Contribution ID: **203** Type: **not specified**

Flavor-changing light bosons with accidental longevity

Tuesday 9 May 2023 17:00 (15 minutes)

We consider a model with a complex scalar field that couples to (e, μ) or (μ, τ) within the "longevity" window: $[|m_{l_1} - m_{l_2}|, m_{l_1} + m_{l_2}]$ in which l_1 and l_2 are the two different charged leptons. Within such a mass window, even a relatively large coupling ({\em e.g.} of the size commensurate with the current accuracy/discrepancy in the muon $g-2$ experiment) leads to long lifetimes and macroscopic propagation distance between production and decay points.
We propose to exploit several existing neutrino experiments and one future experiment to probe the parameter space of this model. For the $\mu - e$ sector, we exploit the muonium decay branching ratio and the production and decay sequence at the LSND experiment, excluding the parametric region suggested by $g_\mu - 2$ anomaly. For the $\tau - \mu$ sector, we analyze three main production mechanisms of scalars at beam dump experiments: the Drell-Yan process, the heavy meson decay, and the muon scattering. We explore the constraints from the past CHARM and NuTeV
experiments, and evaluate sensitivity for the proposed beam dump experiment, SHiP.
The latter can thoroughly probe the parameter space relevant for the $g_\mu - 2$ anomaly.

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Session Classification: BSM XI

Track Classification: BSM