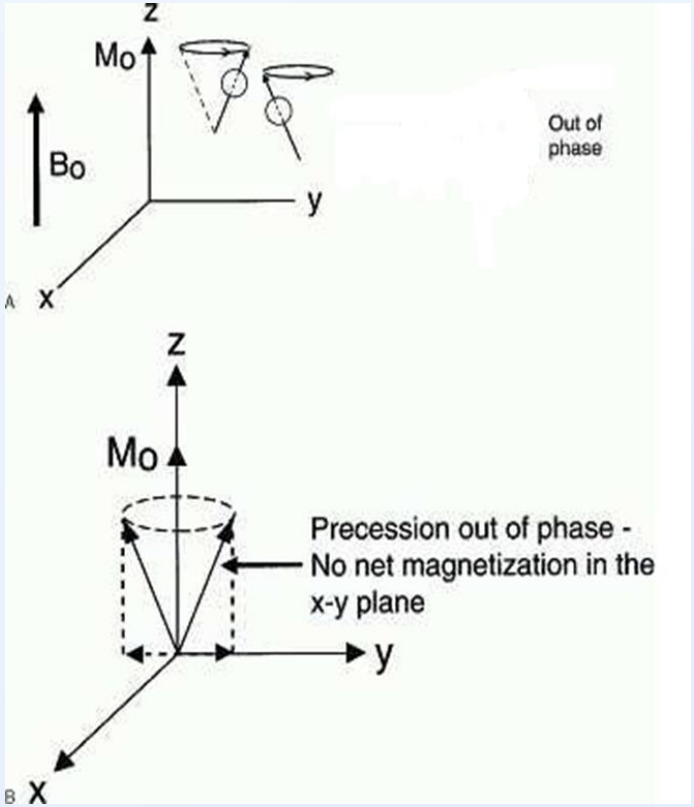
Lesson 3 (A): Flip angle

Aims

- To explain the following topics about flip angle:
- Definition
- Formula
- Different flip angles
- M0 and Mxy at different flip angles

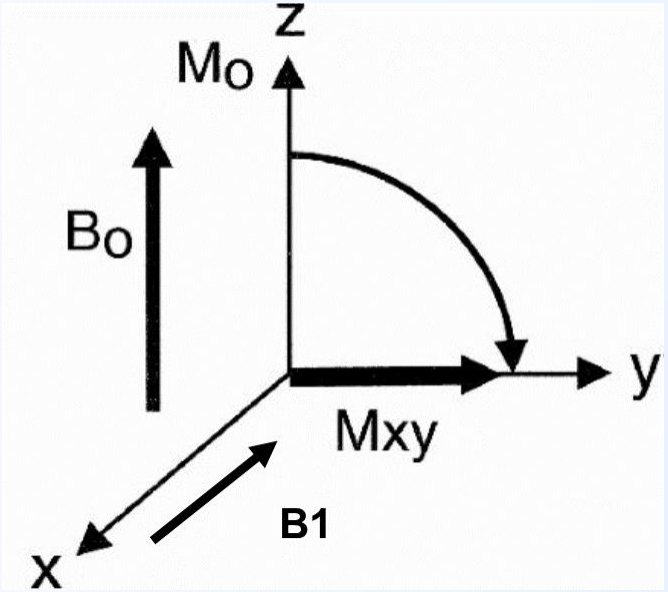
Before the RF pulse

- The protons precess about the z axis.
- They are out of phase
- There is only M0.
- No net transverse component (Mxy).



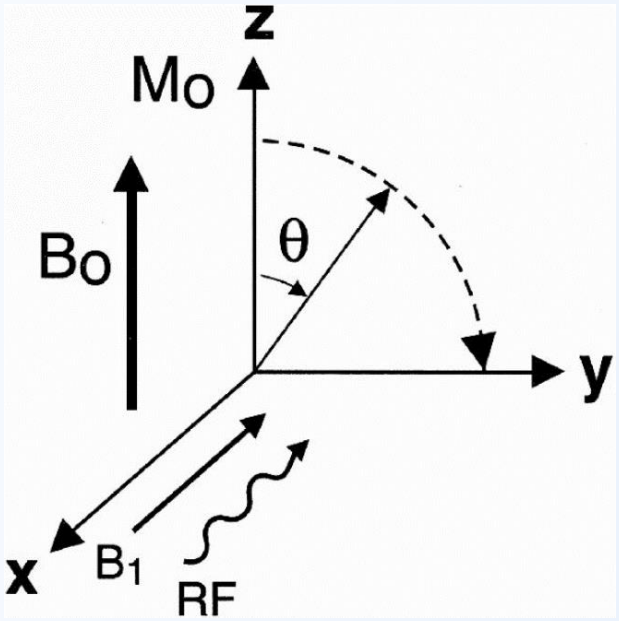
After the RF pulse

- The protons are introduced to a new magnetic field B1. →
- They will be in phase.
- This effect creates transverse magnetization (Mxy).



