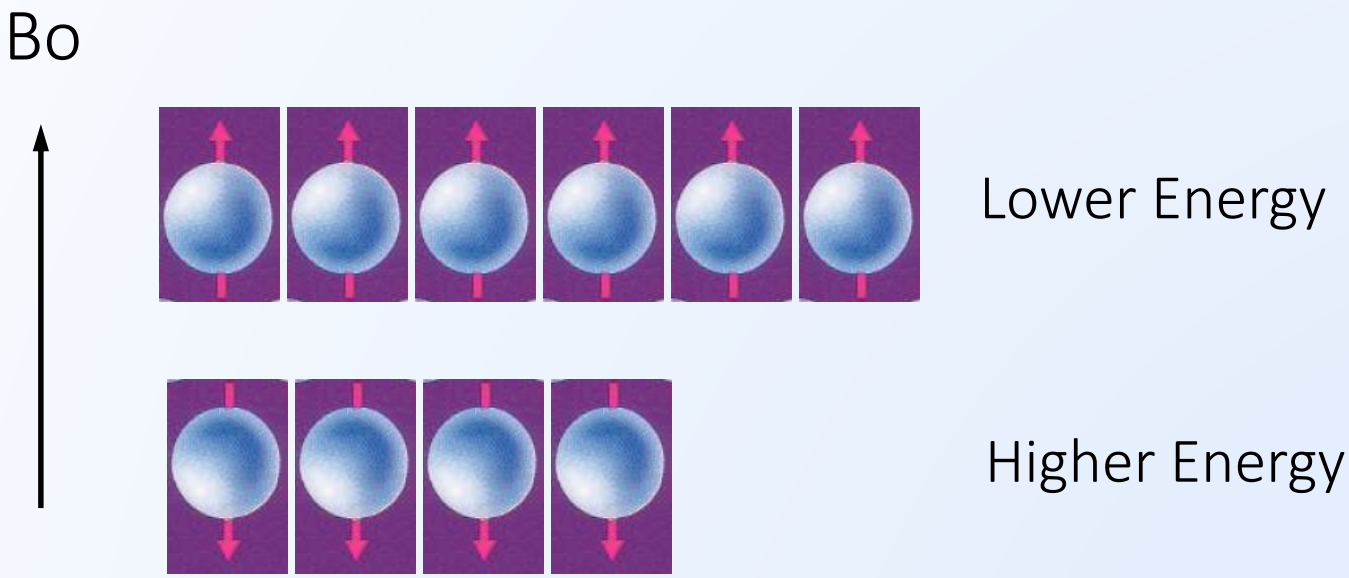
- Learning the following topics:
- Basic quantum mechanics theory of MR
- Role of RF pulse in MRI
- Nutation
- Resonance

