PROGRESS TOWARDS THE FIRST MEASUREMENT OF THE DEUTERON ELECTRIC DIPOLE MOMENT AT COSY

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MATTER-ANTIMATTER ASYMMETRY

\[
\frac{n_b - n_{\bar{b}}}{\gamma} = (6.14 \pm 0.25) \cdot 10^{-10} \quad (\text{WMAP 2003})
\]

\[
\frac{n_b - n_{\bar{b}}}{\gamma} \sim 10^{-18} \quad \text{according to the SM}
\]

A. Sakharov (1967) for baryogenesis:

C, CP violation \rightarrow EDM
ELECTRIC DIPOLE MOMENT

EDM violates both T, P symmetries

EDM violates CP symmetry
(CPT conserved)

EDM is a probe for CP violation beyond the SM

Towards the first deuteron EDM measurements at COSY

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THOMAS - BMT EQUATION

\[
\frac{d \vec{S}}{dt} = \vec{\Omega} \times \vec{S} = -\frac{q}{m} \left\{ G \gamma \vec{B} + \left( \frac{1}{\gamma^2 - 1} - G \right) \vec{\beta} \times \vec{E} c + \frac{d}{q \hbar S} (\vec{E} + c \vec{\beta} \times \vec{B}) \right\} \times \vec{S}
\]

At storage rings: vertical \( B \) field, radial \( E \) field

MDM causes fast spin precession in horizontal plane

EDM causes slow spin rotation out of horizontal plane, up and down

In pure magnetic ring (COSY) motional electric field \((c \vec{\beta} \times \vec{B})\)

↓

access to EDM

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EDM AT COSY

COSY (Jülich, Germany)

- magnetic storage ring
- polarized protons and deuterons up to 3 GeV/c

Starting point for direct deuteron EDM measurement

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EFFECT ON PRECESSION AXIS

EDM absence case

EDM effect

Magnetic misalignment effect

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MEASURING METHOD

In the magnetic ring
momentum ↑↑ spin → spin kicked up
momentum ↑↓ spin → spin kicked down
no accumulation of vertical asymmetry

tiny oscillations of vertical polarization with amplitude of $10^{-10}$

RF Wien filter
*Heberling, Hölscher and J. Slim*

- Lorentz force $\vec{F}_L = q(\vec{E} + \vec{v} \times \vec{B}) = 0$
- $\vec{B} = (0, B_y, 0)$ and $\vec{E} = (E_x, 0, 0)$

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POLARIZATION BUILD-UP

- Wien filter operated with B filed normal to the ring plane
- \( \alpha(t) = \arctan \left( \frac{P_y}{P_{xz}} \right) \)
- Observed initial slopes of polarization build-up varied of Wien filter and solenoid rotations
- Observed slopes correspond to the EDM of \( d \sim 10^{-17} \ e \cdot cm \)
• Wien filter operated with B field normal to the ring plane

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FIRST RESULTS

Orientation of precession axis at location of RF Wien filter determined from the minimum of the surface

Spin tracking calculations are going to provide the orientation of spin precession axis without EDM

Towards the first deuteron EDM measurements at COSY

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SUMMARY

- EDM measurements are needed for understanding the source of CP violation
- First measurement of deuteron EDM is performed at COSY
- Experiment performed is a proof of principal of EDM measurement at storage rings
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THANK YOU!