A 42: Atomic Systems in External Fields II

Time: Friday 11:00–12:45 Location: N 3

A 42.1 Fri 11:00 N 3

^{3}Helium magnetometers for high fields — •Peter Blümler[1], Martin Fertl[1], Hans-Joachim Grafe[2], Robert Graf[3], and Werner Heil[1] — [1]Institute of Physics, University of Mainz, 55128 Mainz, Germany — [2]Leibniz Institute for Solid State and Materials Research (IFW), 01069 Dresden, Germany — [3]MPI for Polymer Research, 55128 Mainz, Germany

Low magnetic fields ($< 10^{-12}$ T) can be measured with extreme precision using SQUID or SERF sensors. But at higher fields nuclear magnetic resonance provides the greatest accuracy. Continuous frequency measurements require samples with long coherence times, as obtainable from motionally averaged hyperpolarized nobel gases at a few millibar pressure. ^{3}He is ideal because it can be hyperpolarized by metastability optical pumping, interacts only weakly with its environment, and has an independently determined gyromagnetic ratio. With suitable low-susceptibility containers, extremely long T_2^* times (100 - 200 s) and absolute field measurements are possible. In addition to low-pressure hyperpolarized ^{3}He for ultra-precise magnetometry ($< 10^{-12}$), we have also produced high-pressure (up to 50 bar) thermally polarized ^{3}He-filled cells for applications where optical polarization is impractical. These robust NMR magnetometers can operate from 1 - 300 K, and we describe methods to tune T_1 for rapid sampling across 5 - 300 K (DOI: 10.1063/5.0258240). Overall, ^{3}He magnetometers show strong potential as a new standard for high-precision magnetometry at high magnetic fields.

A 42.2 Fri 11:15 N 3

Drone Integration of an Optically Pumped Magnetometer for Airborne Magnetic Field Sensing — •Ruggero Giampaoli, Ingo Hilschenz, Gunnar Langfahl, Denis Uhland, and Ilja Gerhardt — light & matter group, Institute for Solid State Physics, Leibniz University Hannover, Appelstrasse 2, D-30167 Hannover, Germany

We report on the integration and testing of a compact, alkali-vapor optically pumped magnetometer (OPM) mounted on an unshielded drone platform for magnetic field measurements in flight. The system is intended for use in applications such as mineral exploration, landmine detection, and unexploded ordnance detection. The system features a rubidium-based vapor OPM, which operates at high sampling rates suitable for drone operation. The design focuses on producing a robust, flexible and portable setup, allowing the testing of different configurations and components to ensure seamless integration with the onboard electronics. A flight-test campaign is conducted to assess the performance of the magnetometer in flight and to establish a basis for future refinement toward a full airborne gradiometer configuration. We discuss the integration process, key engineering challenges, and initial test results, outlining progress toward the robust real-world deployment of an optically pumped magnetometer.

A 42.3 Fri 11:30 N 3

High-sensitivity magnetometry with an ensemble of nitrogen-vacancy centers in diamond — •Phani Peddibhotla[1], Shashank Kumar[1], Bapan Debnath[1], Pranit Terse[1], Sakshi Dwivedy[1], Sourav Chatterjee[2], and Pralekh Dubey[1] — [1]Indian Institute of Science Education and Research, Bhopal, India — [2]2TCS Research, TATA Consultancy Services, Kolkata, India

Nitrogen-vacancy (NV) centers are atom-like defects in diamond which enable quantitative magnetic field measurements with high sensitivity and spatial resolution. Using an ensemble of NV centers, we demonstrate magnetic field sensitivities approaching 100 pT per root Hz under ambient conditions, at low frequencies (10 to 100 Hz), and over a large dynamic range. We also discuss applications of NV magnetometry for detection of defects in steel with sub-millimeter spatial resolution.

