

PHYS 360A/B
Experiment 20: Nuclear Magnetic Resonance

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Abstract

1 Introduction

Hello World!

2 Theoretical Background

3 Experimental Design and Procedure

3.1 Finding Resonance

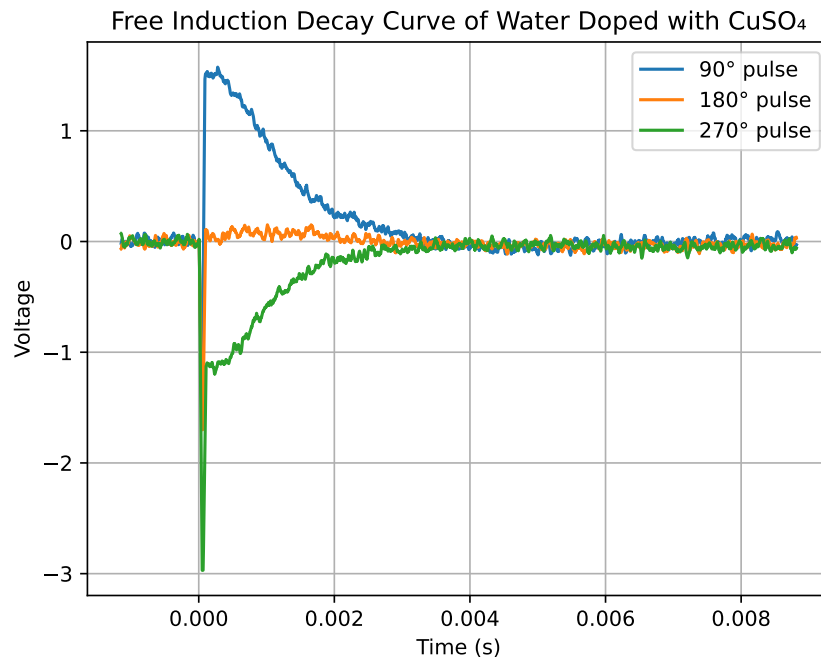
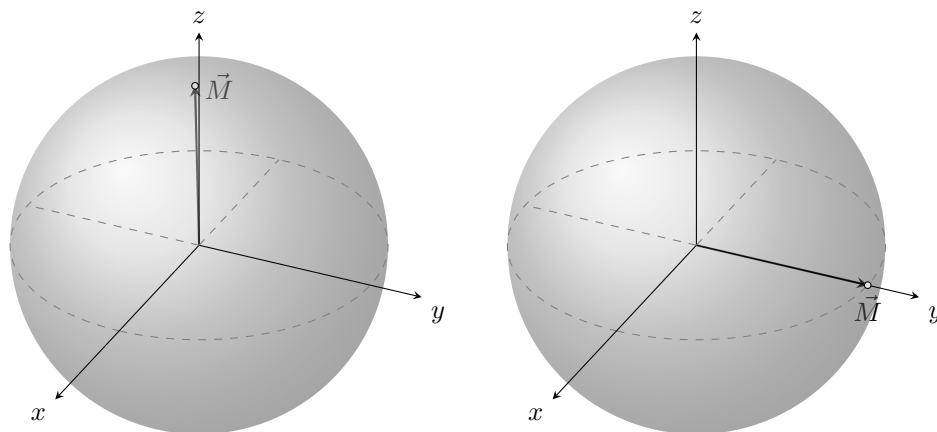


Figure 1: Free Induction Decay NMR signals for 90°, 180°, and 270° pulses

3.1.1 Voltage at $t = 0$ s

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:



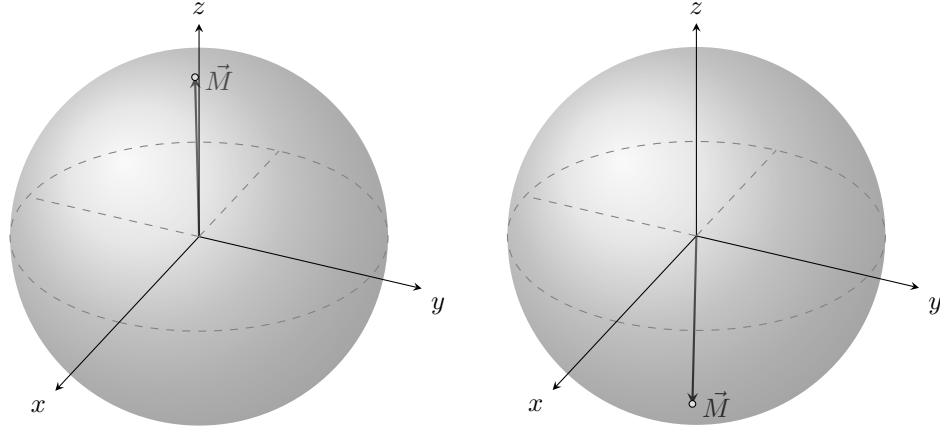
- Now, nearly half the spins are in the “up” state and the other half are in the “down” state.
- Since \vec{M} is in the x-y plane, the z component of the magnetization vector vanishes:

$$M_z = 0$$

- 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} induced¹ a current in the coil as shown in the 90° trace of Figure 1.

180° Pulse

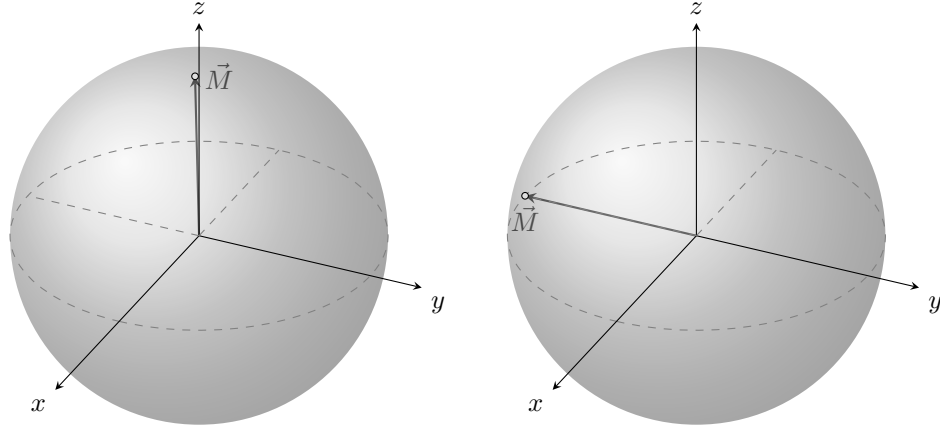
- If we apply the pulse for twice as long (increase the pulse width to twice that of the 90° pulse), we rotate the magnetization vector by 180° :



- 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° case².

¹According to Faraday’s law.

²And vice versa.

- According to Faraday's law, the direction of the current \vec{M}_{180° induces in the coil is opposite to that of \vec{M}_{90° .
- This is why we see a current that is $-I_{90^\circ}$ 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 begin 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