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Towards implementing quantum logic spectroscopy for (anti-)proton g-factor measurements

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Comparisons of fundamental properties of matter and antimatter provide stringent tests of CPT symmetry [1]. Throughout the past years, measurements of proton and antiproton g-factors in Penning traps have been carried out with outstanding precision, setting new constraints on CPT violating effects of the SME [2,3]. However, these experiments rely on time consuming particle cooling and state detection schemes based on image current detection (see e.g. [3]),
currently limiting measurement sampling rate and accuracy.
To overcome these limitations, we develop new cooling and state readout techniques following a proposal by Heinzen and Wineland [4,5]. In our approach, we want to couple an (anti-)proton to a laser (ground-state) cooled $^{9}Be^{+}$ using free-space Coulomb-coupling in a double-well potential. This should allow to ground-state cool the (anti-)proton and detect its spin state by means of a quantum-logic inspired readout protocol [6].
In this contribution, we present the basic concept of our approach as well as latest advances of our experiment on resolved axial sideband cooling and fast adiabatic transport of a single $^{9}Be^{+}$, which are mandatory steps towards implementing quantum-logic spectroscopy.

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