T 105: Search for new particles 6

Time: Friday 9:00–10:30 Location: Geb. 20.30: 1.067

T 105.1 Fri 9:00 Geb. 20.30: 1.067

The Search for Electric Dipole Moments of Charged Particles in Storage Rings — •Achim Andres for the JEDI-Collaboration — IKP, Jülich, Germany

The matter-antimatter asymmetry in the universe, unexplained by the Standard Model of elementary particle physics, requires CP-violating phenomena, as proposed by A. Sakharov. Subatomic elementary particles with Permanent Electric Dipole Moments (EDMs) violate time reversal and parity asymmetries, implicating CP violation if the CPT theorem holds. In addition, the axion or axion like particles (ALPs), initially proposed to explain CP violation in quantum chromodynamics and potentially constituting dark matter, induce an oscillating Electric Dipole Moment (EDM) along the spin direction when coupled with gluons.

The Cooler Synchrotron COSY at Forschungszentrum Jülich provides polarized and unpolarized protons and deuterons up to a momentum of 3.7 GeV/c and serves as an ideal platform for the JEDI - Collaboration (Jülich Electric Dipole moment Investigations) to conduct the first direct measurement of the permanent deuteron EDM by observing its influence on spin motion. In addition to this measurement of the static EDM, upper limits of the oscillating deuteron EDM due to Axions or ALPs have been measured. Both effects result in a build-up of a vertical polarization component which can be measured with a polarimeter. This presentation will describe both the permanent EDM and the oscillating axion-induced EDM experiments.

T 105.2 Fri 9:15 Geb. 20.30: 1.067

King Plots: Constraining New Physics using Isotope Shift Spectroscopy — •Agnese Mariotti[1], Erik Benkler[2], Julian Berengut[8], Shuying Chen[2], Jose R. Crespo Lopez-Urrutia[3], Melina Filzinger[2], Elina Fuchs[1,2,4], Nils Huntemann[2], Steven A. King[2], Fiona Kirk[2], Nils H. Rehbehn[3], Jan Richter[2], Matteo Robbiati[4,6,7], Micheal K. Rosner[3], Piet O. Schmidt[2,5], Lucas J. Spiess[2], Andrey Surzyhkov[2], Anna Viatkina[2], Malte Wehrheim[2], Alexander Wilzewski[2], Diana A. Craik[9], Jeremy Flannery[9], Jonathan Home[9], Luca Huber[9], Roland Roland[9], Menno Door[3], Klaus Blaum[3], and Martin R. Steinel[2] — [1]LUH-ITP — [2]PTB — [3]MPI — [4]CERN — [5]LUH-IQ — [6]TIF Lab — [7]TII — [8]UNSW — [9]ETH/TBD

With 95% of the universe's content still unexplained by modern physics, the motivations for new physics searches are becoming more and more evident. The approach used in our work exploits the high precision of low-energy experiments to identify deviations from the theoretical predictions of the Standard Model. We utilize a combination of isotope shift measurements and King plots, which allows to minimize the required theoretical input and is sensitive to a new interaction that couples electrons and neutrons. A wise combination of experimental data enables us to set strong constraints on such coupling. Here, we show how we improve the previous bounds by building King plots with the recent measurement of isotope shift in Ca14+, carried out at PTB. Additionally, we present two ways of utilizing the available data: a geometrical approach and a fitting method.

T 105.3 Fri 9:30 Geb. 20.30: 1.067

Search for new light bosons with the KATRIN experiment — •Joscha Lauer for the KATRIN-Collaboration — Karlsruhe Institute of Technology (KIT)

The Karlsruhe Tritium Neutrino (KATRIN) experiment is designed to measure the effective electron antineutrino mass with a sensitivity better than $m_\nu c^2 = 0.3\,\mathrm{eV}$ (90% C.L.) in a kinematic approach by applying precision electron spectroscopy to the beta decay of molecular tritium. This determination occurs in the spectral endpoint (E_0) region, i.e. up to some tens of eV below $E_0 \approx 18.6\,\mathrm{keV}$.

