Search for Axion-Like Particles with Polarized Beams at Storage Rings

Daoning Gu on behalf of the JEDI Collaboration

1. III. Physikalisches Institut B, RWTH Aachen University, Aachen, Germany, 2. Forschungszentrum Jülich, Jülich, Germany, 3. GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany.

Introduction

❖ In storage rings with polarized beams:

Axion/ALP field → Oscillating electric dipole moment (oEDM)

❖ Spin motion in storage rings:

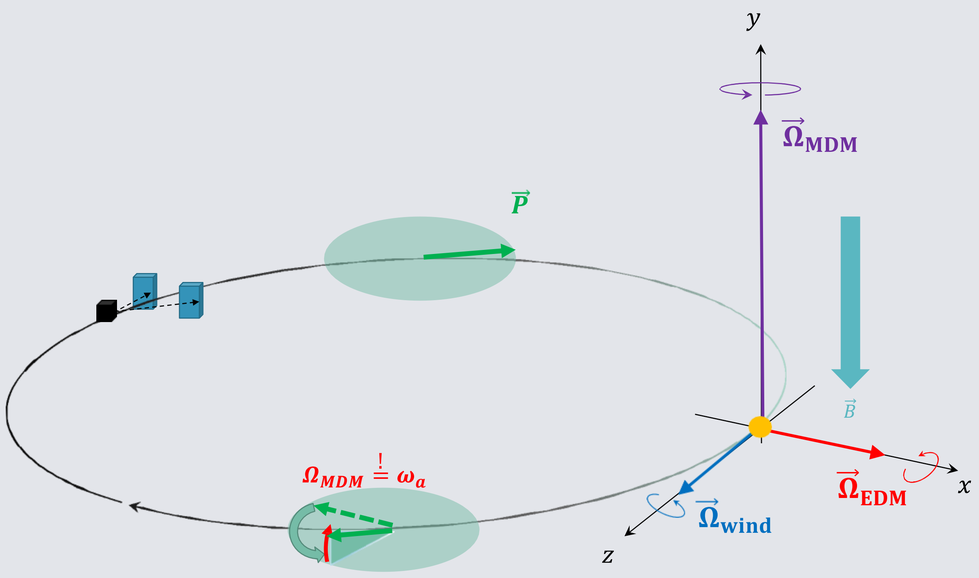
$$\frac{d\vec{s}}{dt} = \left(\vec{\Omega}_{MDM} + \vec{\Omega}_{EDM} + \vec{\Omega}_{wind}\right) \times \vec{s}$$

$$\vec{\Omega}_{MDM} = -\frac{q}{m} G\vec{B}, \qquad \vec{\Omega}_{EDM} = -\frac{1}{S\hbar} dc\vec{\beta} \times \vec{B}.$$

$$d = d_{DC} + d_{AC}\cos(\omega_a t + \varphi_o)$$

oEDM induced by axion field

Experimental Method

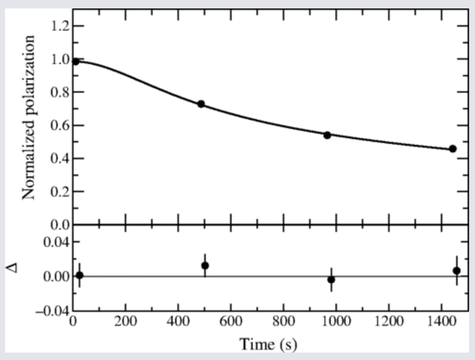


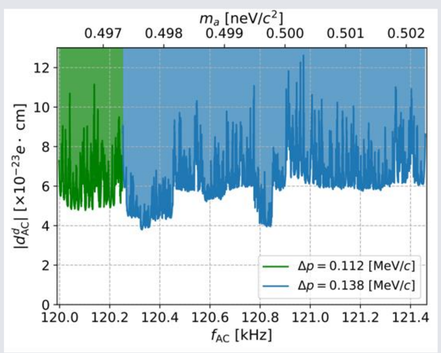
❖ Store polarized hadrons.

❖ Preserving the polarization is a prerequisite (long SCT).

❖ If $m_a c^2 \equiv \hbar\omega_a = \Omega_{MDM}\hbar$, polarization will turn out of the horizontal plane, resulting in a vertical polarization.

❖ First proof-of-principle experiment was performed with a polarized deuteron beam at COSY, Forschungszentrum Jülich.





Spin Coherence Time (SCT)

❖ Spin tune: $\nu_s = G\gamma$.

❖ SCT = time after total polarization drops to 1/e.

❖ Depolarization sources.

❖ Optimization:

① Electron cooling.

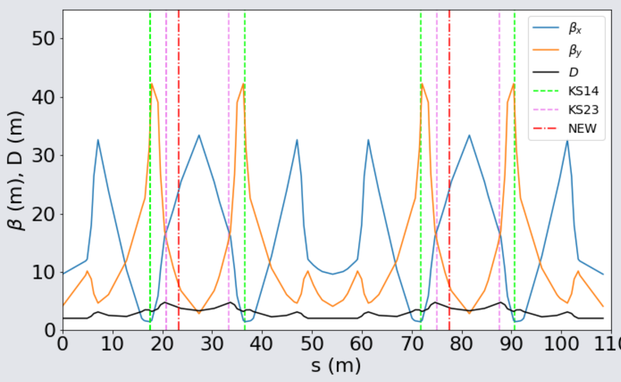
② Beam bunching.

