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Electromagnetic finite-size effects to the hadronic vacuum polarisation

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The present $3.5\,\sigma$ discrepancy between the theoretical prediction and experimental value of the muon anomalous magnetic moment requires improved accuracy for both measurements and calculations. On the theory side, the hadronic vacuum polarisation (HVP) is one of the main sources of uncertainty at the moment. This can be calculated in finite volume (FV) on the lattice, and in order to reach sub-percent precision on the HVP, $\mathcal{O}(\alpha)$ electromagnetic corrections need to be added. Due to the massless nature of photons the FV effects go as a polynomial in $1/L$, so including QED on the lattice is potentially problematic. We have analytically calculated the $1/L$ expansion of the HVP at NLO in the the electromagnetic coupling in QED$_L$ and found it to start at $1/L^3$, i.e. suppressed by one power as compared to the a priori possible $1/L^2$. We have also shown that this is universal. The analytical $1/L$ expansion has been compared numerically with lattice perturbation theory as well as lattice calculations and there is good agreement.

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