EUCARD workshop ”Search for the electron EDM in an electrostatic storage ring”

Thursday 10 September 2015 - Friday 11 September 2015

Mainz

Book of Abstracts

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Beam and Spin Dynamics for Charged Particle EDM Searches in Storage Rings

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Permanent EDMs (electric dipole moment) of fundamental particles violate both time invariance T and parity P. Assuming the CPT theorem this implies CP violation. The Standard Model predicts non-vanishing EDMs, their magnitudes, however, are expected to be unobservably small with current techniques. Hence, the discovery of a non-zero EDM would be a signal for "new physics".
As a first step towards EDM searches of charged particles in storage rings, R&D work at the Cooler Synchrotron COSY is pursued. Subsequently, a first direct EDM measurement of a charged particle will be performed at COSY, and, on a longer time scale, the design and construction of a dedicated storage ring will be carried out.
Full spin-tracking simulations of the entire experiment are absolutely crucial to explore the feasibility of the planned storage ring EDM experiments and to investigate systematic limitations. Existing spin tracking programs like COSY Infinity have to be extended to properly simulate spin motion in presence of an EDM. In addition, benchmarking experiments are performed at the Cooler Synchrotron COSY to check and to further improve the simulation tools.

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Development of a Rogowski Coil as a new Beam Position Monitor

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So far there have been no direct Electric Dipole Moment (EDM) measurements for charged hadrons. Therefore, a direct measurement of non-zero EDMs would be a first indication for physics beyond the Standard Model.
A first step of the JEDI collaboration towards a precursor experiment for an EDM measurement is the development of new high-precision Beam Position Monitors (BPMs) for hadrons and testing them in the laboratory and at the storage ring COSY (COoler SYnchrotron) in Jülich.
The first results from a measurement at COSY with a Rogowski Coil as a horizontal BPM will be presented.

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Electrostatic deflector development for JEDI

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The direct measurement of the proton or deuteron electric dipole moment has never been performed before. These experiments can be done at storage rings. As a starting point for a first measurement,

the pure magnetic storage ring COSY at Forschungszentrum Jülich can be used. A deticated stroage ring will require electrostatic elements. For testing the electrode material, shape, surface treatment and high voltage tests, a new laboratory was set up at Aachen University. The Aachen laboratory, experimental setup and first tests will be presented.

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Figures of merit for Mott polarimetry

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In the medium relativistic region (1.05< gamma < 100),
Mott polarimetry is a suitable method to detect electron polarisation. The figure of Merit of such polarimeters is discussed with respect to other polarimeters such as Möller or Compton absorbers

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Magnetic Shielding Issues in the Field of EDM Research

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The effect of the ubiquitous static and dynamic magnetic fields may easily mask the signals due to the electric dipole moment in EDM investigations, because of the dominant magnetic dipole moment of the particles. For the reduction of the impact of magnetic fields on the experiment it has to be shielded by a solid magnetic enclosure, a surrounding actively-controlled coil array, or a combination of both. The talk will highlight several aspects of magnetic shielding and its effectiveness for EDM experiments.

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Optimal Momentum for an eEDM Experiment

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I will discuss the optimal momentum for an electron EDM experiment. The so-called magic momentum is when we freeze the spin precession due to the magnetic moment with only an electric field. The electron magic momentum is 15 MeV/c. At other momenta, we need both an electric and a magnetic field to freeze the spin precession due to the magnetic moment. The motional electric field is E + vxB. Below the magic momentum, these two terms have the same sign, while above they have opposite signs. The spin precession due to an edm (d) is d x(E + vxB). Thus for momenta lower than the magic momentum, we get greater spin precession due to the edm than at the magic momentum. I will discuss this and lattice issues, systematics, etc. vs. the electron momentum.

