Particle Physics Homework

1. Relativistic kinematics

2023/09/18
(deadline: 2023/09/25)

1. A muon of energy 5 GeV is created in the atmosphere at a height of $h = 15$ km by the collision of a cosmic ray with a gas molecule. Assuming that it travels perpendicularly to the Earth's surface, what is the probability that it reaches the ground?

2. A photon of energy E hits a mirror moving with velocity β in the lab frame. The photon hits the mirror perpendicularly to its surface, and is reflected elastically. What is the energy of the reflected photon in the lab frame?

3. Consider two Lorentz boosts Λ_1 and Λ_2 in the x direction, with velocities β_1 and β_2, respectively. Show that the composition $\Lambda = \Lambda_2 \Lambda_1$ of the two transformations is characterised by a velocity $\beta \neq \beta_1 + \beta_2$, while for the corresponding rapidities ζ and $\zeta_{1,2}$, $\beta = \tanh \zeta$ and $\beta_{1,2} = \tanh \zeta_{1,2}$, one has $\zeta = \zeta_1 + \zeta_2$.

Hints

Exercise 1: remember that the probability of decaying per unit time is a constant. What value does that constant have?

Exercises 2 and 3: use the explicit form of Lorentz transformations.