BARIUM TAGGING FOR nEXO

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AGENDA:

• Introduction
• 0νββ decay
• What is Ba-tagging?
• Ba-II system
• Experimental setup
INTRODUCTION: Ba-tagging Overview

• Ba-tagging is about identifying the $^{136}$Ba$^+$ ion produced in the double beta decay ($\beta\beta$) of $^{136}$Xe
• This would eliminate all non-$\beta\beta$ background events
Neutrinoless Double Beta Decay ($0\nu\beta\beta$)

- Left is allowed by Standard Model ($2\nu\beta\beta$)
- Right is forbidden by Standard Model ($0\nu\beta\beta$)
Ba-tagging

- Identify $^{136}$Ba$^+$ ion from $\beta\beta$ decay of $^{136}$Xe
- Trap/identify Ba$^+$
  - 1. $^{136}$Xe decays, producing $^{136}$Ba$^{++}$ ion
  - 2. $^{136}$Ba$^{++}$ ion extracted to low pressure region
  - 3. $^{136}$Ba$^{++}$ ionized to $^{136}$Ba$^+$
  - 4. Resonant laser fluorescence used to identify $^{136}$Ba$^+$
Ba-II System

- $\text{Ba}^+$ ion has 1 e in 6s valence shell
- 6s (ground), 6p ($1^{\text{st}}$ excited) and 5d (meta-stable) form Ba-II system
- Use meta-stable nature of 5d to detect/identify $\text{Ba}^+$
Ba-ll System continued

• Continually pump 6s -> 6p transition with 493 nm laser
• When excited to 6p, can decay to 6s or 5d
• Ions in trap can be forced into 5d
• Decay to 6s emits 493 nm photon which is detected and pumping is allowed to continue
• If decays to 5d, 649 nm photon emitted, pumping is stopped
• Then stimulated with 649 nm laser, 5d -> 6p transition occurs, fluorescence restarts
• Difference in fluorescence of just the 493 nm laser and both the 493 nm and 649 nm laser is 6s -> 6p, from this the number of Ba ions in trap can be calculated
Experimental Setup Equipment

• Blue laser (493 nm) is Toptica TA-SHG pro High Power Frequency Doubled Diode System
• Red laser (649 nm) is Toptica TA pro Amplified Tuneable Single-Mode Laser System
• WS-U Wavelength meter
• Stabilized HeNe Laser SL-03 (632.8 nm)
• 2 Acousto-optic modulators (AOM’s)
Experimental Setup

Diagram showing the experimental setup with labeled components:
- To ion trap
- Interferometer
- He-Ne calibration laser
- 493 nm laser
- 650 nm laser
- Dichroic mirror
- AOMs
- Beam samplers
Schematic of Blue Laser
Schematic of Red Laser
Current state of Ba-tagging

• SHG doubling not operational on blue laser
• Tapered Amplifier not operational on red laser
• Another experiment in the lab was in the way of the ion trap
• Pumps for the ion trap missing
Conclusion

• Gained experience working individually/in a small team
• Gained experience with the hardware aspect of physics
• Learned about theory and operation of lasers
• Learned about application of quantum mechanics
Thanks for listening!