Proton spins before magnetic field

- 

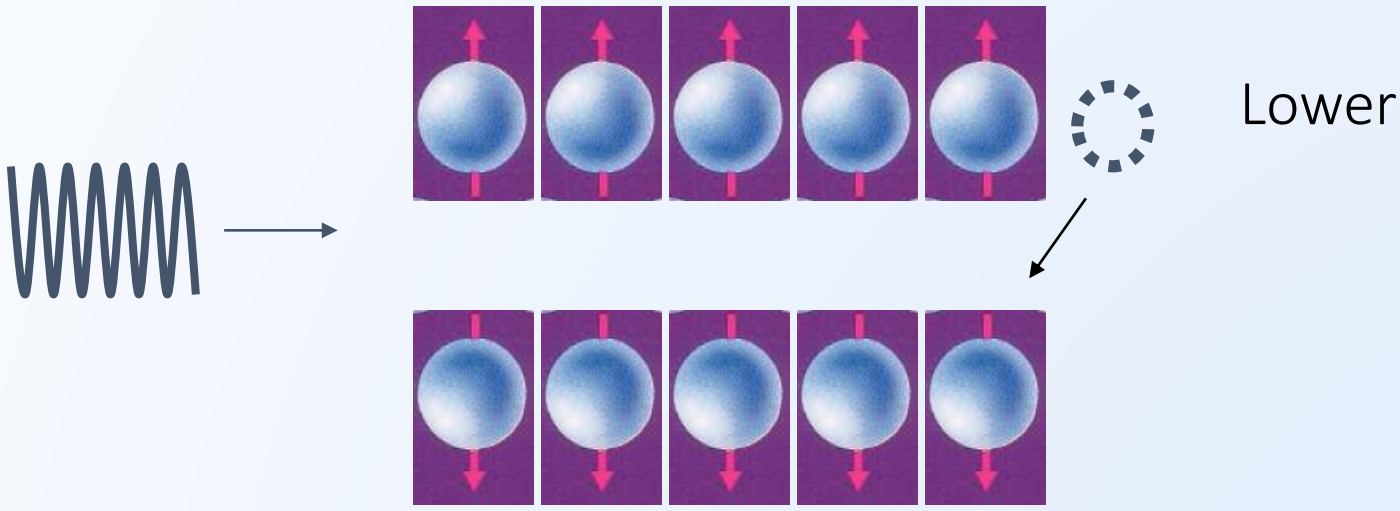
Basic quantum mechanics theory of MR

- Spin system before RF pulse



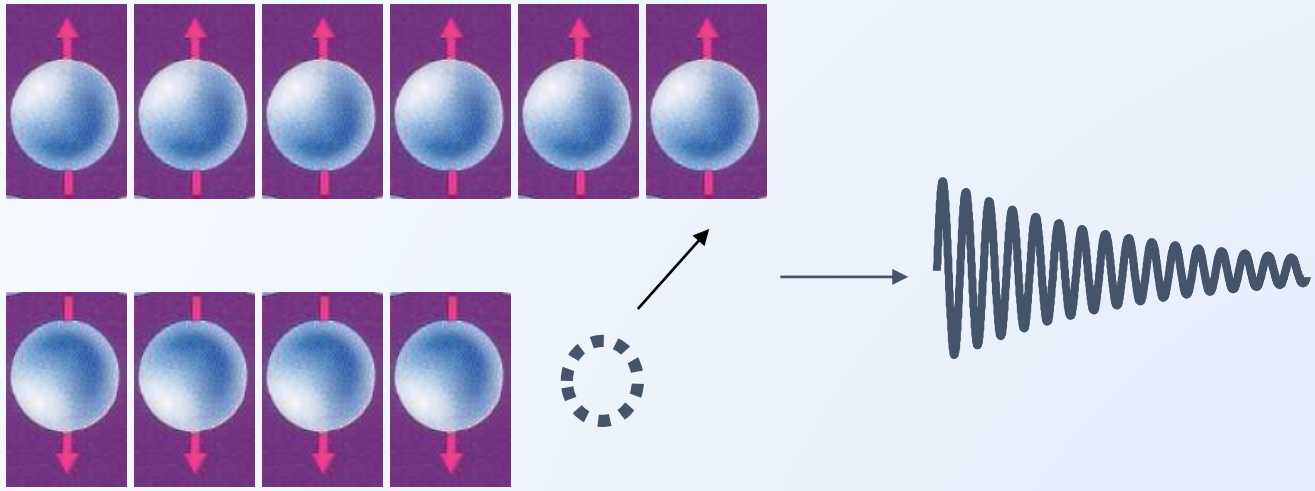
Basic quantum mechanics theory of MR

- Effect of RF pulse on spin system

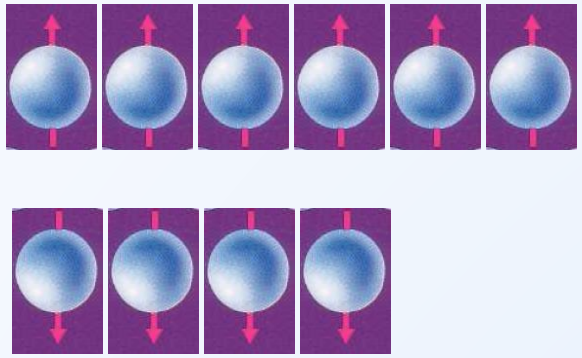