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Potential for a search for a cartan spacetime torsion and a CPT violation in gravity in an electrostatic electron storage ring

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Electrostatic (all-electric) storage rings are very appropriate for a search for EDMs of particles and nuclei with g>2. We propose other applications of such rings. Strong reduction of g-2 spin rotations in these rings allows one to use them for a measurement of the spin-rotation coupling in the Earth's rotating frame and significantly improves conditions of such a measurement as compared with earlier propositions [1]. The angular frequency of the spin rotation about the vertical axis Ω affected by the frame rotation and by the Coriolis force depends on the geographical latitude. If a Cartan spacetime torsion is nonzero, it changes the spin-rotation coupling. A long spin coherence time makes it possible to measure Ω with a high precision and to establish a new bound on the torsion. For example, the precision of 7X10^{-9} rad/s improves the current bound by two orders of magnitude. For this purpose, the g-2 spin rotation should be compared for clockwise and counterclockwise beams.

The use of the electrostatic electron storage ring presents also a possibility to perform the first experiment on a check of the CPT conservation in gravity. For this purpose, g-2 experiments with positrons with the same momentum should be also carried out. A CPT violation leads to a difference of g-2 frequencies for electrons and positrons.

The work is supported by the BRFFR and by the Heisenberg-Landau program.

[1] A.J. Silenko and O.V. Teryaev, Phys. Rev. D 76, 061101(R) (2007).

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Storage Ring EDM Measurement Using Resonant Polarimetry

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It is proposed to use a resonant cavity sensitive to the magnetization of a polarized beam for polarimetry in storage ring EDM measurements. "Rolling" the beam polarization of a nearly frozen spin beam around a radial axis has two essential features. It preserves the EDM effect (as a shift in roll rate) and (the reason for inducing the roll) it shifts the frequency of the magnetization signal away from the nearest revolution frequency harmonic. This is essential for distinguishing the magnetization signal from a potentially much larger direct Coulomb-induced response of the resonator. Resonant polarimetry is passive and non-destructive and has ideal analysing power. Being coherent, a resonant polarimeter can be used to stabilize one degree of freedom of the beam polarization. The roll is imposed on the beam polarization by a reversible Wien filter. Assuming the reversal is perfect, the backward/forward roll rate difference provides a frequency domain measure of the pa
rticle EDM

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The MESA project and its electron polarimeters

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The electron edm as a Sensitive Probe of Higgs CP Violation

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Summary:

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What can we learn from an electron storage ring EDM

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I will present the motivations for building an electron all-electric storage ring. One can test a number of systems, e.g., the SQUID-based beam position monitors, button-based beam position monitors, beam dynamics, fringe field issues, beam-beam effects, etc. Several ideas of measuring the electron polarization are already presented which, if successful, will allow testing issues like spin coherence time, fringe-field effect on polarization, etc

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design a symplectic tracking of an electrostatic storage ring for EDM search

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we designed using MADX an electrostatic ring for EDM, and performed symplectic tracking of orbits and spin of the same using a leapfrog algorithm

Summary:

We designed a FODO lattice of an electrostatic storage ring for EDM work using MADX, modified to accept electric bends and multipoles. We performed, to a first order a MADX matrix tracking for orbit and a SPINK tracking of the spin and then a symplectic tracking using a leapfrog integrator of the diffrential equations of motion and spin. We will discuss in detail the leapfrog algorithm. The code has been written to be run on a cluster computer to track a full beam of particles. The issue of spin polarization coherence time is in particular discussed.

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electron spin measurements by undulator radiation

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Synchrotron radiation by particles with spin show a contribution due to the spin. In particular from the line spectrum of radiation produced by an udulator the components of the spin can be measured. This mechanism can be effectively used in electron EDM measurements.

Summary:

Spin of electrons has been beasured in LEP at CERN using a laser beam backscatterd from an electron beam. The pbysical mechanism of laser backscattering is the same af that of undulator produded sinchrotron radiation. Using an undulator is a simple way to measure the components of spin, and therefore a possible EDM of particles stored in an electric storage ring. Since the radiadition intensity is inversely proportional to the square of the mass of the particles, its use on an electron beam is particularly promising. We will show the line spectrum of undulator radiation from such an electron beam and calculation of the intensity of the radiation