Status – Isospin breaking corrections

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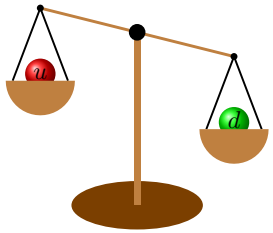
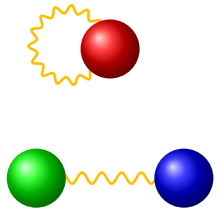
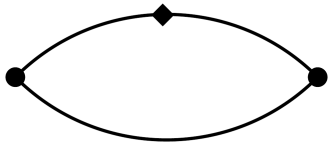
Introduction

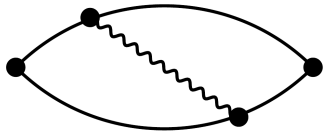




- Isospin Breaking Corrections:
  - different masses for up- and down quark
  - Quarks have electric charge



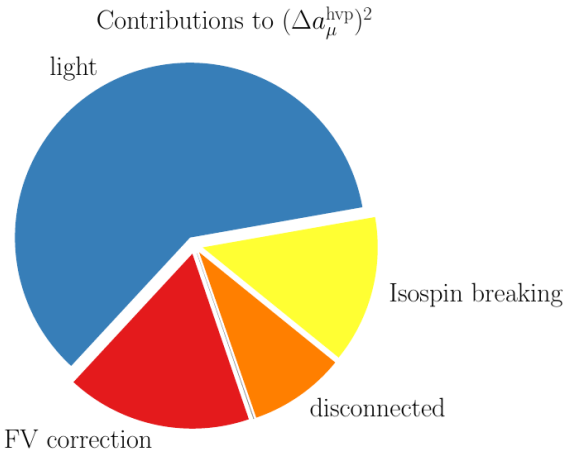
$\sim \mathcal{O}(\delta m/\Lambda_{\mathrm{QCD}})$



$\sim \mathcal{O}(\alpha)$

- lattice calculation with $< \mathbf{1\%}$ precision requires isospin breaking

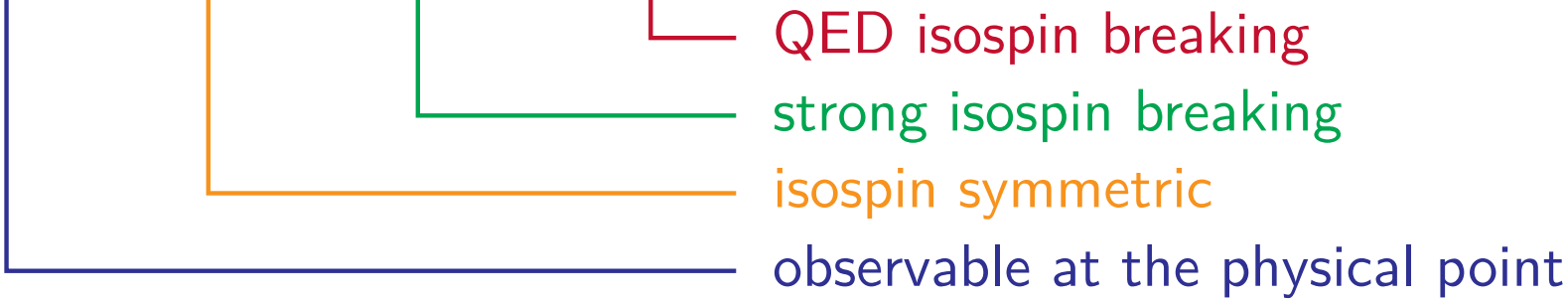
- Right: breakdown of the variance of BMW result
  [BMWc Nature 593 7857, 51-55 (2021)]
  Figure taken from [Simon Kuberski PoS Lattice 2023]



Separation Prescription

- Decomposing into isospin symmetric and isospin breaking

$$X^{\phi} = \overline{X} + X_{SU(2)} + X_{\gamma} \qquad \hat{X} \equiv \overline{X} + X_{SU(2)}$$



- observable at the physical point unambigously defined given a complete set of inputs (e.g. hadron masses)
- separation into $\overline{X}$, $X_{SU(2)}$ and X_{γ} requires separation scheme

  $\longrightarrow$ define arbitrary values $\overline{\Pi}$ and $\hat{\Pi}$ for a set of quantities Π

  $\longrightarrow$ scheme dependence
- need $N_f + 1$ quantities to determine $(m_u, m_d, m_s, \cdots, a)$

Scheme proposal?

- *Converging on QCD+QED prescriptions*, May 2023, Edinburgh
- preliminary proposal (paper proposed to FLAG)

	$\hat{\Pi}$	$\bar{\Pi}$
M_{π^+}	**135.0** MeV	**135.0** MeV
M_{K^+}	**491.6** MeV	**494.6** MeV
M_{K^0}	**497.6** MeV	**494.6** MeV
$M_{D_s^+}$	**1967** MeV	**1967** MeV
$M_{B_s^0}$	**5367** MeV	**5367** MeV
f_{π^+}	**130.5** MeV	**130.5** MeV

