Progress report on computing the disconnected QCD and the QCD+QED hadronic contributions to the muon's anomalous magnetic moment.

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[1]Fermilab Lattice, HPQCD and MILC collaborations

Introduction

- The exciting recent results from the Fermilab Muon g-2 experiment for the Muon Anomalous Magnetic Moment (2104.03281) motivates reducing the error on lattice calculations of the hadronic contribution to a_μ^{LO}.
- In 1902.04223 we presented results for the connected light quark contribution a_μ^{LO} with an error of 1.4%.

To reduce the error we need to explicitly calculate:

- Disconnected contributions
- QCD+QED corrections

See Shaun Lahert's talk at this conference for a report on our work on reducing the error on the light quark connected contribution.

Disconnected contributions $a_\mu^{HVP(LO)DISC}$

The leading-order contribution to the anomalous magnetic moment from the HVP is

$$a_\mu^{\rm HVP} = 4\alpha^2 \int_0^\infty dq^2 f(q^2)\hat{\Pi}(q^2).$$

The disconnected piece requires the non-perturbative calculation of the quark-line disconnected correlation of vector currents
The non-perturbative calculation requires the correlation of vector currents

$$d(t) = \frac{1}{3V}\sum_{j=0,1,2}\sum_{t'} \mathcal{V}_j(t+t')\mathcal{V}_j(t')$$

where $\mathcal{V}_j(t)$ is vector loop with component i at time t and V is the space-time volume.

$$\mathcal{V}_j = \frac{1}{3}(\mathcal{V}_j^{u/d} - \mathcal{V}_j^{s})$$

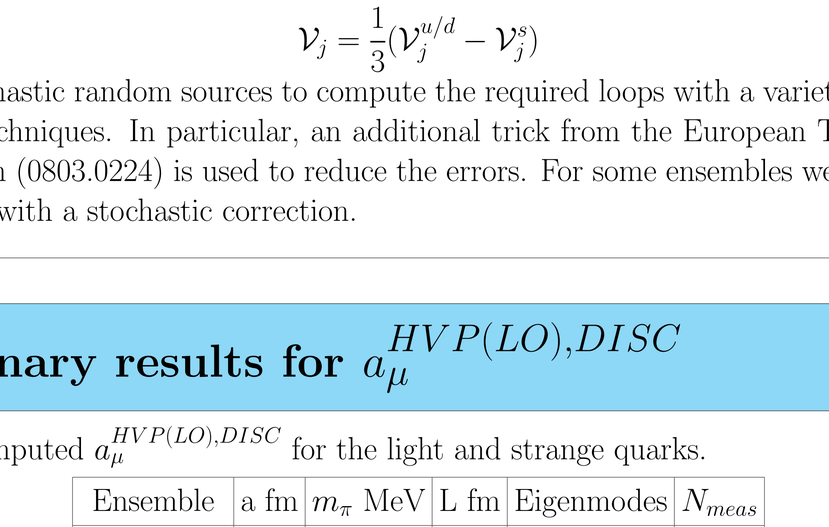
We use stochastic random sources to compute the required loops with a variety of variance reduction techniques. In particular, an additional trick from the European Twisted Mass collaboration (0803.0224) is used to reduce the errors. For some ensembles we also use low eigenmodes with a stochastic correction.

Preliminary results for $a_\mu^{HVP(LO),DISC}$

We have computed $a_\mu^{HVP(LO),DISC}$ for the light and strange quarks.

Ensemble	a fm	m_π MeV	L fm	Eigenmodes	N_{meas}
Very coarse	0.15	134.7	4.8	300	1692
Coarse	0.12	134.9	5.8	-	787
Fine	0.09	128.3	5.8	1000	271

The correlators are multiplied by a **random blinding factor**.



The graph also shows the data corrected for finite volume and taste corrections.
The continuum and chiral extrapolation fit model is

$$D = a_0\left(1 + a_1 a^2 + a_2\left(\frac{m_\pi^2 - m_{\pi,phys}^2}{m_{\pi,phys}^2}\right)\right)$$

where a is the lattice spacing units GeV^{-1} with priors: $a_0 = 14(8)$, $a_1 = 0(1)$ and $a_2 = 0(3)$.

