Precise Physics of Simple Atoms

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Simplicity of "simple" atoms has been for a while a challenge to precision theory and experiment. Are the simple hydrogen-like atomic systems simple enough to be calculated with an accuracy, appropriate to compete to the best experimental results? That is a question, that theorists have tried to response. The most simple atoms are different two-body bound systems with a low value of the nuclear charge: $Z = 1$ (hydrogen, deuterium, muonium and positronium) and $Z = 2$ (single-charged ions of helium-3 and helium-4) etc. We present state of art in physics of simple atoms and discuss in detail theoretical and experimental status of studying such atoms.

In particular, we consider few theoretical problems:

- Small parameters for simple atoms are lower than 1/100 ($\alpha \simeq 1/137$, $m_e/m_\mu \simeq 1/207$ etc), however, most of known expansions over them used to behave not quite well because of large logarithms ($\ln(1/\alpha) \sim ln(m_\mu/m_e) \sim 5$) and large numerical coefficients. Appearance of increasing powers of these large logarithms make any estimation of a theoretical accuracy to be a hard problem.

- Two kinds of higher-order QED corrections have not been known up-to-date and limit the precision of the present theoretical evaluations. One of them arises from expansions of the electron two-loop self-energy contribution in strengh of the Coulomb interaction ($Z\alpha$). That is a problem to compute the Lamb shift in the hydrogen, helium ion and some higher-Z atomic systems. Similar higher-order (in $(Z\alpha)$) terms should appear for calculations of a bound electron g-factor in hydrogen-like ions at $Z \sim 20 - 30$.

- The other important task is to evaluate radiative-recoil contributions with essential binding effects. Such contributions are important for the hyperfine structure in muonium and for positronium spectrum.

- Important problem is contributions beyond QED and, in particular, influence of strong interactions. For instance, our possibility to do any calculation for the hydrogen and deuterium atoms is completely limited now by our knowledge of the proton and deutron structure.

Most of these questions and a more broad range of problems in physics of simple atoms were considered at a Satellite meeting to the ICAP (Hydrogen Atom, 2: *Precise Physics of Simple Atomic System*) and in their book of abstracts one can find detail on theoretical and experimental status of physics of simple atoms, including hydrogen, muonium, positronium, helium,

few-electron ions at different Z, muonic and exotic atoms, antihydrogen. Several metrological problems due to precison spectroscopy and determination and possible variation of fundamental constants were also among the topics of the satellite meeting.