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Stringent tests of bound-state QED using highly charged ions

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The ultra-precise determination of the g-factor of highly charged ions is a unique possibility to test the validity of the Standard Model, particularly Quantum Electrodynamics (QED) in extreme electric fields up to 10^{16} V/cm. While the weak-field regime has been exquisitely tested, in the presence of strong fields higher-order contributions beyond the Standard Model might become significant. It is possible to sensitively search for such effects by measuring the Larmor- and cyclotron frequencies of single, highly charged ions in a cryogenic Penning trap with high precision. This way, by measuring the g-factor of medium heavy hydrogenlike ions with previously unprecedented precision, we have been able to perform the most stringent test of QED in strong fields. Particularly the effect of the nucleus on the g-factor of the electron is a novel and unique access to nuclear size and structure information.
To push these tests far into the strong-field, heavy ion regime, we have developed and commissioned the ALPHATRAP experiment at the MPIK in Heidelberg. ALPHATRAP has recently performed the first high-precision measurement of the g-factor of a boronlike highly charged ion, $^{40}Ar^{13+}$. This not only enables a sensitive test of multi-electron QED, but also paves the way towards a determination of the finestructure constant α. Furthermore, using a novel detection scheme, also the finestructure splitting in $^{40}Ar^{13+}$ has been detected by means of laser spectroscopy. The recent results of ALPHATRAP and the future prospects will be presented.

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