

# Measurement of Hydrogen $T_1$ and $T_2$ Relaxation Times in Copper Sulfate Solutions Using PNMR

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# Outline

Background  
Methods  
Results  
Conclusion

Theory  
Goal and Motivation  
PNMR Techniques

## ① Background

Theory  
Goal and Motivation  
PNMR Techniques

## ② Methods

180° | 90°

## ③ Results

## ④ Conclusion

Conclusion  
Continuing Study

## What is PNMR?

PNMR, or Pulsed Nuclear Magnetic Resonance, falls under the umbrella of MRI techniques that many of us are familiar with.

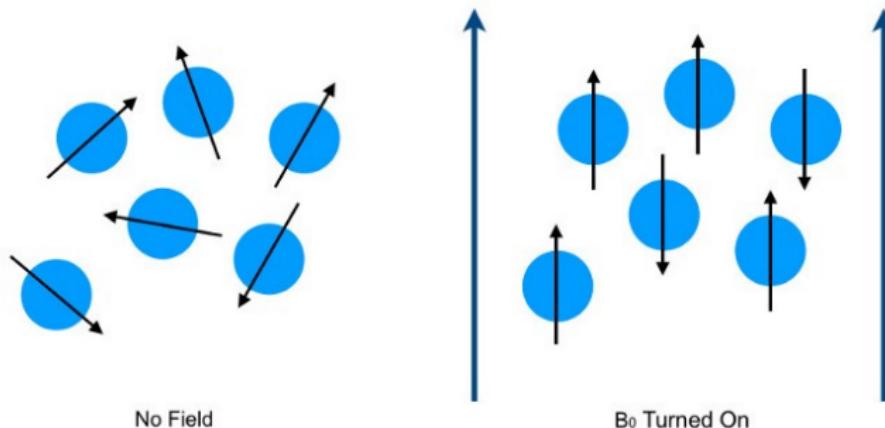


Figure: Initial Polarization [3]

## Relaxation Path

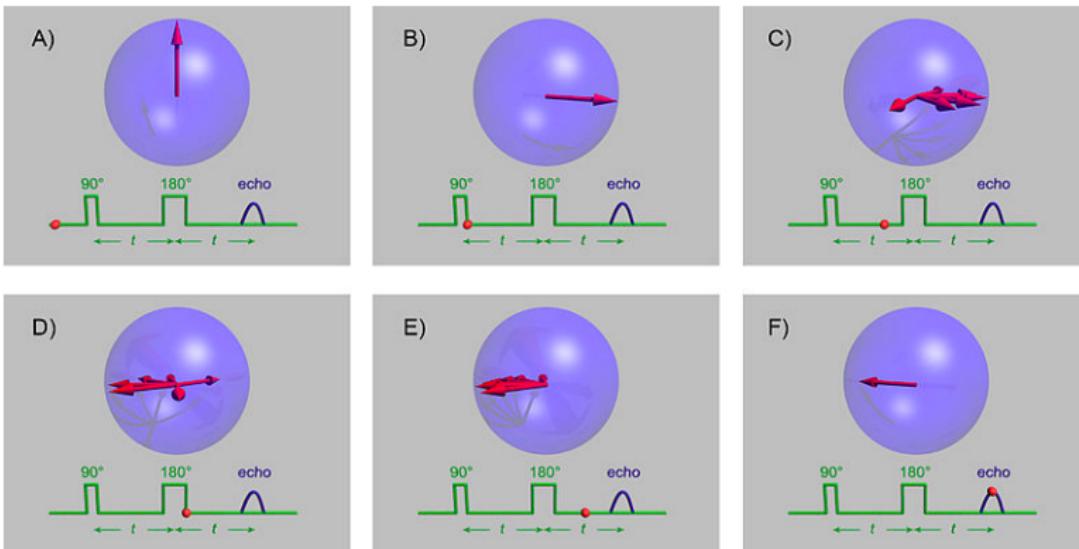
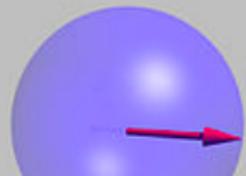