Basic quantum mechanics theory of MR

- Spin system after RF pulse

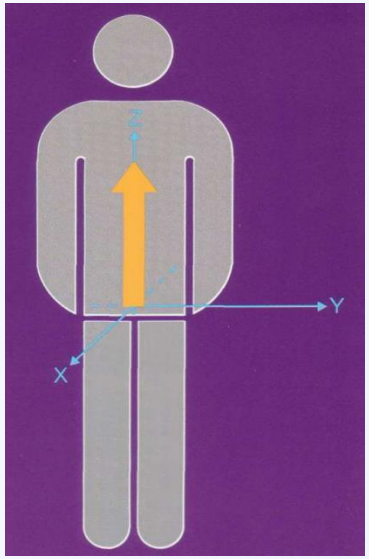


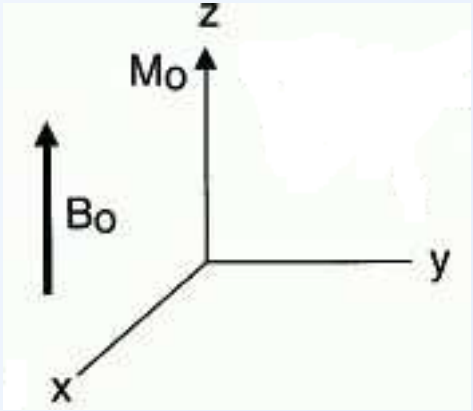
Bo

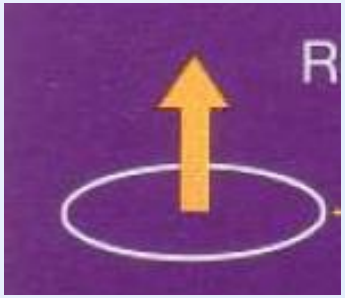


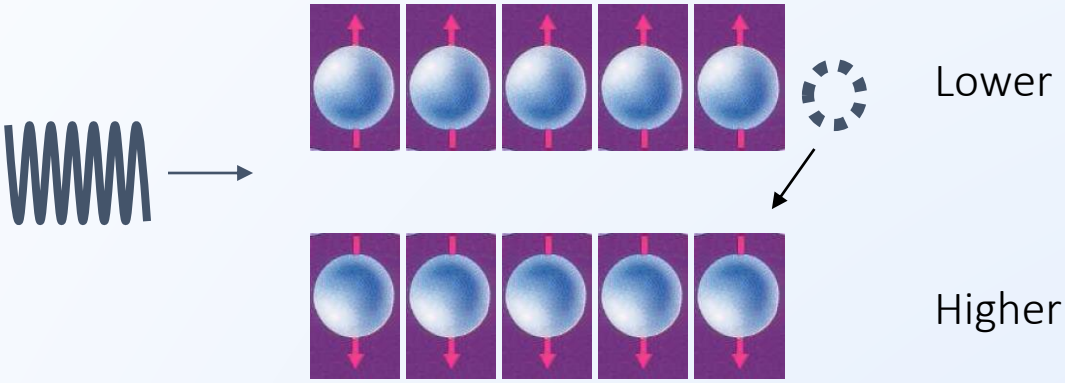
Lower Energy

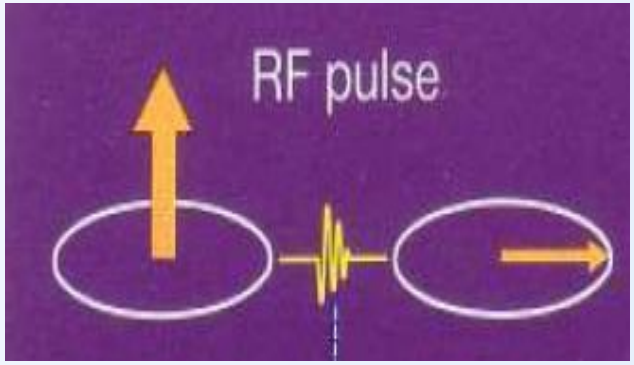
Higher Energy

