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1. $X_1' = 0$ hingga $X_2' = l_0$

$L = X_2 - X_1$

$x' = \gamma(x - ut)$

$t' = \gamma(t - \frac{ux}{c^2})$

$\gamma = \frac{1}{\sqrt{1 - \frac{u^2}{c^2}}}$

Waktu sama $(t_1 = t_2)$

$x_1' = \gamma(x_1 - ut)$

$x_2' = \gamma(x_2 - ut)$

$l_0 = x_2' - x_1'$

$l_0 = \gamma(x_2 - ut) - \gamma(x_1 - ut)$ → $l_0 = \gamma(x_2 - x_1)$ atau $L = \frac{l_0}{\gamma}$ → $\gamma = \frac{1}{\sqrt{1 - \frac{u^2}{c^2}}}$

$L = l_0\sqrt{1 - \frac{u^2}{c^2}}$

2. Dik :

$E = 25$ GeV

$d = 3000$ m

$m_0 = 0{,}511$ meV/c^2

$c = 3 \times 10^8$ m/s

Dit :

a. kecepatan elektron yang energinya 25 GeV ?

b. Waktu yang diperlukan untuk menempuh jarak 3000 m ?

c. panjang akselerator dalam kerangka acuan elektron ?

d. Waktu tempuh elektron dalam kerangka acuan inersianya sendiri ?

Jawab :

a). $E = \gamma m_0 l^2$

$\gamma = \frac{E}{m_0 l^2}$

$= \frac{25 \times 10^9 \text{ eV}}{0{,}511 \times 10^6 \text{ eV}}$

$= 4{,}89 \times 10^4$

$1 - \frac{V^2}{c^2} = \frac{1}{\gamma^2}$

$\frac{V^2}{c^2} = 1 - \frac{1}{(4{,}89 \times 10^4)^2}$ → $V = c\sqrt{1 - \frac{1}{(4{,}89 \times 10^4)^2}}$

$V \approx c1(1 - 1{,}05 \times 10^{-10})$

$V \simeq 2{,}99999 \times 10^8$ m/s

selisih dengan kecepatan cahaya

$c - v \approx 0{,}031$ m/s

jadi elektron hampir bergerak dengan kecepatan cahaya

b). $t = \frac{d}{v}$

$t = \frac{3000\ m}{2,9999 \times 10^8\ m/s}$

$t = 1,0000000001 \times 10^{-5}\ s$

$\approx 10\ \mu s$

c). $l' = l\sqrt{1 - \frac{v^2}{c^2}}$

karena $\gamma = 4,89 \times 10^4$, maka

$l' = \frac{3000}{4,89 \times 10^4}$

$l' = 0,061\ m = 6,1\ cm$

d). $t' = \frac{t}{\gamma}$

$t' = \frac{10^{-5}}{4,89 \times 10^4}$

$t' = 2,04 \times 10^{-4}\ s = 0,204\ ms$

3. Dik:

$\lambda_0 = 122\ nm$

$\lambda' = 366\ nm$

$c = 3 \times 10^8\ m/s$

Dit:

a). kecepatan galaksi v jika spektrum bergerak dari λ_0 menjadi λ' ?

b). panjang gelombang baru λ jika galaksi mendekati kita dengan kecepatan yang sama?

jawab:

a). $\frac{\lambda'}{\lambda_0} = \sqrt{\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}}$

$\frac{366nm}{122\ nm} = \sqrt{\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}}$

$3\ nm = \sqrt{\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}}$

$9 = \frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}$

$9(1 - \frac{v}{c}) = 1 + \frac{v}{c}$

$9 - 9\frac{v}{c} = 1 + \frac{v}{c}$

$\rightarrow 8 = 10\frac{v}{c}$

$v = \frac{8}{10} c = 0,8c$

$v = 0,8\ (3 \times 10^8\ m/s)$

$= 2,4 \times 10^8\ m/s$

b). $\frac{\lambda''}{\lambda_0} = \sqrt{\frac{1 - \frac{v}{c}}{1 + \frac{v}{c}}}$

$\lambda'' = \lambda_0 \times \sqrt{\frac{1 - 0,8}{1 + 0,8}}$

$= \lambda_0 \times \sqrt{\frac{0,2}{1,8}}$

$= 122 \times \sqrt{0,1111}$

$= 122 \times 0,3323$

$\lambda'' = 40,67\ nm$

4). Dik :

E per atom : 200 MeV

muranium : ~~1 kg~~ 1 kg

A : 235

1 MeV = $1{,}602 \times 10^{-13}$ J

c : 3×10^{8} m/s

m atom : $\frac{235}{6{,}022 \times 10^{23}}$

Dit :

Perubahan massa Dm akibat reaksi 1 kg uranium ?

