Mathematisch-Naturwissenschaftliche Fakultät
Wissenschaftliche Einrichtung Physik

Physikalisches Kolloquium

Donnerstag, 16.07.2026, 16:30 Uhr – Hörsaal 5F

A New Era for Antihydrogen Experiments

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Investigating the fundamental properties of exotic systems in the laboratory provides a unique window into the fundamental laws governing the Universe. Few systems are as captivating as antimatter, whose apparent scarcity in the observable Universe remains one of the most important open questions in modern physics. Precision studies of antihydrogen therefore offer a powerful means to test the fundamental symmetries underlying our current understanding of nature.

The ALPHA experiment at CERN synthesizes, traps, and studies antihydrogen in order to compare its properties with those of hydrogen. Since first trapping antihydrogen 16 years ago, ALPHA has achieved a number of major milestones, including 12-digit precision spectroscopy of the 1S--2S transition as a stringent test of CPT invariance [1] and the first direct observation that antihydrogen falls downward in Earth's gravitational field, providing a test of the weak equivalence principle with antimatter [2].

Further improving precision requires reducing antihydrogen energy. Laser cooling [3] is limited by recoil effects, while adiabatic expansion cooling, an independently demonstrated technique [4], lowers energy via slow trap expansion. Enabled by recent advances in antihydrogen trapping, we present a hybrid cooling technique that combines both methods, achieving a substantial reduction in antihydrogen mean energy – around 20× lower than with laser cooling alone – reaching the millikelvin regime. We demonstrate this technique with preliminary data showing significant narrowing of the 1S-2S spectroscopic lineshape using hybrid cooling. This marks a major step forward for antihydrogen experiments, unlocking the potential for unprecedented precision in future studies, including gravitational measurements.

1. ALPHA. *Characterization of the 1S2S transition in antihydrogen*. Nature, 557(7703):71–75, 2018.
2. ALPHA. *Observation of the effect of gravity on the motion of antimatter*. Nature, 621(7980):716–722, 2023.
3. ALPHA. *Laser cooling of antihydrogen atoms*. Nature, 592(7852):35–42, 2021.
4. ALPHA. *Adiabatic expansion cooling of antihydrogen*, Phys. Rev. Research **6**, L032065, 2024.

Ab 16:00 Uhr Kaffee, Tee und Gebäck im Foyer links neben dem Hörsaal 5H Math.-Nat.-Fakultät (Gebäude 25.22. Ebene 00)

Für die Dozenten der Physik
Prof. Dr. Stefan Ulmer