SYDM 3: Session 3

Time: Tuesday 17:00–19:00 Location: P/H1

SYDM 3.1 Tue 17:00 P/H1

A precision measurement of the proton g-factor — Georg Ludwig Schneider[1] and •Nathan Leefer[2] for the BASE-Collaboration — [1]Johannes Gutenberg-Universität Mainz, Mainz, Germany — [2]Helmholtz Institut-Mainz, Mainz, Germany

The proton g-factor experiment at Mainz recently used a double Penning-trap apparatus to measure the proton g-factor with a fractional accuracy of 3.3×10^{-9}, improving on the previous direct measurement in a trap by nearly three orders of magnitude. We now aim to increase this accuracy further with a number of upgrades to the trap and detection systems. These upgrades include: a better compensated precision trap; a reduction of the residual quadratic magnetic-field inhomogeneity in the precision trap region; the installation of a superconducting, self-shielding coil for improved magnetic field stability; new low-noise amplifiers for particle detection; and a superconducting cyclotron resonator for more efficient resistive cooling of the proton. We have also implemented phase-sensitive detection techniques for faster determination of both the proton spin-state and cyclotron frequency. This talk will briefly review the previous result and discuss the current status of these upgrades.

Ultimately, a measurement with a measurement precision better than 10^{-10} is feasible, and the same advances developed at our experiment can be used at the companion antiproton BASE experiment currently being operated at CERN. The eventual comparison of proton and anti-proton g-factors will be one of the most stringent direct tests of CPT symmetry for baryons.

SYDM 3.2 Tue 17:15 P/H1

Ultracold trapped molecules for tests of fundamental symmetries — •Joost van den Berg, Sreekanth Mathavan, Corine Meinema, Artem Zapara, Klaus Jungmann, and Steven Hoekstra — Van Swinderen Institute, University of Groningen, The Netherlands

Effects such as parity violation and electron electric dipole moments can be greatly enhanced in diatomic molecules because of their energy level structure. Therefore ultracold molecules can be used for precision tests of fundamental physics to look for physics beyond the Standard Model. Recent developments make it possible to create and trap cold samples of molecules. Trapped molecules offer a coherent measurement time which can be two orders of magnitude larger than a molecular beam experiment. We aim for a measurement of molecular parity violation with trapped, laser cooled molecules and we will present the tools which we are developing in our lab in order to reach this goal. These tools can be useful for the broad field of molecular experiments looking for physics beyond the standard model, such as permanent electric dipole moments or dark Z-bosons.

SYDM 3.3 Tue 17:30 P/H1

Search for a permanent Xe-EDM - Experimental status — •Stefan Zimmer[1], Werner Heil[1], Sergei Karpuk[1], Kathlynne Tullney[1], Yuri Sobolev[1], Fabian Allmendinger[2], Ulrich Schmidt[2], Olivier Grasdijk[3], Klaus Jungmann[3], Lorenz Willmann[3], Hans-Joachim Krause[4], and Andreas Offenhäuser[4] — [1]Institut für Physik, Universität Mainz — [2]Physikalisches Institut, Universität Heidelberg — [3]University of Groningen — [4]Forschungszentrum Jülich

A permanent EDM of the isotope 129Xe would imply a breakdown of both parity P and time-reversal symmetry T and, through the CPT theorem, a breakdown in CP. Our goal is to improve the present experimental limit (dXe<3*10-27 ecm) by about four orders of magnitude (most precise EDM limit measured in the diamagnetic atom 199Hg (dHg<3.1*10-29 ecm)). The non-observation of particle and atom EDMs has ruled out more speculative models (beyond Standard Model) than any other single experimental approach in particle physics. We propose a 3He/129Xe clock comparison experiment with the detection of free spin precession of the nuclear polarized gas samples with a SQUID. The precession of co-located 3He/129Xe nuclear spins can be used as ultra-sensitive probe for non-magnetic spin interactions of type $\Delta\nu$~dXe*E, since the magnetic dipole interaction (Zeeman-term) drops out in the frequency difference $\Delta\nu$ of the Larmor frequencies. The detection of free spin precession with spin coherence times T > 1 day doesn't have the systematic limitations of a feedback loop necessary to sustain coherent spin precession.

