

New Apparatus for Double Nuclear Magnetic Resonance Experiments

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Department of Chemistry

Songi Han Lab

NMR is Utilized in Medicine and Chemistry

Magnetic Resonance Imaging
(MRI)



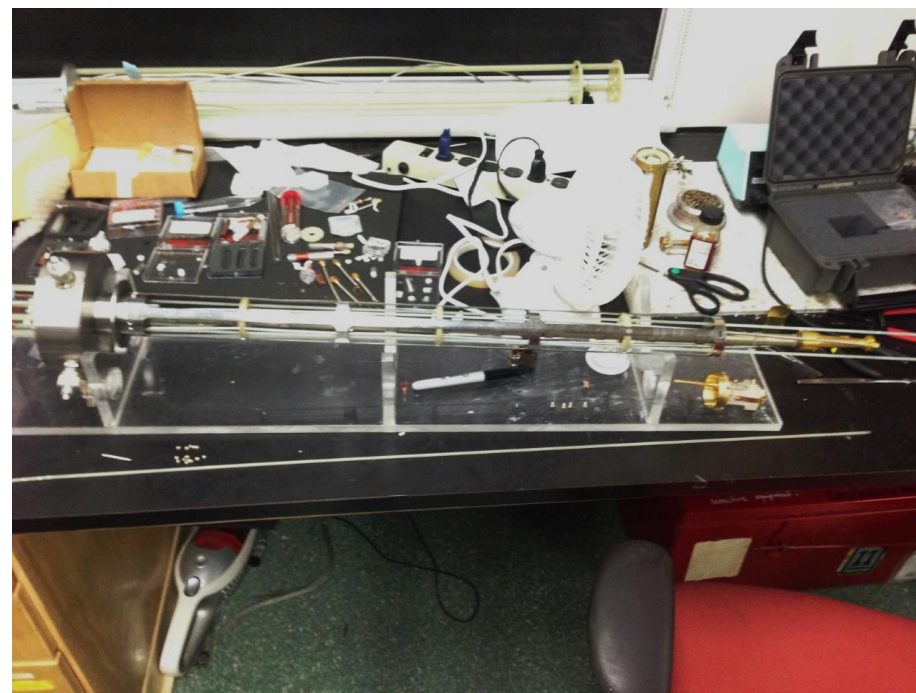
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Magnetic Resonance Imaging (MRI)



NMR in Medicine

NMR Spectroscopy

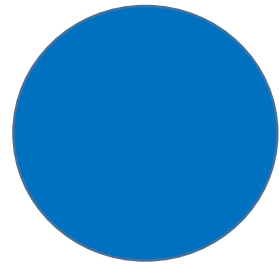


NMR in Chemistry

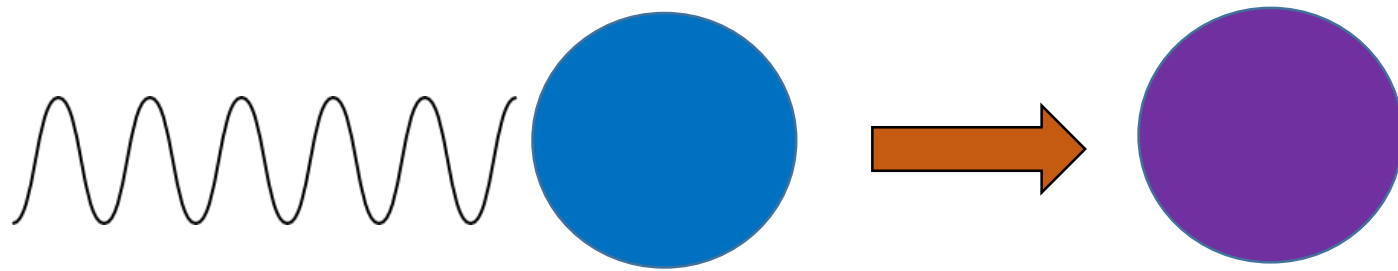
1. Background of NMR

2. Current Application of NMR Techniques

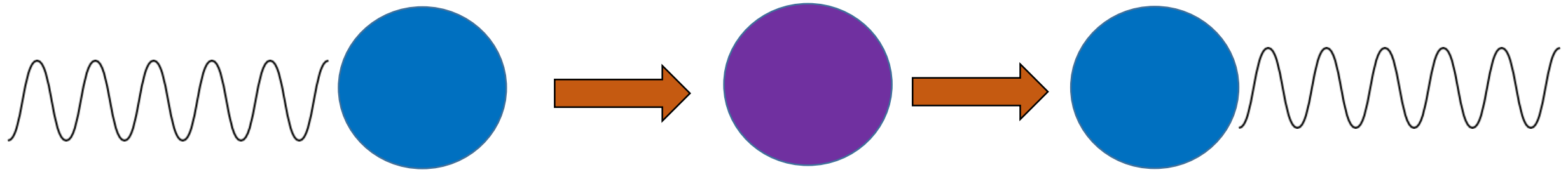
Basics of NMR: Excitation and Relaxation



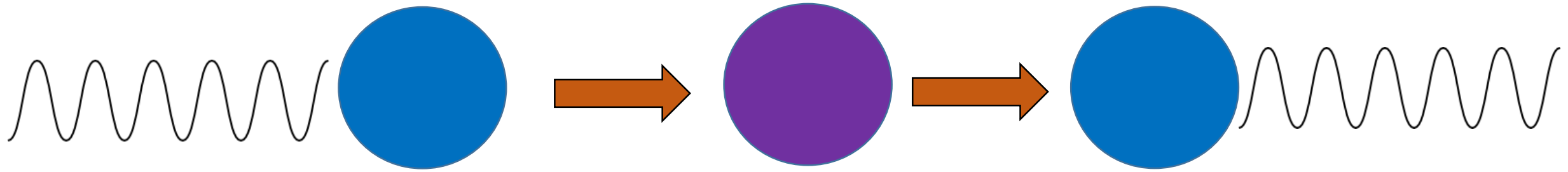
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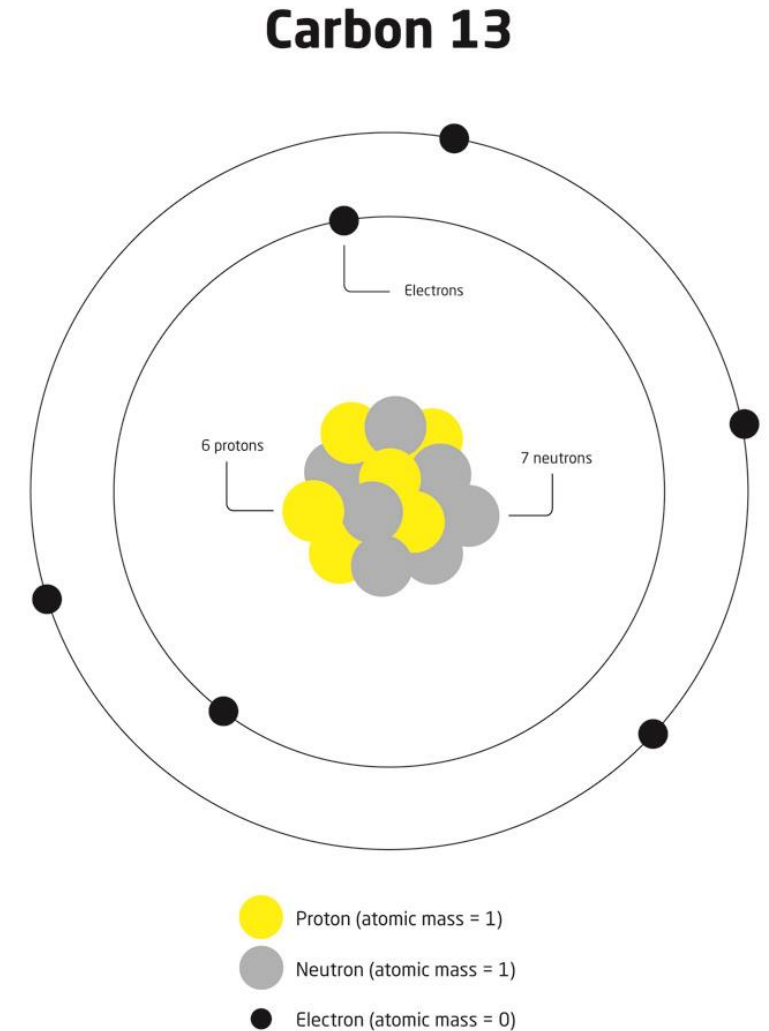
Need nuclei with spin

What Does it Mean to Have Spin?

- Unequal balance of protons vs. neutrons

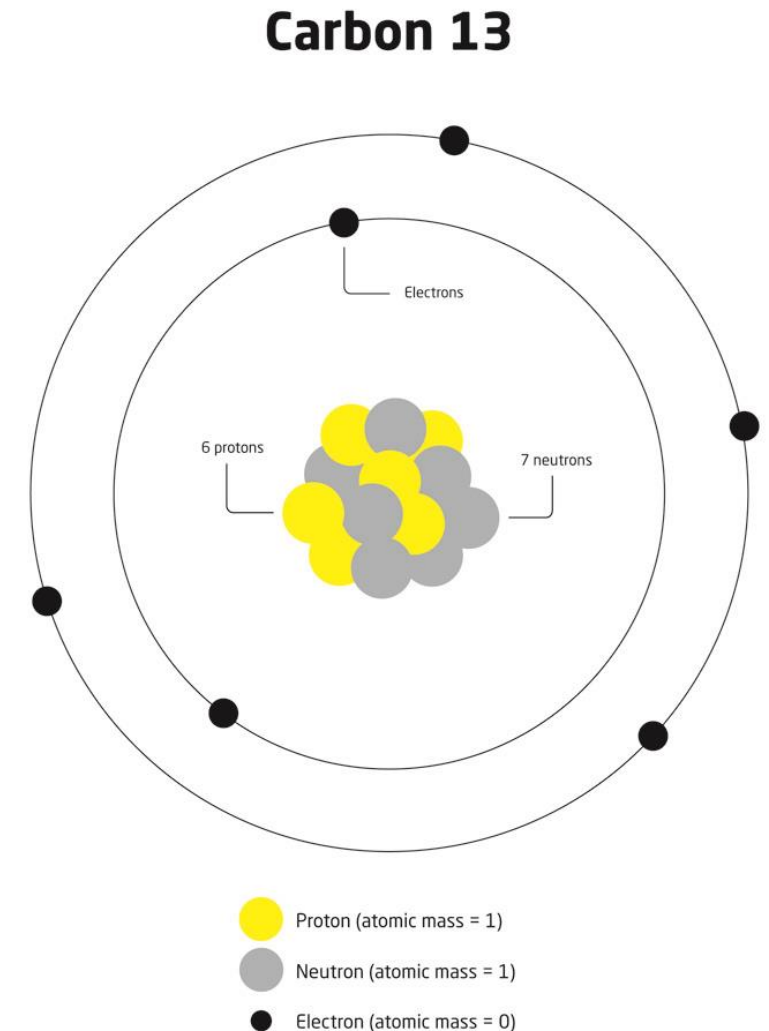
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 - Carbon 13: 6 protons, 7 neutrons

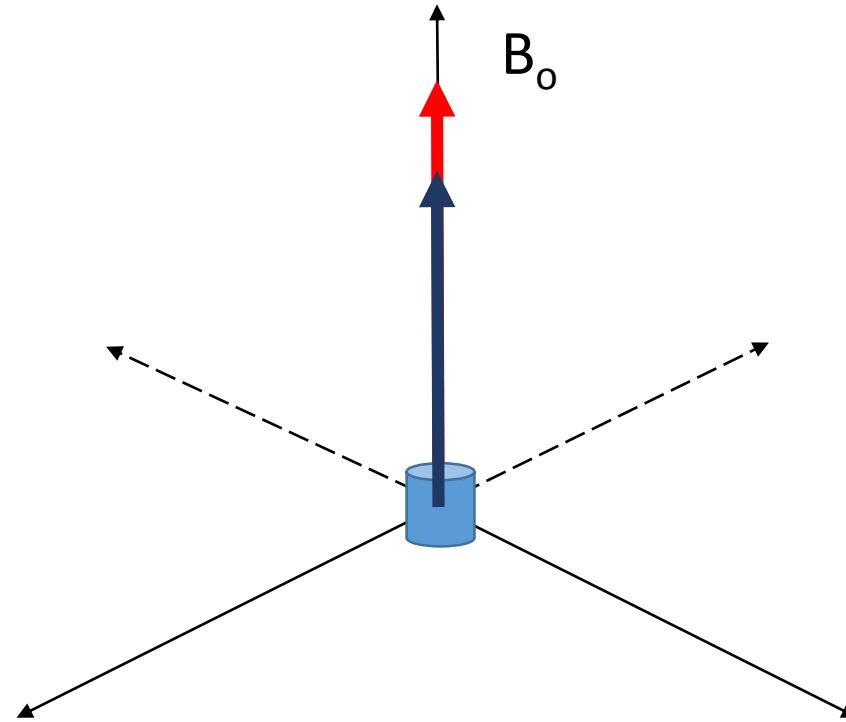


What Does it Mean for a Nucleus to Have Spin?

