CRC 1227
Designed Quantum States of Matter

GUEST LECTURE

Dr. Christian Smorra

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(Guest of Prof. Dr. Christian Ospelkaus)

Leibniz Universität Hannover
DQ-mat Colloquium
26 November 2020, 3.30 pm
(via Zoom-Meeting)

"Methods for improving high-precision matter-antimatter comparisons"

The observation of dark matter and the matter-antimatter asymmetry in our universe comprise a challenge to the Standard Model of particle physics, which does not provide satisfying explanations for these observations. Furthermore, the Standard Model defies so far all tests for new physics by our laboratory experiments, so that we need to increase the sensitivity of our search methods and find new ways to uncover the nature of these phenomena.
The BASE collaboration has recently reported improved limits on CPT violation in the baryon sector by comparing the antiproton and proton charge-to-mass ratios [1], and their magnetic moments [2,3] with 3000-fold higher sensitivity than in competing efforts, and performed the most precise measurement of a nuclear magnetic moment. These measurements enabled also constraining a potential interaction between axion-like dark matter and antiprotons for the first time [4].
In my presentation, I will present the present status of the high-precision measurements on protons and antiprotons in the BASE collaboration, and the methods that are presently developed to improve the sensitivity to new physics effects. In particular, I will present preliminary results of sympathetically cooling protons by image-current interaction, which will enable fast cooling of protons and antiprotons, and enhance the measurement precision in their magnetic moment measurements.
Further, I will present the status of developing transportable antiproton traps to supply experiments outside the antiproton decelerator of CERN with antiprotons. Transportable traps will boost the precision of antiproton precision measurements, since measurements can take place in a calm magnetic environment, where a factor of 10 improvement in precision can be expected based on state-of-art methods compared to measuring in the antiproton decelerator hall. Further, transportable antiproton traps may also enable novel antiparticle experiments that may further increase the sensitivity of antimatter tests on new physics beyond the possibilities in state-of-art experiments.

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[1] S. Ulmer, C. Smorra *et al.*, Nature **524**, 196-199 (2015).
[2] C. Smorra *et al.*, Nature **550**, 371-374 (2017).
[3] G. Schneider *et al.*, Science **385**, 1081-84 (2017).
[4] C. Smorra *et al.*, Nature **575**, 310-314 (2019).

All DQ-mat members and all interested
are cordially invited to attend.