QCD + QED
Discussion

Lattice@CERN2024

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RBC and UKQCD Collaborations

QED-related Challenges

1. Large finite-volume sensitivity: varies with formulation:

   QED_L, QED_r, QED_m, QED_C, QED_∞ ....

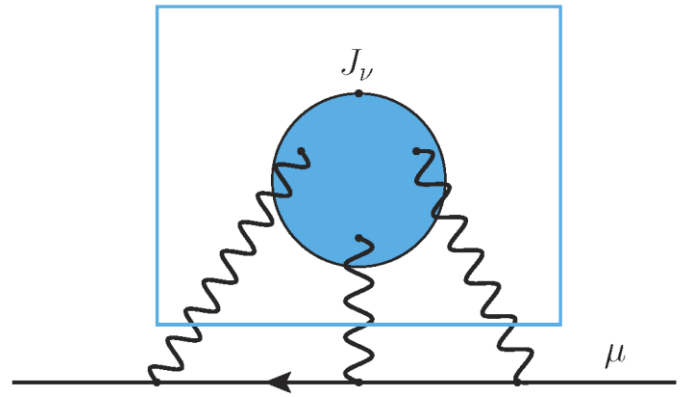
2. Multi-particle low-energy states
3. New complicated analytic component
4. Renormalization – expanded need for multi-loop perturbative results
5. Definition of $\alpha = 0$ theory and enhanced demands on its precision
6. QED vacuum corrections (non-quenched QED)

QED$_\infty$

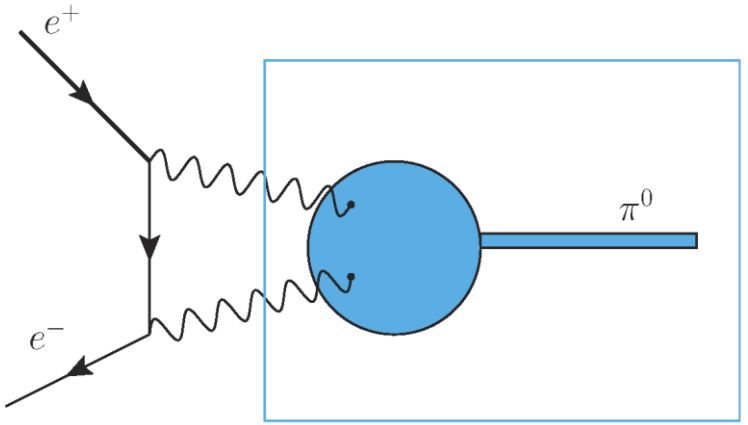
- HLBL:

  Combine infinite volume QED with QCD in the finite volume

  - arXiv:1107.4388 [hep-lat]
  - arXiv:1609.08454 [hep-lat],
  - arXiv:1705.01067 [hep-lat]