Figure: General Relaxation Path [1]

## 90° Pulses

B)



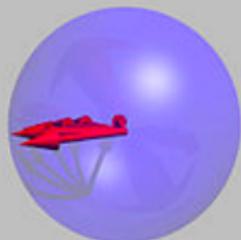
C)



Figure: Result of the 90° Pulse [1]

## 180° Pulses

E)



F)

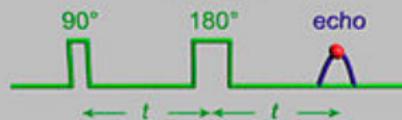
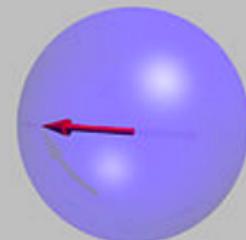


Figure: Result of the 180° Pulse [1]

# Goal and Motivation

- t

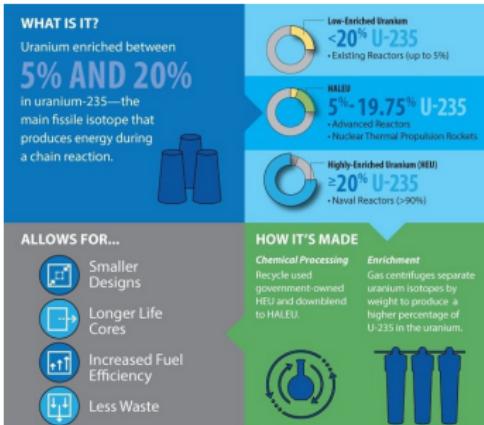


Figure: DOE HALEU Overview

# Conventional MRI

I

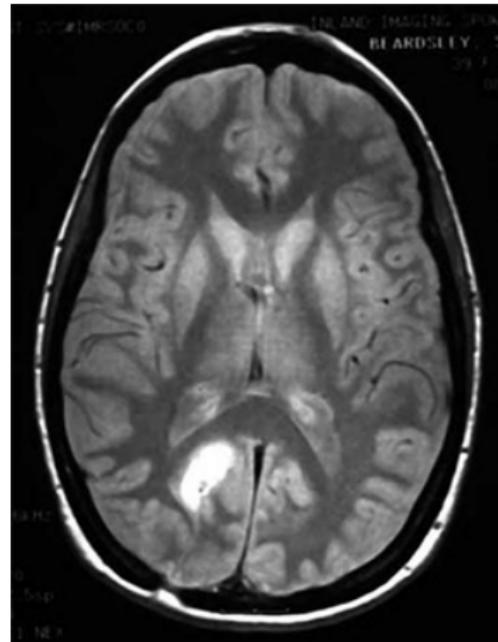


Figure: MRI Scan of a Brain [4]

# Conventional MRI

I

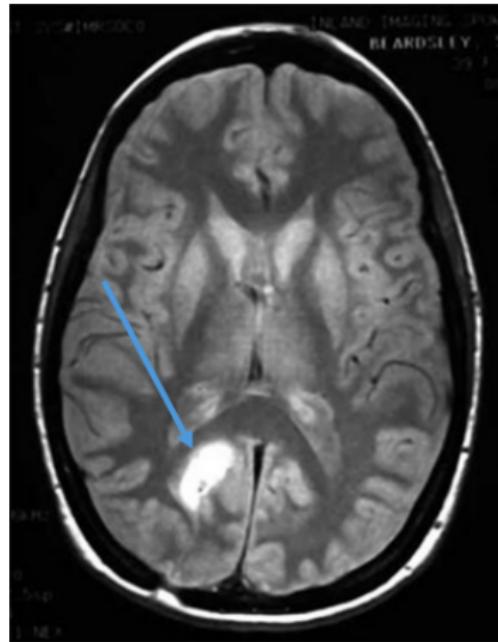


Figure: MRI Scan of a Brain [4]