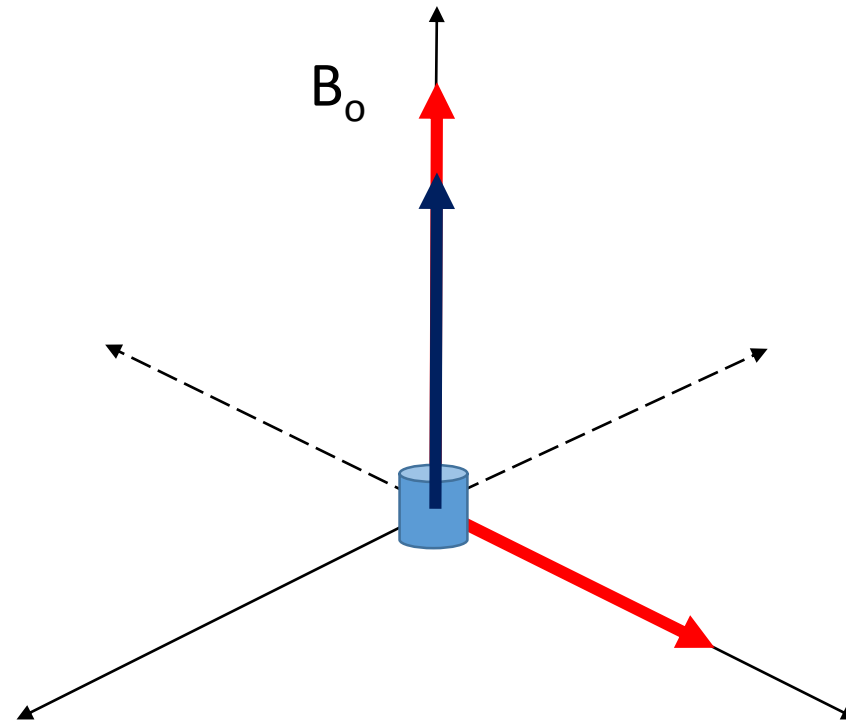
- Unequal balance of protons vs. neutrons
 - Carbon 13: 6 protons, 7 neutrons
- Things with spin act like little magnets



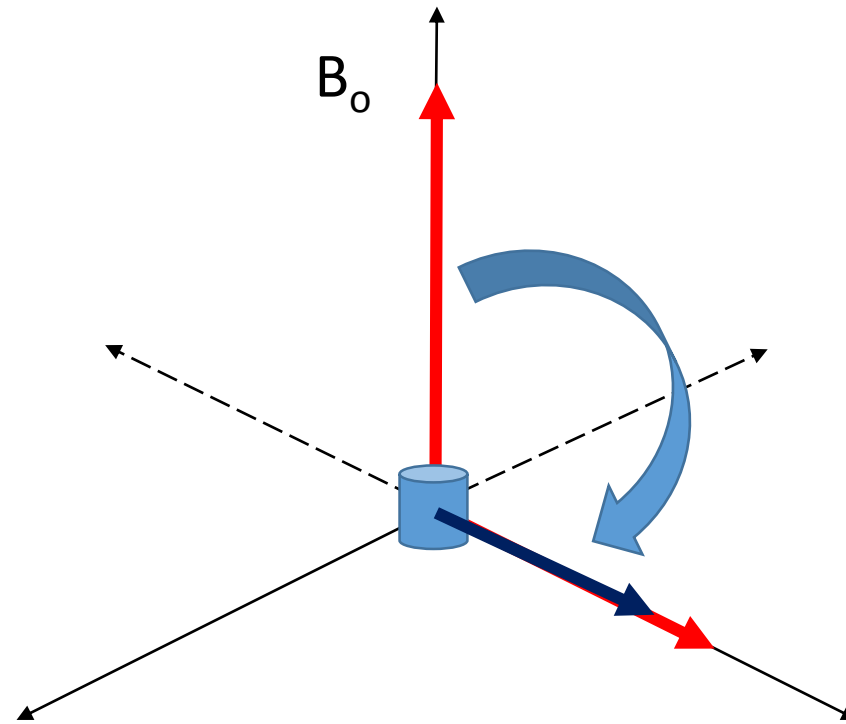
Align the spins in a strong, static magnetic field



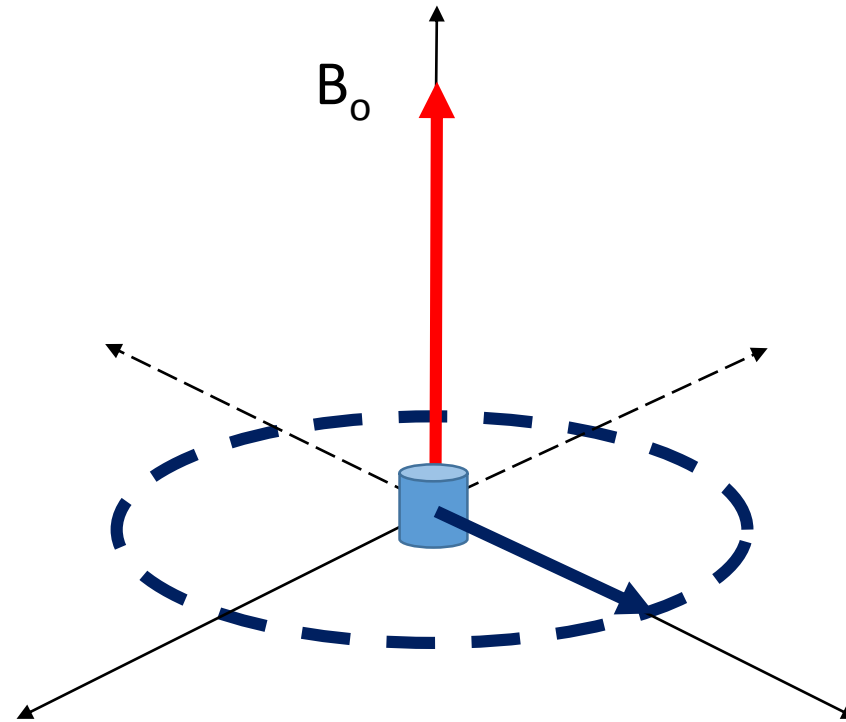
Push the Spins Down 90 degrees with a Magnetic Pulse



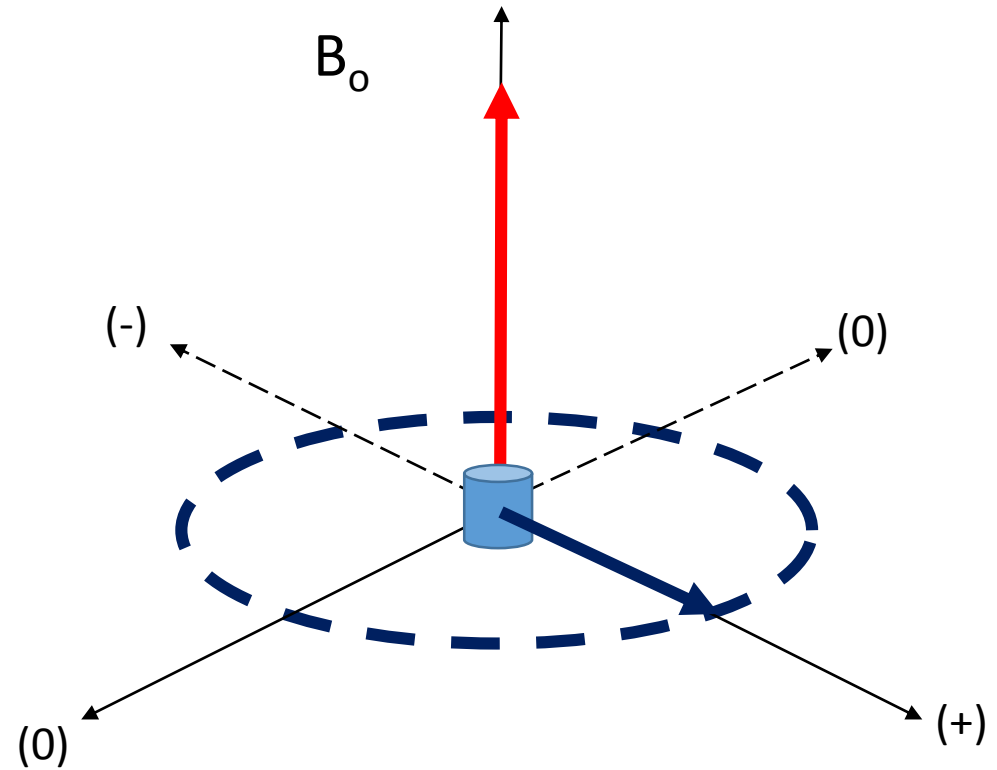
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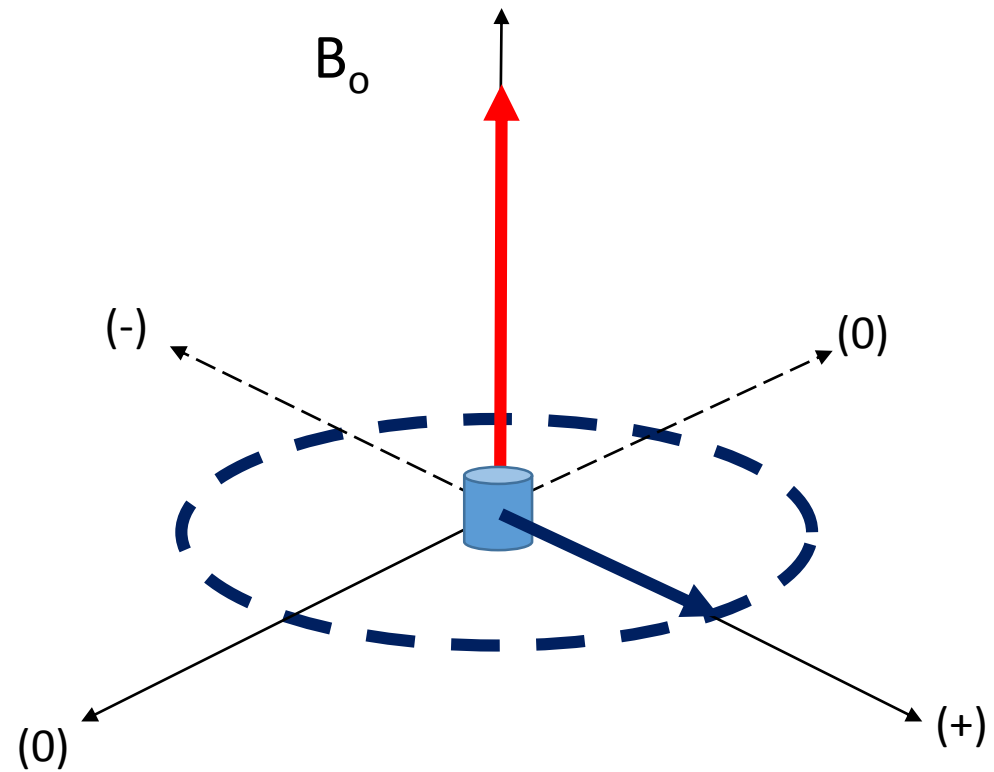
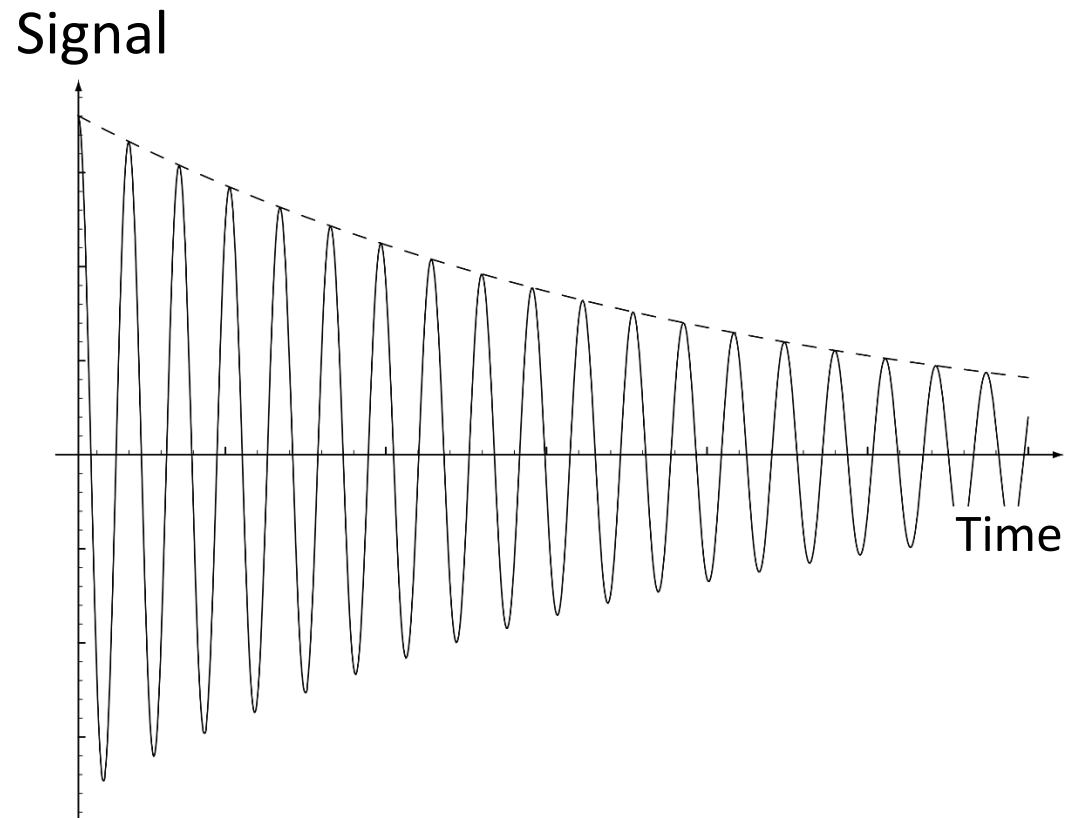
Spins then Precess, Emitting Detectable Signal



