... od zadnjič

$$\left[M\left({}^{112}_{48}Cd\right) + M\left({}^{114}_{48}Cd\right)\right]c^2 = (A+1-Z+A-1-Z)\,m_n c^2 + 2Zm_p c^2 - 2w_0 A + 2w_1 A^{\frac{2}{3}} + 2w_2 \frac{Z^2}{A^{\frac{1}{3}}} + 2w_3 \frac{(A-2Z)^2}{A} - 2w_4 \frac{1}{A^{\frac{3}{4}}}$$

$2(A-Z)$

$A = 113 \Rightarrow A-1 = 112$

$A+1 = 114$

↓ to je 2x masa ${}^{113}_{48}Cd$

4. člen $\delta_{ZN}\left({}^{112}_{48}Cd\right) = \delta_{ZN}\left({}^{114}_{48}Cd\right) = -1$

$\delta_{ZN}\left({}^{113}_{48}Cd\right) = 0$

$= 2M\left({}^{113}_{48}Cd\right)c^2 - 2w_4 \frac{1}{A^{\frac{3}{4}}}$

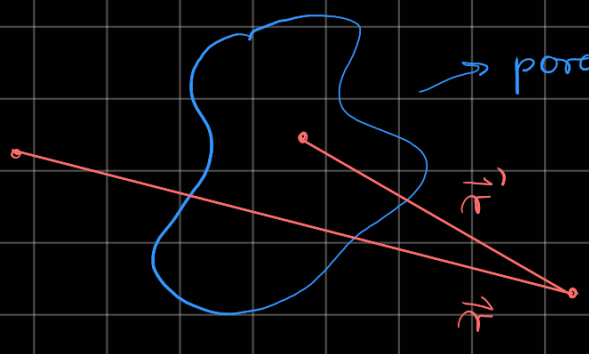
Neznane w_0, w_1, w_2, w_3 mo skrili v poznane mase, w_4, ki pa nas zanima pa je izpostavljen

$$w_4 = \frac{\left[2M\left({}^{113}_{48}Cd\right) - M\left({}^{112}_{48}Cd\right) - M\left({}^{114}_{48}Cd\right)\right]c^2 A^{\frac{3}{4}}}{2}$$

($A^{\frac{3}{4}}$: $A = {}^{113}$)

