Atomic Parity Violation in a single trapped Ra^+ ion.

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Atomic Parity Violation (APV) provides for determining electroweak parameters in the Standard Model. In particular, the weak mixing angle ($sin^2\theta_W$) can be determined from single trapped Ra^+ ion [1]. This experiment at the lowest accessible momentum transfer provides for a sensitive test of the running of the electroweak mixing angle. The effects of weak interactions can be measured in Ra^+ by exploiting the properties of light shift in the $7s^2S_{1/2} - 6d^2D_{3/2}$ transition. Light shifts permit the mapping of weak interaction effects on the energy splitting of the magnetic sub-levels in the Ra^+ ion.

A particular experimental requirement for an APV experiment is the localization of the ion within a fraction of an optical wavelength in the presence of two light fields of known frequency. Alkaline earth metal ions are very well suited for such experiments, because atomic structure calculations are possible to the required sub-percent level of precision [2]. The contribution of the weak interactions grow significantly faster than the third power of the atomic number Z. Therefore the heaviest alkaline earth element Radium (Z=88) has been chosen for our experiment. In Ra^+, the weak interaction contributions are about 50 times larger than in the so far best investigated atom, i.e. Cs. A 5-fold improvement in the weak mixing angle appears possible within less than one week of measurement time.

High precision optical frequency metrology is possible with single trapped ions, which is a key ingredient for the measurement. Several Radium isotopes for our experiment have been produced at the TRIμP facility at KVI. In preparation of the parity experiment we have already determined the hyperfine structure of the $6d^2D_{3/2}$ states [3], the isotope shift of the $6d^2D_{3/2} - 7p^2P_{1/2}$ transition in the isotopes $^{209-214}Ra^+$ [4] as well as the lifetime of the $6d^2D_{5/2}$ state. These measurements agree well with theory at a level of a few percent [5,6].

We present here the status of the experiment, where the Ba^+ ion serves as a precursor. The lifetime of the $5d^2D_{5/2}$ state in a single trapped Ba^+ ion has been precisely measured. The determination of the light shift in the $5d^2D_{3/2} - 6s^2S_{1/2}$ transition in this system is the next step on the way towards single trapped Ra^+ ion APV experiment. The preparation of an offline ^{223}Ra source is in progress. The setup for a single Ra^+ ion parity experiment is also well suited for realizing a most stable optical clock.

References

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