

On the possibility of non-neutral antiproton plasmas and antihydrogen plasmas

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A large number of slow antiprotons have been confined in particle traps at Antiproton Decelerator (AD) in CERN. However, a unique feature as a non-neutral antiproton plasma has not been reported. It is thought that the size of the antiproton cloud was smaller than its Debye length. Progresses in accumulating a larger number of low energy antiprotons with AD, Radio Frequency Quadrupole Decelerator (RFQD), and Musashi trap in ASACUSA enables the confinement of a larger antiproton cloud. Further improvement in stacking antiproton pulses will lead to the observation of the plasma oscillations of a non-neutral antiproton plasma. This is also favorable for the effective production of low energy antiproton beams to be used in atomic collision experiments.

The possibility of producing non-neutral antihydrogen plasmas is also considered with a magnetic mirror configuration. Although antihydrogen atoms were created by mixing a positron plasma and antiproton cloud, it was a kind of beam-plasma system. The basic procedure is to accumulate both antiprotons and positrons in a nested Penning trap in a magnetic mirror field. It is assumed here that more positrons are trapped than antiprotons. Adiabatic expansion of particles along the magnetic field by reducing the trapping potential results in an anisotropic energy distribution. Then, the positron plasma can be trapped with the magnetic mirror field and antiprotons can be trapped simultaneously with the magnetic field and the space potential of the positron plasma. A strongly magnetized positron plasma may enhance the confinement time of the non-neutral antihydrogen plasma.