Preliminary window analysis of $a_\mu^{HVP(LO),DISC}$

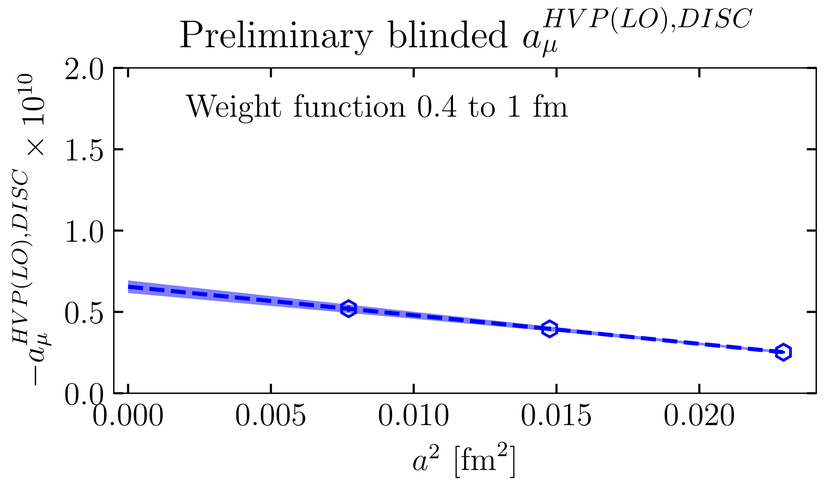
To compare different calculations a weight function is multiplied into the correlator.

$$\Theta(t;t',\Delta) \equiv \frac{1}{2} + \frac{1}{2}\tanh[\frac{t-t'}{\Delta}]$$

where $\Delta = 0.15$ fm

$$W(t;t_1,t_2) \equiv \Theta(t;t_1,\Delta) - \Theta(t;t_2,\Delta)$$

The weight function ($t_1 = 0.4$ fm $t_2 = 1.0$ fm) is applied to the blinded correlators.



- No taste corrections have been applied in the above graph.
- RBC and UKQCD (1801.07224), and BMWc (2002.12347) also found a large suppression of $a_\mu^{HVP(LO),DISC}$ for this window.

Connected quenched QED corrections

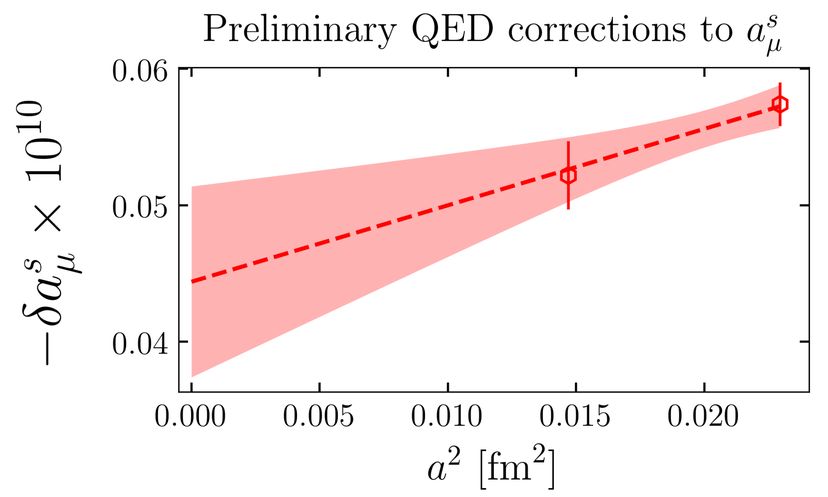
- We use the electro-quenched approximation.
- The calculation used quenched QED fields fixed to the Feynman gauge with zero modes dealt with using the QED$_L$ prescription.
- We use the truncated solver method with 16 sloppy inversions and 1 precise inversion.

Ensemble	a fm	m_π MeV	L fm	N_{meas}	Quark masses
Very coarse	0.15	134.7	4.8	356	m_l, $3m_l$, $5m_l$, $7m_l$, m_s,
Coarse (I)	0.12	132.7	5.8	208	$3m_l$, $5m_l$, $7m_l$, m_s

We plot the QED contribution to the strange a_μ^s.

$$\delta a_\mu^s = a_\mu^s[QCD + qQED] - a_\mu^s[QCD]$$

We have **not** yet retuned the quark masses to include the QED contribution.



Conclusions

Future work

- We are about to start to generate correlators for the connected QCD+quenchedQED correlators at the lattice spacing 0.09 fm.
- We are generating an ensemble of configurations with QCD + dynamical QED at the lattice spacing of 0.15 fm.

We finally plan to compute the QED contribution in the disconnected diagrams.