## Metabolite Identification

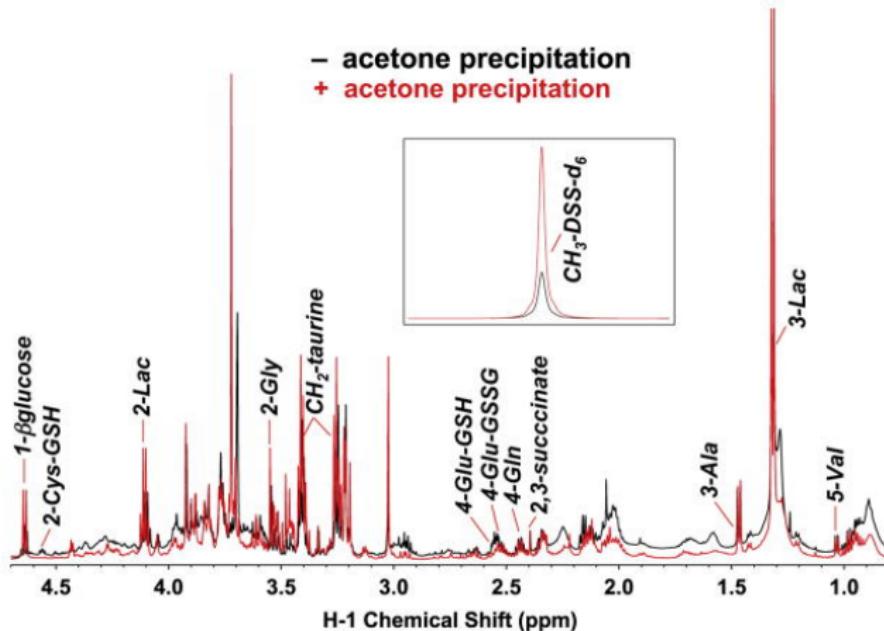


Figure: [2]

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## 180°|90° Pulses

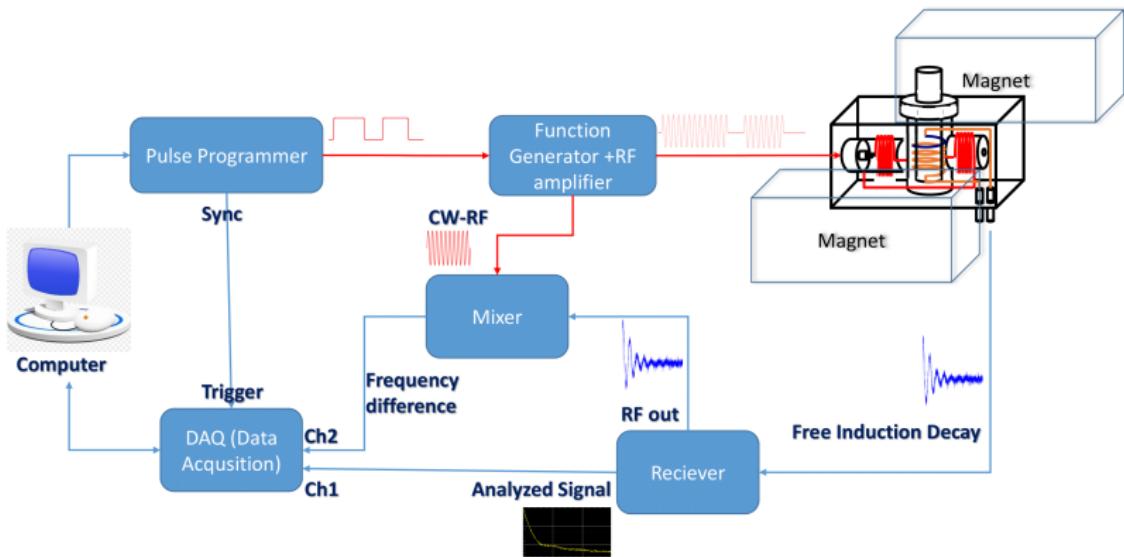


Figure:

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## Sample Relaxation Times

Sample	Conc. [mg/ml]	$T_1$ [ms]	$T_2$ [ms]
A	$34.0 \pm 6.0 \times 10^{-2}$	$3.9 \pm 3.9 \times 10^{-2}$	$4.2 \pm 1.3 \times 10^{-1}$
B	$65 \pm 1.1 \times 10^{-1}$	$2.3 \pm 1.7 \times 10^{-2}$	$2.4 \pm 1.2 \times 10^{-1}$
C	$85.3 \pm 1.2 \times 10^{-1}$	$1.7 \pm 1.2 \times 10^{-2}$	$1.7 \pm 8.5 \times 10^{-2}$
D	$3.37 \pm 1.6 \times 10^{-2}$	$13 \pm 2.5 \times 10^{-1}$	—
E	$30.5 \pm 9.2 \times 10^{-2}$	$4.7 \pm 2.1 \times 10^{-2}$	$4.6 \pm 4.9 \times 10^{-2}$
F	$92 \pm 1.2 \times 10^{-1}$	$1.45 \pm 1.6 \times 10^{-2}$	$1.6 \pm 6.6 \times 10^{-2}$
G	$12.24 \pm 2.1 \times 10^{-2}$	$8.8 \pm 8.2 \times 10^{-2}$	$11 \pm 2 \times 10^{-1}$
H	$53.31 \pm 8.1 \times 10^{-2}$	$2.02 \pm 3 \times 10^{-2}$	$2.2 \pm 1.1 \times 10^{-1}$
I	$84 \pm 1.1 \times 10^{-1}$	$1.6 \pm 3 \times 10^{-2}$	$1.7 \pm 4.4 \times 10^{-2}$
J	$27.5 \pm 5.4 \times 10^{-2}$	$4.9 \pm 2.2 \times 10^{-2}$	$4.6 \pm 6.0 \times 10^{-2}$
K	$28 \pm 1.8 \times 10^{-2}$	$3.7 \pm 2.6 \times 10^{-2}$	$3.9 \pm 9.3 \times 10^{-2}$

Table:  $CuSO_4$  Samples

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## Further Analysis of Sample K