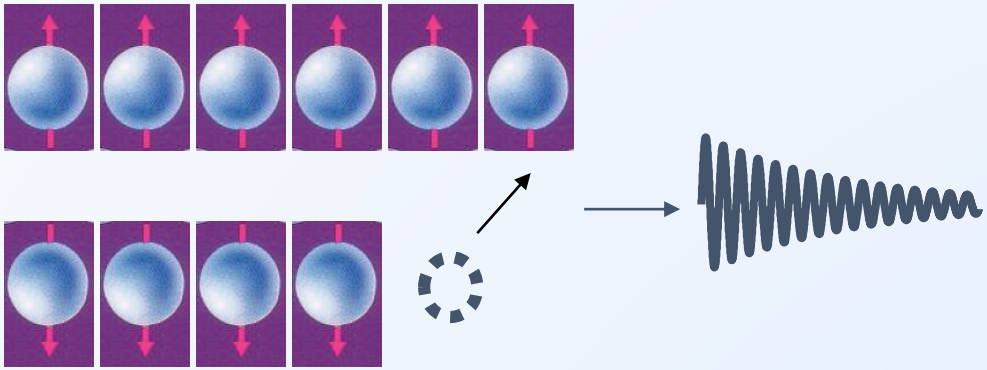


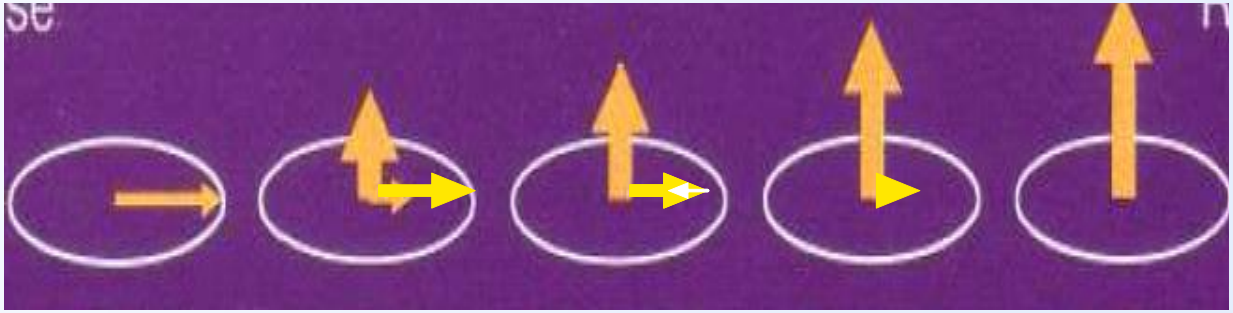




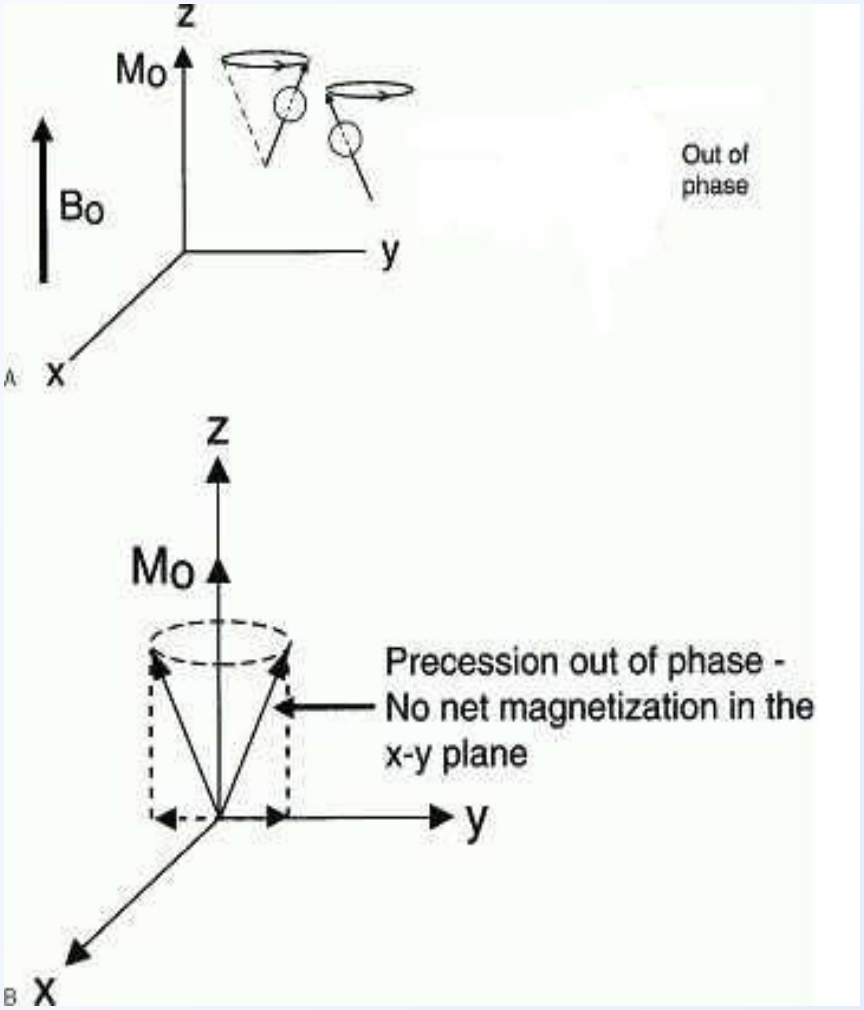

Lower
Higher


RF pulse

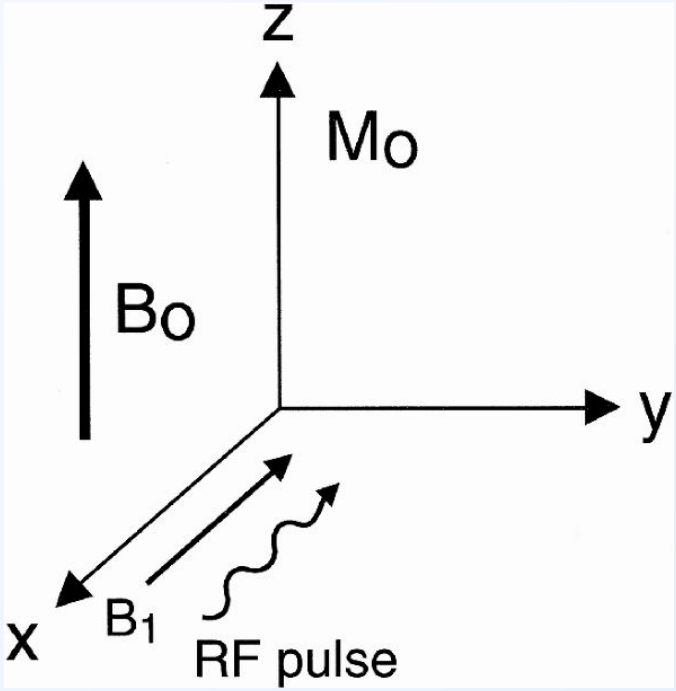




Before the RF pulse

- 

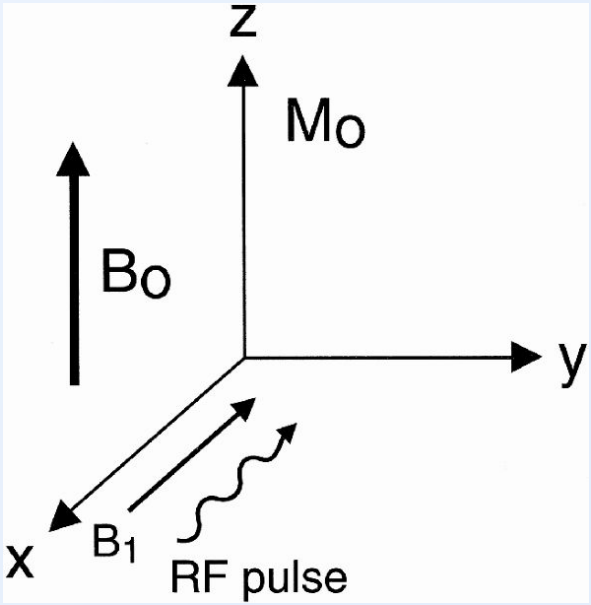
Transition of the RF pulse



