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Matkul : Fisika Modern

① Diketahui : $x_1 = 0$ hingga $x_2' = L_0$

$L = x_2 - x_1$

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

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

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

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

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

② Diketahui : $E = 25$ GeV
$d = 3000$ m
$m_0 = 0{,}511$ MeV/$c^2$
$c = 3 \times 10^8$ m/s

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

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

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

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

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

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

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

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

Selisih dengan kec cahaya $c - v = 0{,}031$ m/s

Jadi elektron hampir bergerak dengan kec. cahaya.

b). $t = \frac{d}{v} = \frac{3000\ m}{2,9999 \times 10^8\ m/s}$

$t \approx 1,0000000001 \times 10^{-3}\ s$

$= 10\ \mu s$

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

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

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

$L' \approx 0,1061\ m = 6,1\ cm$

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

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

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

③ Diketahui : $\lambda_0 = 122\ nm$

$\lambda_1 = 366\ nm$

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

Ditanya : a). kec galaksi v jika spektrum bergeser dari $\lambda_0$ menjadi $\lambda'$ ?

b). panjang gelombang baru $\lambda$ jika galaksi mendekati kita dengan kecepatan yang sama?

Jawab : a). $\frac{\lambda_1}{\lambda_0} = \sqrt{\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}}$

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

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

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

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

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

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

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

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

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

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

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

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

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

$= 122 \times 0,3323$

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

④ Diketahui : E per atom = 200 MeV
A = 235
1 MeV = $1{,}602 \times 10^{-13}$ J
c = $3 \times 10^8$ 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 x $1{,}602 \times 10^{-13}$ 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

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

$$m = \frac{(8{,}20 \times 10^{13}\ J)}{(3 \times 10^8\ m/s)^2} = 9{,}11 \times 10^{-4}\ kg$$

⑤ Diketahui : $m_p$ = 1,007276 V
$m_n$ = 1,008665 u
M helium = 4,001506 u
1 u = $1{,}66054 \times 10^{-23}$ kg
1 $uc^2$ = 931,5 MeV

Ditanya : a) energi ikat inti helium 56
b). beda massa inti helium dengan total massa partikel penyusun dalam kg

Jawab.
a). Massa total = 2 mp + 2 mn
= 2 (1,007276) + 2 (1,008665)
= 4,0318824

Δm = M total - M helium
= 4,0318824 - 4,00506
= 0,03033764

E = $\Delta mc^2$
= $(3{,}044 \times 10^{-29}\ kg)\ (2{,}9979 \times 10^{m/s})^2$
= $4{,}533 \times 10^{-12}$ J = 28,3 MeV

b). Δm kg = (10,00037 u) x ($1{,}66054 \times 10^{-27}$ kg)
= $3{,}04 \times 10^{-29}$ kg

⑥ Diketahui : $V_A = 0{,}8c$ Ditanya : kecepatan pesawat A menurut pengamat
$V_B = 0{,}6c$ dibulan ($V'$) ?

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

⑦ Diketahui : $P = 20$ Co Ditanya : Jumlah atom yg dipancarkan?

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

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

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

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

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

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

⑧ Diketahui : $W = 2{,}2\ eV$

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

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

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

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

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

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

$E = \frac{5{,}68 \times 10^{-19}}{1{,}6 \times 10^{-19}} = 3{,}553\ eV$

$K = E - W$

$= 3{,}553 - 2{,}2 = 1{,}35\ eV$