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PHYSIKALISCHES KOLLOQUIUM

UNIVERSITÄT DES SAARLANDES

Prof. Dr. Stefan Ulmer
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Exploring New Frontiers in Precision Antimatter Spectroscopy

Thursday, 29.01.2026, at 2.00 p.m. **c. t.**
Building C6.4, Lecture Hall II (00.9)

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The striking imbalance of matter and antimatter in our universe inspires experiments to compare the fundamental properties of matter/antimatter conjugates with high precision. The BASE collaboration at the antiproton decelerator of CERN is performing such high-precision comparisons with protons and antiprotons. Using advanced cryogenic Penning traps, we have performed the most precise comparison of the proton-to-antiproton charge-to-mass ratio with a fractional uncertainty of 16 parts in a trillion [1], and have invented a novel spectroscopy technique, that allowed for the first direct high-precision measurement of the antiproton magnetic moment with a fractional accuracy of 1.5 parts in a billion [2]. Together with our last measurement of the proton magnetic moment [3], this improves the precision of previous magnetic moment-based tests of the fundamental CPT invariance by more than a factor of 3000. A time series analysis of the sampled magnetic moment resonance furthermore enabled us to set first direct constraints on the interaction of antiprotons with axion-like particles (ALPs) [4], and most recently, we have used our ultra-sensitive single particle detection systems to derive constraints on the conversion of ALPs into photons [5]. In parallel, we are working on the implementation of new measurement technology to sympathetically cool antiprotons [6] and to apply quantum logic inspired spectroscopy techniques [7]. In addition to that, we are currently developing the transportable antiproton-trap BASE-STEP, to relocate antiproton spectroscopy experiments from CERN's accelerator environment to dedicated precision laboratory space at Heinrich Heine University Düsseldorf. Very recently, the first loaded transport of this trap has been demonstrated successfully [8]. I will give a general introduction to the topic, will review the recent results, with particular focus on recent developments towards an at least 10-fold improved coherent measurement of the antiproton magnetic moment [9], and towards the first antiproton transport.

[1] M. J. Borchert et al., Nature **601**, 35 (2022).
[2] C. Smorra et al., Nature **550**, 371 (2017).
[3] G. Schneider et al., Science **358**, 1081 (2017).
[4] C. Smorra et al., Nature **575**, 310 (2019).
[5] J. A. Devlin et al., Phys. Rev. Lett. **126**, 041321 (2021).
[6] M. A. Bohman et al. Nature **596**, 514 (2021).
[7] J. M. Conrejo et al., *New J. Phys.* **23** 073045 (2022).
[8] M. Leonhardt et al., Nature **641**, 871 (2026).
[9] B. M. Latacz et al., Nature **644**, 64 (2026).

You can participate online via MS Teams: https://shorturl.at/5vw2E

Interested people are cordially invited.

Coffee and cookies are served at 2.00 p.m. in front of the Lecture Hall

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