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Two-trap cooling promises antimatter precision

The BASE collaboration has performed the first demonstration of two-trap sympathetic cooling, promising substantial improvements to studies of antiprotons

25 AUGUST, 2021 | By Mark Rayner (/authors/mark-rayner)

(//cds.cern.ch/images/CERN-HOMEWEB-PHO-2021-138-1)

Cool experiment — Matthew Bohman (left) and Christian Smorra point out the location of the Penning trap where individual protons are cooled in the new two-trap cooling apparatus at the University of Mainz. (Image: Stefan F. Sämmer/JGU)

Picture two children playing on swings in a playground. One is a daredevil, launching themselves high off the ground in big arcs. The other daydreams, swinging gently.

Now picture the children holding either end of a long spring. Tension in the spring now accelerates the daydreaming child forwards and backwards to follow their friend, whose swings are slowed and shortened.

This is the principle behind a groundbreaking new technological demonstration reported today in Nature by the BASE collaboration – an international particle-physics collaboration based at CERN's antimatter factory. The energetic child represents a single proton oscillating inside the magnetic and electric fields of a Penning trap. The daydreamer represents a laser-cooled cloud of beryllium ions inside a second trap. The spring represents a unique innovation by the BASE collaboration: a superconducting resonant electric circuit that transfers energy from the proton to the ions, just as the spring transfers energy from one swing to the other. Smaller swings mean a lower temperature proton and greater precision in experimental studies.

"This is an important milestone in precision Penning trap spectroscopy," says BASE deputy spokesperson Christian Smorra of RIKEN and the University of Mainz, where the demonstration was performed. "With optimised procedures we should be able to reach particle temperatures of the order of 20 to 50 mK, ideally in cooling times of the order of 10 seconds. Previous methods allowed us to reach 100 mK in 10 hours."

The speedy new two-trap cooling procedure promises a huge increase in the statistics that are available to experimenters. It is also a game-changing development for the study of BASE's main particle of interest: the antiproton. Conventional cooling techniques are difficult to apply to antimatter because it is highly challenging to put matter and antimatter in the same trap. Applying the new technique should allow a significant improvement on BASE's already world-leading measurements of fundamental properties of antiprotons. Such measurements have the potential to shed light on one of the biggest unanswered questions in fundamental physics: the unexplained surfeit of matter over antimatter in the universe.

"Our vision is to continually improve the precision of our matter–antimatter comparisons to develop a better understanding of the cosmological matter–antimatter asymmetry," says BASE spokesperson Stefan Ulmer of RIKEN. "The newly developed technique will become a key method in these experiments, which aim to measure fundamental antimatter constants at the sub-parts-per-trillion level."

For more details check out the full report (https://cerncourier.com/a/base-demonstrates-two-trap-cooling/) in CERN Courier *magazine.*

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