- reminder decomposition

$$X^{\phi} = \overline{X} + X_{SU(2)} + X_{\gamma}$$

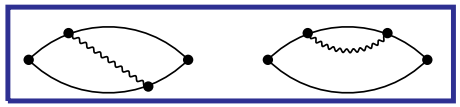
$m_u = m_d$, $\alpha = 0$ ←

$$\hat{X} \equiv \overline{X} + X_{SU(2)}$$

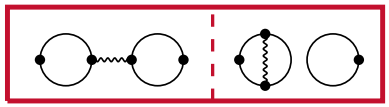
→ $m_u \neq m_d$, $\alpha = 0$

- open question for white paper: How/If to include this scheme proposal (in coordination with FLAG)

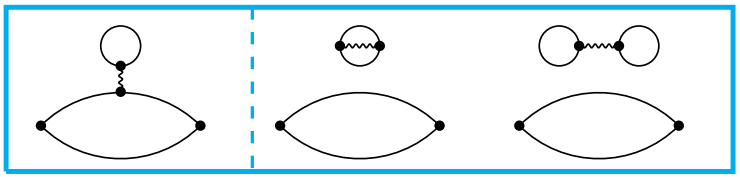
Isospin Breaking Corrections – Status of Results



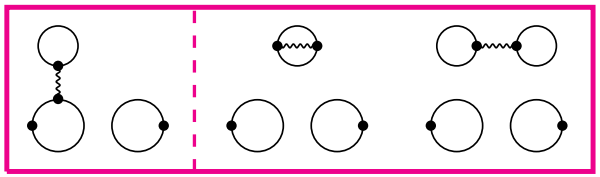
BMW **−1.27(40)(33)**
RBC/UKQCD **5.9(5.7)(1.7)**
ETM **1.1(1.0)**



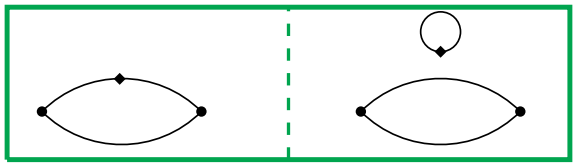
−0.55(15)(11) BMW
−6.9(2.1)(2.0) RBC/UKQCD



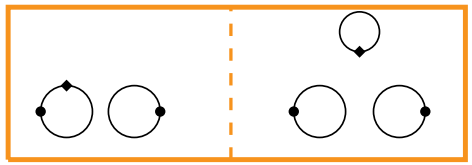
−0.0095(86)(99) **0.42(20)(19)** BMW



0.011(24)(14) **−0.047(33)(23)** BMW



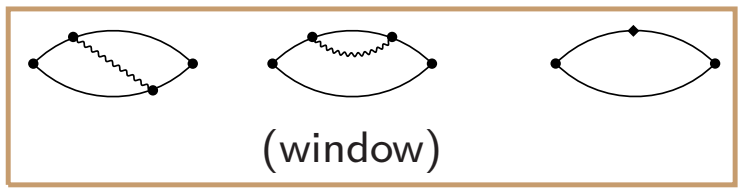
6.59(63)(53) BMW
10.6(4.3)(6.8) RBC/UKQCD
6.0(2.3) ETM
7.7(3.7) **9.0(2.3)** FHM
9.0(0.8)(1.2) LM



−4.63(54)(69) BMW

BMW [Nature (2021)]
RBC/UKQCD [PRL 121 (2018) 2, 022003]
ETM [Phys. Rev. D 99, 114502 (2019)]
FHM [Phys.Rev.Lett. 120 (2018) 15, 152001]
LM [Phys.Rev.D 101 (2020) 074515]
Mainz [Phys. Rev. D 106, 114502 (2022)]

bold: new (not discussed in first WP)



0.70(45) Mainz

Comparison of different results

- only one complete calculation by BMW

$$\delta a_\mu^{\mathrm{HVP}} = \mathbf{0.5(1.4)} \times \mathbf{10^{10}}$$

- direct comparisons between (or combinations of) results of various collaborations difficult

- different schemes used (listed in the first WP or the update)
  - BMW: $M^2 = \frac{1}{2}(M^2_{\bar{u}u} + M^2_{\bar{d}d})$, $\Delta M^2 = M^2_{\bar{d}d} - M^2_{\bar{u}u}$, $M^2_{\bar{s}s}$
  - Mainz: $M^2_{\pi^0}$, $M^2_{K^+} + M^2_{K^0} - M^2_{\pi^+}$, $M^2_{K^+} - M^2_{K^0} - M^2_{\pi^+} + M^2_{\pi^0}$
  - LM: implicit by m_s/m_{ud}, m_u/m_d from the FLAG 19
  - RBC/UKQCD: M_{π^+}, M_{K^+}, M_{K^0}
  - ETM: m_{ud}, m_s and m_c (GRS scheme)
  - FHM: M_π, M_K

Summary – Status of WP section

Structure & Current Status ($\gtrsim$ 1 page)

- Introduction to IB corrections
- reference to previous whitepaper for various diagrams/contributions
- the need for a separation scheme (move earlier in the WP?)
- ? scheme proposal ?
- Summary table of available results
- schemes used for available results (or reference to previous WP)

Outstanding Points for discussion:

- To (or not to) include the separation scheme proposal
  - needs coordination with FLAG
  - timeline FLAG? Possibly refer to upcoming FLAG?
- If WP includes lattice prediction for a_μ^{HVP}:
  $\longrightarrow$ suggestion: use BMW result for $\delta a_\mu^{\mathrm{HVP}}$