Open KIAS Winter School Project on
Charged Lepton Flavor Violation and Top Physics
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Prob. 1 (a) Write down the operators describing proton decay ($\Delta B = 1$), and derive the bound on the new physics scale from the lower bound on the proton lifetime.
(b) Write down the operators describing $n - \bar{n}$ (neutron-antineutron) oscilaltion ($\Delta B = 2$). Using the lower bound on the transition rate, estimate the new physics scale for $n-\bar{n}$ (neutron-antineutron) oscilaltion, and compare it with the scale derived from proton decay in Prob. 1 (a).
(c) Write down the operators describing $\mu \to e\gamma$ and $\mu \to 3e$, and estimate the lower bounds on the new physics scale for these decays using the current upper bounds on the branching ratios for these decays.

Prob. 2 (a) Discuss the correlation between the electron spin and its energy in muon decay $\mu^- \to \overline{e^-\nu_e}\nu_\mu$. Compare this with the positron spin in antimuon decay $\mu^+ \to e^+\nu_e\overline{\nu_\mu}$. You can use the $(V-A)\times(V-A)$ nature of weak interacions (charged current).
(b) Consider Higgs decays

$$\begin{aligned} H &\to W^+W^- \to (l^+\nu_l)(l^-\overline{\nu_l}) \\ &\to \tau^+\tau^- \to (\pi^+\overline{\nu_\tau})(\pi^-\nu_\tau) \end{aligned}$$

Discuss the correlation between the energy of the final charged leptons or charged pions and the helicity of W's or τ's using the helicity conservation and $(V-A)\times(V-A)$ nature of weak interactions (charged current) and assuming the spin of Higgs boson is either 0 or 2.
(c) Consider the top decays $t \to bW^+$ followed by $W^+ \to l^+\nu_l$. Discuss the correlation between the energy of the final charged lepton and its helicity, relative to the direction of the initial top spin.
Note : You can access "Particle Data Group" at http://pdg.lbl.gov and get informations on the particle properties in order to solve these problems.