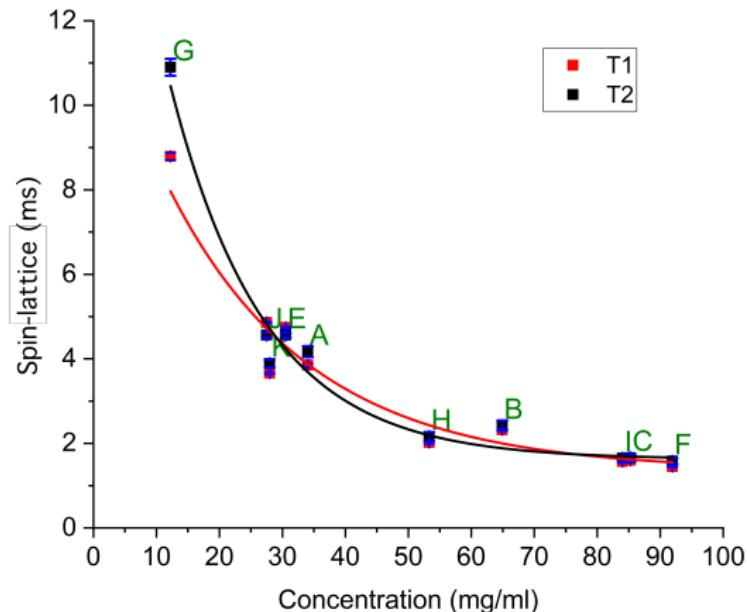


Figure: Relaxation Time vs. Concentration

## Further Analysis of Sample K

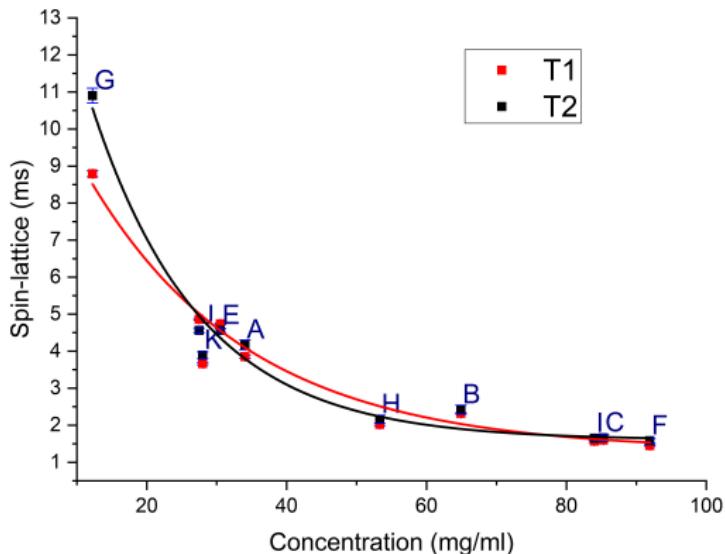


Figure: Relaxation Time vs. Concentration

## Further Analysis of Sample K

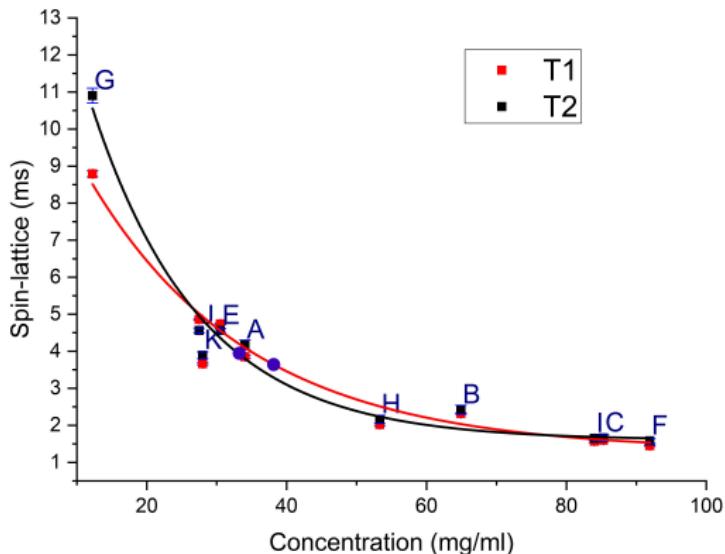


Figure: Relaxation Time vs. Concentration

## References |



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## Acknowledgement



