

1. $x'_1 = 0$ hingga $x'_2 = L_0$

$$L = x_2 - x_1$$

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

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

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

$\therefore$ waktu sama ($t_1 = t_2$)

$$x'_1 = \gamma (x_1 - ut)$$

$$x'_2 = \gamma (x_2 - ut)$$

$$L_0 = x'_2 - x'_1$$

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

$$L_0 = \gamma (x_2 - x_1) \quad \text{atau}$$

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

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

2. Diketahui : $E = 25 \text{ GeV}$

$$d = 3000 \text{ m}$$

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

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

Ditanya : a). kecepatan elektron yg energinya 25 GeV ?

b). Waktu yg diperlukan elektron untuk menempuh jarak 3000 m?

c). panjang akselerator dalam kerangka acuan elektron?

d). waktu tempuh elektron dalam kerangka acuan inertialnya sendiri?

Jawab :

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

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

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

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

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

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

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

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

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

selisih dengan kecepatan cahaya :

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

Jadi, elektron hampir bergerak dengan kecepatan cahaya.

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

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

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

$$\approx 10 \text{ ns}$$

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

Karena $\gamma \approx 4,89 \times 10^4$, maka

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

$$L' \approx 0,061 \text{ m} = 6,1 \text{ cm}$$

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

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

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

3. Diketahui : $\lambda_0 = 122 \text{ nm}$

$$\lambda' = 366 \text{ nm}$$

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

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

b). Panjang gelombang baru λ jika galaksi mendekati kita dengan kecepatan yg sama v ?

Jawab :

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

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

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

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

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

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

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

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

$$v = 0,8 c$$

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

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

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

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

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

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

$$= 122 \times 0,3333$$

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

4. Diketahui : $E_{\text{per atom}} = 200 \text{ MeV}$

$$\text{Muranium} = 1 \text{ kg} = 1000 \text{ kg}$$

$$A = 235$$

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

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

$$M_{\text{Atom}} = \frac{2359}{6,022 \times 10^{23}}$$

Ditanya : Perubahan massa Δm akibat reaksi fiksi 1 kg uranium ?

Jawab :

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

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

Jumlah atom dlm uranium 1 kg :

$$N = \frac{1000 \text{ g}}{M_{\text{atom}}}$$

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

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

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

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

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

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

5. Diketahui : $m_p = 1,007276 \text{ u}$

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

$m_n = 1,008665 \text{ u}$

$1 \text{ u} c^2 = 931,5 \text{ MeV}$

$M_{\text{helium}} = 4,001506 \text{ u}$

Ditanya : a) energi ikat inti helium E_b

b) beda massa inti helium dgn total massa partikel penyusun dalam kg

Jawab :

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

$$= 2(1,007276 \text{ u}) + 2(1,008665 \text{ u})$$

$$= 4,03182 \text{ u}$$

$$\Delta m = \text{Massa total} - M_{\text{helium}}$$

$$= 4,03182 \text{ u} - 4,001506 \text{ u}$$

$$= 0,030316 \text{ u}$$

$$E = \Delta m c^2$$

$$= 15,044 \times 10^{-29} \text{ kg} (2,9979 \times 10^8 \text{ m/s})^2$$

$$= 4,533 \times 10^{-12} \text{ J}$$

$$= 28,3 \text{ MeV}$$

b). $\Delta m_{\text{kg}} = (0,030316 \text{ u}) \times$

$$(1,66054 \times 10^{-27} \text{ kg})$$

$$= 5,04 \times 10^{-29} \text{ kg.}$$

6. Diketahui : $V_A = 0,8 c$

$V_B = 0,6 c$

Ditanya : kecepatan pesawat A menurut pengamat di bulan (V') ?

Jawab :

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

7. Diketahui : $P = 20 \text{ W}$

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

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

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

ditanya : Jumlah foton yg dipancarkan perdetk. (N)!

Jawab :

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

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

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

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

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

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

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

Ditanya : energi frek maksimum foto elektron (K) dalam eV?

Jawab :

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

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

$$= 3,55 \text{ eV}$$

$$K = E - W$$

$$= 3,55 - 2,2$$

$$= 1,35 \text{ eV}$$