Adinia Meirya Pratiwi
2313022066 / 1B A
Fisika Modern

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 ($t_1 = t_2$)

$X_1' = \gamma(x_1 - ut)$

$X_2' = \gamma(x_2 - ut)$

$L_0 = X_2' - X_1'$

$L_0 = \gamma(x_2 - ut) - \gamma(x_1 - ut)$

$\rightarrow L_0 = \gamma(x_2 - x_1)$ atau

$L = \frac{L_0}{\gamma} \rightarrow \gamma = \frac{1}{\sqrt{1 - \frac{u^2}{c^2}}}$

$L = L_0\sqrt{1 - \frac{v^2}{c^2}}$

2. Diketahui :

$E = 25$ GeV

$d = 3000$ m

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

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

Ditanya : 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 inersialnya sendiri?

Jawab :

a) $E = \gamma m_0 c^2$

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

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

$= 4{,}89 \times 10^9$

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

$\frac{v^2}{c^2} = 1 - \frac{1}{(4{,}89 \times 10^9)^2}$

$\rightarrow v = c\sqrt{1 - \frac{1}{(4{,}89 \times 10^9)^2}}$

$v \approx c\,(1 - 1{,}05 \times 10^{-10})$

$v \approx 2{,}99999 \times 10^8$ m/s

sesuai dengan kecepatan cahaya

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

jadi elektron hampir bergerak dengan kecepatan cahaya.

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

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

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

$\approx 10\ \mu s$

c). $t' = t\sqrt{1 - \frac{v^2}{c^2}}$

karena $\gamma \approx 4,89 \times 10^9$, maka

$t' = \frac{3000}{4,89 \times 10^9}$

$t' \approx 0,061\ m = 6,1\ cm$

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

$t' = \frac{10^{-5}}{4,89 \times 10^9}$

$t' \approx 2,04 \times 10^{-9}\ s = 0,204\ \mu s$

3. Diketahui : $\lambda_0 = 122\ nm$

$\lambda' = 366\ nm$

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

Ditanya : a). kecepatan galaksi v jika spektrum bergeser dari λ_0 menjadi λ' ?

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

Jawab :

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$= 122 \times 0,3333$

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

4. Diketahui :

E per atom = 200 MeV

Muranium :

A = 235

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

c = 3×10^{8} m/s

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

Ditanya : Perubahan massa Δm akibat reaksi 1 kg uranium?

Jawab :

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

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

Jumlah atom dalam uranium 1 kg :

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

$= \frac{1000 g}{\frac{235}{6,022 \times 10^{23}}} = 2,56 \times 10^{24}$ 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$)^2$

$\approx 9,11 \times 10^{-4}$ kg

5. Diketahui :

$m_p = 1,007276$ u

$m_n = 1,008665$ u

$m_{helium} = 4,001506$ u

1 u = $1,66054 \times 10^{-27}$ kg

1 uc^2 = 931,5 MeV

Ditanya :

a) Energi ikat inti helium E_b

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

Jawab :

a). massa total = $2m_p + 2m_n$

= $2(1,007276) + 2(1,008665)$

= 4,031882 u.

Δm = $m_{total} - m_{helium}$

= 4,031882 u − 4,00506

= 0,030376 u

$E = \Delta mc^2$

= $(3,049 \times 10^{-29}$ kg$)(2,9979 \times 10^{8}$ m/s$)^2$

= $4,133 \times 10^{-12}$ J = 28,3 MeV

b). Δm kg = $(0,030376$ u$) \times (1,66054 \times 10^{-27}$ kg/u$)$

= $3,09 \times 10^{-29}$ kg.

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6. Diketahui :

$v_A = 0{,}8\,c$

$v_B = 0{,}6\,c$

Ditanya : 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. Diketahui :

$P = 20\,w$

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

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

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

Ditanya : Jumlah foton yang dipancarkan ?

Jawab :

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

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

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

8. Diketahui : $W = 2{,}12\,eV$

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

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

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

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

Ditanya : Energi kinetik maksimum foto elektron (h) dalam eV ?

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jawab :

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

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

$$K = E - W$$

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

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