Light neutral pseudoscalars and vector bosons arise in many theories beyond the Standard Model (BSM). Constraints on the couplings of such particles to neutrinos or electrons can be derived from cosmological, astrophysical and laboratory observations. High-statistics beta spectroscopy with KATRIN is a complementary probe for these new physics theories; with light bosons emitted in tritium beta decay, the spectrum is altered as described in JHEP 01 (2019) 206. This talk introduces possible interactions of light BSM bosons with their imprint on the observed electron spectrum. We estimate the sensitivity of the second KATRIN measurement campaign to the light boson couplings.

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T 105.4 Fri 9:45 Geb. 20.30: 1.067

New physics searches with the precision spectroscopy of highly charged ions — •Matteo Moretti, Zoltan Harman, and Christoph H. Keitel — Max Planck Institute for Nuclear Physics, Heidelberg, Germany

High-precision spectroscopy of bound-electron systems enables searches for new physics. The comparison of precisely measured observables such as transition energies or g factors with sufficiently accurate quantum electrodynamic (QED) calculations allows in principle the isolation of effects due to physics beyond the Standard Model. Recently, such a procedure was applied to set a bound on the coupling constant of a massive scalar boson exchanged between an electron and a nucleon [1,2]. Here we develop a one-particle exchange interaction among two bound electrons in a highly charged ion. The simplest way to treat this interaction is through the involvement of a massive scalar particle among electrons in the $1s$–$2s$ states. The correction due to this effect to g factor is evaluated for three-electron ions, i.e. for the simplest electronic systems possessing net electron spin. For such ions, both QED theory and experiment are on a high level of sophistication, therefore, we anticipate competitive bounds for the coupling constant. Further studies are being performed for pseudo-scalar, vector and axial-vector exchange bosons. – [1] V. Debierre, C. H. Keitel, Z. Harman, Phys. Lett. B **807**, 135527 (2020); [2] T. Sailer, V. Debierre, Z. Harman, *et al.,* Nature **606**, 479 (2022).

T 105.5 Fri 10:00 Geb. 20.30: 1.067

Fifth-force searches with the bound-electron *g* factor — •Zoltan Harman, Vincent Debierre, and Christoph H. Keitel — Max Planck Institute for Nuclear Physics, Heidelberg, Germany

The use of high-precision measurements of the g factor of one- and few-electron ions and its isotope shifts is put forward as a probe for beyond Standard Model (BSM) physics [1]. The contribution of a hypothetical new force to the g factor can be calculated for H-like, Li-like and B-like ions, and employed to derive bounds on the parameters of such a force. This procedure makes use of the high level of sophistication reached in the evaluation of QED contributions to the g factor of highly charged ions [2]. The weighted difference, and, particularly, the isotope shift of g factors are used to increase the experimental sensitivity to the new physics contribution. We have found that a recent Penning-trap measurement of the isotopic shift of the g factor of the isotopes $^{20}\mathrm{Ne}^{9+}$ and $^{22}\mathrm{Ne}^{9+}$ to sub-parts-per-trillion precision relative to their g factors offers a promising alternative approach to set bounds on BSM interactions [3]. Furthermore, it is found that, combining measurements from different isotopes of H-like, Li-like and B-like ions [1] at accuracy levels projected to be accessible in the near future, experimental results would constrain the new physics coupling constant further than the best current atomic data and theory. – [1] V. Debierre, C. H. Keitel, Z. Harman, Phys. Lett. B **807**, 135527 (2020); [2] J. Morgner, B. Tu, C. M. König, *et al.,* Nature **622**, 53 (2023); [3] T. Sailer, V. Debierre, Z. Harman, *et al.,* Nature **606**, 479 (2022).

T 105.6 Fri 10:15 Geb. 20.30: 1.067

Sensitivity of magnetic monopole detection at the Belle II PXD — •Matthäus Krein, Katharina Dort, and Sören Lange — Justus-Liebig-University, Gießen, Germany

Particles with isolated magnetic charge, so-called magnetic monopoles, are of high experimental and theoretical interest. As most theories predict a high energy loss of these particles in matter, magnetic monopoles, which could be produced in collider experiments, would only reach the inner detectors close to the interaction point. The Belle II pixel detector, which has a minimum radial distance of only 1.4 cm from the interaction point, is therefore well suited for detection. In this contribution, we focus on light monopoles of below 1 GeV and present the sensitivity to these particles at Belle II. Our analysis uses so-called autoencoder neural networks for background suppression. Our study predicts exclusion limits on the order of $10^{-39}\,\mathrm{cm}^2$, which are competitive to established limits.

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