Homework 1
Due date: 2019.04.01

Problem 1. In $\hbar = c = 1$ units, the lifetime of a positronium in the ground state is given as

$$\tau = \frac{2}{m_e \alpha^5} \,,$$

where m_e is the mass of the electron and α is the fine structure constant.

1) In $\hbar = c = 1$ units, what is the value of τ in GeV^{-1}? [1 point]

2) In SI units, what is the value of τ in second? [1 point]

Note: please round your results to two significant figures, and don't worry about uncertainties. Please use $\alpha = 1/137$, and look up the mass of electron in PDG.

Problem 2. Work out the kinematics of Compton scattering in the lab frame. A photon of wavelength λ collides elastically with a charged particle of mass m at rest. If the direction of the outgoing photon is at an angle θ with respect to the incoming photon, find the wavelength λ' of the outgoing photon. Please give the answer in terms of λ, m and θ, in $\hbar = c = 1$ units. [3 points]

Problem 3. Consider the reaction $e^+e^- \to HZ$, i.e., electron + positron $\to$ Higgs + Z.

1) In the lab frame in which the electron is at rest, what is the minimum value of the positron energy (in GeV) for this reaction to happen. [4 points]

2) In the center-of-mass frame of the incoming electron and positron, what is the minimum value of the positron energy (in GeV) for this reaction to happen. [2 points]

3) In the center-of-mass frame of the incoming electron and positron, if the energies of the positron and electron are both 250 GeV, on average how far a produced Higgs can travel (in cm) before it decays? (Assume that the decay width of the Higgs, as measured in the rest frame of the Higgs, is 4.07 MeV.) [4 points]

Note: please round your results to two significant figures, and don't worry about uncertainties. Please look up the masses of the particles in PDG.