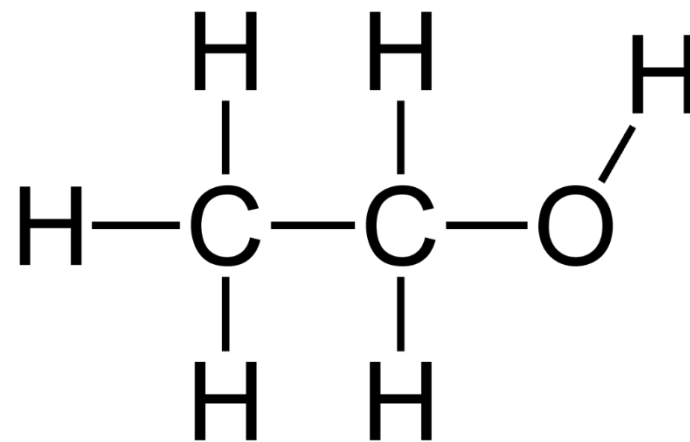
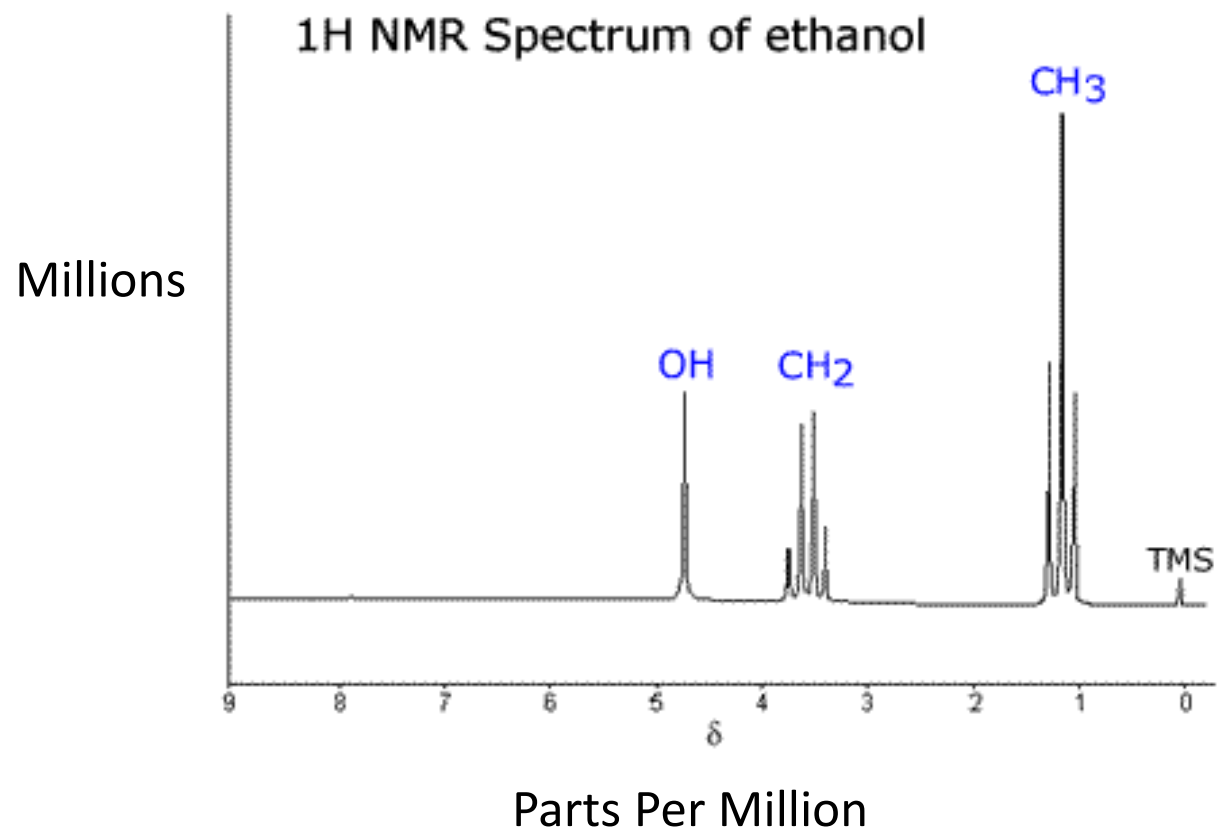
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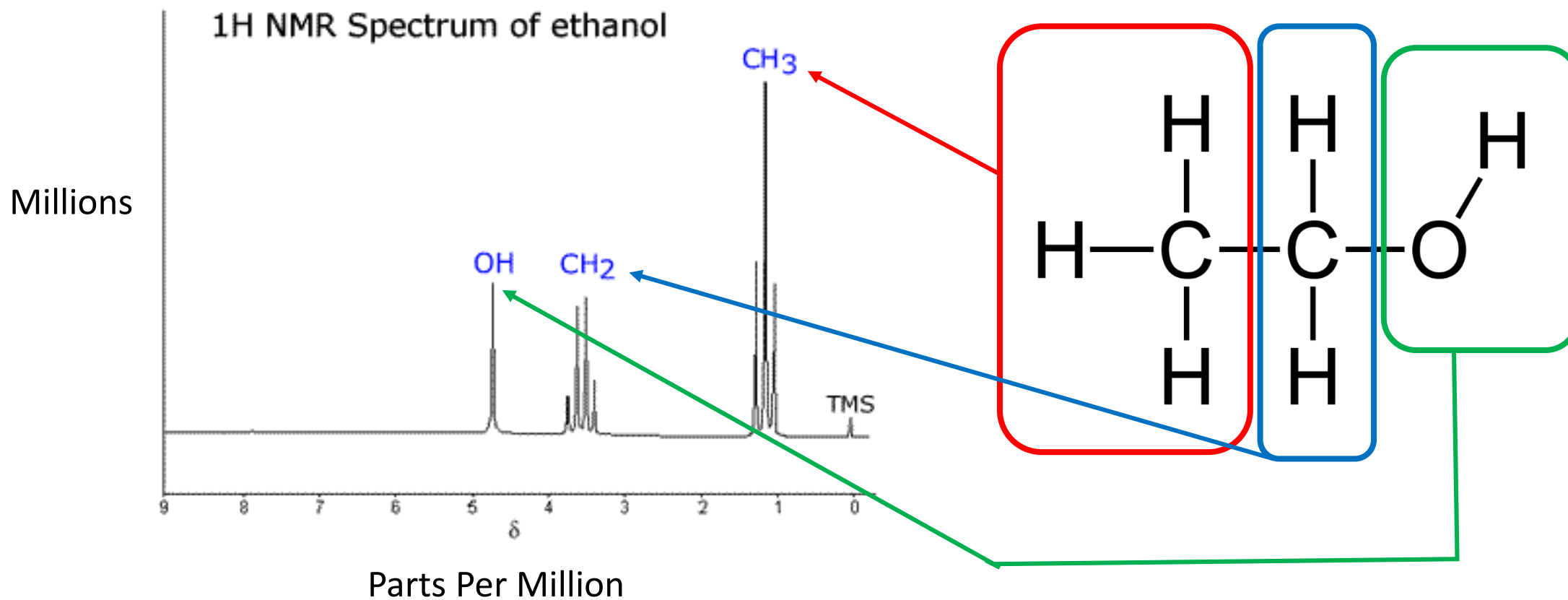
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Interpreting NMR Data to Find a Molecule's Structure



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2. **Current Application of NMR Techniques**

