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# Computing the QED corrections to the Coulomb potential: an example of a 6-loop 2-scale calculation

*Monday 8 September 2025 11:00 (30 minutes)*

QED in the classical Coulomb field of a nucleus serves as a good approximation for obtaining high-precision results in atomic physics. The external field is a subject to radiative corrections. These corrections can be explained perturbatively in terms of the QED Feynman diagrams containing scalar-like propagators for the external field together with the usual QED propagators.

A calculation of these corrections of orders $\alpha^2(Z\alpha)^3$ and $\alpha^2(Z\alpha)^5$ will be presented; here, $Z$ is the nucleus charge, $Z\alpha$ is used as a separate variable. The calculation uses the QED Feynman diagrams directly and determines the corrected potential as a function of the external momentum (on points). The diagrams incorporate two independent mass scales - electron mass and external momentum - and can have up to six independent loops.

Such high-order calculations would be impossible without a specialized method, which will be briefly explained. Special attention will be paid to the following points:
1. The divergence removal and renormalization is performed in Feynman parametric space, point by point, before integration; things like dimensional regularization are never used.
2. A special nonadaptive Monte Carlo integration algorithm is used to make the results accurate and to avoid the numerical instability caused by the presence of significantly different scales.

The calculation method is a modification of the one used by the author for the 5-loop electron anomalous magnetic moment calculation.

The results will be compared to the previously known ones, and the implication for high-precision atomic physics will be discussed.

## Significance

1. The presented computation method is extremely fast for high-order Feynman integrals. It can be used (ideologically) for other problems and processes.
2. The obtained results allow us to obtain preciser corrections to the energy spectra of hydrogen-like atoms and ions. It is still important for comparing with the experimental data.

## References

## Experiment context, if any

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