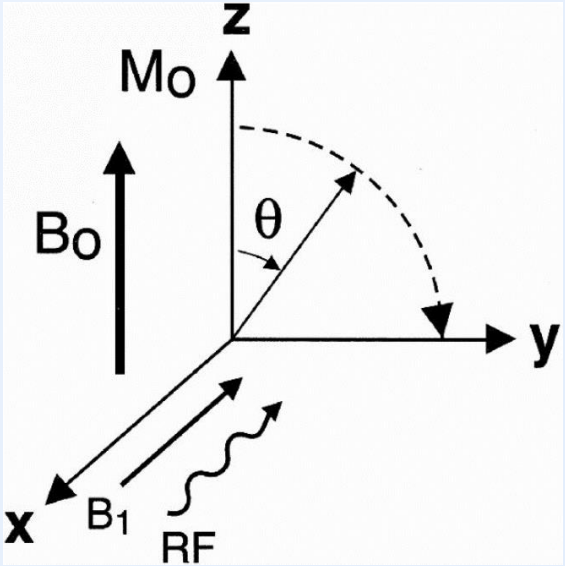
Flip angle

- A certain amount of time after the application of the RF pulse, the magnetization vector is partially "flipped" toward the x-y plane, forming an angle θ with the z axis.



Flip angle

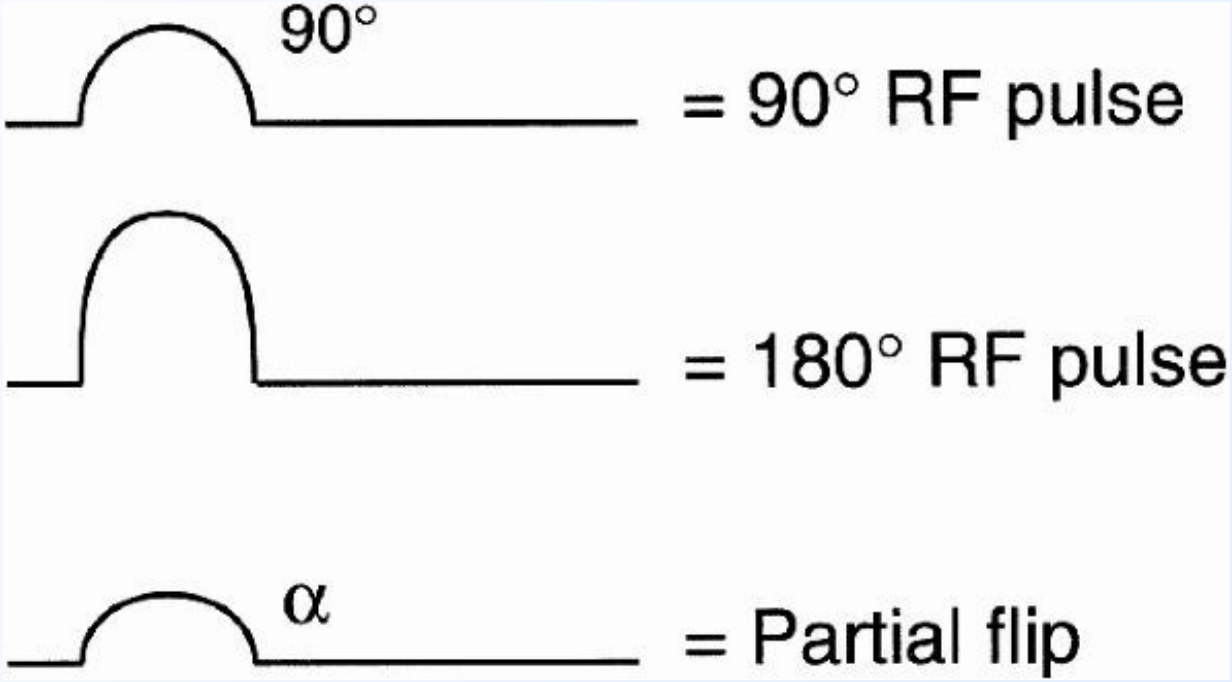
- The flip angle (θ, α, FA) is proportional to:
- $\theta = \gamma B1 \tau$
- γ = the gyromagnetic ratio
- B1 = the strength of the RF magnetic field, i.e., the strength of the RF pulse
- τ = the duration of the RF pulse
- $\theta = \gamma B1 \tau$ →
- $\theta = \omega 1 \tau$