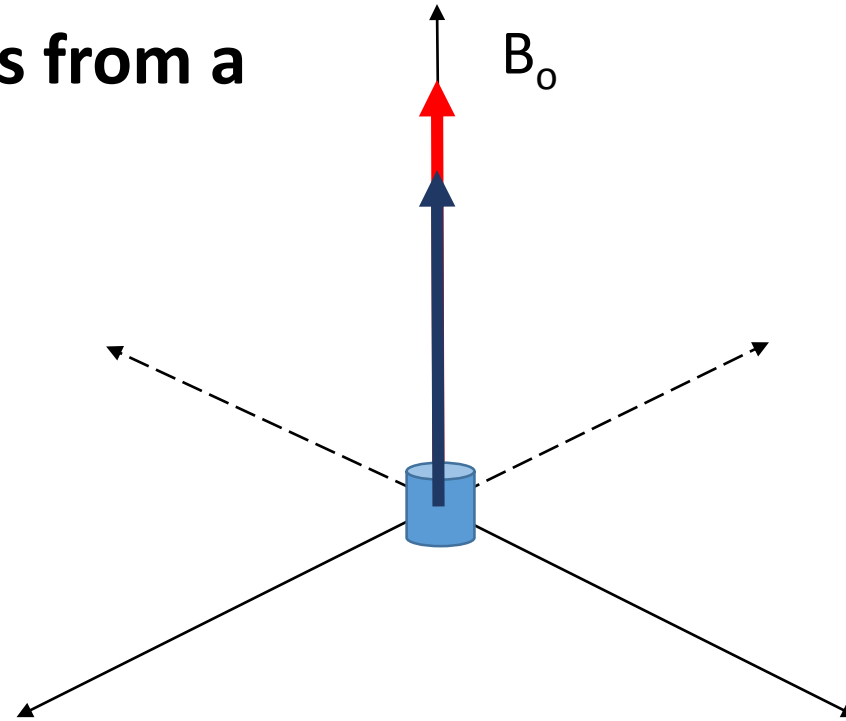
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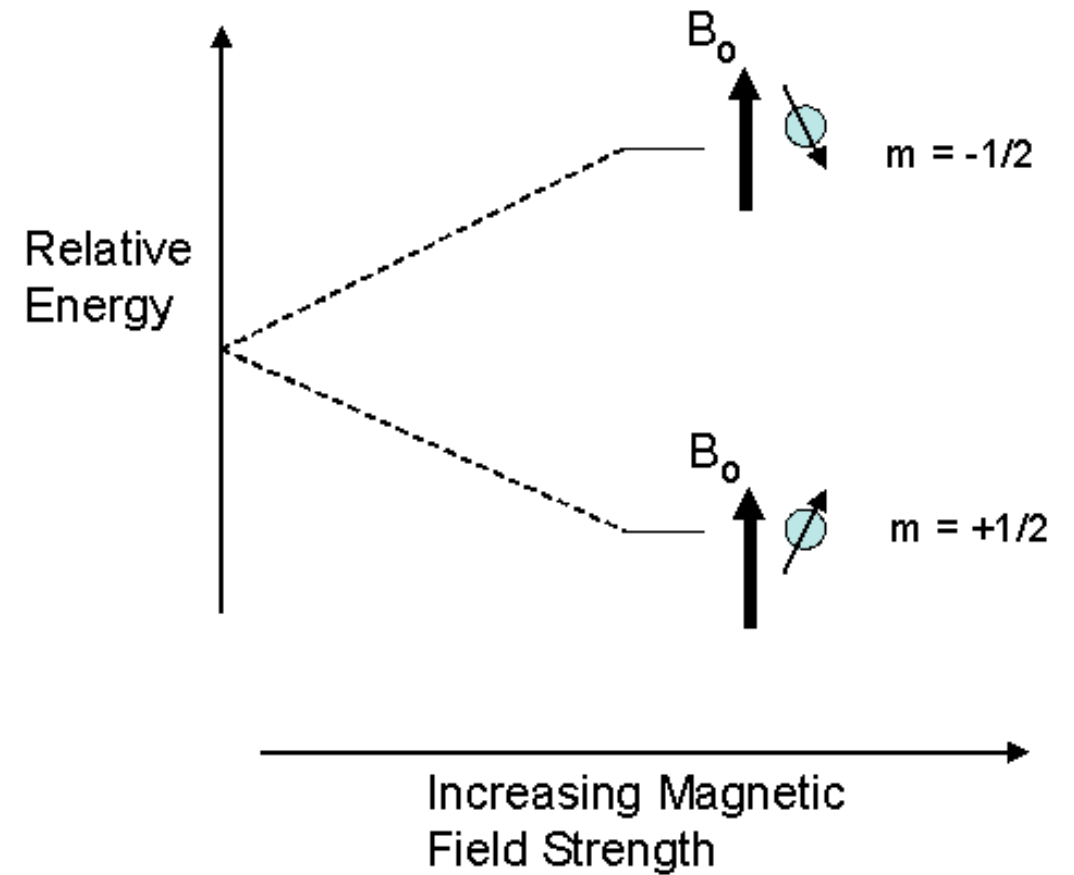
Dynamic Nuclear Polarization