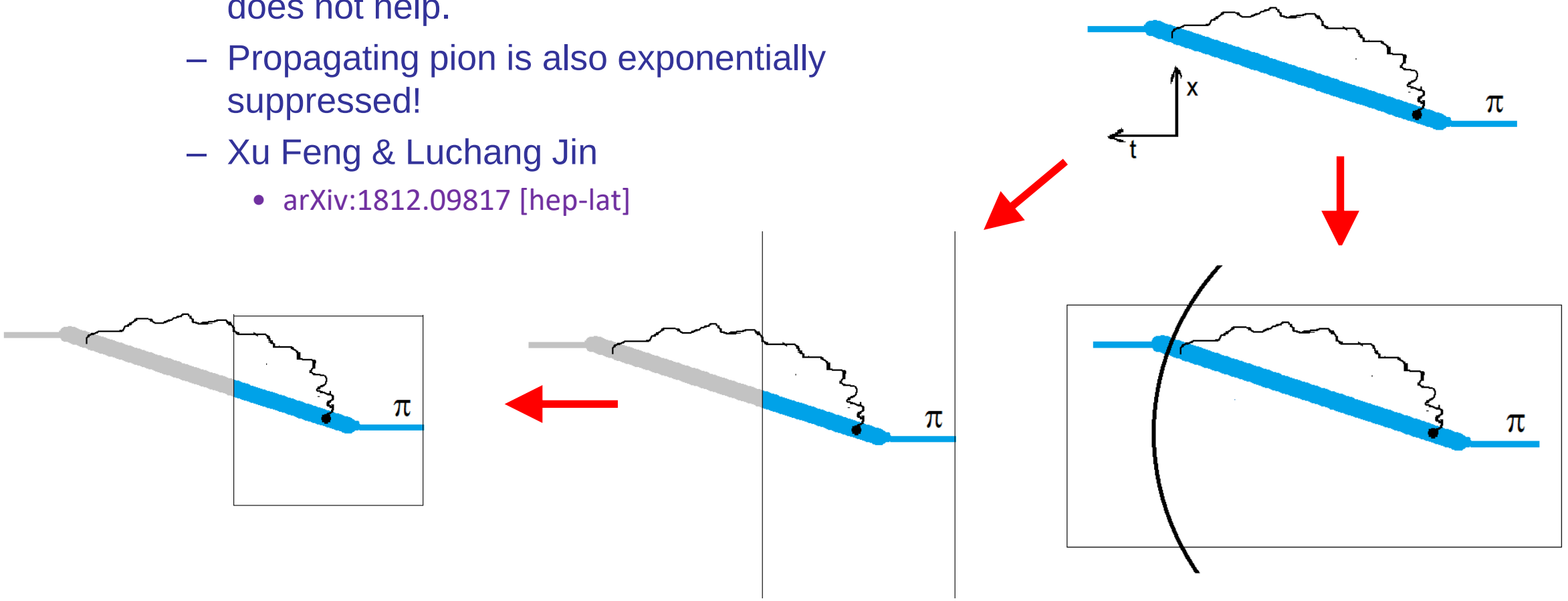


- $\pi^0 \rightarrow e^+ e^-$:
  - evaluate QED in Minkowski space
  - Wick rotate photon momentum
  - Evaluate QCD in finite Euclidean volume
  - arXiv:2208.03834[hep-lat]



QED_∞ + IVR

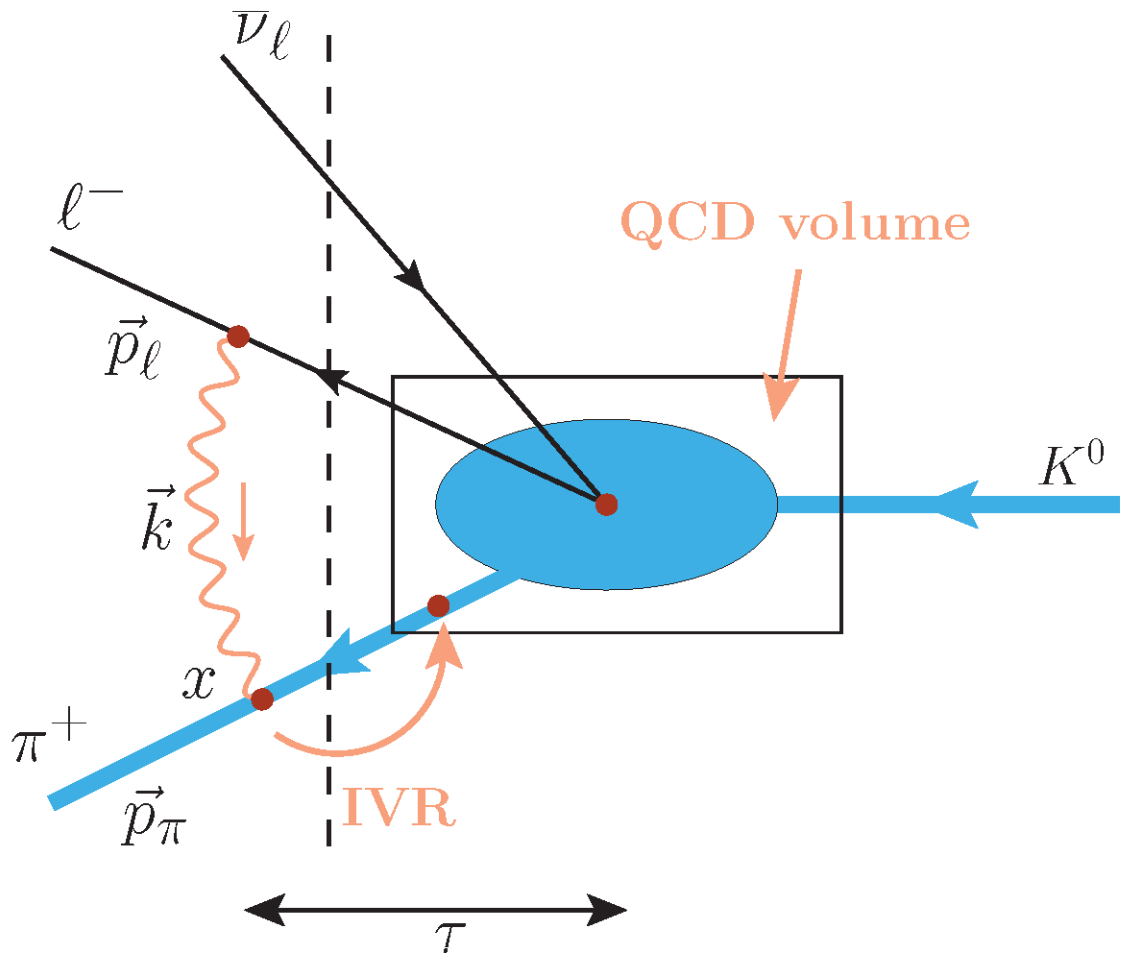
- Pion self-energy, $M_{\pi^+} - M_{\pi^0}$
  - Exponential suppression as currents separate does not help.
  - Propagating pion is also exponentially suppressed!
  - Xu Feng & Luchang Jin
    - arXiv:1812.09817 [hep-lat]



$M_{\pi^+} - M_{\pi^0}$

- $M_{\pi^+} - M_{\pi^0} = 4.534(42)_{stat}(43)_{sys}$ MeV
- Experiment = 4.5936(5) MeV
- Xu Feng & Luchang Jin arXiv:2108.05311 [hep-lat]

Example: E&M corrections for Kl3



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