PHYS 360A/B
Experiment 20: Nuclear Magnetic Resonance

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October 16, 2023

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Abstract

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Hello World!

2 Theoretical Background

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3.1 Finding Resonance

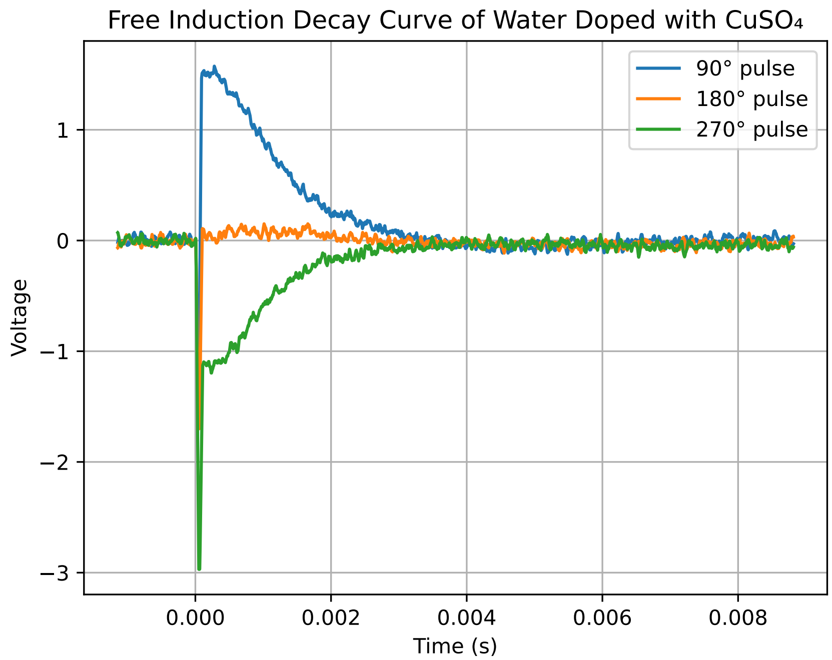
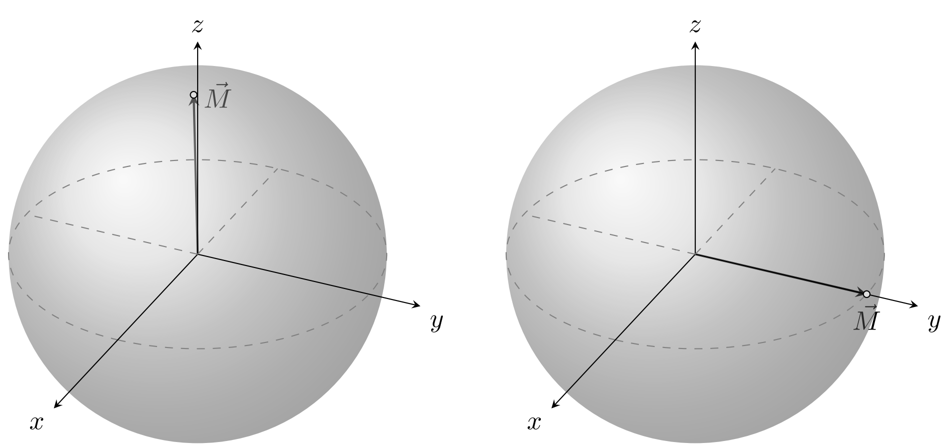


Figure 1: Free Induction Decay NMR signals for 90°, 180°, and 270° pulses

3.1.1 Voltage at t = 0s

90° Pulse

- A 90° pulse is a pulse that is applied long enough to tip the magnetization vector by 90° from its initial direction (at a small angle with the positive z-axis) in the rotating frame:



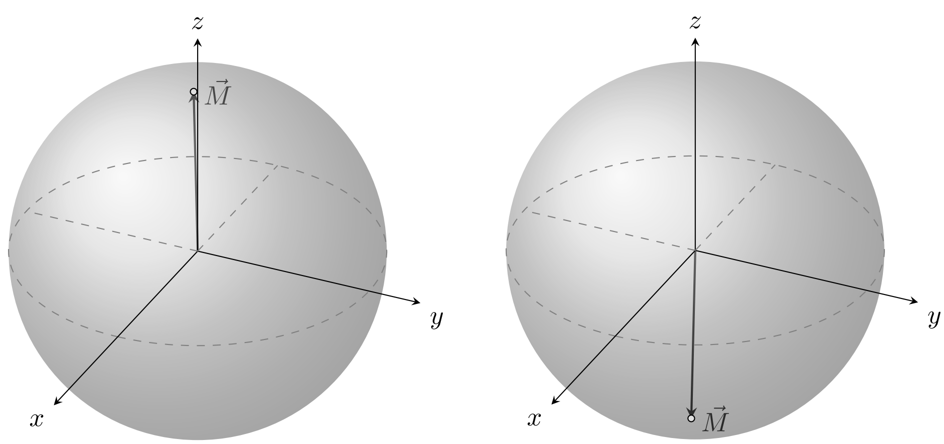
- Now, nearly half the spins are in the "up" state and the other half are in the "down" state.
- Since $\vec{M}$ is in the x-y plane, the z component of the magnetization vector vanishes:

$$M_z = 0$$

- This is a higher energy state than the equilibrium state with the magnetization vector, $\vec{M}$, pointing along the positive z-axis.
- The receiver gain was adjusted so that the precessing $\vec{M}$ induced[1] a current in the coil as shown in the 90° trace of Figure 1.

180° Pulse

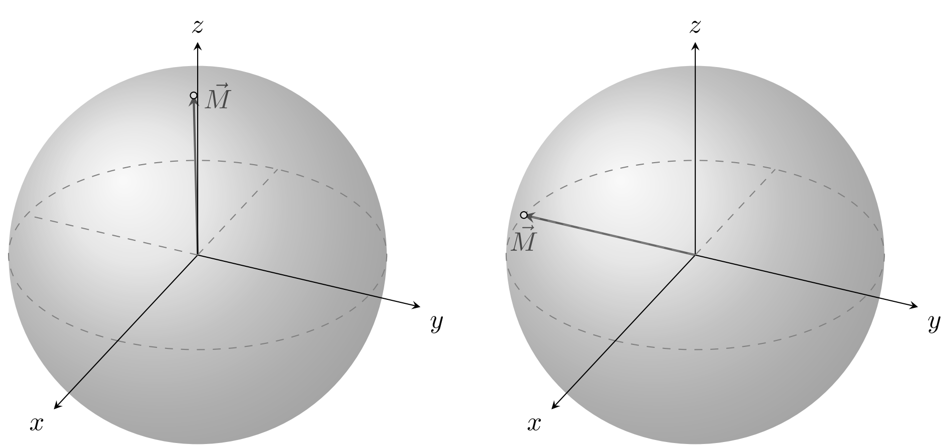
- If we apply the pulse for twice as long (increase the pulse width to twice that of the 90° pulse), we rotate the magnetization vector by 180° :



- Most of the spin are now in the "down" state.
- However, this magnetization vector doesn't induce current in the coils since the component in the x-y plane is nearly 0.

270° Pulse

- This time, the pulse is applied long enough to rotate $\vec{M}$ by an additional 180° from the 90° case:



- That is, $\vec{M}$ returns to the x-y plane but is anti-parallel to $\vec{M}$ in the 90° pulse case:

$$\vec{M}_{180^\circ} = -\vec{M}_{90^\circ}$$

- It hence precesses in the opposite sense of rotation as the 90° case[2].

[1] According to Faraday's law.
[2] And vice versa.

- According to Faraday's law, the direction of the current $\vec{M}_{180^\circ}$ induces in the coil is opposite to that of $\vec{M}_{90^\circ}$.

- This is why we see a current that is -I_{90° induced in the 270° case in Figure 1.

3.1.2 Free Induction Decay

- For all three pulses, we see that the signal vanishes over time.

- Recall that for the 90° and 270° pulses, the magnetization vector is in the x-y plane.

- Because of small variations in the magnetic field that the magnetic moments, $\vec{\mu}$, for each particle experience, the magnetic moments being to randomly dephase.

- They spread out in the x-y plane causing the magnetization vector and hence the induced current to vanish as a whole.

4 Analysis

5 Conclusion