Kern- und Teilchenphysik II
Spring Term 2015

Exercise Sheet 5

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1. τ lepton life time

Assuming τ lepton decays only leptonic calculate the expected lifetime of the τ lepton. Check your calculations against the most precise experimental value [HFAG 2014]:

$$\tau_\tau = (290.29 \pm 0.52)\ \text{ps} \tag{1}$$

3 pt

Why did we get a different result then experiments measured?

1 pt

2. Majorana fermions

The most promising New Physics candidates are so called Majorana fermions. These particles are their own antiparticles and in the SM the only particles that can be majorana fermions are neutrinos. Why does this happen?

1 pt

Please show that the bispinor ψ is Lorentz invariant under charge conjugate operator ($i\gamma^2$).

2 pt

Let's write the bispinor as $\psi = (\psi_A, \psi_B)^T$. Please show that spinors ψ_B and ψ_A are not independent(use again the $i\gamma^2$ operator).

2 pt

Why this happend? Why do we need just one component of bispinor to describe the full majorana neutrino system?

1 pt

3. Dark photon

One of the candidate for new physics particle is so called dark photon. For this exercise let's assume that this is a massive! spin 0 particle for which we make the following QED rules:

1. Dark photon propagator:

$$\frac{-i}{q^2 - (m_\gamma c^2)} \tag{2}$$

2. Vertex factor is: *1*

Rest of its properties are identical as "normal" photon. Assuming it's kinematically allowed, calculate the decay rate of $\gamma_{dark} \to e^- e^+$

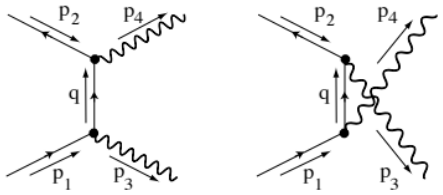
3 pt

Find the lifetime of the dark photon assuming its mass to be 1 GeV/c^2.

1 pt

Write down the matrix element for a process: $e^+e^- \to \gamma_{dark}\gamma_{dark}$ (hint see figure below).

3 pt



Calculate $< |\mathcal{M}| >$ assuming the CM energy of electron position to be much larger then the photon and electron masses.

3 pt