Applying NMR Concepts to Dynamic Nuclear Polarization

The blue moment comes from a polarization of spins

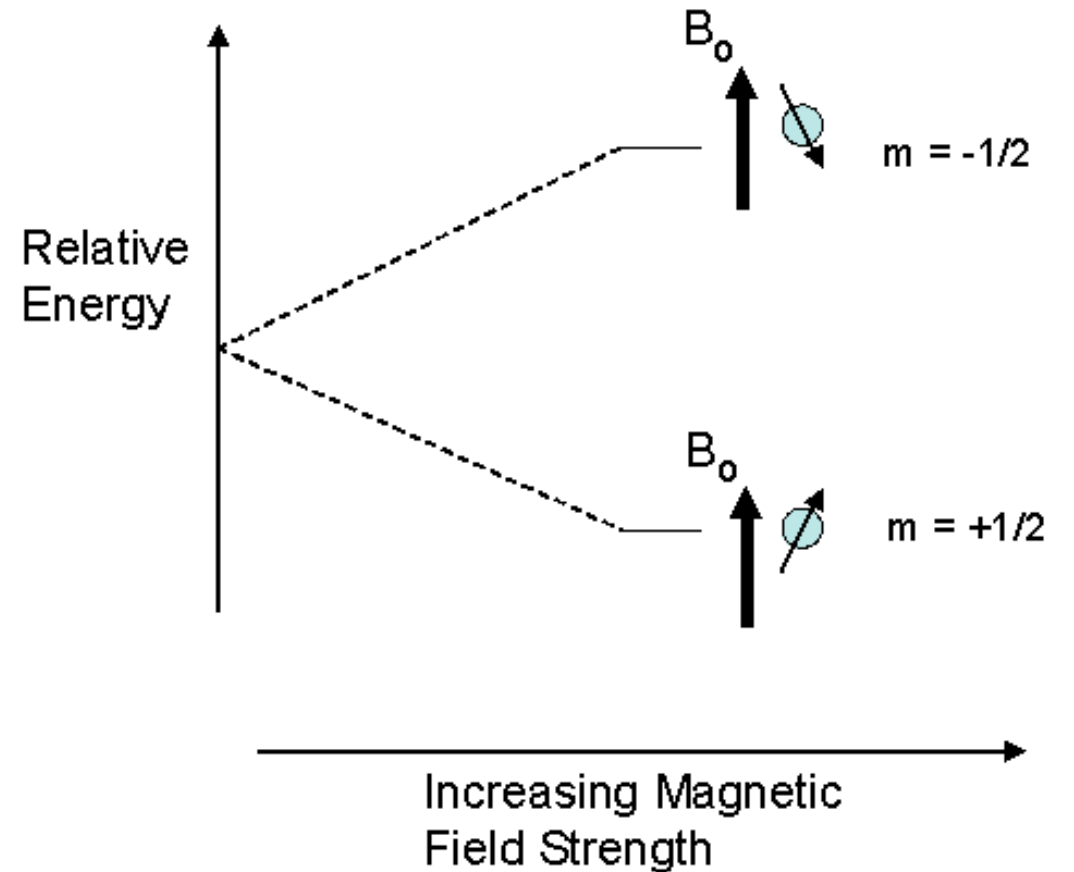


Applying NMR Concepts to DNP



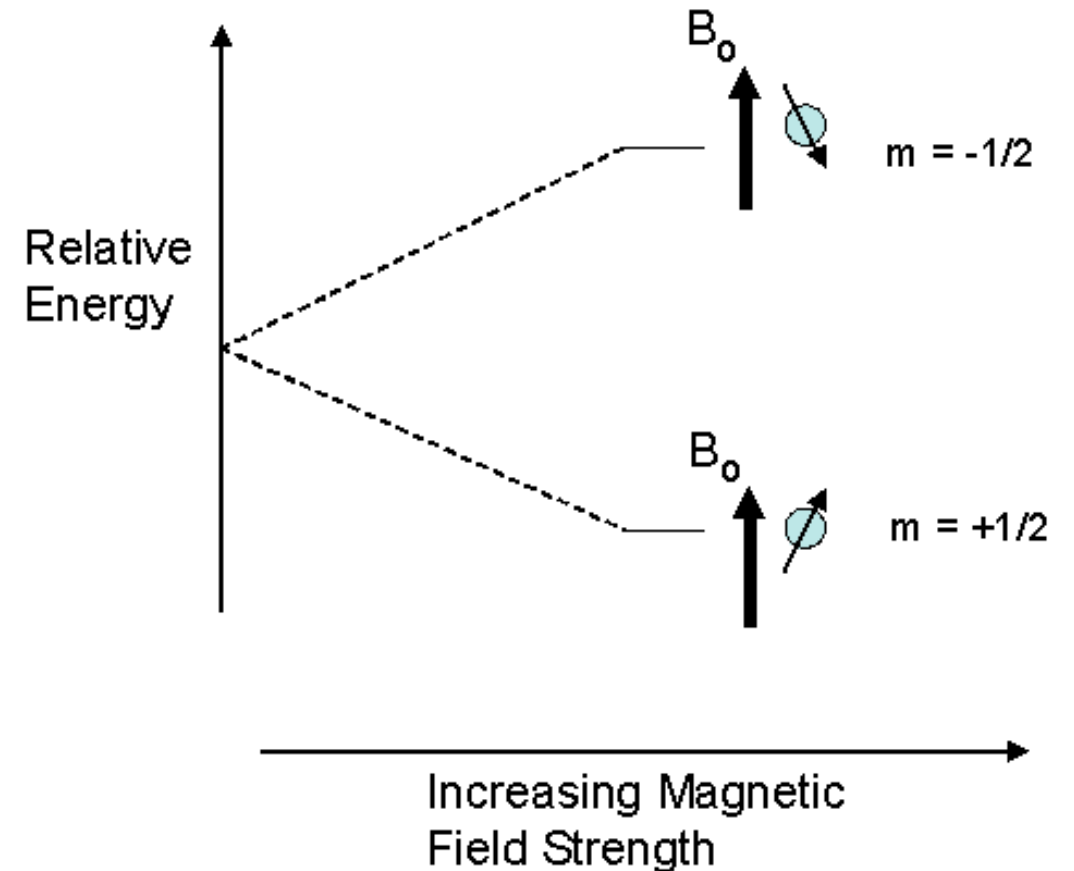
Applying NMR Concepts to DNP

- Spins interact with each other



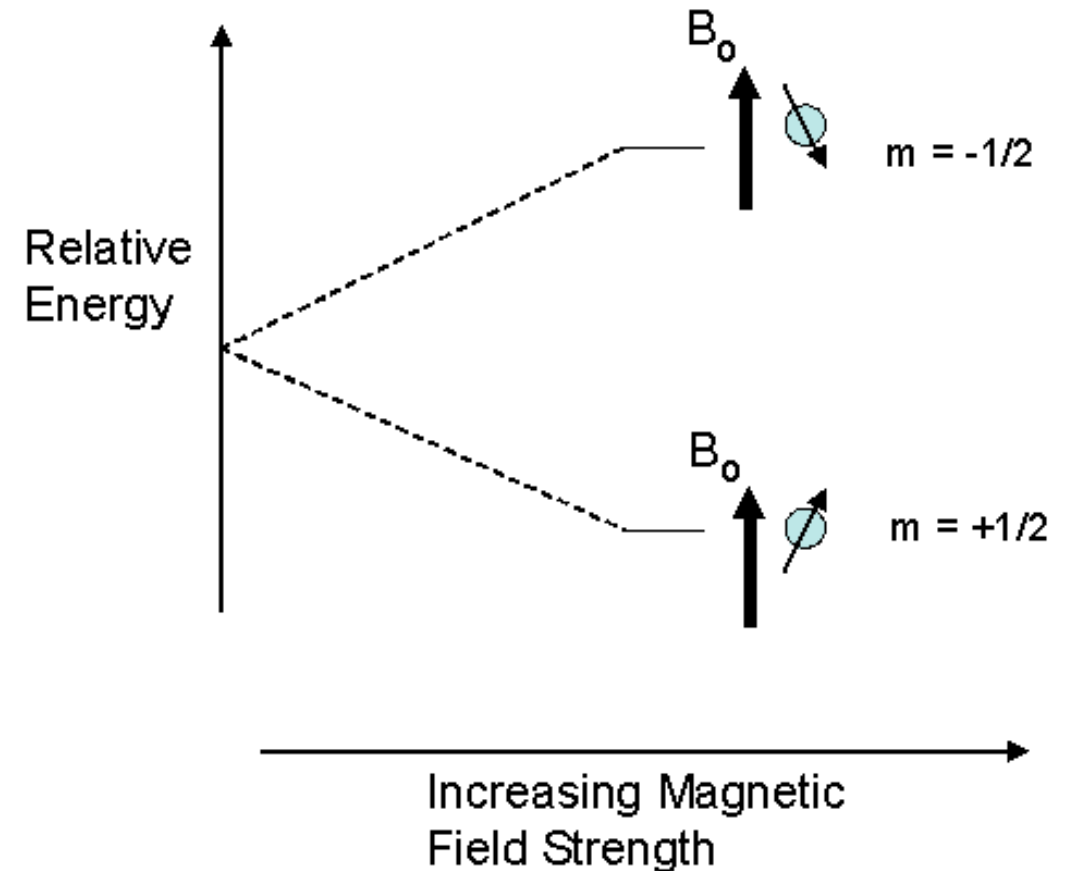
Applying NMR Concepts to DNP

- Spins interact with each other
- **You can transfer spin polarization from one species to another**



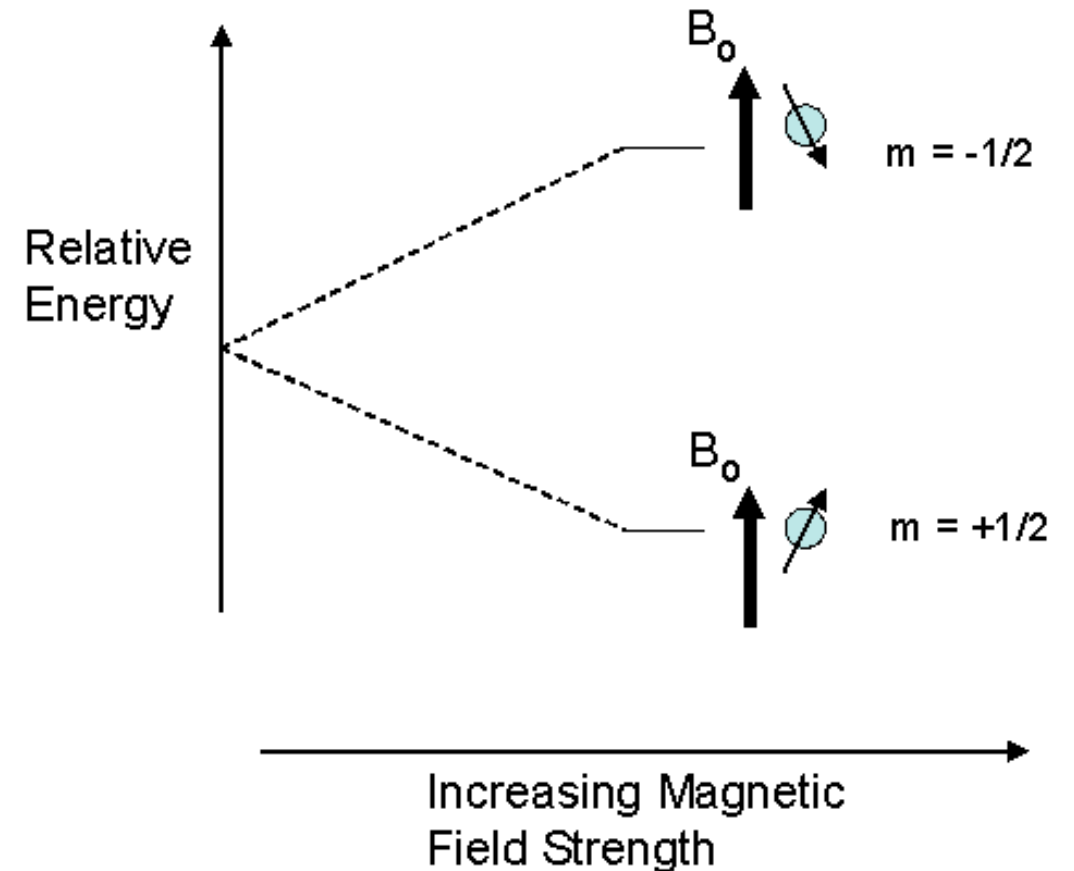
Applying NMR Concepts to DNP

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- Electron spins are easily polarized

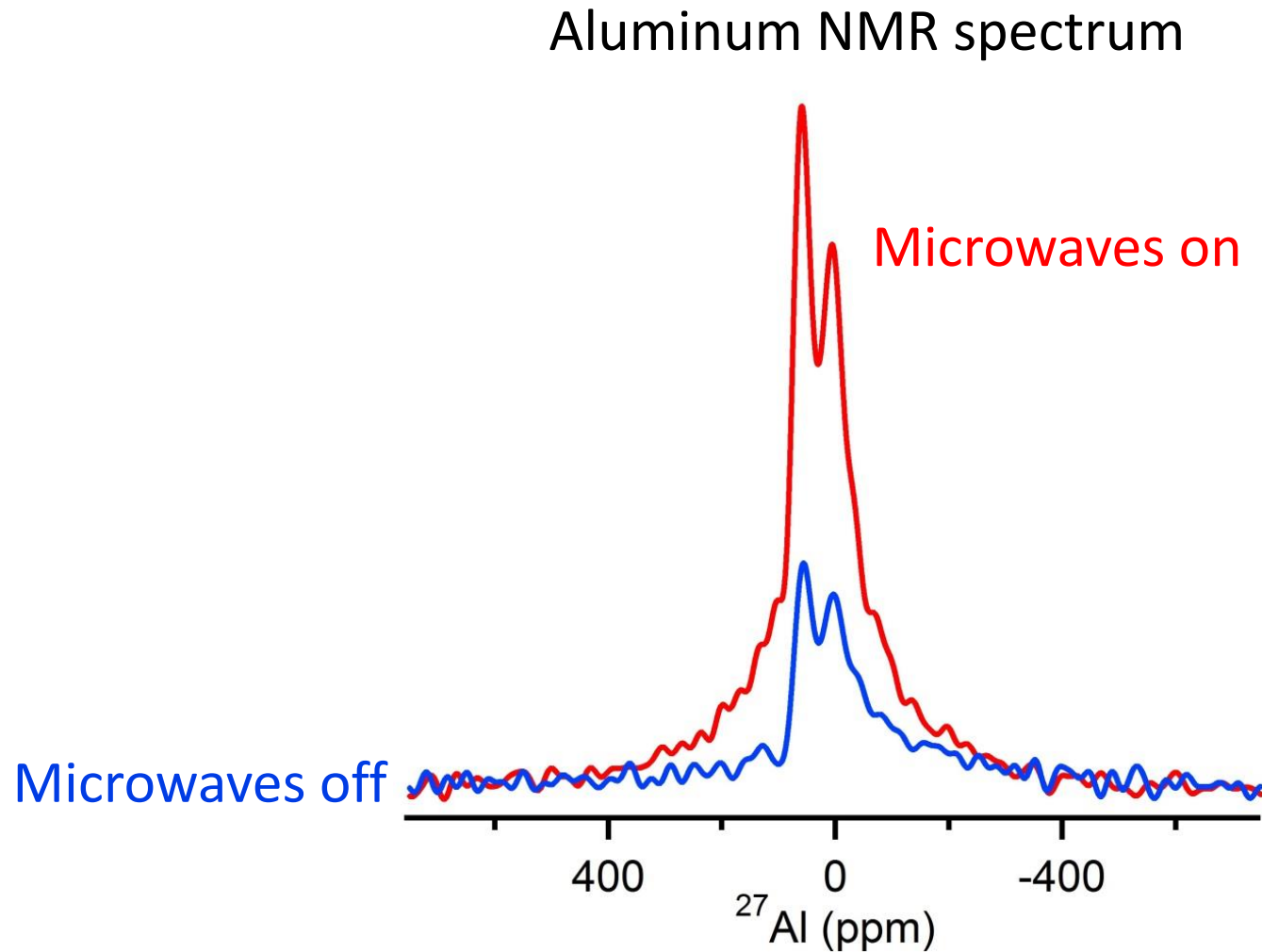


Applying NMR Concepts to DNP

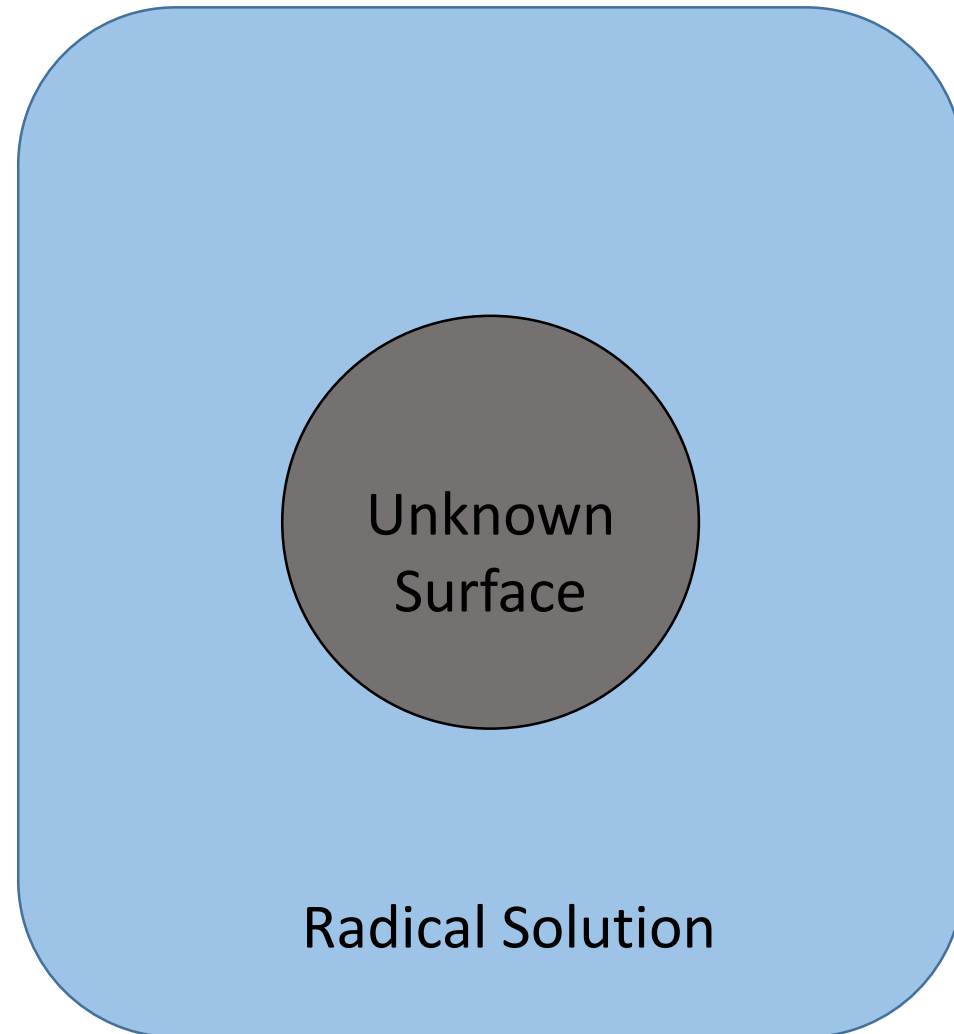
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 - $e^- \rightarrow {}^1\text{H} \rightarrow {}^{13}\text{C}$



