Magnetic Shielding for Neutron EDM Experiment

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$10^{-26} \text{ e.cm}$

Really?

10^{-32} \text{ e.cm}

$0 \text{ e.cm}$

Closest Experimental Approximation

Expected!!!

Standard Model

$\vec{d} = \vec{q} \cdot \vec{D}$
Why to study neutron EDM?

1. Violation of Parity Transformation

\[ \vec{r} = (x, y, z) \xrightarrow{\hat{P}} -\vec{r} = (-x, -y, -z) \]

2. Violation of T-Symmetry

\[ \hat{T} \mid \psi(x, t) \rangle \geq \mid \psi(x, -t) \rangle \]

So what???
Big Bang!!!!!
How to Measure?

$10^{-28}_{} e.cm$

Torque due to magnetic field:

$$\vec{\tau}_B = \vec{\mu}_n \times \vec{B}_0$$

Torque due to electric field:

$$\vec{\tau}_E = \vec{d}_n \times \vec{E}_0$$

Experimentally,

$$\vec{\tau}_B \neq \vec{\tau}_E$$
Larmor Precession

\[ \nu_n = -(2\mu_n B_0 \pm 2d_n E_0) / h = \nu_0 \pm \Delta \nu \]

When \( E_0 = 0 \),

\[ \nu_0 = -(2\mu_n B_0) / h \]

When \( E_0 \neq 0 \),

\[ \Delta \nu = 2d_n E_0 / h \]

and, \( B_0 \ll \ll 1 \)

\[ B_0 \approx 2 \times 10^{-11} \text{ Gauss} \]

N.B. Earth’s Magnetic Field = 0.5 Gauss
\[ \frac{d}{2} = 0.5445a \]
Length of square coil \((2a)\) = 2.445m
Distance between two coils \((d)\) = 1.3313025m
Coil Turns = 70
Total Resistance = 46.2\(\Omega\)
\[ I = 84A \rightarrow B_z = 0.5286 \text{ gauss} \]
Magnetic Shielding Cylinders

\[ \text{Shielding} (s) = \frac{\text{External Field}}{\text{Shielded Field}} \]

Source: mumetal.co.uk
Metglas Cylinders

Metglas Cylinder Mapping:

Magnetic Field Mapping (Along Z) in Metglas Cylinder
\( (x=y=0) \)

- With 1 Layer Circumferential Stripes
- With 2 Layer Circumferential Stripes (inside) and Axial Stripes (outside)
- With Larger Cylinder with Circumferential Stripes
- 2 Layers Metglas with added 4th loop

Magnetic Field Mapping (Transverse) in Metglas Cylinder
\( (x=y=0) \)

- With 1 Layer Circumferential Stripes
- With 2 Layer Circumferential Stripes (inside) and Axial Stripes (outside)
- With Larger Cylinder with Circumferential Stripes
- 2 Layers Metglas with added 4th loop
Mumetal Cylinders

Magnetic Field Mapping (Along Z) in Mumetal Cylinder
(x=y=0)
Feedback Loop

\[ \Delta B = \frac{\mu_0 \Delta I}{4\pi} K \]
Feedback Loop

\[ B_z = -1.148 \times 10^{-6} \text{ G} \]
Max: \(1.01 \times 10^{-5}\text{G}\)
Min: \(1.463 \times 10^{-10}\text{G}\)
Feedback Loop

Feedback Loop Testing: Run at 0.2 sec wait time

Feedback Loop Testing: Run at 0.2 sec wait time

Background Magnetic Field (Bz) Reading
1. The LabVIEW software was successfully used for developing a program that would be able to manipulate the probe motion and reading as desired.

2. A square Helmholtz coil was successfully constructed to cancel out the earth’s magnetic field across its center.

3. Magnetic field shielding with Metglas and Mu metal shields combinations were studied.

4. Feedback loop with the optimal wait time of 0.215 seconds and that would be able to cancel out the field to the level of $10^{-10}$ gauss was developed.
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Questions???