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Foreword

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Low energy antiproton physics centres around the antiproton, the antimatter counterpart of the most abundant element in the Universe, the proton. This interdisciplinary field spans particle, nuclear, atomic, applied, and astro-physics. It confronts directly the assumed symmetry between matter and antimatter, addressing a foundation of the modern theory of particle physics known as CPT symmetry. CPT is so fundamental that its violation would require a complete rewriting of physics textbooks. Precision studies with antiprotons may also shed light on the question of why our Universe is made of matter but not antimatter. Recent months have witnessed dramatic breakthroughs in the field at CERN's Antiproton Decelerator (AD), including trapping of antihydrogen atoms and developments towards an antihydrogen beam. Satellite and balloon experiments are searching for cosmic antimatter, the results of which could have profound implications on cosmology. Antiprotons are also used to study properties and structures of atoms, nuclei and hadrons, for which the start of a next generation antiproton facility, FAIR, in Darmstadt, will usher in a new era.

It was against this stimulating backdrop that LEAP 2011—the *10th International Conference on Low Energy Antiproton Physics*—was held at TRIUMF in Vancouver, Canada, from 27 April to 1 May 2011. The conference was organized and supported by the Canadian institutions involved in the ALPHA experiment (universities of British Columbia, Calgary, Simon Fraser, York and TRIUMF), with additional support from the Canadian Institute of Nuclear Physics. LEAP 2011 was the first for North America as the series has traditionally been held in

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Europe. The previous very successful meetings were held at Stockholm (1990), Courmayeur (1992), Bled (1994), Dinkelsbuhl (1996), Villasimius (1998), Venice (2000), Yokohama (2003), Bonn (2005) and Vienna (2008). The LEAP 2011 conference was attended by nearly 100 participants, with over 60 plenary speakers, many of them young researchers, invited to present their talks. Several review talks by senior physicists facilitated dialogue across the disciplines. In addition, a dozen posters were presented, and their presenters were allowed a 2-minute talk advertising their work at a plenary, a format which worked quite effectively.

The conference started with warm welcoming remarks from TRIUMF Director, Nigel Lockyer, and Science Division Head, Reiner Kruecken, followed by a session on antihydrogen physics where Butler (CERN) reported recent trapping of antihydrogen by the ALPHA collaboration, while Kuroda (Tokyo) described ASACUSA's development towards an antihydrogen beam. Both results together were ranked among top physics news in 2010 by Physics World magazine. From ATRAP, Hessels (York) described new results on centrifugal separation and adiabatic cooling of antiprotons. Other antihydrogen presentations included ASACUSA's proposed microwave spectroscopy with an antihydrogen beam by Juhasz (Stefan Meyer Institute), and ATRAP's improved antihydrogen production by Müllers (Mainz). As well, new possibilities for antimatter gravity experiments, AEGIS and GBAR, were reported by Jorgensen (CERN), Storey (Zurich) and Debu (Saclay). Several ALPHA presentations on antihydrogen, evaporative cooling and autoresonance excitation of antiproton plasmas, key techniques that enabled trapping of antihydrogen, were covered by Silveira (RIKEN), Bertsche (Swansea) and So (Berkeley). Details of the analysis that identified rare occurrences of annihilations of trapped antihydrogen were described by Hydomako (Calgary) and Amole (York). Fajans (Berkeley) reported a recent result on dynamical studies on antiproton-electron plasma equilibration. ALPHA's next major goal, microwave spectroscopy on trapped antihydrogen, was described by Ashkezari (Simon Fraser) and Friesen (Calgary). Finally, details of ALPHA's antihydrogen confinement for 1000 s, a result announced at this conference, was given in a poster by Fujiwara (TRIUMF/Calgary).

The positron, or anti-electron, is the other ingredient in antihydrogen atoms. A review on positron accumulation techniques was given by Surko (UC San Diego), the inventor of the Surko trap now used by many of the antihydrogen experiments. Storry (York) described ATRAP's positron system, and van der Werf (Swansea) reported a new theoretical model on plasma compression, both using variations of the Surko trap. Yamazaki and Ishida (Tokyo) reported new measurements on energy levels of positronium atoms, with emphasis on a novel sub-THz source.

