$K_{\rm L} \to \mu^+\mu^-$ from lattice QCD

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July 14, 2023 @ Physikzentrum Bad Honnef

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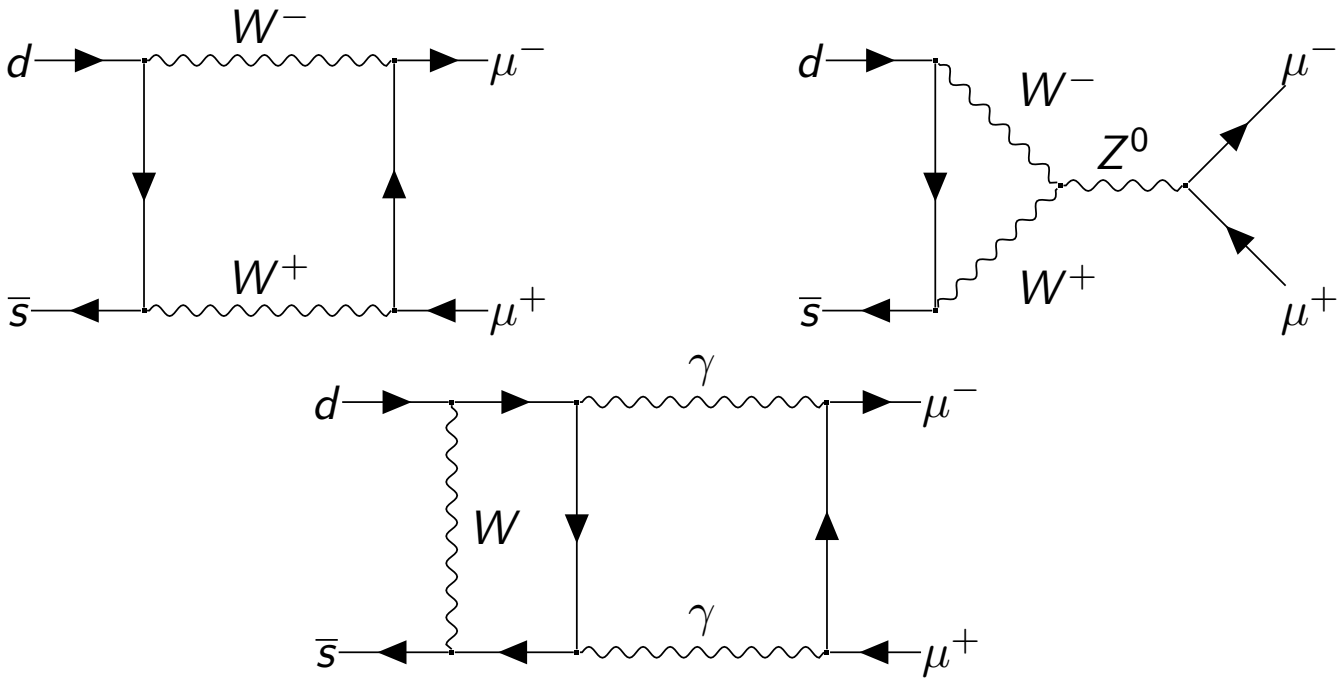
Introduction

- In the Standard Model (SM), KL2mu comes in at one-loop level with exchange of two W-bosons or two W- and a Z-boson (short-distance contribution, SD).
- Precisely measured ($\mathrm{Br}(K_\mathrm{L} \to \mu^+\mu^-) = 6.84 \pm 0.11 \times 10^{-9}$) $\Rightarrow$ good test for the SM and potential interest for the physics beyond the SM.
- Current theory limitation is the long-distance contribution (LD) involving two-photon exchange entering at $\mathrm{O}(G_\mathrm{F}\alpha_\mathrm{QED}^2)$, parametrically comparable to the SD contribution: the real part of the amplitude is not well understood.



Formalism

- Strategy: perturbatively expanded kernel function in $G_{\rm F}$ and $\alpha_{\rm QED}$ + hadronic correlation function computed on the lattice.

$$\mathcal{A}_{ss'}(k^+,k^-) = \int d^4p \int d^4u \int d^4v\; e^{-i\left(\frac{P}{2}+p\right)u}\, e^{-i\left(\frac{P}{2}-p\right)v} \frac{1}{(\frac{P}{2}-p)^2+m_\gamma^2-i\varepsilon}\cdot\frac{1}{(\frac{P}{2}+p)^2+m_\gamma^2-i\varepsilon}$$
$$\times\frac{\overline{u}_s(k^-)\gamma_\nu\{\gamma\cdot(\frac{P}{2}+p-k^+)+m_\mu\}\gamma_\mu v_{s'}(k^+)}{(\frac{P}{2}+p-k^+)^2+m_\mu^2-i\varepsilon}\cdot\left\langle 0\left|T\left\{J_\mu(u)J_\nu(v)\mathcal{H}_W(0)\right\}\right|K_L\right\rangle.$$

- Analytic continuation of the kernel: $\Rightarrow$ unphysical exponentially growing contribution from states lighter than the kaon at rest.
- Finite number of such states on a finite lattice $\Rightarrow$ explicit, precise subtraction of such is possible.