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Precision calculation of muon decay asymmetry for EDM searches

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The search for a non-zero electric dipole moment (EDM) of the muon is a sensitive tool to test the Standard Model, as it would indicate a further violation of the charge-parity (CP) symmetry. The current best upper limit, established by the E821 experiment at BNL, is $d_\mu < 1.8 \times 10^{-19}\ e \cdot$ cm at 95% of confidence level. The forthcoming μEDM experiment at PSI aims to improve this limit by four orders of magnitude by using the frozen-spin technique within a compact storage trap. Since the muon EDM is extracted by measuring the time evolution of the directional asymmetry of the emitted positrons, an accurate calculation of the muon decay asymmetry is needed. This contribution presents an improved theoretical computation of the $\mu^+ \to e^+ \nu_e \bar{\nu}_\mu$ decay for arbitrarily polarised muons, focusing on the boosted positron energy spectrum and the corresponding positron asymmetry. The calculation includes complete QED corrections at $\mathcal{O}(\alpha^2)$ with full mass effects, as well as logarithmically enhanced terms at higher orders. In particular, logarithms due to collinear emissions are computed with a next-to-leading logarithmic accuracy up to $\mathcal{O}(\alpha^4)$ by solving order-by-order the QED evolution equation. At the endpoint of the energy spectrum, soft photon emissions result in large logarithms that are resummed with a next-to-next-to-leading logarithmic accuracy via analytic exponentiation. The calculation is applied to the kinematic configuration of the μEDM experiment to study the impact of such radiative corrections on the experimental sensitivity.

References:

[1] A. Adelmann et al., A compact frozen-spin trap for the search for the electric dipole moment of the muon [2501.18979].

[2] P. Banerjee et al., High-precision muon decay predictions for ALP searches [2211.01040].

Secondary track

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