Transition of an RF pulse along the x axis perpendicular to the magnetization vector M0, i.e., the axis of B0.

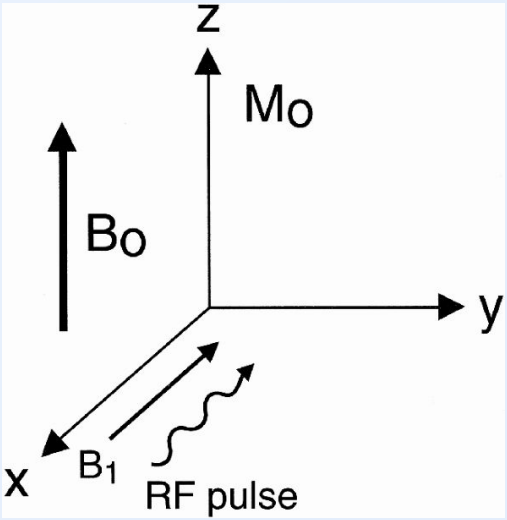
After the RF pulse

- There are 2 magnetic fields:
- B0 and B1
- B0: A very strong external magnetic field (e.g., 1.5 T)
- B1: A very weak magnetic field generated by the RF pulse (e.g., 50 mT).



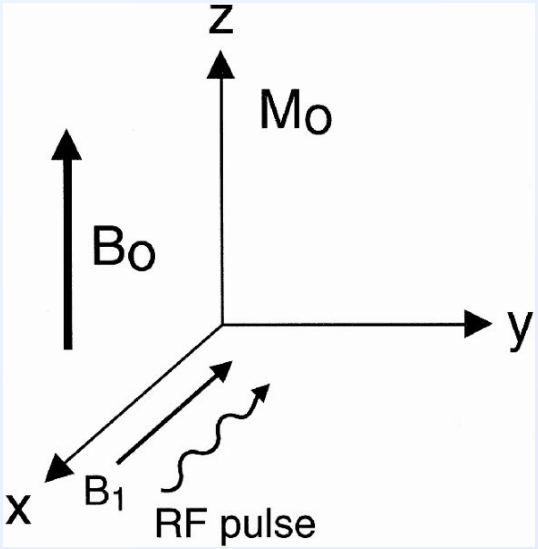
After the RF pulse – B0 and B1

- Is there other difference between B0 and B1?
- B0 is a fixed magnetic field.
- B1 is an oscillating magnetic field.
- B1 oscillates because:
- It is derived from the magnetic component of an oscillating electromagnetic wave.



