90° Pulse - the foundation of an FID

Torque $\tau = \mu_m \times \vec{H}_{xy} = \mu_m \cdot H_{xy} \cdot \sin \theta$
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Torque \( \tau = \mu_m \times \vec{H}_{xy} = \mu_m \cdot H_{xy} \cdot \sin \theta \)

- If we apply \( H_{xy} \) for just the right amount of time (only), we can rotate \( \mu_m \) exactly 90°, placing it in the xy-plane.
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- If we apply $H_{xy}$ for just the right amount of time (only), we can rotate $\mu_m$ exactly 90°, placing it in the xy-plane.

- The bulk magnetization, $\mu_m$ will then precess around $H_z$. If we place a detector in the xy-plane, we will see a magnetic moment that oscillates in a sinusoidal fashion at exactly $\omega_0$.

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$\cos(\omega_0 t)$

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Fourier Transform

Torque = \( \tau = \vec{\mu}_m \times \vec{H}_{xy} = \mu_m \cdot H_{xy} \cdot \sin \theta \)
90° Pulse - the foundation of an FID

\[
\cos(\omega_0 t)
\]

Fourier Transform

\[
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Torque \( \tau = \mu_m \times H_{xy} = \mu_m \cdot H_{xy} \cdot \sin \theta \)
Bulk Magnetization
Bulk Magnetization
Bulk Magnetization

T1 relaxation
Bulk Magnetization
T1 relaxation
Bulk Magnetization

T1 relaxation
Bulk Magnetization
Bulk Magnetization

![Diagram of bulk magnetization with axes labeled x, y, and z, and a detector marked on the x-axis.]
Bulk Magnetization

Detector
Bulk Magnetization
Bulk Magnetization

(Lab Frame) (Rotating Frame)
Bulk Magnetization

(Lab Frame)  (Rotating Frame)
Bulk Magnetization

(Lab Frame)  (Rotating Frame)
Bulk Magnetization

(Lab Frame)

(Rotating Frame)
Collecting a spectrum

1D spectrum  90(ϕ) - observe
Collecting a spectrum

1D spectrum  $90(\phi)$ - observe
(Rotating Frame)
Collecting a spectrum

1D spectrum $90(\phi)$ - observe

(Rotating Frame)
Collecting a spectrum

1D spectrum  $90(\phi)$ - observe

(Rotating Frame)
Collecting a spectrum

1D spectrum  $90(\phi)$ - observe

(Rotating Frame)
Bulk Magnetization

(rotating frame)

90 - $\tau$ - 180 - observe "spin echo"
Bulk Magnetization

(rotating frame)

90 - \( \tau \) - 180 - observe "spin echo"
Bulk Magnetization

(rotating frame)

90 - $\tau$ - 180 - observe “spin echo”
Bulk Magnetization

(rotating frame)

90 - τ - 180 - observe “spin echo”
Bulk Magnetization

(rotating frame)

90 - \(\tau\) - 180 - observe "spin echo"
Bulk Magnetization

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90 - \(\tau\) - 180 - observe “spin echo”
Bulk Magnetization

(rotating frame)

90 - τ - 180 - observe “spin echo”
Bulk Magnetization

(rotating frame)

90 - $\tau$ - 180 - observe "spin echo"
Bulk Magnetization

(rotating frame)

90 - τ - 180 - observe "spin echo"
Bulk Magnetization

(rotating frame)

90 - τ - 180 - observe "spin echo"
Bulk Magnetization

(rotating frame)

90 - $\tau$ - 180 - observe "spin echo"

180° pulse

xy
Bulk Magnetization

(rotating frame)

90 - \(\tau\) - 180 - observe "spin echo"
Bulk Magnetization

(rotating frame)

90 - $\tau$ - 180 - observe "spin echo"
Pulse Sequences

90 - $\tau$ - 180 - observe  “spin echo”

- The above is the simplest “two dimensional” NMR pulse sequence
- The time $\tau$ is the first “dimension”
- The observe time is the second “dimension”