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## Relaxation Path

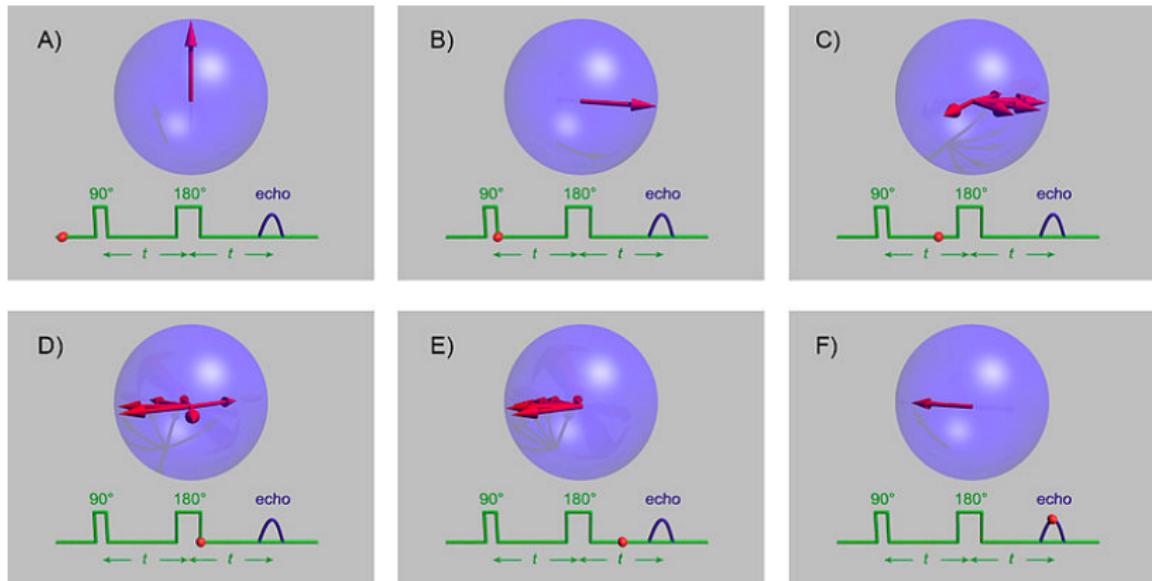
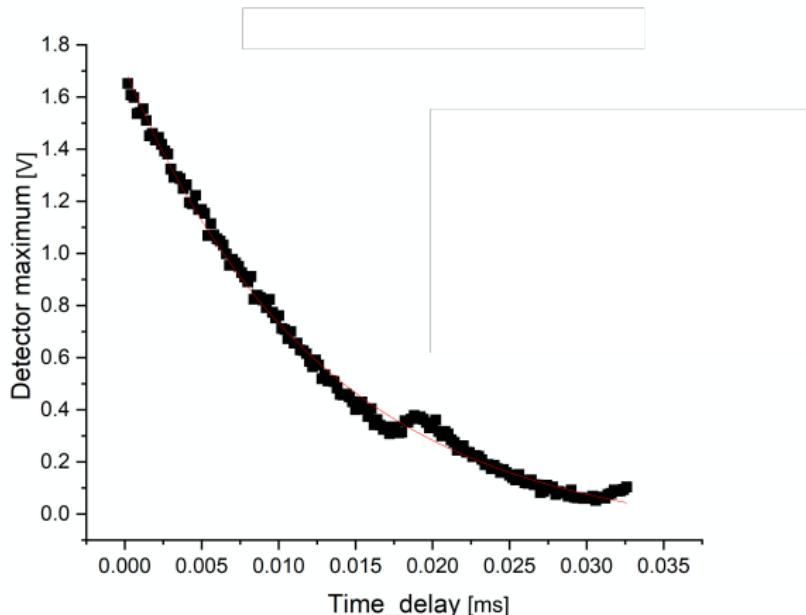


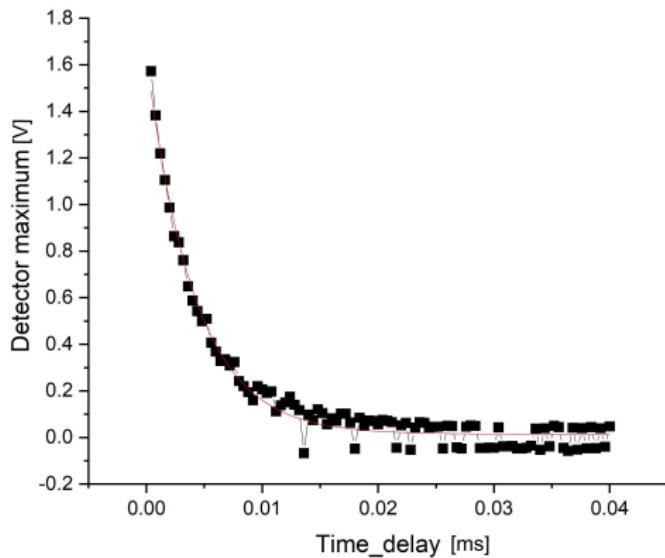
Figure: General Relaxation Path [1]



## Frequency Deviation

Figure: Sample D  $[3.37 \pm 1.6 \times 10^{-2}]$ :  $T_1$

## Exceeding Relaxation Time

Figure: Sample A [ $34.0 \pm 6.0 \times 10^{-2}$ ]:  $T_2$