DAMOP08-2008-000017

Abstract for an Invited Paper
for the DAMOP08 Meeting of
the American Physical Society

Observation of Molecular Positronium, A Many-Positron Many-Electron System.

DAVID CASSIDY, University of California, Riverside

The introduction of positron trapping techniques over the last twenty years or so has made possible a number of new experimental areas, and has revitalized the field of low energy positron physics. Positron plasmas have been used to create beams of unprecedented quality for precision atomic physics experiments, and have also been invaluable in the production of low energy antihydrogen. Another area in which these methods have proved to be useful is in studies of systems containing more than one positron. By capturing tens of millions of particles in an accumulator and then releasing them in a short burst it is possible to create instantaneous positron currents in excess of 10 mA. Implanting such bursts into an appropriate target can lead to the formation of positronium atoms that are able to interact with one another. An obvious outcome of such interactions is the formation of molecular positronium, which we have observed on both the internal surfaces of porous silica and on a clean metal surface. In this presentation I shall outline the techniques we have used to study interactions between positronium atoms, and in particular the first observation of molecular positronium. The experiments we have performed constitute the first step in a larger program to study multi-positronium interactions, specifically the formation of a Bose-Einstein condensate (BEC). With only minor modifications to our present system it should be possible to increase the density of interacting positronium atoms so that they may form a BEC with a critical temperature above 10 K. A condensate of this sort would provide a nearly ideal weakly interacting system of fundamental interest that could be used as the basis of a positronium "atom laser". This in turn would allow us to construct a Mach-Zender type interferometer and directly measure the matter-antimatter gravitational interaction. Since the CPT theorem implies that matter and antimatter should have been created in equal amounts following the big bang, that fact that the observable universe appears to consist almost entirely of matter remains an outstanding problem, one of literally astronomical proportions; any discovery of an unexpected asymmetry between matter and antimatter could help to resolve this mystery.