Tareas 4 Tópicos de la Física Moderna

Martes, 22 de Septiembre 2020

1. An airplane travels at a constant speed v for a distance of 3000 km as measured by a stationary observer. The pilot measures the flight time to be Δt and the stationary observer measures the flight time to be $\Delta t'$. (a) Which time interval is longer? (b) If $|\Delta t - \Delta t'| = 4\,\text{ns}$, determine the speed of the airplane.

2. In the laboratory frame a particle with the speed $v = 0.99c$ travels a distance of 1 mm before spontaneously decaying. What is the proper lifetime of the particle?

3. (a) The muon ($\mu^{\pm}$) has a proper lifetime of $2.2\,\mu$s. If a μ has a speed of $0.99c$, what is the average distance that it travels before decaying? (b) The charged pion ($\pi^{\pm}$) has a proper lifetime of 26 ns. If a π has a speed of $0.99c$, what is the average distance that it travels before decaying?

4. *The twin paradox.* An astronaut is accelerated in his spaceship to a cruising speed v and travels from earth to a faraway destination and back, a total distance d. The astronaut's twin stays at home on the earth. Assume that the time needed to reach cruising speed and the time needed to turn the spaceship around are negligible compared to the time taken to complete the trip. (a) Analyze the trip in the frame of the twin that stays home. Which twin has aged more and by how much? (b) Analyze the trip in the frame of the traveling twin. Which twin has aged more and by how much? (c) Which twin has actually aged more and by how much? (d) What is the speed needed to go to α-Centaur within a reasonable time for this problem? (e) To get to the moon took 3 days. Use this speed.

5. What is the speed of a particle that has a momentum equal to its mass times the speed of light?

6. Determine the momentum and speed of a proton that has a kinetic energy of 1.00 GeV.

7. Read *Measurement of the neutrino velocity with the OPERA detector in the CNGS beam.* arXiv:1109.4897v1 [hep-ex]. Discuss the implications of the result reported in this paper would be correct. Also discuss where the measurement could be wrong.

8. An electron and a proton have the same radius of curvature in a uniform magnetic field, and the electron speed is twice that of the proton. What is the momentum of each particle?

9. Calculate the radius of curvature of a 10 GeV electron in a magnetic field of 1 T.

10. The carbon-14 nucleus decays into a nitrogen-14 nucleus plus an electron and a massless particle called the electron-antineutrino ($^{14}\text{C} \to {}^{14}\text{N}\, e^-\, \overline{\nu_e}$). Calculate the amount of energy released in the decay, assuming that the mass of the (anti)neutrino is zero. (is this correct?)

11. Lambda particles ($m = 1116\,\text{MeV}/c^2$) are produced with momenta of $100\,\text{GeV}/c$ as the result of energetic proton-proton collisions ($pp \to \Lambda^0 X$). The Λ^0 decays into a proton and a pion ($\Lambda^0 \to p\pi^-$) with a lifetime of 10^{-10} s. In the frame in which the Λ^0 has $p = 100\,\text{GeV}/c$, which particle has a larger momentum on the average, the proton or the pion? Why?

12. A relativistic subatomic particle of mass m is moving away from a detector when it spontaneously decays, sending a photon toward the detector. The photon is observed to be red shifted by a factor 100, that is, its energy is 1 % of the energy of the photon measured in the frame where the decaying particle is at rest. What is the speed of the decaying particle?

13. Read again the article *WA89 Collaboration, M.I. Adamovich et al., "Measurement of the Ω_c^0 lifetime"*, published in Physics Letters B 358 (1995) 151-161. How far flies a Ω_c^0, which decays after 100 fs (≈ 2 average lifetimes), with a momentum of 200 GeV?

14. A proton with a momentum of $200\,\text{GeV}/c$ collides with a proton at rest. Calculate the total energy in the center-of-mass system.

15. A photon with kinetic energy equal to the mass energy of an electron collides with an electron at rest and scatters at an angle of $\pi/2$. Calculate the energy of the electron after the collision.

16. (a) A photon with an energy of 10 GeV scatters with an electron at rest and scatters backwards. What is the energy of the electron after the collision? What is the energy of the photon after the collision? (b) A photon with an energy of 10 GeV scatters with an electron that has an energy of 10 GeV. The photon scatters backwards. What is the energy of the electron after the collision? What is the energy of the photon after the collision?

17. A photon collides with an electron at rest creating an electron-positron pair ($\gamma e^- \to e^+ e^- e^-$). Calculate the minimum photon energy for this process.

18. Investigate for what Hans Dehmelt received the Nobel Prize in 1989.