About Me

Background, past activities

Andreas Risch

Student at Heidelberg and Durham (UK): Physics & Mathematics

Data analyst at DB Analytics at Frankfurt

(DB Mobility Logistics, Department for Transport Network Development and Transport Models)

Doctoral student at the Institute for Nuclear Physics at Mainz

Dissertation: Isospin breaking effects in hadronic matrix elements on the lattice

Since 2021: PostDoc at DESY Zeuthen

(John von Neumann-Institut for Computing NIC/Zeuthen Particle Physics Theory)

Research interests: Lattice QCD+QED, hadron spectroscopy & precision observables, lattice algorithmic improvements

My Current Work

Activities and challenges

Lattice regularisation of the Euclidean path integral:

- Rigorous, non-perturbative, gauge-invariant

$$\langle O[\Phi]\rangle = \frac{1}{Z}\int \prod_{x\in\Lambda} \mathrm{d}\Phi(x)\, e^{-S[\Phi]}\, O[\Phi]$$

finite lattice spacing a
& finite lattice extent aN_μ

$$\Lambda = \{x \in \mathbb{R}^4 | x^\mu = an^\mu, n^\mu \in \{0,1,\dots,N^\mu - 1\}\}$$

- Field integration via Monte Carlo (MC) simulations

Investigation of isospin breaking (IB) effects:

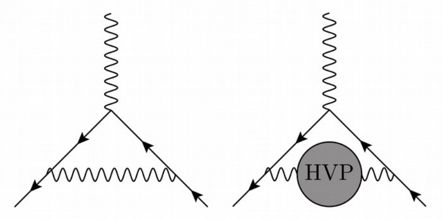
- MC simulations commonly for performed for $\mathrm{QCD}_{\mathrm{iso}}$
- IB effects: $\mathrm{QCD}_{\mathrm{iso}}$, $m_u = m_d,\ \alpha = 0$ ⟷ $\mathrm{QCD}+\mathrm{QED}$, $m_u \neq m_d,\ \alpha \neq 0$
- Relevant for hadronic precision observables with <1% error

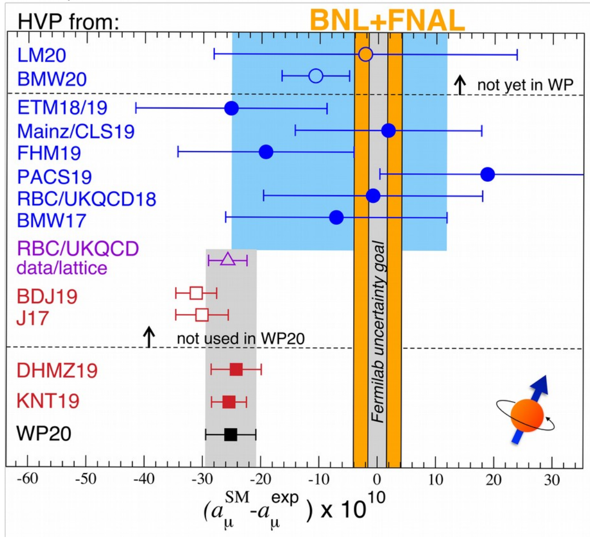
Hadronic precision observables:

- Hadronic vacuum polarisation (HVP) contribution to $(g-2)_\mu$

$\vec{M} = g_\mu \frac{e}{2m_\mu}\vec{S}$ gyromagnetic ratio g_μ $\quad a_\mu = \frac{g_\mu - 2}{2}$ 0.35 ppm

$$a_\mu^{\mathrm{HVP}} = \left(\frac{\alpha}{\pi}\right)^2 \int_0^\infty \mathrm{d}x^0\, \widetilde{K}(x^0, m_\mu)\, \frac{1}{3}\sum_{\mu=1}^{3} \int \mathrm{d}x^3\, \langle 0|\mathcal{V}_\mu^\gamma(x)\mathcal{V}_\mu^\gamma(0)|0\rangle$$





- Related observables:
- $\alpha(q^2),\ \sin^2\theta_W(q^2)$
- 

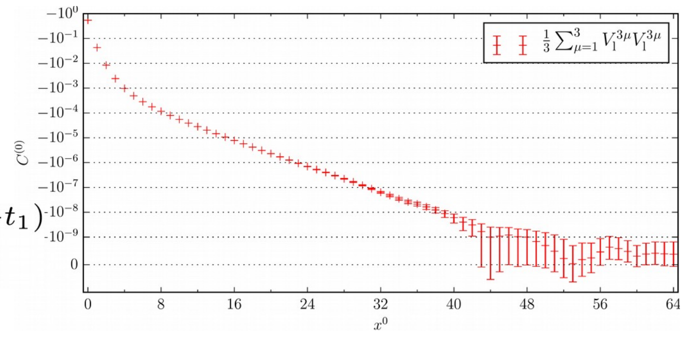
Hadron spectroscopy:

- Masses of mesons & baryons

$$\langle H|O^\dagger|0\rangle \neq 0$$

$$\langle 0|O(t_2)O^\dagger(t_1)|0\rangle = \sum_n |\langle 0|O|n\rangle|^2 e^{-E_n(t_2-t_1)}$$

for $t_2 > t_1$



Improvement of lattice actions:

- Reduce lattice artefacts?
- Increase algorithmic stability?

