Precision isotope shift measurements of calcium ions using photon recoil spectroscopy

F. Gebert[1], Y. Wan[1], F. Wolf[1], J. C. Heip[1], J. Berengut[2], C. Shi[1], and P.O. Schmidt[1,3]

[1] *QUEST Institut, Physikalisch-Technische Bundesanstalt, Braunschweig, Germany*
[2] *School of Physics, University of New South Wales, Sydney, Australia*
[3] *Institut für Quantenoptik, Leibniz Universität Hannover, Germany*

Presenting Author: chunyan.shi@quantummetrology.de

Precision laser spectroscopy of trapped atoms is an important technique in fundamental physics. As a powerful tool, the laser induced fluorescence spectroscopy technique has been widely used. However, for non-closed broad transition, this technique is not well-suited. We present isotope shift measurements of the $^2D_{3/2} - {}^2P_{1/2}$ and the $^2S_{1/2} - {}^2P_{1/2}$ transitions in calcium ions by extending the photon recoil spectroscopy (PRS) technique to non-closed transition. In PRS, a spectroscopy ion is trapped and sympathetically cooled to the motional ground state by a co-trapped logic ion [1]. Photon recoil from absorption on the spectroscopy transition results in motional excitation, which is detected on the cooling ion using quantum logic techniques. In this way, we are able to detect around 10 scattered photons for the nearly-closed $^2S_{1/2} - {}^2P_{1/2}$ transition of Ca^+ [2]. To achieve single-photon efficiency for the non-closed $^2D_{3/2} - {}^2P_{1/2}$ transition, a new approach is employed, in which a single-photon repumping event is efficiently translated into the motion of the two ion crystal by amplifying the recoil from absorption of photons resonant with the $^2S_{1/2} - {}^2P_{1/2}$ transition. The residual motional ground state population is then probed using a stimulated Raman adiabatic passage pulse driving a motional sideband on the cooling ion. Using the two techniques, we performed the first high precision absolute frequency measurement of the $^2D_{3/2} - {}^2P_{1/2}$ and the $^2S_{1/2} - {}^2P_{1/2}$ transitions for the isotopes $^{40}Ca^+$, $^{42}Ca^+$, $^{44}Ca^+$, $^{48}Ca^+$ with accuracy below 100 kHz [3]. Based on the precision isotope shift measurement we performed a multidimensional King's plot analysis and were able to significant improve the uncertainty of changes in the mean square nuclear charge radii. Furthermore, we will present recent measurement results of the $^2S_{1/2} - {}^2P_{3/2}$ transition in calcium ions.

References

[1] Y. Wan *et al.* Phys. Rev. A **91**, 043425 (2015).
[2] Y. Wan *et al.* Nat. Commun **5**, 4096 (2014).
[3] F. Gebert *et al.* preprint arXiv:1504.03139 (2015).