Contribution ID: **28** Type: **not specified**

Looking for an axion in a haystack of muons

Tuesday, 16 May 2023 16:25 (15 minutes)

The search for charged Lepton Flavour Violation (cLFV) in muon decays is a sensitive probe to test the Standard Model at the intensity frontier. The MEG II and Mu3e experiments at the Paul Scherrer Institut are respectively designed to detect $\mu \to e\gamma$ and $\mu \to eee$ with an unprecedented accuracy. In addition, both experiments are sensitive to cLFV decays of a muon into an invisible axion-like particle X. In this regard, a viable channel is given by the two-body decay $\mu \to eX$, whose signature is a monochromatic signal close to kinematic endpoint of the $\mu \to e\nu\bar{\nu}$ background. The hunt for such an elusive signal requires extremely accurate theoretical predictions for simulation and data analysis.

In this contribution, I will present a new state-of-the-art computation of $\mu \to eX$ and $\mu \to e\nu\bar{\nu}$. Both decays have been implemented in McMule, a novel Monte Carlo framework for the evaluation of higher-order radiative corrections for low-energy processes with leptons. In addition to taking into account all polarisation and mass effects, the signal $\mu \to eX$ includes next-to-leading order corrections, while the background $\mu \to e\nu\bar{\nu}$ includes next-to-next-to-leading order corrections and logarithmically enhanced terms at even higher orders. I will also discuss the impact of the results on the sensitivity of MEG II and Mu3e on the branching ratio of $\mu \to eX$.

Main reference: arXiv:2211.01040

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Session Classification: Young Researchers Talks