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Contents

Calculation of Momentum Transfer in Hyperon Production

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Abstract

We calculated momentum transfer of the reactions such as $K^{-}+n\rightarrow\Lambda+\pi^{-}$, $\pi^{+}+n\rightarrow\Lambda+K^{+}$ and $K^{-}+p\rightarrow\Xi^{-}+K^{+}$ by using Newton-Raphson method. Firstly, we study four- vector and product of two four-vector which is invariant for any frame. We calculated the threshold energies of these reaction by using four-vector. The threshold energies are obtained as 238.9MeV,898.07MeV and 1156.62MeV respectively. We solved numerically to obtained momentum transfer of three reactions for various incident momentum. It is observed that we can produce Λ-hyper nuclei for $K^{-}+n\rightarrow\pi^{-}+\Lambda$ reaction and $\pi^{+}+n\rightarrow K^{+}+\Lambda$ reaction and hyperon for $K^{-}+p\rightarrow K^{+}+\Xi$ reaction.

I. Introduction

The discovery of various elementary particles was followed by an extensive stu[illegible] their characteristic properties. This led to the determination of their mass, charge, life [illegible] quantum numbers, decay schemes, interactions etc.

As regards the classification, the elementary particles may be classified in a num[illegible] different ways depending on their masses, interactions, statistics etc. Commonly, how[illegible] they are classified into such categories as : (i) photons (ii) leptons and(iii) hadrons. Had[illegible] further classified as (a) mesons and (b) baryons. The names refer to the masses – baryo[illegible] heavy, meson means intermediate or medium and lepton means small. Photon is stable [illegible] neutral having no rest mass and no rest energy, but possesses by virtue of its motion [illegible] $h\nu/c^2$. Its spin is 1. Leptons – Leptons are weakly interacting particles. There are six le[illegible] These are electrons, muons, tauons and three neutrinos : electron-neutrino, muon-neutr[illegible] tau-neutrino.

Electrons are the first elementary particles discovered. They are negatively [illegible] stable having a rest mass 9.11×10^{-31}kg and a rest energy $0.511\text{MeV}/c^2$. It is a spin $\frac{1}{2}$ [illegible] Muons were first observed in cosmic radiation and have a mass about $200m_e$. Muons [illegible] $\frac{1}{2}$ particle. Tauons have recently been discovered, having a large mass $(1784.2\text{MeV}/c^2)$ [illegible] are unstable and decay into muons and two neutrinos. $\tau^{-}\rightarrow\mu^{-}+\bar{\nu}_{\mu}+\nu_{\tau}$. The neutr[illegible] first discovered in β- emission, and thereafter other neutrinos were obtained in other [illegible] reactions. All neutrinos are stable, having zero charge, spin $\frac{1}{2}$ and negligible mass. [illegible] leptons interact weakly with other particles and they are all fermions as they obey the F[illegible] Dirac statistics. Hadrons : Mesons – These particles have mass between that of a [illegible] and of a nucleon and are strongly interacting. These include pions $(\pi^{\pm,0})$, Kaons [illegible] meson (η^{0}), charmed mesons $(D^{\pm,0})$ and beautiful mesons (B). Pions that can [illegible] positively and negatively charged or neutral particles have got zero spin and are respons[illegible]

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short range nuclear forces and information about pions have been given in an earlier chapter. K-mesons or Kaons are produced due to the interactions of high energy particles at very short range due to strong nuclear forces. A detailed study of kaons would be made shortly. The η^0 exists as a neutral particle which has a very short life time. Baryons – Particles having rest mass intermediate between that of a nucleon and deuteron are called baryons which are further subdivided as :

(i)Nucleons – These consists of the first two baryons : protons and neutrons. The proton is stable. A free neutron is unstable with a mean life of 920 s and decays into a proton, an electron and an electron-antineutrino. (ii)Hyperons – Other baryons, called hyperons, include lambda (Λ^0), sigmas $(\Sigma^{\pm,0})$, Xis $(\Xi^{-,0})$ and omega (Ω^-). Hyperons are unstable particles first discovered in cosmic rays.All the baryons are fermions obeying the Fermi-Dirac statistics.

1.1 Classification of Collisions

The reason for introducing energy and momentum is, of course, that these quantities are conserved in any physical process. In relativity, as in classical mechanics, the cleanest application of these conservation laws is to collisions. A classical collision, in which object A hits object B, producing objects C and D. its nature, a collision is something that happens so fast that no external force, such as gravity, or friction with the track, has an appreciable influence. Classically, mass and momentum are always conserved in such a process; kinetic energy may or may not be conserved.

Classical Collisions

1. Mass is conserved, $m_A + m_B = m_C + m_D$.
2. Momentum is conserved, $p_A + p_B = p_C + p_D$.
3. Kinetic energy may or may not be conserved.

In fact, we may distinguish three types of collisions: "sticky", ones in which the kinetic energy decreases (typically, it is converted into heat); "explosive" ones, in which the kinetic energy increases (for example, suppose A has a compressed spring on its front bumper, and the catch is released in the course of the collision so that spring energy is converted into kinetic energy); and elastic ones, in which the kinetic energy is conserved.

Type of Collisions (Classical)

(a) Sticky: Kinetic energy decreases, $T_A + T_B \rangle T_C + T_D$.

(b) Explosive: Kinetic energy increases, $T_A + T_B \langle T_C + T_D$.

(c) Elastic: Kinetic energy conserved, $T_A + T_B = T_C + T_D$.

In the extreme case of type (a), the two particles stick together, and there is really only one final object: A + B $\rightarrow$ C. In the extreme case of type,(b) a singleobject decays into two, A $\rightarrow$ C + D .In a relativistic collision, energy and momentum are always conserved. In other words all four components of the energy-momentum four-vector are conserved. As in the classical case, kinetic energy may or may not be conserved.

Relativistic Collisions

1. Energy is conserved, $E_A + E_B = E_C + E_D$.
2. Momentum is conserved $p_A + p_B = p_C + p_D$.
3. Kinetic energy may or may not be conserved.