Controlling relaxation of nuclear spin qubit ensembles for a more sensitive search for axion-like dark matter

Janos Adam
17.06.2021
Boston University
PATRAS 2021
Future phases of CASPEr-Electric

**CASPEr-Electric Gen 1 results**

![Graph showing Compton frequency vs. mass](image)

**Future generations**


**How to increase sensitivity further?**

- Bigger sample (80 cm)
- **Increase Polarization**

\[ p = \frac{n_\uparrow - n_\downarrow}{n_\uparrow + n_\downarrow} \sim \frac{\mu B}{k_B T} \sim 10^{-4} \]
Future phases of CASPER-Electric

How to increase sensitivity further?
- Bigger sample (80 cm)
- Increase Polarization

\[ p = \frac{n_1 - n_\uparrow}{n_1 + n_\downarrow} \sim \frac{\mu B}{k_B T} \sim 10^{-4} \]

By shining laser we can create transient paramagnetic centers

Dynamic Nuclear Polarization (DNP)
DNP is transmitting polarization from electrons to nuclei

Decrease temperature

BUT...
Our sample doesn’t have unpaired electron spins

BUT...
T1 (spin-lattice relaxation) becomes long (~ hours)


Reduction of relaxation time by paramagnetic centers

Detecting light induced paramagnetic centers using electron paramagnetic resonance (EPR)

EPR spectrum of PMN-PT at 10K, 9.4 GHz, illuminated by 405 nm

Signal around $g = 2$ only if illuminated

Extracted parameters:
Spin density, relaxation times

[Manuscript in preparation]
Reduction of relaxation time by paramagnetic centers

Detecting light induced paramagnetic centers using electron paramagnetic resonance (EPR)

EPR spectrum of PMN-PT at 10K, 9.4 GHz, illuminated by 405 nm

Signal around $g = 2$ only if illuminated

Extracted parameters:
Spin density, relaxation times

Spin relaxation time measurement of $^{207}$Pb nuclear spins at 4K

$T_1^{\text{dark}} = 20.2 \pm 1.9 \text{ min}$
$T_1^{\text{light}} = 13.2 \pm 0.4 \text{ min}$

Estimate is consistent with observation

M. Goldman, Phys. Rev. 138, A1675 (1965)

We are able to control nuclear relaxation time by light-induced transient paramagnetic centers
Thank you!

Contact:
janadam@bu.edu