جامعة الملك سعود
King Saud University
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Homework I – 1st semester 2019-2020

Degree Program: BSc. Physics (General) Class:
Course Title: Elementary Particle Physics Semester: 1st
Professor's name: Dr Salwa ALSALEH
Course Code: Phys-480

Q.1) **Particle Properties**
Search the **Particle Data Group** (PDG) for

1. Lifetime and/or decay width ;
2. mass;

of the following particles : (e^-, μ^-, π,W,Z, t-quark, Higgs boson)
Moreover, determine if the particle is composite or elementary (so far)
You can find the PDG via the website `http://pdg.lbl.gov`

Q.2) **Allowed or forbidden**
We assume the conservation of baryon number B, lepton flavour number L_e, L_μ, L_τ, electric charge, angular momentum and four-momentum.
Determine if these interactions are allowed or not ()so far !)

- $\nu_\mu\, p \to \mu^- n$,
- $\mu^- \to e^- \nu_\mu$,
- $\mu^- \to e^- \bar{\nu}_e \nu_\mu$,
- $K^+ \to \pi^0 \mu^+ \nu_\mu$,
- $h \to \gamma Z$.

Q.3) **Pioncaré algebra**
A relativistic quantum system is symmetric under the Pioncaré transformations

1. List all the generators of the Pioncaré transformations.
2. (Bonus) Show that the algebra of rotations in 3d real space $so(3)$ is contained in the Pioncaré algebra.

Q.4) **Special relativity of colliders**

1. Calculate the ratio v_1/v_2 where v_1 is the speed of an electron used at run 1 of LEP experiment having an energy$E_1 = 45$GeV , and v_2 is the speed of another electron at LEP run 2 with an energy of $E_2 = 100$GeV.
2. At the Large Hadron Collider (LHC), run 2 (2015-2018) a single proton is given and energy $E = 6.5$TeV. Calculate its momentum and the error in momentum when assuming that it is ultra-relativistic .

Q.5) **Relativistic collisions**

At the future runs of the LHC we expect to accelerate and collide 2 protons each having an energy of 7TeV.

1. Calculate the centre of mass energy, called $\sqrt{s}$.
2. If we have an H-atom (essentially a proton) as a fixed target, and we want to obtain the same $\sqrt{s}$ at the future LHC energy by hitting it with an accelerated proton. Calculate the energy of that proton in this case. What do you notice ?

Q.6) **Lifetime and decay length**

Consider the decay $\pi^+ \to \mu^+ \nu_\mu$ and $\pi^- \to \mu^- \bar{\nu}_\mu$ If you knew that the lifetime of the charged pion is $\tau_{\pi^\pm} = 2.6 \cdot 10^{-8}$ s . What is the decay length (distance travelled until the decay on average) of a 5GeV pion ?