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Antiproton Research Resumes at CERN FREE

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Physics Today **53** (10), 22 (2000);
https://doi.org/10.1063/1.1325188

Antiproton Research Resumes at CERN

Experiments designed to probe differences between matter and antimatter using low-energy antiprotons have been on hold since CERN shut down its Low-Energy Antiproton Ring (LEAR) in December 1996. But the progress made at LEAR motivated the construction at CERN of a $5 million new facility, the Antiproton Decelerator (AD) (see PHYSICS TODAY, March 1996, page 17; November 1996, page 9; and May 1997, page 19). The photo shows the dipole (red) and quadrupole (blue) magnets in a section of the new ring. Antiprotons enter from the transfer line on the right.


CERN

Based on LEAR's refurbished antiproton collector, the AD costs only one-tenth as much as LEAR to run. The machine stores only about one percent of the antiprotons that LEAR held, but it sends them out at a rate sufficient for the antiproton experiments (currently in pulses of roughly 10^7 particles every two minutes). The antimatter experiments greatly benefit from no longer having to share the beam with other types of experiments. The AD sends 5-MeV antiprotons to the waiting experiments, which must reduce these energies by factors of 10^{10}.

The AD has been supplying antiprotons to three experiments since July. The goal of two experiments, ATRAP and ATHENA, is to form and study atoms of antihydrogen (in which a positron orbits an antiproton). The ATRAP experiment evolved from the TRAP experiment at LEAR, which developed many techniques for trapping and cooling antiprotons. ATRAP is designed to confine both antiprotons and positrons in the same, relatively small, trap (with a radius of 1.2 cm). The ATHENA experiment, built from scratch for the AD, features separate, larger traps for the oppositely charged particles. Each team plans eventually to nudge together the separate collections of antiprotons and positrons to form antihydrogen atoms. The third experimental collaboration, ASACUSA, is continuing measurements begun at LEAR of the spectral lines of helium atoms in which an antiproton has replaced an orbital electron; the group hopes to determine accurately such properties of the antiproton as its mass and magnetic moment.

Initial reports from the AD are very positive. Speaking for the ATRAP team, Gerald Gabrielse of Harvard University reported that, by late August, he and his colleagues had accumulated nearly 0.1 million antiprotons at 4.2 K in the course of an hour and had simultaneously cooled more than 2 million positrons, also to 4.2 K—the coldest collection of positrons so far assembled. They have seen evidence that the antiprotons are being cooled by collisions with the positrons stored in the same trap. The ATHENA experimenters have also cooled antiprotons to 4.2 K, trapping more than 10 000 per shot, according to collaboration spokesman Rolf Landua of CERN. At the same time, they have accumulated positrons at the high rate of about one million per second; a next step is to cool the positrons to liquid helium temperatures by transferring them to a cryogenic chamber. Despite the tough challenges that still lie ahead, experimenters with the antihydrogen teams dream of success by year's end. Meanwhile, the ASACUSA collaboration, according to spokesman Ryugo Hayano of the University of Tokyo, is getting two to three times better resolution with the AD, thanks both to the new machine and to improvements in their apparatus. Already team members have seen a new resonance in antiprotonic helium, and they hope to improve the value of the antiprotonic Rydberg constant determined at LEAR. **BARBARA GOSS LEVI**

superconductors. At liquid nitrogen temperatures, the decreased T_c essentially canceled the gains from the improved intergrain coupling.

Recently, however, the Augsburg group has found a potential way to circumvent this drawback, doping only the GBs to achieve good GB coupling while maintaining a high T_c within the grains. Again using a test system with a 24° GB, the researchers deposited a bilayer with undoped YBCO capped by a thin layer of 30% Ca-doped YBCO.[1] Because of its low T_c, this top layer doesn't significantly contribute to the current flow through the film at 77 K, but it does provide a source for Ca that can migrate down into the undoped layers. "We expected that calcium would diffuse into the grain boundaries much more than into the bulk," explains Mannhart. "It appears to have really worked."

Figure 1 shows the critical current densities measured as a function of temperature for undoped, doped, and multilayer YBCO bicrystals, all with 24° GB angles. The multilayer combinations of undoped and Ca-doped YBCO successfully demonstrate the desired result: The T_c remains high, and yet the critical current density across the GB is significantly enhanced—by more than a factor of six in some doped-undoped-doped trilayers. An increase by more than a factor of two is typical in bilayers, which may be the more practical structure for commercial wire applications.

No special annealing was performed on the bilayer and trilayer samples; the time spent at high temperatures during the deposition process appears to be sufficient for the diffusion of Ca into the GBs. Mannhart notes, though, that the experimenters have yet to measure the actual amount of Ca that ended up at the GBs of the undoped layer.

The next step

Still unanswered is the important question of whether the results seen