SYDM 3.4 Tue 17:45 P/H1

Towards a data-driven estimate of the pseudoscalar-pole contribution to hadronic light-by-light scattering in the muon $g-2$ — •Andreas Nyffeler — Institut für Kernphysik, Johannes Gutenberg-Universität Mainz, Deutschland

The evaluation of the numerically dominant pseudoscalar-pole contribution to hadronic light-by-light scattering in the muon $g-2$ involves the pseudoscalar-photon transition form factor $F_{P\gamma^*\gamma^*}(Q_1^2, Q_2^2)$ with $P = \pi^0, \eta, \eta'$ and, in general, two off-shell photons with spacelike momenta Q_i^2. We determine which regions of photon momenta give the main contribution in the corresponding 3-dimensional integral representation for hadronic light-by-light scattering. Furthermore, we discuss how the precision of future measurements of the doubly off-shell form factor, or its determination via a dispersion relation, impacts the precision of a data-driven estimate of this contribution to hadronic light-by-light scattering.

SYDM 3.5 Tue 18:00 P/H1

Isospin breaking effects in the leading hadronic contribution to the muon g-2 — •Jan Haas, Gernot Eichmann, Christian Fischer, and Richard Williams — Institut für Theoretische Physik, JLU Giessen

The functional approach of Dyson-Schwinger and Bethe-Salpeter Equations (DSE/BSE) allows us to investigate nonperturbative properties of QCD. We use it to study the Hadronic Vacuum Polarization contribution to the anomalous magnetic moment of the muon $g_\mu - 2$, extending previous calculations by including isospin symmetry breaking.

SYDM 3.6 Tue 18:15 P/H1

Hadronic Light-by-Light Contribution to the Muon Anomalous Magnetic Moment on the Lattice — •Nils Asmussen, Jeremy Green, Vera Gülpers, Georg von Hippel, Harvey Meyer, Andreas Nyffeler, and Hartmut Wittig — University of Mainz

The experimental value for the muon anomalous magnetic moment, $g-2$, currently shows a $3\,\sigma$ discrepancy with the current Standard Model calculations. The theoretical uncertainty is dominated by the hadronic vacuum polarization and the hadronic light-by-light (HLbL) contributions. For the HLbL, we show an expression for $g-2$, that involves a multidimensional integral over a kernel function and a four-point correlator. We discuss the region of importance given by the kernel function. We examine strategies to evaluate the four-point correlator on the lattice and show exploratory results.

SYDM 3.7 Tue 18:30 P/H1

Time-Domain MW Spectroscopy: Fundamental Physics From Molecular Rotation — •Jens-Uwe Grabow — Institut für Physikalische Chemie und Elektrochemie, Gottfried-Wilhelm-Leibniz-Universität, Hannover, Germany

Even the relativistic Dirac theory did not completely describe the spectrum of the electron in an H-atom. However, at that time, attempts to obtain accurate information have been frustrated by the large Doppler width in comparison to the small shifts. Then, advances in microwave (MW) techniques made it possible to observe the small energy difference of terms that were degenerate in Dirac's theory. This, as well as the small deviation of the electron's gyromagnetic ratio from the value 2, provided an excellent test of quantum electrodynamics (QED).

At present, the electron electric dipole moment (e-EDM) is a particularly good place to find, as proposed by Purcell and Ramsey, a new source for P and T violation. Since the Standart Modell's (SM) prediction is negligible, any observed e-EDM is direct evidence for "New Physics" beyond the SM. As at the time when Dirac's equation was put to test, attempts to obtain accurate information through a spectroscopic study are mostly frustrated by the large Doppler width in comparison to the small shifts. Again, obtaining more accurate information will be the key to provide a delicate test to the proposed theories. And again, employment of an MW method to hunt down a tiny effect has the potential to reveal the even smaller shifts in an e-EDM sensitive rotational transition, making it possible to observe the tiny energy difference of terms that are degenerate without an e-EDM.

SYDM 3.8 Tue 18:45 P/H1

Progress towards a Global Network of Optical Magnetometers for Exotic Physics — •Arne Wickenbrock[1] and Elena Zhivun[2] for the GNOME-Collaboration — [1]Johannes Gutenberg Universität, Mainz, Germany — [2]University of California, Berkeley, California, USA

We present first measurements and experimental progress on a recently proposed novel experimental scheme enabling the investigation of transient exotic spin couplings. The scheme is based on synchronous measurements of optical-magnetometer signals from several devices operating in magnetically shielded environments in distant locations (>100 km). Although signatures of such exotic couplings may be present in the signal from a single magnetometer, it would be challenging to distinguish them from noise. By analyzing the correlation between signals from multiple, geographically separated magnetometers, it is not only possible to identify the exotic transient but also to investigate its nature. The ability of the network to probe presently unconstrained physics beyond the Standard Model is examined by considering the spin coupling to stable topological defects (e.g., domain walls) of axion-like fields.