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Electromagnetic finite size effects to the hadronic vacuum polarisation (12'+3')

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One of the most precisely measured quantities in particle physics is the anomalous magnetic moment $a_\mu = (g_\mu - 2)/2$, where g_μ is the deviation from the Dirac value $g_\mu = 2$. At present, there is roughly a $3\,\sigma$ discrepancy between the value of a_μ calculated in the Standard Model and that experimentally measured at Brookhaven, which could indicate physics beyond the Standard Model. In order to find out down whether or not this is the case, there is a new experiment at Fermilab, expected to have an improved value in the coming couple of years, as well as effort to improve the calculations of the various contributions to the theoretical value. One of the contributions to a_μ is from the hadronic vacuum polarisation (HVP) which in recent years can be calculated in finite volume (FV) on the lattice. The errors due to the FV approximation in such a calculation depend on the size of the lattice, and massive particles have exponentially suppressed effects, i.e. $\exp{(-mL)}$, whereas massless particles have power suppressed effects starting at some power of $1/mL$, so including QED on the lattice could potentially require a very large volume to have the errors under control. We have calculated the $1/mL$ expansion of the HVP at NLO in the the electromagnetic coupling in QED_L and found it to start at $1/(mL)^3$, so that the NLO QED effects are negligible in ordinary lattice calculations. The analytical $1/mL$ expansion was compared numerically with lattice perturbation theory as well as lattice calculations and there is good agreement.

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