P and T Violation in Radium

KLAUS P. JUNGMANN[1]

[1]*University of Groningen, KVI, NL-9747 AA Groningen*

The element Radium (Ra, Z=88) offers excellent opportunities to study both atomic parity violation (APV) with high precision in Ra^+ ions and to search very sensitively for atomic and nuclear permanent electric dipole moments (EDMs) in the neutral Ra atom. At the TRIμP facility of KVI a program is underway to address both issues, experimentally as well as theoretically.

APV effects in Ra^+ are some 50 times larger than in Cs, where the most accurate experiments could be performed so far. The measurements in, e.g., ^{223}Ra or ^{226}Ra promise a 5-fold improvement in the measurement of the Weinberg angle ($\sin^2 \theta_w$) at low momentum transfer in about one day of measurement time. The experiment can be performed with a well localized single trapped ion through a measurement of the light shift in the $7^2S_{1/2} - 6^2D_{3/2}$ transition. For the extraction of relevant parameters the reliability and accuracy of atomic structure calculations is most important. To test and further develop those a program of measurements of lifetimes, isotope shifts and transition wavelength in a variety of transitions in several isotopes is under way.

EDMs can be searched for in Ra atoms both in the ground state and in the excited states. For isotopes near the valley of stability octupole deformation had been established. This is associated with close lying nuclear states of opposite parity and it causes enhancements (some 100) of a possible nucleon EDM which can be measured via the behavior of the neutral Ra atoms in their $7s^2\ ^1S_0$ ground state in an external magnetic field. The $7s7p\ ^3P_1$ and $7s7\ ^3D_2$ excited atomic states in neutral Ra are almost degenerate which causes an enormous enhancement (few 1000) of a possible electron EDM which can be measured through spin precession of the excited state in an external electric field. For this neutral atom trapping is indispensable. The experimental program involves precision spectroscopy of the relevant Ra states and the manipulation of samples of a few atoms. Amongst others, in particular the trapping of small samples of rare atomic species has been developed.

The precision experiments on Ra^+ and Ra are two examples of presently worldwide ongoing projects to study fundamental symmetry violations at low energies using atomic systems.