Antiprotons in a Penning Trap: A New Measurement of the Inertial Mass

A thesis presented

by

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Abstract

Antiprotons from the Low Energy Antiproton Ring (LEAR) at CERN with a kinetic energy of 5.9 MeV are passed through matter and captured in a cylindrical Penning trap. Using electron cooling, they are brought into thermal equilibrium with the 4 K trapping environment and have been stored for up to 2 months directly establishing the antiproton lifetime to be greater than 103 days.

The inertial masses of the antiproton and proton are compared by direct non-destructive measurments of their oscillatory motions in a Penning trap. An open endcap cylindrical trap produces a high purity quadrupole potential and allows antiprotons to be trapped and cooled. A self-shielding superconducting solenoid compensates the fluctuating magnetic field in the accelerator hall.

The measured mass ratio is $m_{\bar{p}}/m_p = 0.999\,999\,977(42)$. The achieved accuracy of 4.2×10^{-8} is one thousand times more precise than obtained with previous techniques, and is the most stringent test of CPT invariance with baryons. As part of a thorough systematic study, independent comparisons to electrons yield the mass ratios $m_{\bar{p}}/m_{e^-}$=1836.152 648(89) and m_p/m_{e^-}=1836.152693(88).

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To the Memory of My Father,

Lawrence Earle Tjoelker

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