Two-loop QED corrections to the bound-electron $g$ factor involving the magnetic loop

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Provides a measure of the Zeeman splitting of energy levels

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\]
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Measurement in Penning trap

Precision: $10^{-11}$ for medium-light H-like ions

Soon to come: same precision for medium and heavy H-like ions (e.g. Ca, Xe, Pb)

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QED calculations

• Perturbative approach: free $e^- +$ perturbative binding to nucleus (series in $(Z \alpha)$)
• Non-perturbative approach: bound state QED

Loops from QED are to be treated perturbatively in all approaches (series in $\alpha$)

Current knowledge of two-loop corrections:

  $(Z \alpha)^5$ [A. Czarnecki, M. Dowling, J. Piclum, R. Szafron, Phys. Rev. Lett. 120, 043203 (2018)]
• Non-perturbative approach: partial knowledge
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50 total diagrams
(29 inequivalent diagrams)

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Diagrams with 2 self-energy loops
$\rightarrow$ Calculation in progress
[B. Sikora, Ph.D. thesis,
Ruprecht-Karls-Universität Heidelberg (2018)]
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This work: revisit diagrams that vanished in the free VP loop approach & calculate lowest nonvanishing contribution