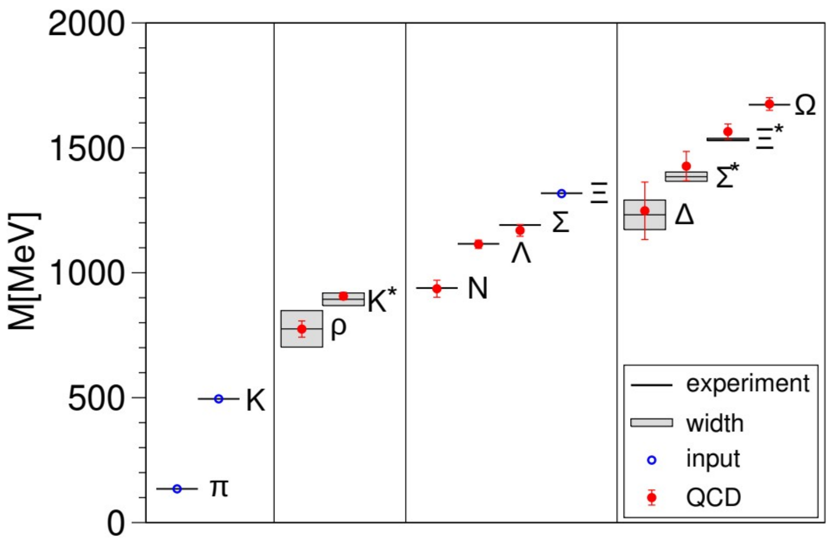
Study influence of gradient flow smearing:

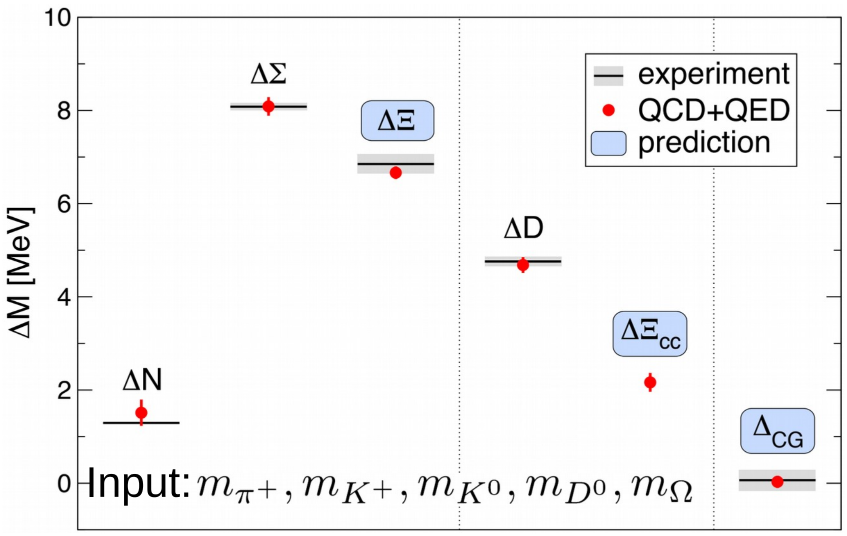
- How much smearing is too much smearing?

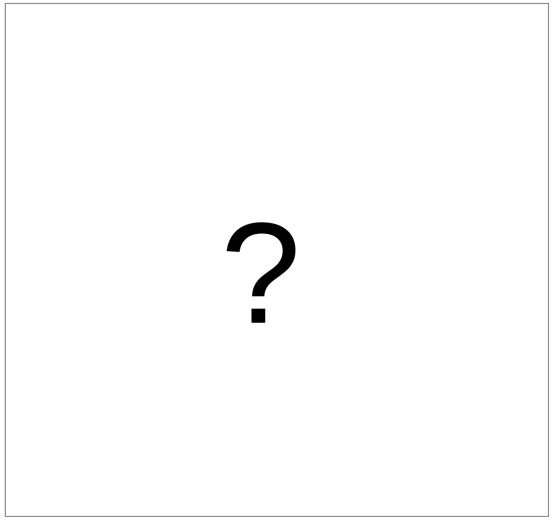
Study modifications of lattice Dirac operator

My Favourite Plot(s)

Or the one question you always wanted to ask!







From: Science 322 (2008) 1224-1227
"Ab-Initio Determination of Light Hadron Masses"

From: Science 347 (2015) 1452-1455
"Ab initio calculation of the neutron-proton mass difference"

$$m_N = 0.936(25)(22)\,\text{GeV}$$

3.5% relative error

$$m_n - m_p = 1.51(16)(23)\,\text{MeV}$$

$$m_n = ?$$

$$m_p = ?$$

<0.1% relative error

2008

2015

20??