A 42.4 Fri 11:45 N 3

Towards improvement of the antiproton magnetic moment with phase-sensitive high-fidelity spin spectroscopy — •Bela Peter Arndt for the BASE-Collaboration — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117, Heidelberg, Germany — GSI-Helmholtzzentrum für Schwerionenforschung GmbH, Planckstraße 1, D-64291 Darmstadt, Germany

The BASE collaboration is dedicated to the development and application of advanced Penning-trap setups as well as cryogenic superconducting detection systems with single-particle resolution. These methods enable stringent tests of CPT invariance through high-precision measurements on protons and antiprotons. Notable results include the antiproton and proton charge-to-mass ratio with a fractional precision of 16 parts per trillion (ppt), as well as the antiproton g-factor with a fractional precision of 1.5 parts per billion (ppb). This presentation will address challenges associated with spin-state detection in g-factor measurements and will summarize the recent improvements implemented and characterized within the BASE experiment. Particular emphasis will be placed on phase-sensitive frequency-measurement techniques and improved particle cooling, both of which enable new experimental approaches that facilitate sub-100-ppt precision and thus more than a 10-fold improvement in the determination of the antiproton and proton g-factors.

A 42.5 Fri 12:00 N 3

Role of Structured Light in Atomic Magnetometers — •Shreyas Ramakrishna[1,2] and Stephan Fritzsche[1,2] — [1]Helmholtz Institute Jena, Germany — [2]Friedrich-Schiller University Jena, Germany

The use of structured light in atomic magnetometers has attracted considerable attention in recent years. Specifically, we can infer magnetic field properties by analyzing how vector light interacts with a polarized atomic ensemble. In this talk, we will show how we can extend this technique to determine the full vector nature: both direction and strength of an arbitrary constant magnetic field. To do this, we model the interaction between vector Bessel light and Rubidium atoms, focusing on the electric dipole transition from $F_g = 1$ to $F_e = 0$ under the influence of test and reference fields.

A 42.6 Fri 12:15 N 3

Completed two-loop QED calculations for improving the bound-electron g-factor theory — •Bastian Sikora, Vladimir A. Yerokhin, Christoph H. Keitel, and Zoltan Harman — Max Planck Institute for Nuclear Physics, Heidelberg, Germany

The bound-electron g-factor in heavy hydrogenlike ions can be measured with extreme precision. However, the theoretical uncertainty of the g-factor is orders of magnitude larger than the experimental uncertainty in this regime, due to uncalculated QED binding corrections at the two-loop level. This was highlighted in a recent collaboration where experimental and theoretical g-factors of the hydrogenlike tin ion were compared [1].

Taking into account the electron-nucleus interaction exactly, we recently completed the computation of QED Feynman diagrams with two self-energy loops. In our new work, we demonstrate that our results lead to a significant improvement of the total theoretical uncertainty of the bound-electron g-factor in the high-Z regime [2].

Our calculations will enable improved tests of QED in planned near-future experiments with heavy hydrogenlike ions, e.g. at ALPHA-TRAP and ARTEMIS. Furthermore, our results are relevant for the determination of fundamental constants and nuclear parameters as well as searches for physics beyond the standard model using heavy ions.

[1] J. Morgner, B. Tu, C. M. König, et al., Nature 622, 53 (2023)

[2] B. Sikora, V. A. Yerokhin, C. H. Keitel and Z. Harman, Phys. Rev. Lett. 134, 123001 (2025)

A 42.7 Fri 12:30 N 3

Lithium Faraday Filter — •Maximilian Luka, Yijun Wang, Denis Uhland, and Ilja Gerhardt — light & matter group, Institute of Solid State Physics, Leibniz University Hannover, Germany

We report the first experimental realization and theoretical modeling of a lithium-based Faraday filter operating at 671 nm. Lithium's D-line splitting of approximately 10 GHz, combined with the requirement for operating temperatures above 260 °C, positions the system in a regime that is exceptional among alkali metals. A custom-designed heat pipe was developed to ensure stable lithium vapor generation and to enable the application of longitudinal magnetic fields up to 300 G. To accurately model the filter response, we extended the open-source "ElecSus" library to include lithium's closely spaced D_1 and D_2 transitions, enabling simultaneous simulation of both lines and direct comparison with experimental data. The modified code reproduces the measured spectra with excellent agreement, predicting and confirming a peak transmission exceeding 80 % under optimized conditions. This work expands the family of alkali-metal Faraday filters and provides a framework for lithium-based optical systems, ranging from precision spectroscopy to atmospheric detection of anthropogenic satellite debris.