

Particle Physics Homework

Due: June 20th, 2001

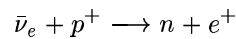
1. Given the masses of the following particles, work out their rest energy.

(a) proton: $1.672 \times 10^{-27} \text{ kg}$

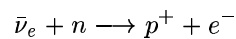
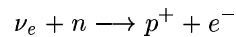
(b) neutron: $1.674 \times 10^{-27} \text{ kg}$

- (c) Now using your Particle Data Guide(PDG), look up the rest mass of the π^+ and μ . Using Einstein's equation, calculate their energies in Joules.

2. In class we showed that the reaction



obeys the conservation laws and occurs. For the following two equations, use the conservation laws to see if the reactions could occur.



If the reaction does not obey the conservation laws, state which law(s) were broken.

3. Recall that muons appear when protons from space collide with nuclei in the earth's upper atmosphere. These reactions occur at altitudes of 6 km or more. The lifetime of a muon in its rest frame is only $2.2 \mu\text{s}$ and muons travel at speeds of $2.994 \times 10^8 \frac{\text{m}}{\text{s}}$ or $0.998c$. Using this information, naively we find that the muons can only travel 660 meters.

$$d = vt_0 = 2.994 \times 10^8 \frac{\text{m}}{\text{s}} \times 2.2 \times 10^{-6} \text{ s} = 660 \text{ m}$$

We know (because we paid attention in class) that relativity can help us understand how the muon reaches the earth.

- (a) Calculate the lifetime of the muon in the reference frame of an observer on earth.
- (b) Using this lifetime, calculate the distance the muon travels.
- (c) From the perspective of the muon (i.e. an observer "riding on" the muon) calculate the distance it travels to earth using the relativistic equations we learned in class.