Nama : Pripta Apriyani
NPM : 2313022016
Kelas : 23B
Matkul : fisika Modern

Penyelesaian Tugas pertemuan 7

1. $x_1' = 0$ hingga $x_2' = l_0$

$L = x_2 - x_1$

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

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

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

- 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

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

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

2. Diketahui : $E = 25$ GeV

$d = 3000$ m

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

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

Ditanya : a. v? c. L'?

b. t? d. t'?

Jawab :

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

$$\gamma = \frac{E}{m_0 c^2} = \frac{25 \times 10^9 \text{ eV}}{0{,}511 \times 10^6 \text{ eV}} = 4{,}89 \times 10^4$$

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

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

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

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

$$v \approx 2{,}9999 \times 10^8 \text{ m/s}$$

Selisih dengan kecepatan cahaya $c - v \approx 0{,}031$ m/s.

Jadi, elektron hampir bergerak dengan kecepatan cahaya.

b. $t = \frac{d}{v} = \frac{3000 \text{ m}}{2{,}9999 \times 10^8 \text{ m/s}} = 1{,}000000000001 \times 10^{-3}$ s $= 10$ ns

c. $L' = L\sqrt{1 - \frac{v^2}{c^2}}$ karena $\gamma = 4{,}89 \times 10^4$, maka $L' = \frac{3000}{4{,}89 \times 10^4}$

$= 0{,}061$ m $\rightarrow$ 6,1 cm

d. $t' = \frac{t}{\gamma} = \frac{10^{-5}}{4{,}89 \times 10^{4}} = 2{,}04 \times 10^{-4}\ s = 0{,}204\ Ns$

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

$\lambda' = 366\ nm$

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

Ditanya : a. Kecepatan gravitasi v, jika spekterum bergerak dari λ_0 menjadi λ' ?

b. Panjang gelombang baru jika λ'. Jika galaksi mendekati dengan kecepatan yang sama ?

Jawab :

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$= 122 \times 0{,}3323$

$\lambda'' \approx 40{,}67\ nm.$

4. Diketahui : $E_{peratom} = 200$ MeV

$M_{uranium} \rightarrow A = 235$

$1\ MeV = 1{,}602 \times 10^{-12}$ J

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

$M_{atom} = 235\ g : 6{,}022 \times 10^{23}$

Ditanya : Perubahan massa Δm 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 :

$$N = \frac{1000\ g}{M_{atom}} = \frac{1000\ g}{235\ g / 6{,}022 \times 10^{23}} = 2{,}56 \times 10^{24}\ \text{atom.}$$

$E_{total} = 3{,}204 \times 10^{-11}\ J/atom\ (2{,}56 \times 10^{24}) = 8{,}20 \times 10^{13}\ J$

$E = mc^2$

$$\therefore m = \frac{E}{c^2} = \frac{(8{,}20 \times 10^{13}\ J)}{(1 \times 10^{8}\ m/s)^2} = 9{,}11 \times 10^{-4}\ kg.$$

5. Diketahui : $M_p = 1{,}007276$ U

$M_a = 1{,}008665$ U

$M_{helium} = 4{,}001506$ U

$1_u = 1{,}66054 \times 10^{-23}$ kg

$1_u . c^2 = 9{,}31$ J MeV

Ditanya : a. Energi luar inti helium E_b

b. Beda massa inti helium dengan total massa partikel penyusun dalam kg

Jawab :

a. Massa total = $2 M_p + 2 M_n$

$= 2(1,007276) + 2(1,008665) = 4,0318824$

$\Delta m = M_t - M_{hel} = 4,0318824 - 4,00506 = 0,0303764$

$E = \Delta m c^2$

$= (3,044 \times 10^{-24}\ kg)(2,9979 \times 10\ m/s)^2 = 4,533 \times 10^{-12}\ J = 28,3\ MeV$

b. $\Delta m kg = (0,0303764) \times (1,66054 \times 10^{-27}\ kg)$

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

6. Diketahui : $v_A = 0,8\ c$

$v_B = 0,6\ c$

Ditanya : kecepatan pesawat A menurut pengamat dibulan (v') ?

Jawab :

$$v' = \frac{v_A + v_B}{1 + \frac{v_A v_B}{c^2}} = \frac{0,8 + 0,6}{1 + \frac{(0,8)(0,6)}{c^2}} = \frac{1,4\ c}{1 + 0,48} = \frac{1,4}{1,48} = 0,946\ c$$

7. Diketahui : $P = 20$

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

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

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

Ditanya : Jumlah atom yang dipancarkan ?

Jawab :

$$E = \frac{hc}{\lambda} = \frac{(6,626 \times 10^{-34})(3 \times 10^{8})}{589 \times 10^{-9}} = \frac{1,9878 \times 10^{-25}}{589 \times 10^{-9}} = 3,37 \times 10^{-19}\ J$$

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

8. Diketahui : $W = 2,2$ eV

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

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

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

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

Ditanya : Energi kinetik maksimum fotoelektron (k) dalam eV?

Jawab :

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

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

$k = E - W = 3,53 - 2,2 = 1,35$ eV.