DPP10-2010-020031

Abstract for an Invited Paper
for the DPP10 Meeting of
the American Physical Society

Plasmas as the Drivers for Science with Antimatter[1]

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Progress and future challenges in physics and technology with antimatter (positrons and antiprotons) will be described illustrating the important role played by plasma science [1]. Topics include the creation and study of antihydrogen (stable, neutral antimatter) [2,3] and the positronium molecule ($e^+e^-e^+e^-$) [4]; plans to study electron-positron plasmas [5]; the quest for a BEC gas of positronium atoms; positron binding to atoms and molecules [6]; the development of new types of positron beams for materials studies; and prospects for commercial positron traps and beams. Much of this progress has been driven by the development of new plasma techniques. Efficient positron accumulation is obtained using specially designed Penning-Malmberg traps with trapping and cooling provided by molecular gases. Plasmas are compressed radially using rotating electric fields. Long-term storage and cooling to cryogenic temperatures are obtained using traps in UHV environments in several-tesla magnetic fields [2,3]. A method to increase trap capacity by orders of magnitude will be described [7]. Prospects for portable antimatter traps and other exceedingly challenging projects such as a Ps-atom interferometer and an annihilation gamma ray laser will be discussed. Efforts to understand the behavior of antimatter in astrophysical settings will also be discussed. A sampling of references (by 1st author): [1] C. M. Surko, Phys. Pl. 11, 2333 ('04); [2] G. Gabrielse, Physics Today, Mar. ('10), 68; [3] G. B. Andresen, Phys. Rev. Lett. 105, 013003 ('10); [4] D. B. Cassidy, Nature 449, 195 ('07); [5] T. S. Pedersen, Fus. Sci. Tech., 50, 372 ('06); [6] G. F. Gribakin, Rev. Mod. Phys., in press ('10); [7] J. R. Danielson, AIP Conf. Proc. 1114 ('09), 199.

[1]The work at UCSD was done in collaboration with J. Danielson, T. Weber and J. Young and supported by the U. S. NSF, DoE and DTRA.