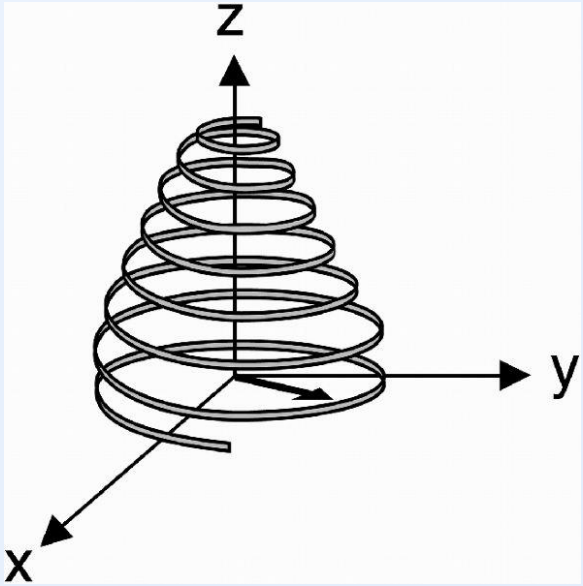
After the RF pulse – ω0 and ω1

- There are 2 magnetic fields →
- There are 2 precessional frequency:
- ω0 and ω1
- ω0 = ?
- ω0 = γ B0
- ω1 = γ B1
- Which one is larger?
- Since B1≪ B0, then ω1≪ ω0.
- →

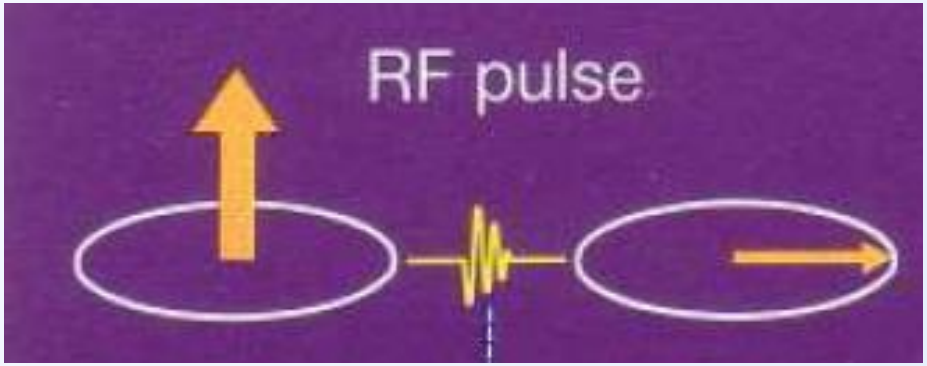


Nutation

- The protons are precessing about the **B0** field (**z** axis) at frequency **ω0** and about the **B1** field (**x** axis) at frequency **ω1** at the **same time**.
- This results in a spiral motion of the net magnetization vector from the **z axis** into the **x-y plane.** This spiral motion is called nutation.



