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Phase sensitive modified cyclotron frequency measurements with single trapped antiprotons

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Even though the standard model has been successful in predicting and describing subatomic phenomena, it requires symmetry under charge, particle and time inversion and can thus not explain certain cosmological observations. A difference in the fundamental properties between matter and antimatter would break CPT invariance, will further our understanding of the shortcomings of the standard model, and could potentially explain aspects of the excess of matter over antimatter. The BASE experiment is testing CPT invariance in the baryonic sector by comparing the ratios of charge-to-mass ratios and the magnetic moments of protons (p) and the antiprotons (p).

BASE uses advanced Penning-trap-systems to confine single particles inside an electrostatic potential well with a constant magnetic field [1]. By measuring the cyclotron frequencies $_c = q/m \cdot B$ of a proton and an antiproton, their charge-to-mass ratio can be determined. Calculating the relative charge to mass ratio eliminates the dependence on the magnetic field and allows specifying it to a fractional precision of 16 p.p.t. [2]. By measuring the Larmor frequency ωL of both particles as well,
the g-factors $g = 2/_N = 2_L/_c$ can be specified to a fractional precision of 0.3 p.p.b. and 1.5 p.p.b. [3, 4].
$(q_{\overline{p}}/m_{\overline{p}})/(q_p/m_p) = -_{c,\overline{p}}/_{c,p} = -1 \pm 1.6 \cdot 10^{-11}$
$(_{L,\overline{p}}/_{c,\overline{p}})/(_{L,p}/_{c,p}) = g_{\overline{p}}/g_p = -1 \pm 1.6 \cdot 10^{-9}$

Since the start of the BASE experiment program, multiple improvements of the applied frequency measurement schemes have been made, decreasing the uncertainties of the measured fundamental quantities by multiple orders of magnitude. With direct frequency measurements limited by their
$T^{-1/2}$ scaling with measurement time, the next step is the implementation of phase information [5] in the determination of the modified cyclotron frequency to reach a T^{-1} scaling.

I will give an overview about BASE, the current frequency measurement schemes used, and the particular limitations and problems that we face using them. I will introduce the concept of phase sensitive frequency measurements in the context of BASE, and discuss their advantages and new
inherent precision limits.

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