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g factor of highly charged ions: αZ expansion for interelectronic interaction correction

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Over the last few decades, significant progress has been made in the study of the g factor of highly charged ions [1,2]. To date, the experimental accuracy for hydrogen-, lithium- and boron-like ions has reached values in the range of 10^{-9} - 10^{-11} [3-7]. These studies have provided the most precise value of the electron mass [8, 9]. Additionally, by measuring the g factor of light and heavy highly charged ions, it is possible to determine the value of the fine structure constant, extract nuclear parameters, and explore potential new physics [10-12].

In our investigation, the interelectronic interaction correction to the g factor of ions with the low nuclear charge number Z are investigated for the Coulomb and various screening potentials.
Within the framework of bound-state QED perturbation theory, the contribution of the interelectronic interaction Δg_{int} can be written as a $1/Z$-parameter expansion:
\begin{equation}
\Delta g_{\text{int}}=(\alpha Z)^2\left[\frac{1}{Z}B_1(\alpha Z)+\frac{1}{Z^2}B_2(\alpha Z)+\ldots\right].
\end{equation}
The coefficients B_i are expanded in the parameter αZ:
\begin{equation}
B_i(\alpha Z) = b_i^{(0)} + (\alpha Z)^2 b_i^{(2)} + (\alpha Z)^4 b_i^{(4)} + \cdots .
\end{equation}
We determine the coefficients $b_k^{(i)}$ in the Coulomb potential and various screening potentials from full numerical calculations of Δg_{int} up to the fifth and third orders respectively. The calculations are based on the dual-kinetic-balance method [13] with a finite basis set composed of B-splines. Corrections due to the interelectronic interaction in the Breit approximation are expanded in powers of αZ for the ground and excited $(1s)^2 2p_{1/2}$ and $(1s)^2 2p_{3/2}$ states. The combination of our results with high precision non-relativistic calculations will enhance the accuracy of theoretical predictions.

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