RF pulse role

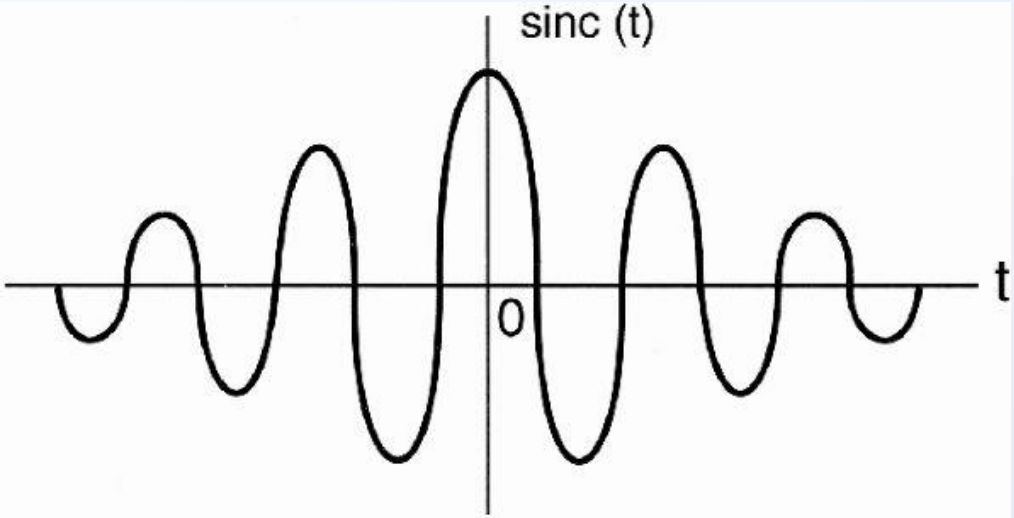
- 

Nutation

- Which RF pulse can produce nutation?

The RF pulse

- The RF pulse has a cos (ωt) wave form.

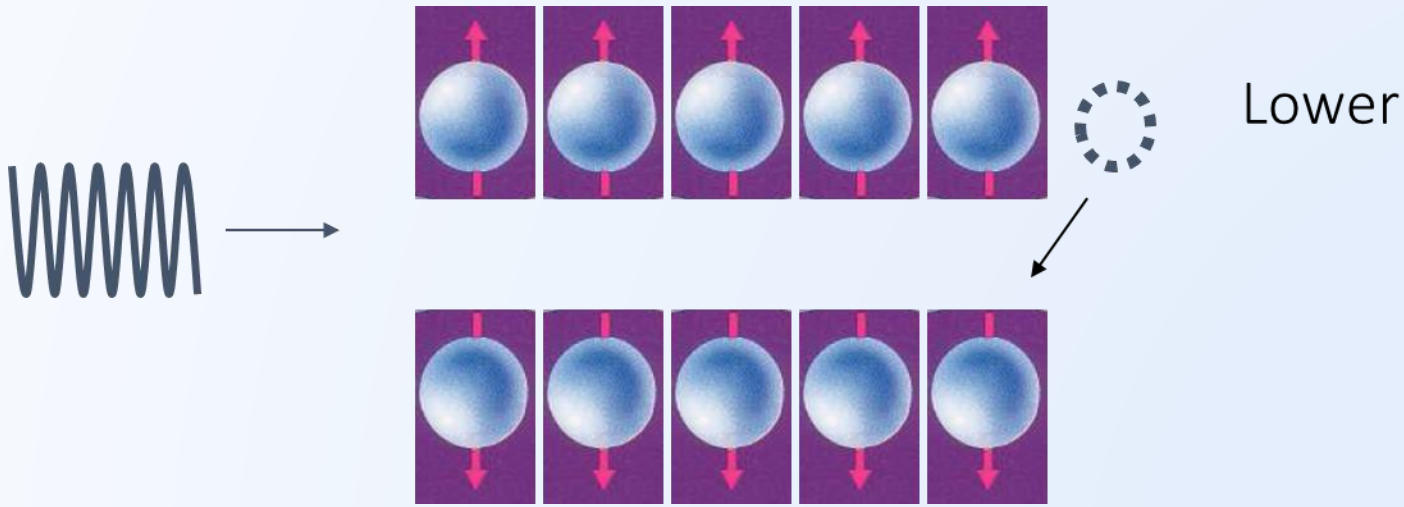


Important point

- The frequency ω of the RF pulse should be identical to the Larmor frequency of the precessing protons.
- Otherwise, the protons will not precess around the B1 axis of the RF pulse.
- This point might be clarified if we first discuss the concept of resonance.

Resonance

- If the frequency ω of the RF pulse matches the frequency of precession of the protons, then resonance occurs.
- Resonance results in the RF pulse adding energy to the protons.



Resonance

- If the RF frequency does not match the precessional frequency of the spins →
- The system won't resonate →
- No energy will be added →
- The protons won't “flip” into the x-y plane →
- No MR signal

Summary

- Basic quantum mechanics theory of MR
- Role of RF pulse in MRI
- Nutation
- Resonance

References

- Hashemi, R. H. and Brandy, W. G. “MRI the Basics”, Second Edition