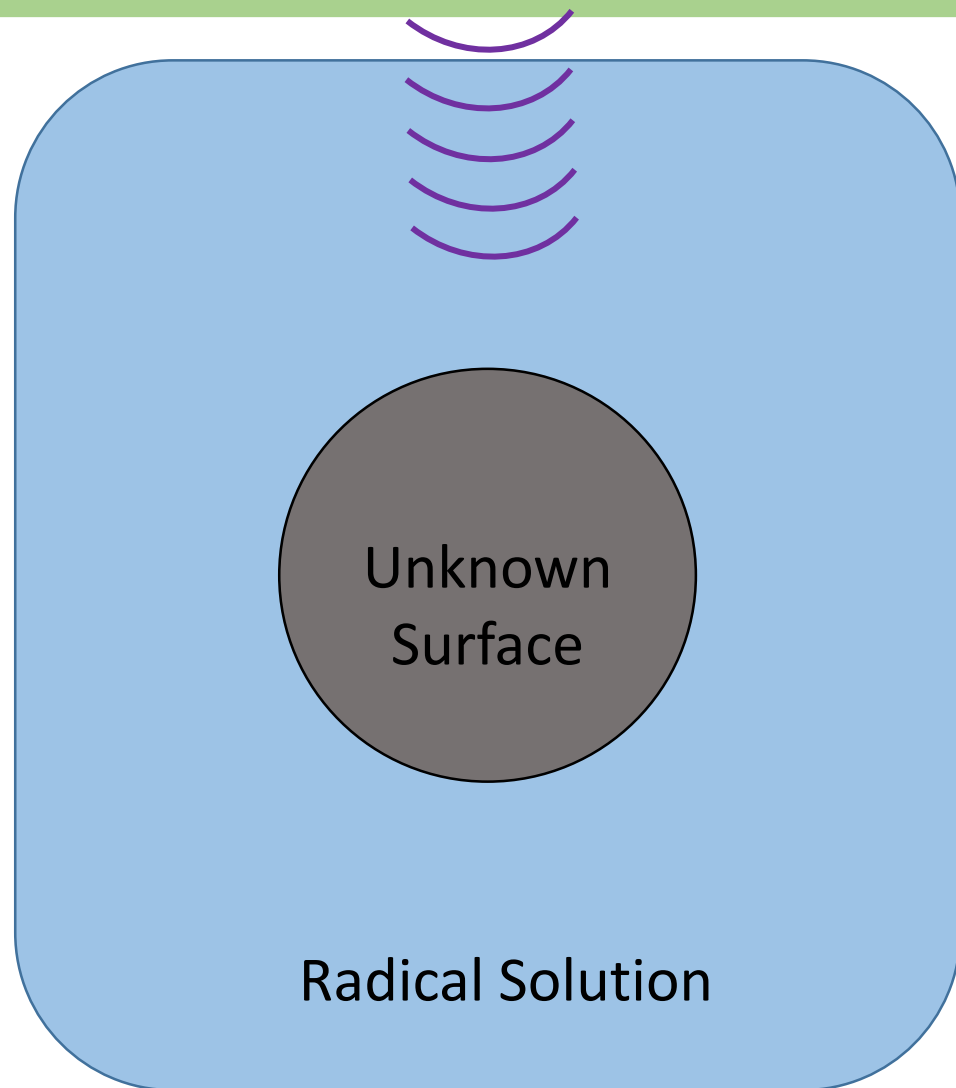
Using DNP Gives Drastic Increase in Signal