$= 93{,}3\ MeV$

Dodatek k predavanju



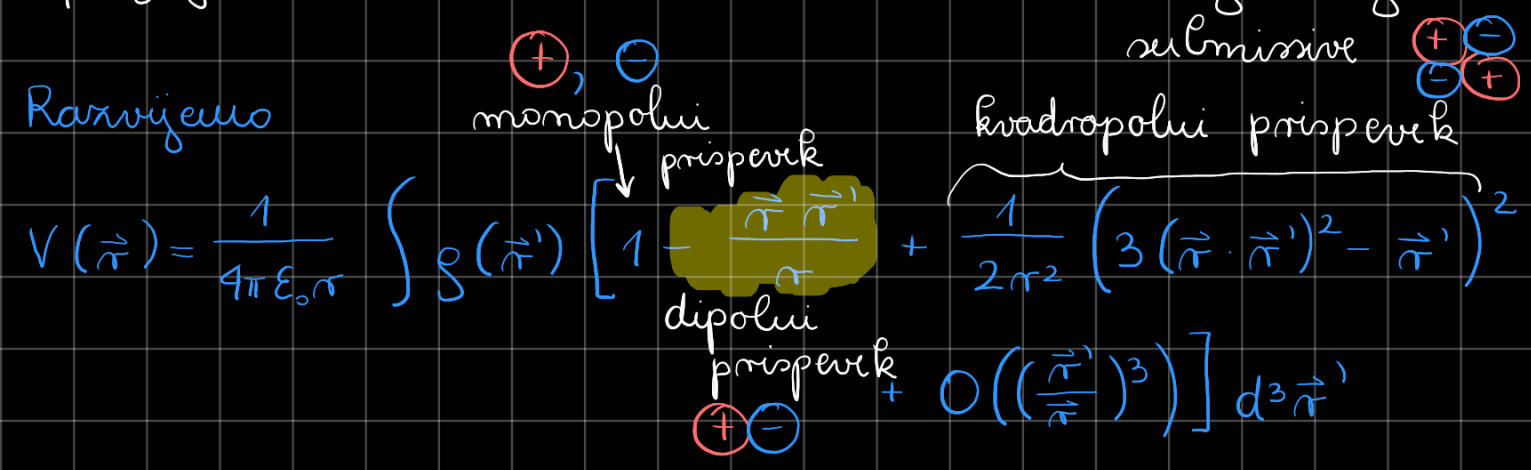
$U(\vec{r}) = ?$

$$U(\vec{r}) = \frac{1}{4\pi\varepsilon_0}\int \frac{\rho(\vec{r}')}{|\vec{r}-\vec{r}'|}\,d^3\vec{r}' \qquad \vec{r} \gg \vec{r}'$$

(ta dodatek)

"Ni pomembno, nu za vaje ne za predavanja, ampak prof. je rekel, da moramo narediti" - Daddy Cuing

Razvijemo



$$V(\vec{r}) = \frac{1}{4\pi\varepsilon_0 r}\int \rho(\vec{r}')\left[1 - \frac{\vec{r}\,\vec{r}'}{r} + \frac{1}{2r^2}\left(3(\vec{r}\cdot\vec{r}')^2 - \vec{r}'\right)^2 + O\left(\left(\frac{\vec{r}'}{\vec{r}}\right)^3\right)\right] d^3\vec{r}'$$

To pridw v poštev pri interakciji med morjo in EM poljem (izpeljava v višjih letih)

$\tilde{V}(t)$

$$\hat{H} = \frac{\hat{p}^2}{2m} + V(t) \xrightarrow[\vec{p} \to \vec{p} - e\vec{A}]{} \left(\hat{p}^2\left[-2e\hat{p}\hat{A} - e^2\hat{A}^2\right]\right)/2m$$

$\vec{A}$ ... vekt. potencial

Verjetnost za prehod

$$|i\rangle \longrightarrow |g\rangle \quad \alpha\, |\langle g|\, V_{ig}\, |i\rangle|^2$$

g ... final, i ... initial

V_{ig} ... dipolni prispevek

$$\langle g|\, \vec{E}\,\vec{\mu}_e\, |i\rangle$$

Topič VI/6 (razširjena naloga)

$$^{235}_{92}U + n \longrightarrow {}^{141}_{55}Cs + {}^{95}_{37}Rb$$

$u = 0'940\ GeV/c^2$

$m_n = 1'01\,u$

$M(^{235}_{92}U) = 235'04\,u$

$M(^{141}_{55}Cs) = 140'92\,u$

$M(^{95}_{37}Rb) = 94'934\,u$

a) sprošča E, ča zanemarimo gibanje reaktantov / produktov?

$$\Delta E = E_k - E_z = [m_{prod}c^2 + E_{v,p}] - [m_{reak}c^2 + E_{v,r}]$$

$\sum m_p + \sum m_n$ # p^+ in n se ohranja

$m_{prod} = m_{reak}$

$$= E_{v,p} - E_{v,r}$$

SEMF

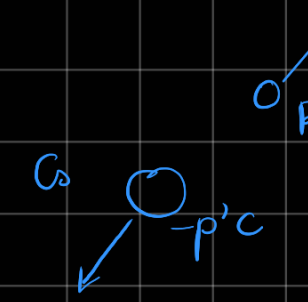
$$E_v(A,Z) = -w_0 A - w_1 A^{\frac{2}{3}} + w_2 \frac{Z^2}{A^{1/3}} + w_3 \frac{(A-2Z)^2}{A} + w_4 \frac{\delta_{zv}}{A^{3/4}}$$

