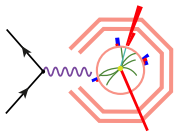
Elementary particle physics (480 phys)
Autumn 2020
Assoc. Prof. Dr Salwa Alsaleh



Homework 1

Problem 1.1 – Natural units (5 Points)

1. In some models of cosmology, the beginning of universe had an inflation period, where the universe was expanding exponentially. The inflation period happened after $1 \times 10^{-32}\,\mathrm{s}$ after the Big Bang. Find the corresponding energy scale in the natural units, and the temperature in Kelvin.

2. Planck mass is a special mass believed to be the mass of smallest black hole given by

$$m_{Pl} = \sqrt{\frac{\hbar c}{G_N}}$$

where $G_N = 6.67 \times 10^{-11}\,\mathrm{m^3 kg^{-1} s^{-2}}$ gravitational constant.
Find the value of plank mass in kg, and then convert it to natural units to get the value sof Planck mass or Planck energy.

3. Find the mass dimension of the Lagrangian density $\mathcal{L}$ in natural units , if you know that the Lagrangian density is related to the action by

$$S = \int d^4x\, \mathcal{L}.$$

Problem 1.2 – Particle properties (5 Points)

Using the Particle Data Group (PDG), find the mass, spin and charge for the following particle, and specify if they are elementary or not.If not specify if it is a meson or baryon.

$$Z^0,\ K_S,\ \Lambda_c,\ \tau,\ \nu_\mu.$$

Hint: You can access the PDG database on the website `http//:pdg.lbl.gov`

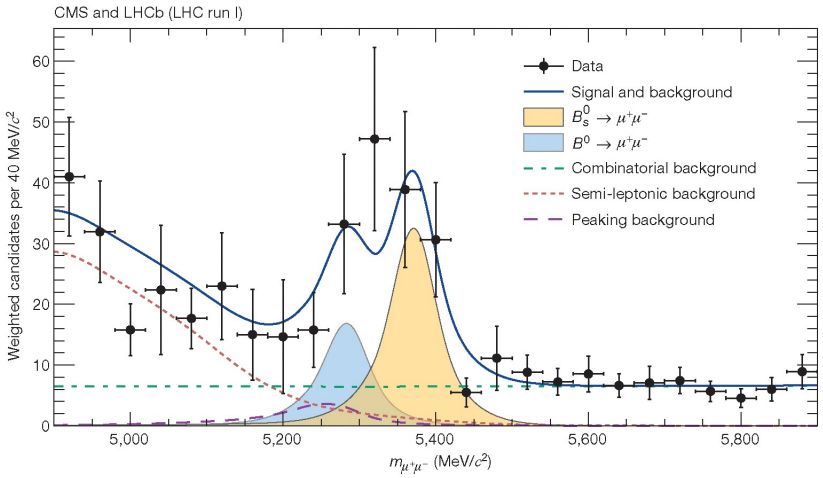
Problem 1.3 – Decays (8 Points)

(A) Indicate if the following decays are allowed by the Standard model or not, and if the decay is allowed what is the interaction mediating such decays

1. $n \to pe^-\bar{\nu}_e$
2. $\pi^0 \to \gamma\gamma$
3. $\pi^- \to \mu^+\nu_\mu$
4. $p \to \pi^+ e^-\nu_e$
5. $Z^0 \to \gamma\gamma$
6. $\mu^- \to \tau^+\nu_\mu$

Hint: Use the PDG as a reference

(B) The LHCb and CMS experiments had a combined mesurment of the rare decay $B^0 \to \mu^-\mu^+$ and $B_s^0 \to \mu^-\mu^+$, and produced the invariant mass distributions seen below.



What is the mass of the B^0 and B_s^0 according to their invariant mass distributions ?

Problem 1.4 – Relativistic dynamics (2 Points)

Solve the following relativistic dynamics problems

1. A proton at the LHC having a total energy of 6.5 TeV, and moving in the z direction w.r.t the LAB frame, write its 4-momentum.
2. If you know that a Λ^0 having an energy of 15 GeV, and mean lifetime of 2.632×10^{-10} s, find its mean decay length