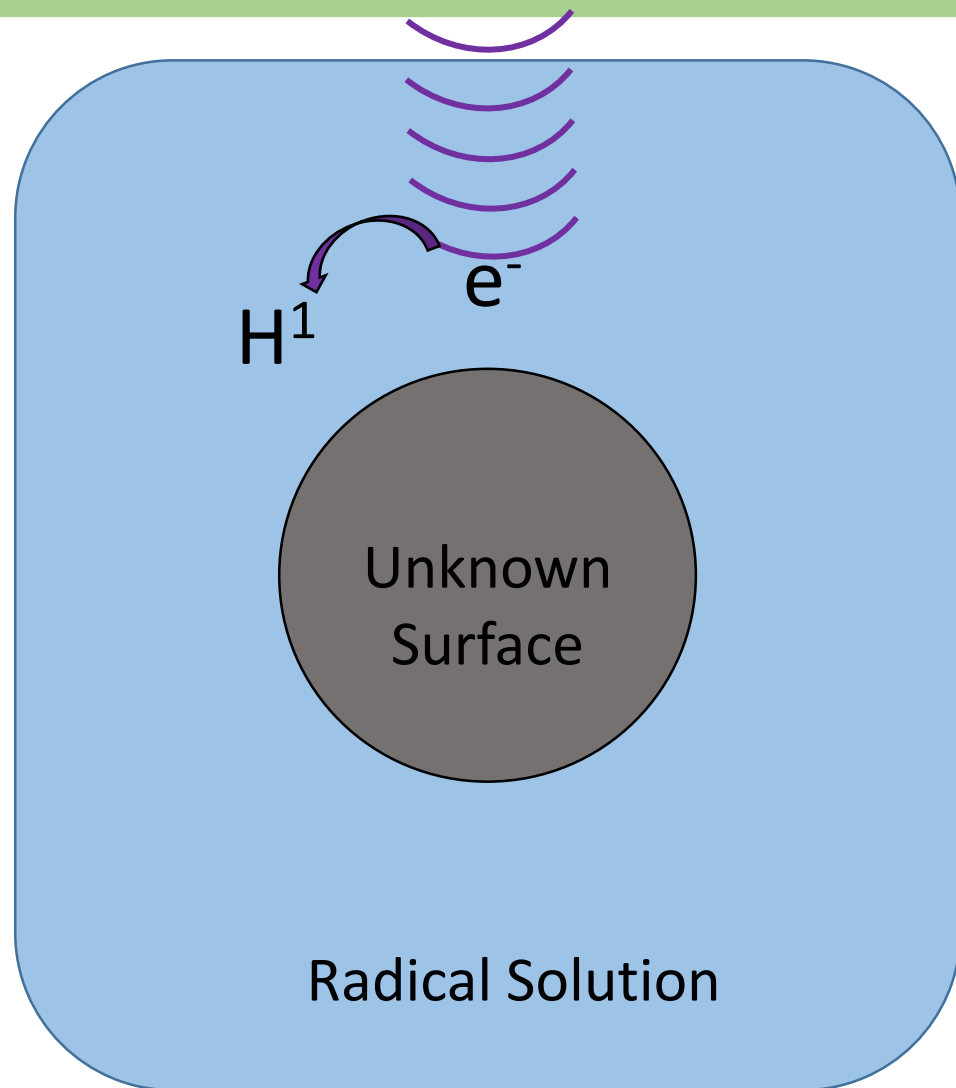
A New Method for DNP



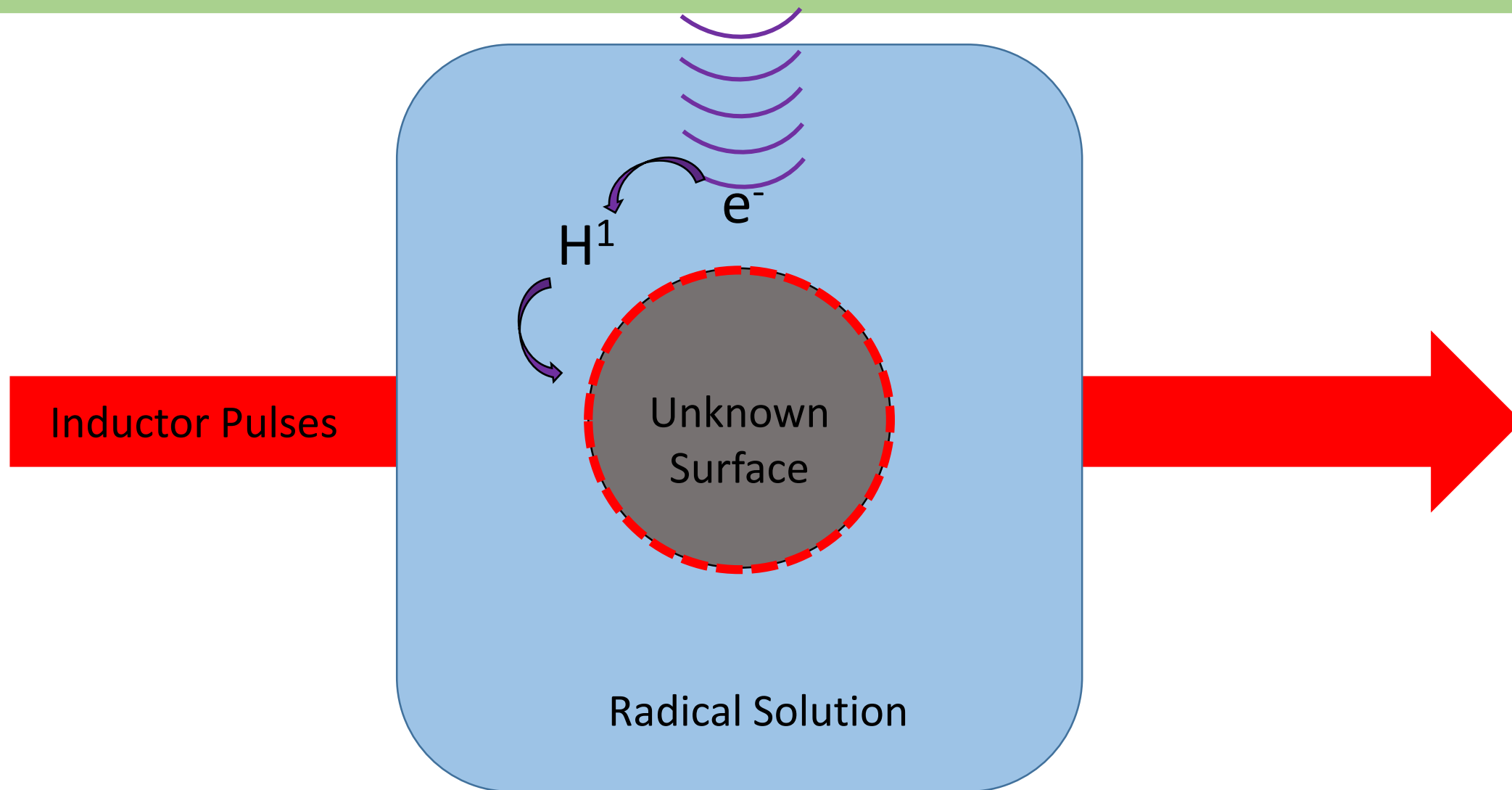
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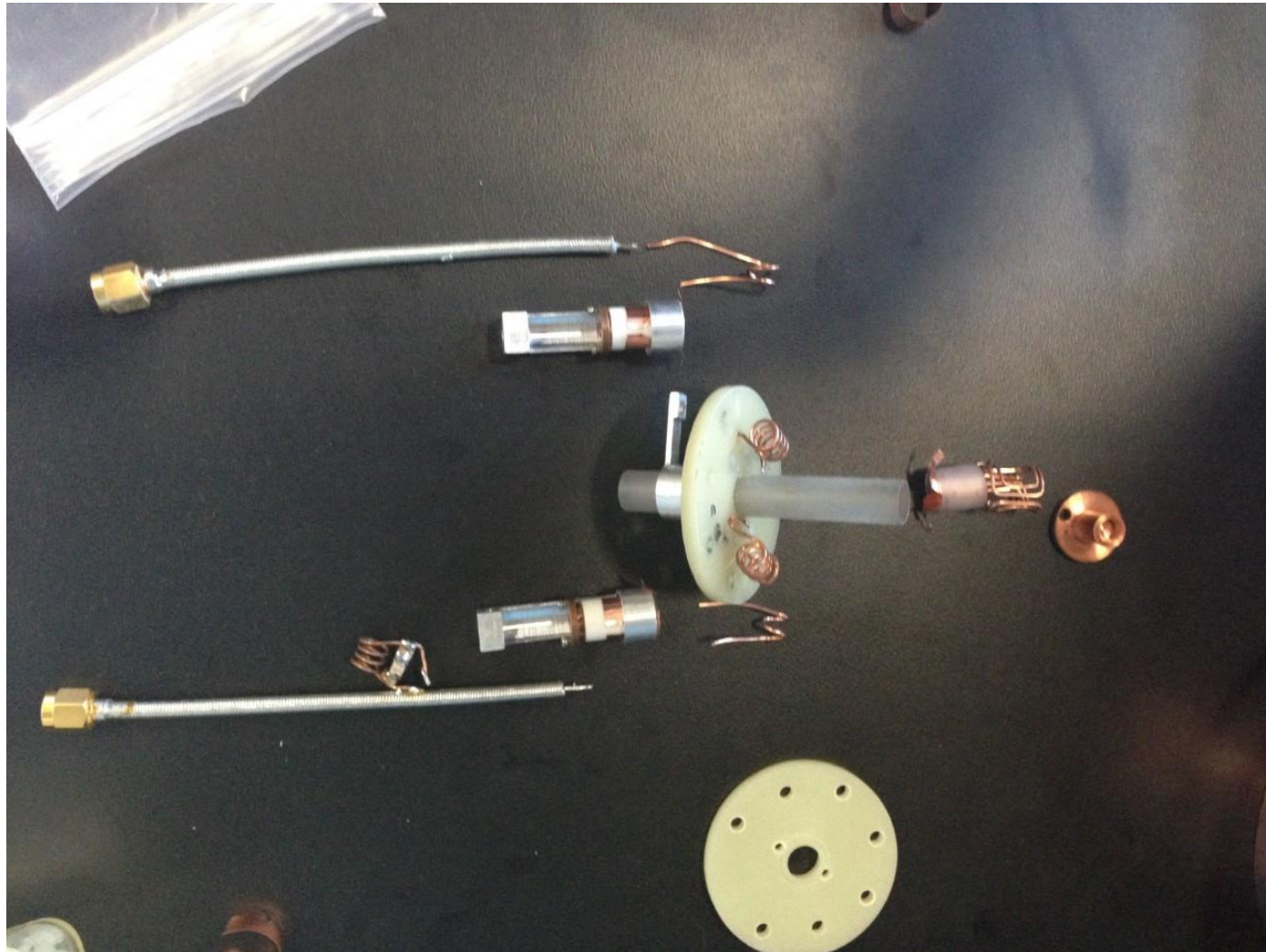
A New Method for DNP



We Need a New, Specially Designed Probe

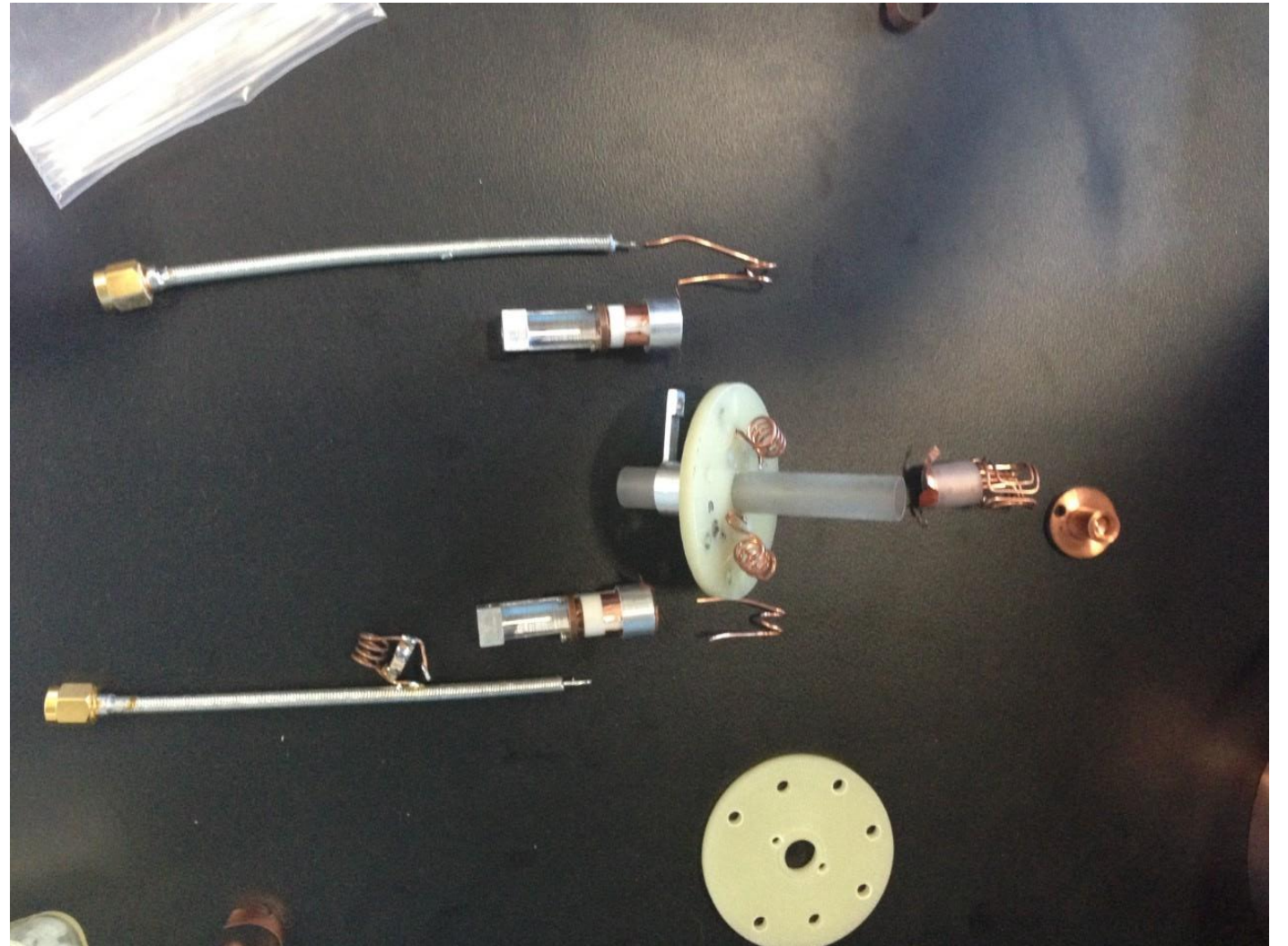
H¹ Channel

C¹³ Channel



NMR Double Resonance Probe

- DNP and cross polarization capabilities
- Easily interchangeable coil
 - Do experiments on a variety of nuclei
- High resolution
- High detectable signal



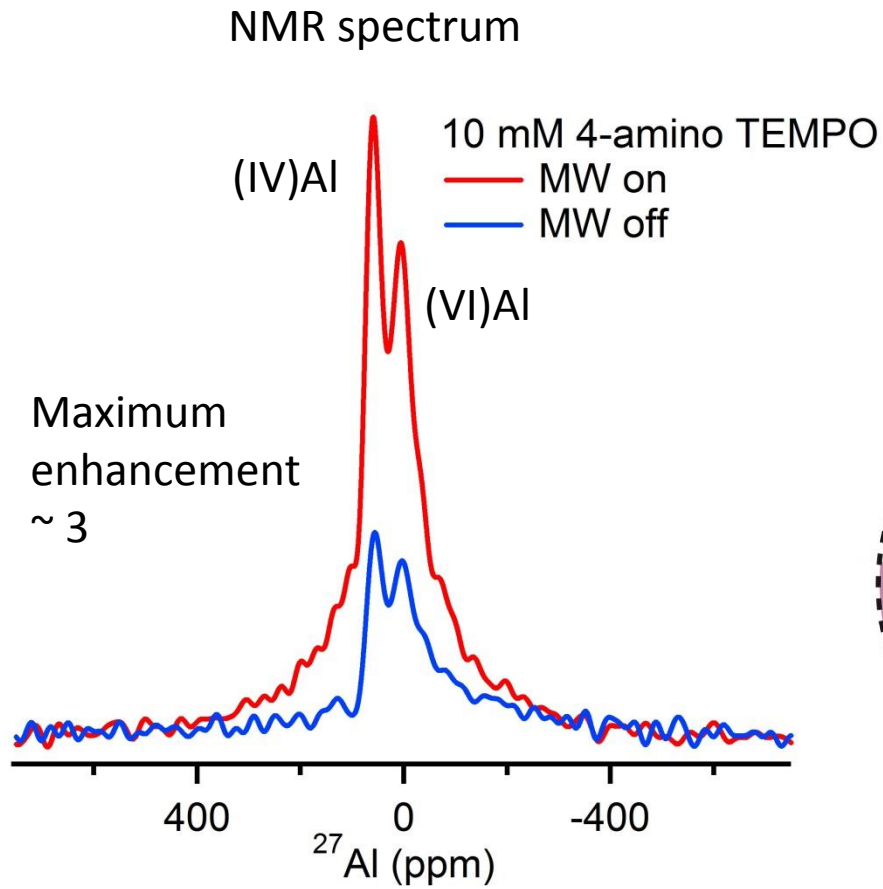
Acknowledgements

- **Gorman Scholar Program**
 - Dean Pierre Wiltzius and Office of the Dean, Math, Life & Physical Sciences
- Anthony Ting Ann Siaw
- Alicia Smith
- Alisa Leavesley
- **Songi Han**
- All members of the Han lab

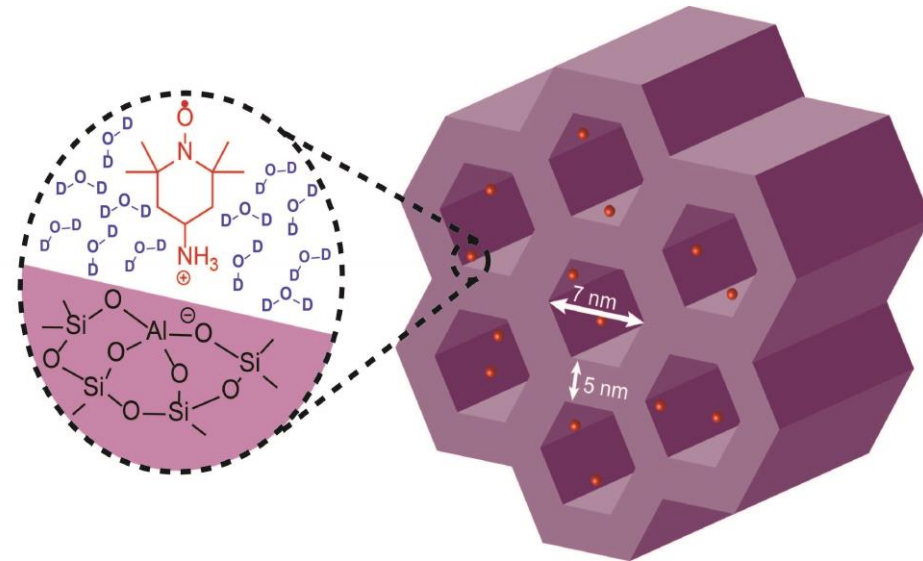
Questions?



