Perspectives for relativistic many-body and QED calculations for highly charged ions

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Quantum electrodynamics is the best understood quantum field theory and is often used as starting point for tests of the standard model. One can compare highly accurate QED and experimental values for the free electron [1] or muon [2] anomalous magnetic moments for example, or study bound states in few electron ions [3]. Advances in high-precision measurements of transition energies, atomic masses, metastable states lifetimes allow for improving tests of bound state QED. Comparisons of atomic clocks may lead to information in the variation of fundamental constants and the use of highly-charged ions long-lived states could help improve their accuracy [4, 5]. Yet, it is becoming more and more difficult to get relevant accuracy for systems with more than a few electrons. This happens in particular when calculating heavy elements properties needed for astrophysics (see, e.g., [6]), atomic mass measurements (see e.g., [7, 8]), to study long lived metastable states for ions clocks[4], to look at "beyond the standard model" physics [9], to calculate transition energies in highly charged ions or to find optical transitions for super-heavy elements laser spectroscopy [10]. Many calculations become too large to be performed in spite of the huge increase in computer power of the last few decades. I will present a few recent examples to show the limits are encountered even in relatively simple systems, and discuss possible progress.

References

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