Novel atomic physics techniques, with their possible applications to antihydrogen, were covered in talks by Wu (Maryland) and Libson (Austin). The former presented a proposal for a new Sisyphus scheme for (anti)hydrogen laser cooling, and the latter discussed atomic coil-gun and single-photon cooling techniques.

This year marks the 20th anniversary of the discovery of long-lived antiprotonic helium at KEK. Exotic atoms and fundamental symmetries studies are an important part of antiproton physics. ASACUSA's recent progress on precision studies of antiprotonic helium was reported by Barna (Tokyo), and microwave measurements of antiprotonic ^{3}He atoms were described by Friedreich (SMI). On related topics, Hayano (Tokyo) gave a review of hadronic atoms with focus on pionic and kaonic

atoms, and Gwinner (Manitoba) provided an overview of the fundamental symmetries program at TRIUMF. Recent, and controversial, results on muonic hydrogen spectroscopy at PSI and its extension to muonic helium were discussed by Nebel (MPI). Marshall (TRIUMF) reported the final results of TWIST at TRIUMF, a precision measurement of muon decay parameters.

Ion traps with single-particle sensitivity are a powerful tool. Quint (GSI) reported a very recent observation of single proton spin flip, a result that paves the path for comparison of the magnetic moments of protons and antiprotons. Dilling (TRIUMF) discussed the TITAN facility, where ion traps are used to study radioactive nuclei.

An important pillar of antiproton physics is hadron and QCD physics at "low energy", ranging from stopped antiprotons to a 15 GeV beam. At the lower energy end, ASACUSA's Venturelli (Brescia) reported on studies of antiproton in-flight annihilation on nuclei. A search at J-PARC for phi meson nucleus bound states using antiproton annihilation on nuclei was discussed by Ohnishi (RIKEN), and a study of double anti-kaonic nuclear clusters in antiproton-^{3}He annihilation was described by Sakuma (RIKEN). Schepers (GSI) gave an overview of the physics program of the major PANDA detector at FAIR, which is expected to start physics runs in 2018. Searches for exotic states and studies of double Λ hypernuclei, discussed by Kopf (Bochum) and Sanchez Lorente (Mainz), illustrated the breadth of physics that can be addressed with PANDA. Crawford (LBNL) reported hot news from BNL on the discovery of the anti-alpha nucleus, the heaviest anti-nucleus observed. HADES, a proton-proton collision experiment at GSI, was described by Siebenson (Munich).

Talks on applications and new techniques included the ACE experiment studying the possible use of antiprotons for cancer therapy by Sellner (Heidelberg), and developments towards spin polarized antiprotons by Lenisa (Ferrara) and Grzonka (Jülich).

The theory talks covered topics ranging from atomic collisions to cosmology. Kirchner (York) reviewed atomic collision physics with antiprotons. A review of interactions of antihydrogen with ordinary matter atoms was given by Froelich (Uppsala), and calculations on gravitational effects of antihydrogen-solid interaction were presented by Voronin (Lebedev Institute). On the hadron physics side, theories of strangeness production in antiproton-proton and antiproton-nucleus collisions were reported by Entem (Salamanca) and Larionov (Giessen). In particle theory, Pospelov (PI/Victoria) reviewed theoretical aspects of CPT violation and commented on possible interpretations of recent experimental data with and without CPT violation. Tasson (Whitman College) discussed inclusion of gravity in the so-called Standard Model Extension, an effective theory based formulation of CPT and Lorentz violation by Kostelecky et al.

LEAP 2011 featured dedicated sessions on the Universe. Ellis (CERN) discussed the nature of dark matter and its connection to low energy hadron physics. Unruh (British Columbia) reported a fascinating experiment confirming aspects of Hawking radiation in an analogue system, particularly his own theoretical prediction from some 30 years ago. Morrissey (TRIUMF) discussed a model that explains both baryon asymmetry and dark matter in one go.

