

BSM- Exercise

- How many physical parameters are there in the SM?
 - Note that a complex phase is not physical if it can be rotated away in the Lagrangian by appropriate field redefinitions.
- Prove that $U(1)_{B-L}$ is anomaly-free in the SM.
- Find Lorentz and gauge invariant dim=5 effective operators of the SM, and discuss how large the associated cutoff scale should be.
- Why proton decay requires both B and L violations?
- Dim=6 operators include B and L violating ones, for instance, $\frac{1}{\Lambda^2} (u_R u_R)(u_R e_R)$. The proton lifetime should be longer than 10^{34} years. Find the lower bound on the cutoff scale using dimensional analysis.
- Find the temperature at which the effective Higgs mass squared becomes negative.
- Calculate the lower bound on bosonic dark matter assuming
 - dark matter velocity = 200km/s
 - dark matter confinement at least on kpc scales