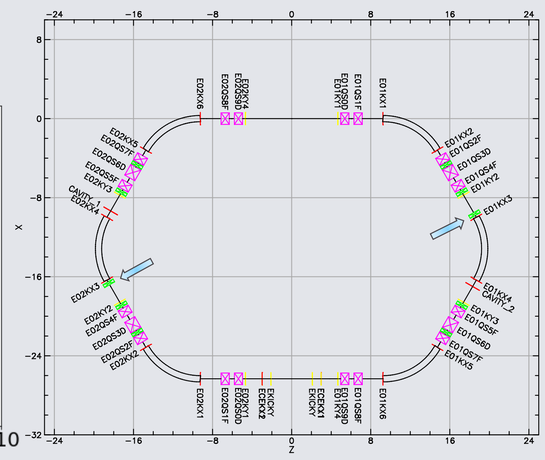
③ Sextupole correction.

At injection

After some time

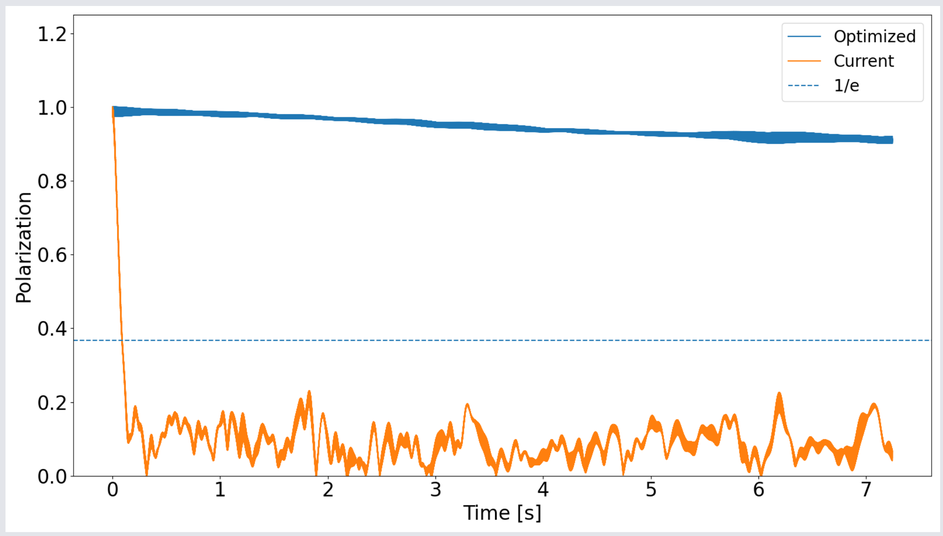
Simulation of ESR@GSI



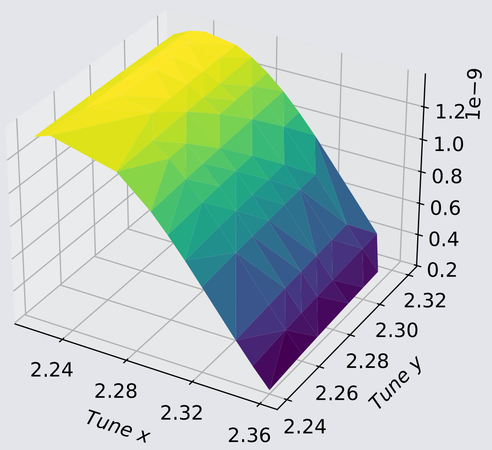


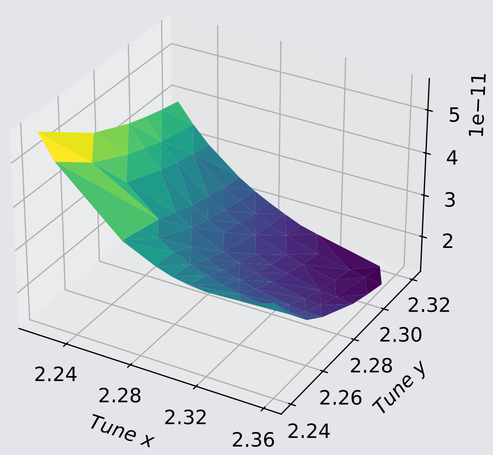
❖ At least 3 groups of sextupole are needed to correct betatron motions and momentum deviations, located at the large β_x , β_y and dispersion D, respectively.

❖ By adding a new group of sextupole, a long SCT was obtained.



❖ Investigation of betatron tunes: unknown higher order effects.





References

1. Stoehlker, T., et al. "Towards experiments with polarized beams and targets at the GSI/FAIR storage rings." 19th Workshop on Polarized Sources, Targets and Polarimetry (PSTP2022). 2023.
2. Guidoboni, G., et al. "How to Reach a Thousand-Second in-Plane Polarization Lifetime with 0.97-GeV/c Deuterons in a Storage Ring." Phys. Rev. Lett. 117 (2016): 054801.
3. Karanth, S, et al. "First Search for Axion-Like Particles in a Storage Ring Using a Polarized Deuteron Beam." Physical Review X 13 (2023): 031004.

daoning.gu@rwth-aachen.de