Jawab :

E : 200 MeV $\times$ $1{,}602 \times 10^{-13}$ J/MeV

: $3{,}204 \times 10^{-11}$ J

Jumlah atom dalam uranium 1 kg :

$N = \frac{1000\ g}{m\ atom}$

$= \frac{1000\ g}{235}$

$\frac{}{6{,}022 \times 10^{23}} = 2{,}56 \times 10^{24}$ atom

E total : $(3{,}204 \times 10^{-11}$ J/atom$)(2{,}56 \times 10^{24})$

: $8{,}20 \times 10^{13}$ J

$E = mc^2 \rightarrow m = E/c^2$

$m = (8{,}20 \times 10^{13}\ j)/(3 \times 10^{8}\ m/s)^2$

$\approx 9{,}41 \times 10^{-4}$ kg

5). Dik :

mp : 1,007276 U

mn : 1,008665 U

m helium : 4,001506 U

Lu : $1{,}66054 \times 10^{-23}$ kg

Luc^2 : 931,5 MeV

Dit :

a). energi ikat inti helium Eb

b). beda massa inti helium dengan total massa partikel penyusun dalam kg.

Jawab :

a). massa total = 2mp + 2mn

: 2 (1,007276) + 2 (1,008665)

: 4,031882 U.

Dm : m total - m helium

: 4,031882 U − 4,00506

: 0,030376 U

$E = \Delta mc^2$

$= (3{,}044 \times 10^{-29}\ kg)(2{,}9979 \times 10^{m/s})^2$

$= 4{,}533 \times 10^{-12}$ J : 28,8 MeV

b). Dmkg = (0,030376 U) x (1,66054 x
kg)

: $3{,}04 \times 10^{-29}$ kg

6. Dik :

$V_A = 0{,}8\ c$

$V_B = 0{,}6\ c$

Dit :

kecepatan pesawat A menurut pengamat dibulan (V') ?

Jawab :

$$V' = \frac{V_A + V_B}{1 + \frac{V_A V_B}{c^2}} = \frac{0{,}8 + 0{,}6\ c}{1 + \frac{(0{,}8)(0{,}6)}{c^2}} = \frac{1{,}4\ c}{1 + 0{,}48} = \frac{1{,}4}{1{,}48} = 0{,}946\ c$$

7). Dik

$P = 20$ watt

$\lambda = 589\ nm = 589 \times 10^{-9}\ m$

$h = 6{,}626 \times 10^{-34}\ Js$

$c = 3 \times 10^{8}\ m/s$

Dit :

Jumlah atom yang dipancarkan ?

Jawab :

$$E = \frac{hc}{\lambda} = \frac{(6{,}626 \times 10^{-34})(3 \times 10^{8})}{589 \times 10^{-9}}$$

$$= \frac{1{,}9878 \times 10^{-25}}{589 \times 10^{-9}} = 3{,}37 \times 10^{-19}\ J$$

$$N = \frac{20}{3{,}37 \times 10^{-19}} = 5{,}94 \times 10^{19}\ \text{foton/detik}$$

8). Dik :

$W = 2{,}2\ eV$

$\lambda = 3500\ A^{\circ} = 3500 \times 10^{-10}\ m = 3{,}5 \times 10^{-7}\ m$

$h = 6{,}626 \times 10^{-34}\ J/s$

$c = 3 \times 10^{8}\ m/s$

$1\ eV = 1{,}6 \times 10^{-19}\ J$

Dit :

Energi kinetik maksimum foto elektron (k) dalam eV?

Jawab :

$$E = \frac{hc}{\lambda} = \frac{(6{,}626 \times 10^{-34})(3 \times 10^{8})}{3{,}5 \times 10^{-7}} = \frac{1{,}9878 \times 10^{-25}}{3{,}5 \times 10^{-7}} \approx 5{,}68 \times 10^{-19}\ J$$

$$E = \frac{5{,}68 \times 10^{-19}}{1{,}6 \times 10^{-19}} = 3{,}53\ eV$$

$k = E - W$

$= 3{,}53 - 2{,}2 = 1{,}35\ eV$