Relativistic, QED, and finite nuclear mass corrections for low lying states of beryllium

Mariusz Puchalski[1], Krzysztof Pachucki[2] and Jacek Komasa[1]

[1]*Department of Chemistry, Adam Mickiewicz University, Poznań, Poland*
[2]*Faculty of Physics, University of Warsaw, Warsaw, Poland*
mpuchals@amu.edu.pl

The variational calculations based on explicitly correlated gaussian basis set enable efficient determination of accurate non-relativistic wave functions and binding energies of the few-electron atoms [1]. In the NRQED perturbative approach with energy expansion terms ordered in powers of the fine structure constant [2], relativistic, quantum electrodynamic and finite nuclear mass effects can be studied systematically using this nonrelativistic wave function.

Accurate results for nonrelativistic energy, relativistic, quantum electrodynamics and finite nuclear mass corrections are obtained for the ground state 2^1S and the excited 3^1S, 2^1P states of the beryllium atom [2]. New values for the ionization energy, transition energies and the isotope mass shift will be presented for the first time or few orders of magnitude more accurately than obtained previously [4-6]. It establishes a framework for a high accuracy theoretical studies.

Nevertheless, the precision of the experimental data available for beryllium is far from being satisfactory compared to the exquisite accuracy of the modern atomic spectroscopy. The level of the absolute precision achieved in modern measurements for three-electron systems[4,5] is as many as four orders of magnitude higher than that obtained in the case of beryllium. As it has been shown for two- and three-electron atoms, the availability of such accurate data, in connection with good understanding of the underlying atomic theory, opens up access to such interesting applications like the determination of the nuclear charge radius or precision tests of the quantum electrodynamics (QED). We hope that the improved theoretical accuracy will stimulate renewed experimental effort in the beryllium atom.

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