HK 28: Fundamentale Symmetrien

Zeit: Dienstag 14:00–16:15 Raum: HSZ-103

Gruppenbericht HK 28.1 Di 14:00 HSZ-103

Measurement of Electric Dipole Moments of Charged Particles in Storage Rings — •Jörg Pretz for the JEDI-Collaboration — RWTH Aachen University, FZ Jülich

Permanent Electric Dipole Moments (EDMs) of fundamental particles violate both time invariance and parity symmetry. Assuming that the CPT theorem holds this implies also CP violation. The CP violation of the Standard Model is orders of magnitude too small to be observed experimentally in EDMs in the foreseeable future. It is also way too small to explain the asymmetry in abundance of matter and anti-mattter in our Universe. Hence, other CP violating mechanisms outside the realm of the Standard Model are searched for and could result in measurable EDMs.

EDM experiments with charged hadrons are proposed at storage rings where polarized particles are exposed to an electric field. If an EDM exists the spin vector will experience a torque resulting in a change of the original spin direction which can be determined with the help of a polarimeter. Although the principle of the measurement is simple, the smallness of the expected effect makes this a challenging experiment requiring new developments in various experimental areas.

Complementary efforts to measure EDMs of proton, deuteron and light nuclei are pursued at Brookhaven National Laboratory and at Forschungszentrum Jülich with with an ultimate goal to reach a sensitivity of $10^{-29}e\cdot$cm.

Gruppenbericht HK 28.2 Di 14:30 HSZ-103

The hyperfine structure of antihydrogen — •Eberhard Widmann — Stefan-Meyer-Institut, Wien, Österreich

Low-energy antiprotons are an ideal tool to study fundamental symmetries, especially CPT symmetry, by the precision spectroscopy of exotic atoms containing an antiproton. The investigation of the hyperfine structure of such atoms allows first of all the determination of the antiproton magnetic moment, the most precise value of which was obtained recently by the ASACUSA collaboration at the Antiproton Decelerator of CERN, albeit with a precision of order 10^{-3}.

As a next step, ASACUSA is preparing an experiment to measure the ground-state hyperfine structure GS-HFS of antihydrogen, which promises much higher accuracy because the corresponding quantity for hydrogen is measured to relative precision of 10^{-12} in the hydrogen maser. In a first phase a beam of polarized antihydrogen atoms formed by a so-called cusp trap will be used, which will allow the determination of the GS-HFS to better than 10^{-6}. This accuracy will already be enough to observe an influence of the finite size of the antiproton, provided the magnetic moment of the antiproton is measured independently in a Penningtrap, as it is planned by two other groups at the AD. In a second phase the Ramsey method of separated oscillatory fields will be used to increase the precision by one order of magnitude.

HK 28.3 Di 15:00 HSZ-103

A highly sensitive ^{3}He-Magnetometer for the future n2EDM-Experiment at Paul Scherrer Institut, Switzerland — •Stefan Zimmer[1], Werner Heil[1], Hans-Christian Koch[1,2], Andreas Kraft[1], and nEDM collaboration[3] — [1]Institut für Physik, Universität Mainz — [2]University of Fribourg — [3]PSI

The measurement of the electric dipole moment of the free neutron (nEDM) is directly linked to the question of an accurante determination of the magnetic field conditions inside the nEDM spectrometer. The method is based on monitoring the free spin precession of nuclear polarized ^{3}He by means of optically pumped Cs-magnetometers. The sensitivity to trace tiny magnetic field fluctuations during a typical Ramsey-cycle of 200s reaches the fTesla level. The talk gives an status report on our ^{3}He magnetometer consisting of a compact ^{3}He polarizer- and compressor-unit, a transfer-line for the hyperpolarized gas into the μ-metal shield which houses the actual nEDM spectrometer with its two flat cylindrical magnetometer vessels sandwiching the double chambers for ultracold neutrons storage.

HK 28.4 Di 15:15 HSZ-103

A novel approach to measure the electric dipole moment of ^{129}Xenon — •Florian Kuchler, Peter Fierlinger, and David Wurm — Excellence Cluster "Universe", Technische Universität München, Boltzmannstr. 2, 85748 Garching

Permanent electric dipole moments (EDM) are promising systems to find new CP violation. The properties of the diamagnetic atom ^{129}Xe make it a particularly interesting candidate for an EDM search, as it enables new experimental strategies. Although the current experimental limit of $d_{Xe} < 4.0 \cdot 10^{-27}$ ecm is many orders of magnitude higher than the Standard Model (SM) prediction, theories beyond the SM usually require larger EDMs.