Experimental searches for antimatter in the Universe was a hot topic given the imminent launch of the AMS experiment. Boezio (Trieste) reported on the still persistent anomaly of the positron flux at high energies from the latest results of

PAMELA. In a talk given by Yoshimura (KEK), a new result on the search for antimatter was announced with BESS-Polar II, a balloon experiment in Antarctica which has sensitivity complementary to satellite experiments. Hailey (Columbia) gave an update on the GAPS experiment whose aim is to search for anti-deuterons from dark matter annihilations using exotic atom techniques.

Looking to the future, a proposal for the FLAIR low energy antiproton facility at GSI was described by Widmann (SMI) and Papash (MPI), while Kaplan (Illinois) discussed a Fermilab proposal. ELENA, an additional cooler ring at the CERN AD, was described by Oelert (Jülich). The conference ended with Oelert's personal view of the prospects in antiproton physics. Just a few weeks after the conference, the construction of ELENA was approved by CERN Council. This will provide much enhanced antiproton physics opportunities at CERN in the coming decade.

This very successful conference was capped off by a social program which included a dinner cruise in Vancouver's spectacular English Bay, and a well-attended public lecture by John Ellis at the University of British Columbia. The future of low energy antiproton physics appears bright.

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The conference details and many of the presentations can be found at http://leap2011.triumf.ca. The next LEAP meeting will be held in Uppsala in 2013, chaired by Tord Johansson and Piotr Froelich.

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LEAP 2011 Chair


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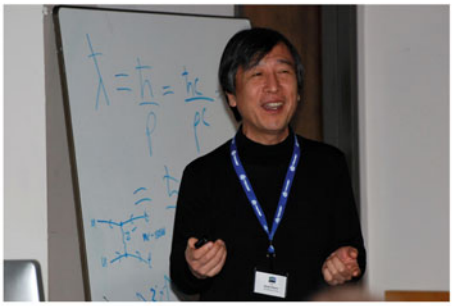

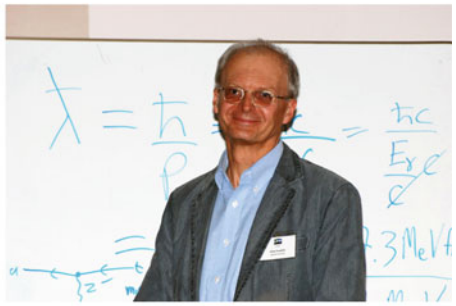

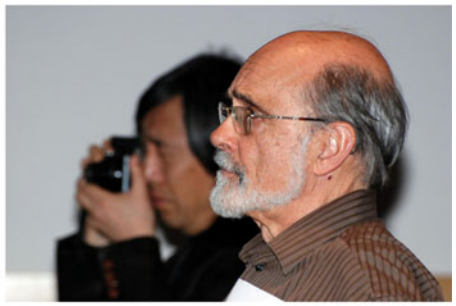





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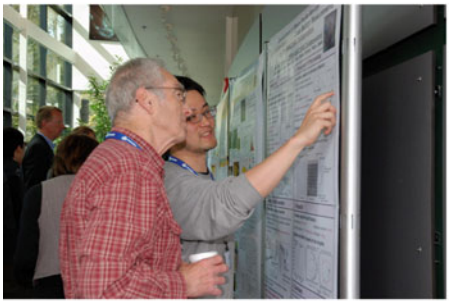
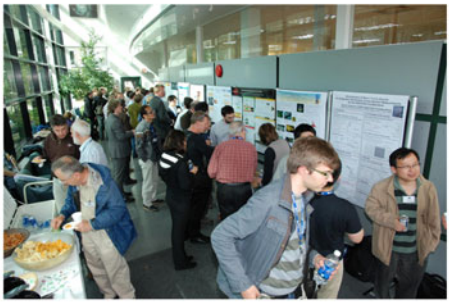

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