Proton decay matrix elements with physical quark masses

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Introduction
Proton decay
- smoking gun of new physics, natural in GUT with \( B \) violation
- search underway in underground experiments: SuperKamiokande etc
- next generation experiment planned: HyperKamiokande, DUNE

Proton decay matrix elements on the lattice
- bridge between GUTs and Experiments

Lattice status
- \( N=2+1 \) DWF results exists (1) \( \Rightarrow \alpha \)
- but, extrapolation w/ \( m_{\text{ud}} = 340 \text{ MeV} \)

Loose End
- chiral extrapolation!
- skirnn model suggests drastic decrease as \( m \rightarrow 0 \) (2)

Use of physical point simulation is next turns

Proton decay matrix elements with physical quark masses (Image)

\[ \text{statistical note} \]
- \( \sim 100 \) configurations
- for each config
- matrix elements: AMA (5):
  - one exact and
  - 256 sloppy solves
- NPR:
  - single point source

RI/MOM Non perturbative renormalization - operator mixing
- flavor structure (uds) case
- only two operators are independent LL & RL
- no chiral symm. \( \rightarrow \) mixing basis contains (6)

\[ Q_{RL} = \left( \frac{|\Phi|^2}{{m_0}^2} \right) \cdot P_{L,R} \]
\[ Q_{LL} = \left( \frac{|\Phi|^2}{{m_0}^2} \right) \cdot P_{L,R} \]
\[ Q_{(L/R)} = \left( \frac{|\Phi|^2}{{m_0}^2} \right) \cdot P_{L,R} \]

\[ \text{Off-diagonal larger than DWF, but, } \sim 1\% \rightarrow \text{treated as negligible below} \]

MSb 2GeV Z factor with RI/SMOM wave function Z
- small SSB & quark mass effect good for physical point ensemble
- \( Z_{\text{MSb}} \) or \( Z_{\text{MSb}} \) with \( Z_{\text{MS}} \) from SF scheme estimate (8)
- A and V vertex from SMOM and SMOMyu schemes (9)

References
(3) [RBC/UKQCD] J.S. Yoo et al, PoS LATTICE2018 187
(9) C. Sturm et al, PRD 80 (2009) 014501