Light Shifts in a single trapped Ra^+ Ion

A. Mohanty, E. A. Dijck, M. Nuñez Portela, O. Böll, K. Jungmann, C.J.G. Onderwater, R.G.E. Timmermans, L. Willmann, H.W. Wilschut

KVI, University of Groningen, Zernikelaan 25, 9747AA Groningen, The Netherlands
a.mohanty@rug.nl

Light shifts permit the mapping of weak interaction effects on the energy splitting of the magnetic sub-levels in the Ra^+ ion. A precise measurement of atomic parity violation (APV) opens the path to an improved determination of electroweak parameters. In particular, the weak mixing angle ($\sin^2 \theta_W$) can be determined using a single trapped Ra^+ ion [1]. This experiment at the lowest accessible momentum transfer provides for a sensitive test of the running of the electro-weak mixing angle. The effects of weak interactions can be measured in Ra^+ by exploiting properties of the light shift of the 7s $^2S_{1/2}$ -6d $^2D_{3/2}$ transition.

A particular experimental requirement for light shift measurement is the localization of the ion within a fraction of an optical wavelength in the presence of two orthogonal light fields of known polarization. Alkaline earth metal ions are very well suited for atomic parity violation experiments, because atomic structure calculations are possible to the required level of precision [2]. The contribution of the weak interaction to the level energies grows 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 experiments. In Ra^+ the weak interaction contributions are about 50 times larger than in the so far best atom investigated, 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. The radium isotopes for our experiments are 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. The measurements provide for verifying thoroughly the atomic structure calculations for a chain of Ra^+ isotopes.

We present here the status of the experiment, where the Ba^+ ion serves as a convenient precursor and the determination of the light shiftin the 5d $^2D_{3/2}$- 6s $^2S_{1/2}$ transition in this system, which is the next step on the way towards single trapped Ra^+ ion APV experiment. The experimental program is in progress and it is accompanied by further developments of the theory at KVI [5].

References:
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