Al-SBA-15 (Si/Al = 5) with 10 mM 4-amino TEMPO in 100% D₂O

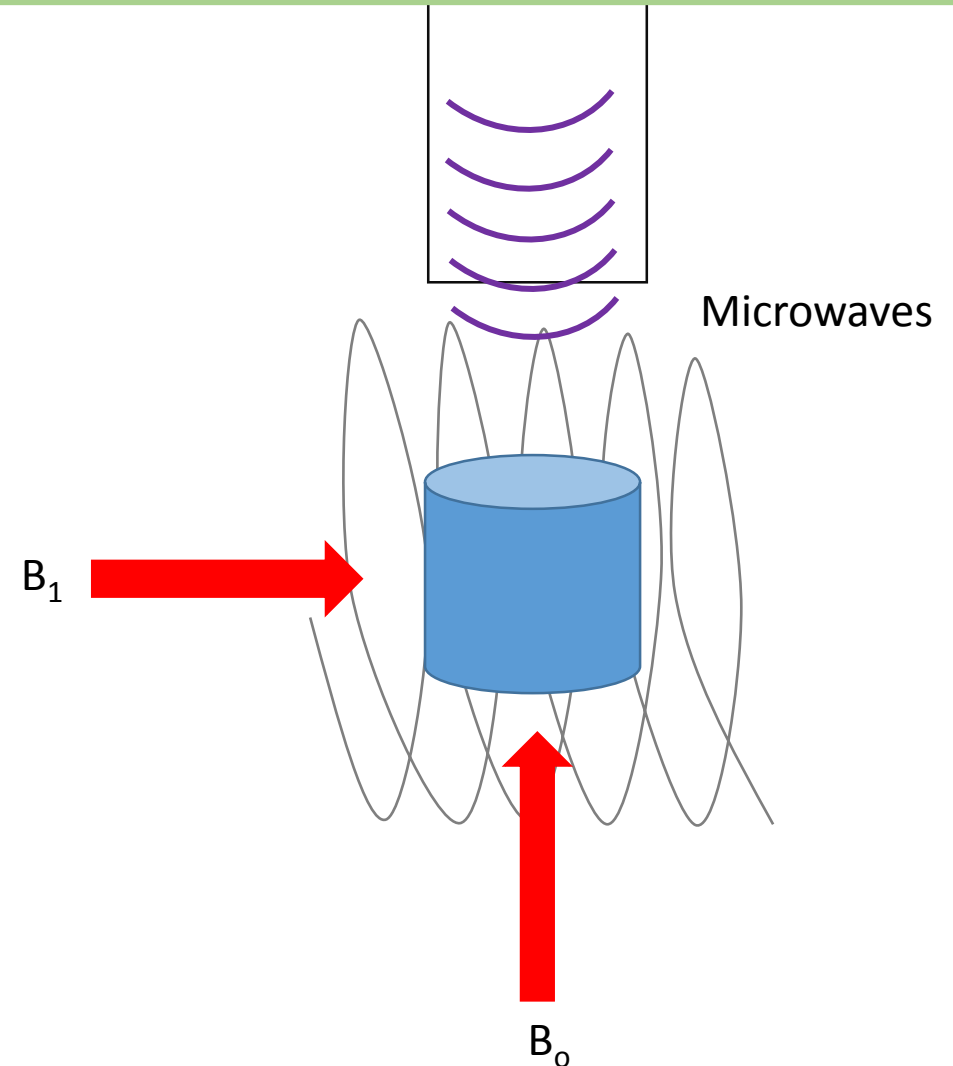


Cartoon Structure of Al-SBA-15



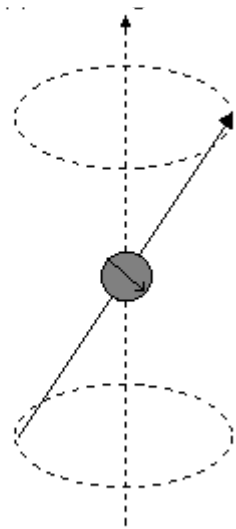
Electron, Proton, Carbon 13 Resonance Chain

- Lower temperatures
 - More Signal
 - Liquid Helium (4.2 K)
 - Room Temp \sim 300 K
- Dynamic Nuclear Polarization (DNP)
 - Electrons resonate with 660 times signal
 - $e^- \longrightarrow {}^1\text{H} \longrightarrow {}^{13}\text{C}$



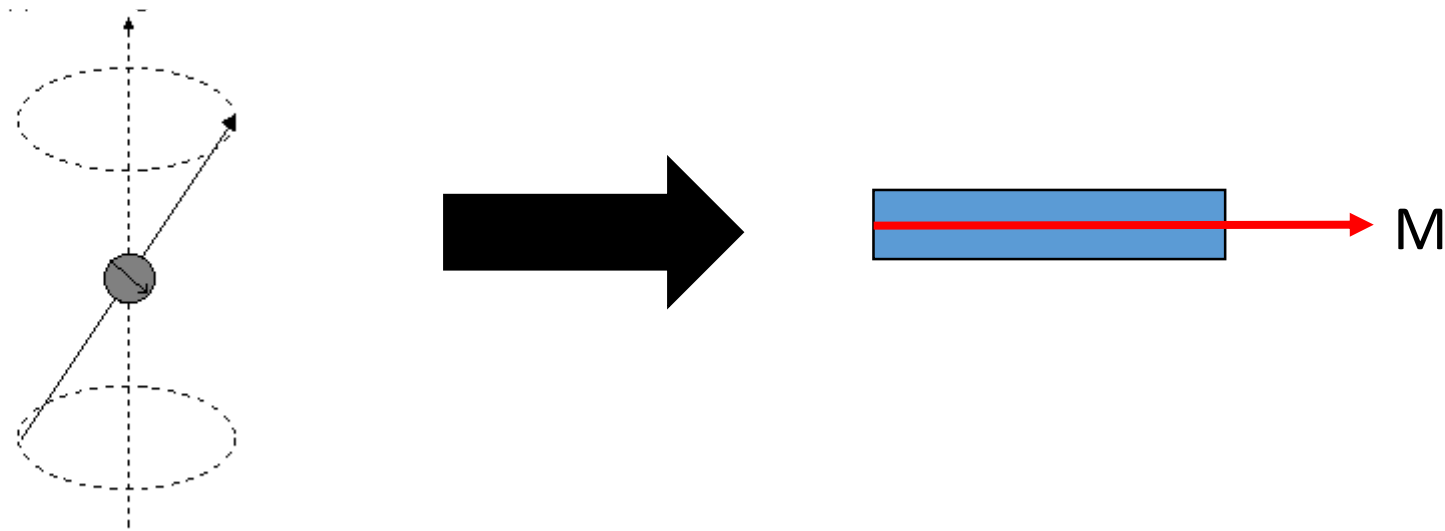
A view of NMR through Classical Mechanics

Nuclei with spin are like little magnets

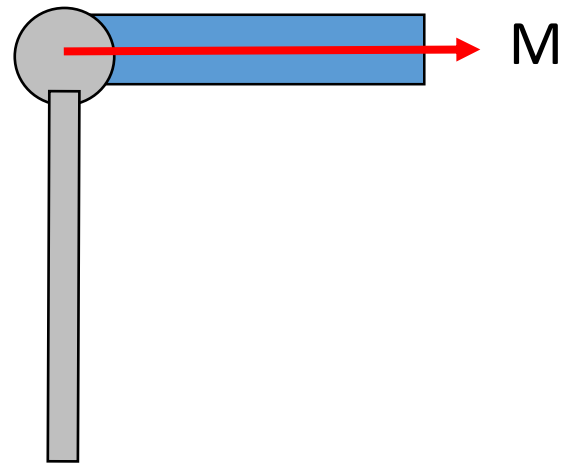


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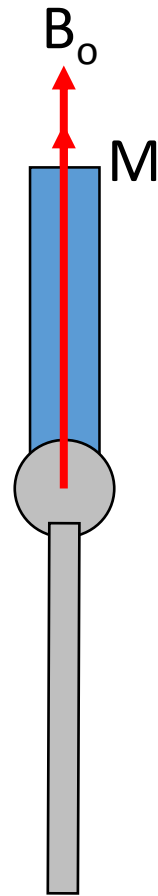
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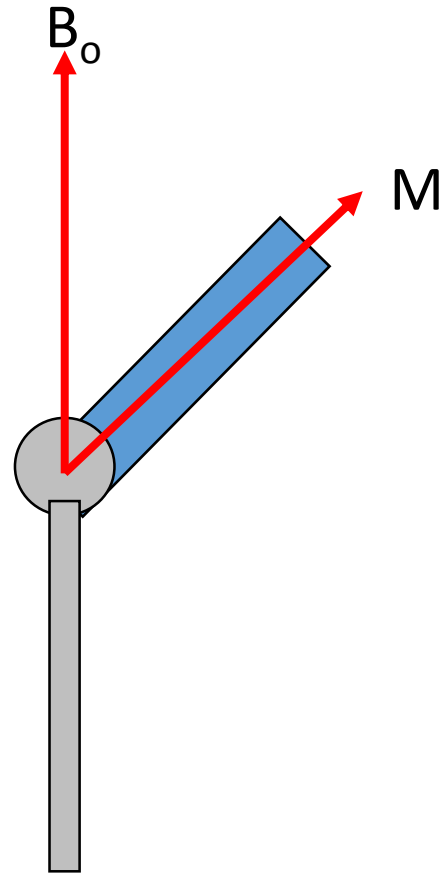
Position the Magnet on a Frictionless Bearing



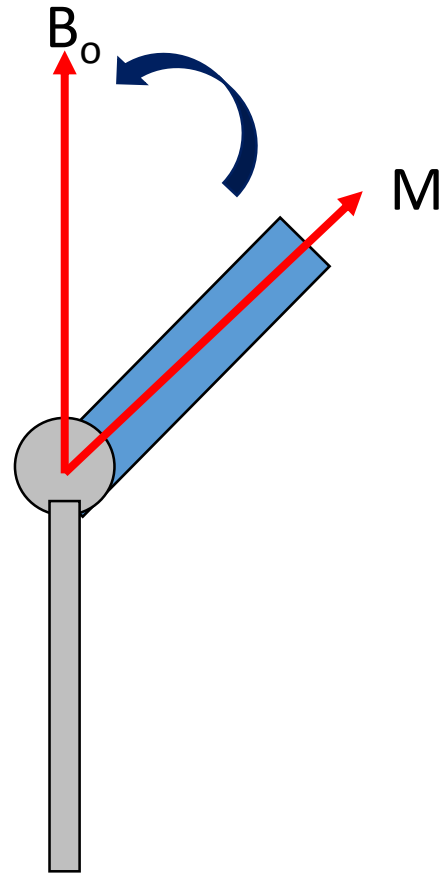
Aligning a magnet in a strong, static magnetic field



Tipping the magnet out of the static field



Tipping the magnet out of the static field



Adding Angular Momentum Makes it Precess

