

Subatomic Physics II

Problem Set 1

Due on October 7, 11:59:59 PM

Problem 1.1: Units

In particle physics, we use natural units: $\hbar = c (= k_B) = 1$. It allows one to link units of distance, time energy, momentum, mass, temperature, etc. Conversion coefficients are listed on the PDG website: <http://pdg.lbl.gov>. Using them, calculate the following quantities:

- It is easy to see that mass and momentum are expressed in units of energy (typically GeV in particle physics). But in what are length, cross section, time and decay rates measured? (1pt)
- It is also customary to set the permittivity of the vacuum $\epsilon_0 = 1$. What does this mean for the magnetic permeability μ_0 ? And what is the charge of the electron? (Don't forget to find out what the dimension of the charge is!) (1pt)
- In a way, natural units set a "natural" scale for objects with a certain mass. If we take the unit of energy to be 1 GeV, what is then the unit of length and that of time? Compare your result to the value for the size of a proton ($m_p \approx 1$ GeV). What do you conclude? But how do you interpret the unit of time? (2pt)

Problem 1.2: Relativity

The average lifetime of a K^+ -meson in its own frame of reference is 12.38 ps. (This is its proper lifetime.)

- If a kaon produced in the collision of a cosmic ray (proton) with an air molecule moves with speed $0.95c$ with respect to the Earth, what is its lifetime as measured by an observer at rest on Earth? (1pt)
- What is the average distance it travels before decaying as measured by an observer at rest on Earth? (1pt)
- What are the momentum and total energy of the kaon as measured by the earthly observer? (1pt)

Problem 1.3: Particle Data Group

The Particle Data Group (PDG) collects, summarizes, and regularly updates information on many measured properties of particles. This information can be found on their website <http://pdg.lbl.gov>. Find on the PDG website answers to the following questions:

- What is the branching ratio of the τ^- -lepton decay to $\pi^- \nu_\tau$? (1pt)
- What is the lifetime of the ground state baryon with the quark structure usb ? Give a bibliographic reference to at least one journal publication which reports a measurement of this lifetime. (1pt)
- E.Parker has in 1970 derived an upper bound on the number of magnetic monopoles in the Galaxy. On what was this based? (1pt)