Flip angle

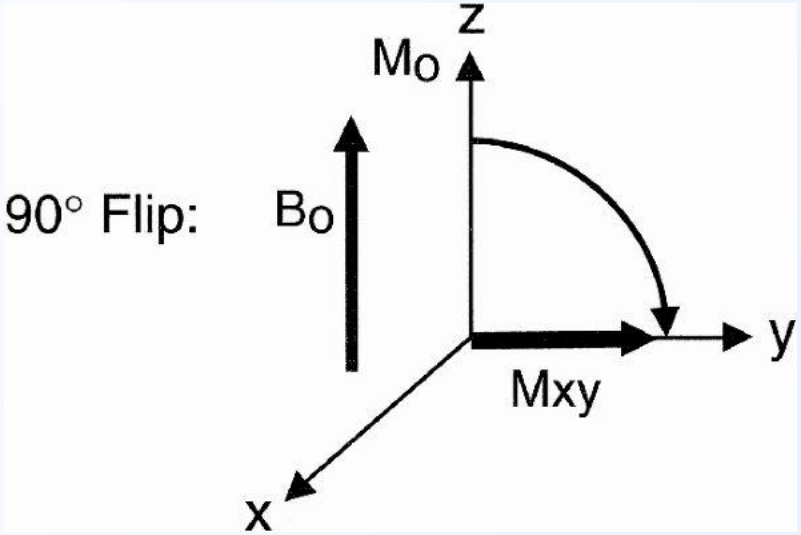
- According to the $\theta = \gamma B1 \tau$, The flip angle is a function of:
- the RF strength (B1) and its duration (τ)

Different flip angles



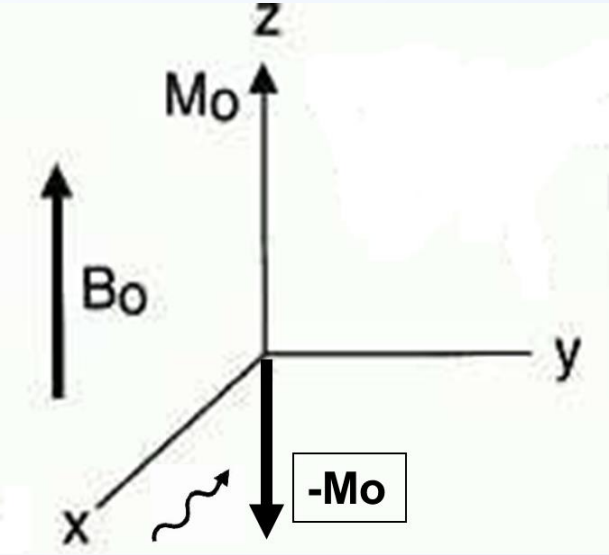
90° RF pulse

- With a 90° RF pulse, the entire vector M0 flips into the x-y plane →
- Mxy = M0



180° RF Pulse

- After a 180° RF pulse, the M0 is inverted, and the spins begin to recover from -M0.
- Mxy=0

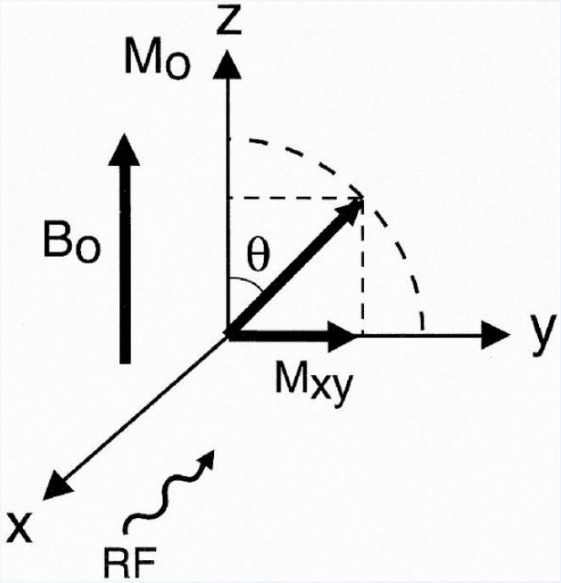


180° RF pulse

- $\theta = \gamma B1 \tau$
- To obtain a 180° RF pulse we can use:
- an RF pulse having the same strength as the 90° pulse but twice as long in duration
- or
- an RF pulse that's twice as strong for the same duration.
- A 180° pulse has twice the power (or twice the duration) of a 90° pulse.

Partial Flip (less than 90°)

- Mxy=?
- The transverse magnetization (Mxy) is smaller than the original longitudinal magnetization (M0) →
- $Mxy = M0 \cdot \sin \theta$



Summary

- Definition of flip angle
- Formula ($\theta = \gamma B1 \tau$)
- Different flip angles (90, 180 and partial flip)
- M0 and Mxy at different flip angles

Reference

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