PH 105 Tutorial Solution

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18)



ρ is at rest

*p͢π*=(pπ , iEπ/c) *p͢ρ* =(0,iEρ/c) *p͢Δ* =(pΔ, iE Δ/c)

Applying conservation of momentum 4 vectors,

*p͢π* + *p͢ρ* = *p͢Δ* --(1)

i.e.

(pπ , i(Eπ+Eρ)/c) = (pΔ, iE Δ/c)

(pπ , i(Eπ+Eρ)/c)2 = (pΔ, iE Δ/c) 2

pπ 2 -(Eπ+Eρ) 2/c2 = pΔ2 - E Δ2/c2 --(2)

We are free to compute the momentum 4 vector in any frame. In order to simply calculations, compute the RHS in the rest frame of the Δ particle.

In this frame pΔ = 0 and E Δ = mΔc2 (rest mass energy)

Simplify (2) to get

-mπ2c4 - mρ2c4 -2Eπ mρ c2 = -mΔ2c4

Eπ = (mΔ2c4 - mπ2c4 - mρ2c4)/2 mρ c2

On solving

***Eπ = 0.34 GeV***

Eπ2= pπ2c2 + mπ2c4

Solve to get

***pπ = 0.31 (GeV/c)***

ii) Speed of Δ particle in lab frame.

*p͢π* + *p͢ρ* = *p͢Δ*

(pπ , i(Eπ+Eρ)/c) = (pΔ, iE Δ/c)

This time solve RHS in Lab frame. Simply, equate the individual components.

***pπ = p Δ  = 0.31 GeV/c***

i(Eπ+Eρ)/c = iE Δ/c

0.34+0.94 =***1.28 = E Δ***

Therefore, γ Δ = E Δ/ mΔc2 = 1.28/1.24 = 1.032

***V Δ  = 0.25c***

iii) Energy and momentum of pions in the frame in which the Δ particle is at rest.

The Δ particle is at rest in a frame moving at v = 0.25c (frame attached to the particle)

Apply the transformation equation to get

pπ' =γ(pπ + i(v/c)\*i Eπ/c)

pπ' = γ(pπ - Eπv/c2)

γ = 1.067

***pπ' = 0.24 (GeV/c)***

iEπ'/c = γ(i Eπ/c – i(v/c)\* pπ)

Eπ' = γ(Eπ - pπv)

***Eπ'= 0.28 GeV***