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A single trapped Ra+ion to measure Atomic Parity Violation

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Atomic Parity Violation (APV) arises from the exchange of Zˆ0 bosons between electrons atomic shell and the quarks within the nucleons of the nucleus. The size of APV effects is strongly enhanced in heavy atoms, even stronger than Zˆ3 [1]. A single trapped Ra+ ion (Z = 88), which is the heaviest available alkaline earth ion, is a superior system for measuring APV; the effects in Ra+ are some 20 times larger than in Ba+ and even 50 times larger than in Cs [1]. From the APVmeasurements one can expect to extract the Weinberg angle at low energies with some 5 times higher accuracy in about one week of measurement time. At that level of accuracy there is sensitivity to Z0' bosons and leptoquarks at mass scales beyond the possibilities of LHC.On the road towards precise APV experiments, on-line laser spectroscopy and atomic lifetime measurements have been performed in a linear Paul trap. The hyperfine structure (HFS) of the 6dˆ2D_{3/2} states [3] and isotope Shift of the 6dˆ2D_{3/2}-7pˆ2P_{1/2} transition have been measured [4] in order to provide benchmarks for the required atomic theory, in particular to probe atomic wave functions. Whereas the hyperfine structure measurements probe the electronic wave functions at the origin, lifetimes probe them at long distances and isotope shifts probe the size and shape of the nuclei [5]. An APV measurement requires the localization of the ion within a fraction of an optical wavelength. To achieve this, current experiments are focused on trapping and laser cooling of Ba+ ions as a precursor for Ra+. Work towards single ion trapping of Ra+, including an offline ˆ{223}Ra source, is in progress [6]. The setup which is used for a competitive APV measurement is also well suited for the realization of a single ion optical clock based on Ra+ [7], where the sensitivity to certain systematic shifts such as the electric quadrupole shift are minimal. Whereas for the APV measurement the light shift needs to be measured as a function of laser intensity very accurately, a clock requires stable control of the S-D transition. A stability of 10ˆ{-18} or beyond appears feasible for a ˆ{223}Ra+ clock.

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Summary

A measurement of atomic parity violation in a single Ra+ ion promises an improved value for the Weinberg angle at low energies. The experiment has sensitivity, e.g., to extra Z0 bosons and leptoquarks.

Primary author: Ms NUNEZ PORTELA, Nunez Portela (RUG / KVI)

Co-authors: Ms MOHANTY, Amita (RUG / KVI); Mr DIJCK, Elwin A. (RUG / KVI); Dr ONDERWATER, Gerco (C.J.G.) (RUG / KVI); Prof. WILSCHUT, Hans (H.W.) (RUG / KVI); Prof. JUNGMANN, Klaus (RUG / KVI); WILLMANN, Lorenz (RUG / KVI); Mr BOELL, Oliver (RUG / KVI); Prof. TIMMERMANS, Rob (R.G.E.) (RUG / KVI); Dr SCHLESSER, Sophie S. (RUG / KVI); Dr HOEKSTRA, Steven (RUG / KVI)

Presenter: WILLMANN, Lorenz

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