Our experiment is based on microscopic hyper-polarized liquid xenon droplets, placed in a low-field NMR setup. Employing superconducting pick-up coils and highly sensitive LTc-SQUIDs for detection of the xenon spin precession we aim to increase the sensitivity to an EDM of ^{129}Xe by three orders of magnitude.

Implementation of rotating electric fields enables a conceptually new EDM measurement technique, allowing thorough investigation of systematic effects. Still, a Ramsey-type spin precession experiment with static electric field can be realized at similar sensitivity within the same setup.

The talk will give both an overview of the xenon EDM experiment and an update on the experimental status.

HK 28.5 Di 15:30 HSZ-103

^{3}He-^{129}Xe-Comagnetometer: Search for a Lorentz-violating background field — •Fabian Allmendinger[1], Ulrich Schmidt[1], Werner Heil[2], Sergei Karpuk[2], Anja Scharth[2], Yuri Sobolev[2], Kathlynne Tullney[2], Martin Burghoff[3], Wolfgang Kilian[3], Silvia Knappe-Grüneberg[3], Allard Schnabel[3], Frank Seifert[3], and Lutz Trahms[3] — [1]Physikalisches Institut, Universität Heidelberg — [2]Institut für Physik, Universität Mainz — [3]PTB Berlin

The minimal Standard Model Extension (SME) of Kostelecký et al. is a low energy effective field theory including operators which break Lorentz symmetry. It predicts an energy shift of nuclear spin states depending on the orientation of the spins relatively to a hypothetical Lorentz-violating background field. Our search for this effect is based on the measurement of free precession of nuclear spin polarized ^{3}He and ^{129}Xe atoms in a homogeneous magnetic guiding field of about 400 nT using LT_C SQUID detectors. As the laboratory frame rotates with the earth, a Lorentz-violating background field would cause a sideral modulation of the precession frequencies. ^{3}He-^{129}Xe-comagnetometry is used to cancel magnetic field drifts. The setup is placed in a strongly magnetically shielded room at the Physikalisch-Technische Bundesanstalt (PTB) in Berlin, allowing long coherence times of several hours for both gases. In this talk we will present the principle of measurement and current results.

HK 28.6 Di 15:45 HSZ-103

Experimental search for the electric dipole moment (EDM) of ^{129}Xe in ^{3}He/^{129}Xe clock-comparison experiments — •Anja Scharth[1], Werner Heil[1], Sergei Karpuk[1], Yury Sobolev[1], Kathlynne Tullney[1], Fabian Allmendinger[2], Ulrich Schmidt[2], Martin Burghoff[3], Wolfgang Kilian[3], Allard Schnabel[3], Frank Seifert[3], Lutz Trahms[3], Olivier Grasdijk[4], Klaus Jungmann[4], and Lorenz Willman[4] — [1]Institut für Physik, Universität Mainz — [2]Physikalisches Institut, Universität Heidelberg — [3]PTB Berlin — [4]University of Groningen

Permanent atomic EDMs would imply a breakdown of both parity and time reversal symmetry and therefore lead to a violation of CP symmetry. Thus searches for the EDM of ^{129}Xe are an unambiguous method to test physics beyond the standard model. Our approach is to use co-located ^{3}He/^{129}Xe spin samples and to measure their coherent spin-precession over extended periods of $\sim$ 1 day, typically. Based on our experience with measurements on Lorentz-invariance [1,2], we intend to reach a measurement sensitivity that will improve the present upper limit $d_{Xe} = 3 \cdot 10^{-27} e \cdot cm$ significantly. Phase I of this experiment will be performed in the magnetically shielded room BMSR-2 of the PTB Berlin using very sensitive SQUID gradiometers as magnetic flux detectors and electric fields of ≈2 kV/cm. The experimental setup and current status of work will be presented.

[1] C.Gemmel et al., Eur. Phys. J D 47, 303 (2010)
[2] C.Gemmel et al., Phys. Rev D 82, 111901(R) (2010)

HK 28.7 Di 16:00 HSZ-103

Test of Time-Reversal Invariance at COSY (TRIC) — Dieter Eversheim[1], •Yury Valdau[2], and Bernd Lorentz[2] — [1]Helmholtz

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At the Cooler Synchrotron COSY a novel (P-even, T-odd) null test of time-reversal invariance to an accuracy of 10^{-6} is planned as an internal target transmission experiment. The parity conserving time-reversal violating observable is the total cross-section asymmetry $A_{y,xz}$. This quantity is measured using a polarized proton beam with an energy of 135 MeV and an internal tensor polarized deuteron target from the PAX atomic beam source. The reaction rate will be determined by the lifetime of the beam. Thus, in this experiment the cooler synchroton ring serves as an ideal forward spectrometer, as a detector, and an accelerator. First steps of the experimental set-up are discussed.