vzeti splošne vrednosti iz Strnada

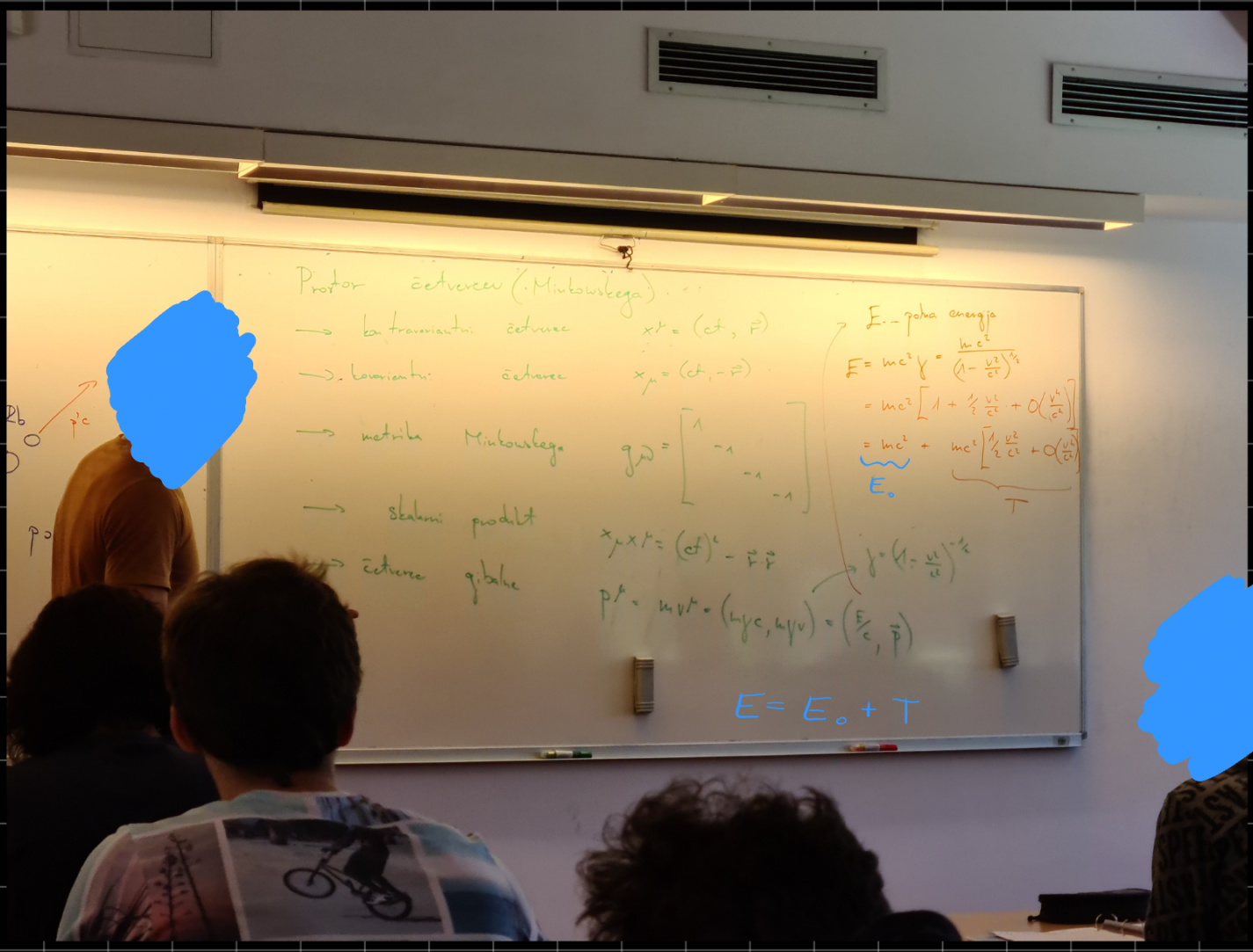
$$= E_v(141,55) + E_v(95,37) - E_v(235,92) = -179'7\,MeV$$

b) težiščni sistem, uran in nevtron se gibljeta

// pred reakcijo



// po reakciji



Ponovitev MF1

Skalarni produkt x ohranja (rotacija, translacija + še nekaj)

Težiščni sistem $p_{1\mu}\, c = (E^\mu_{=mc^2}, 0)$

Lab. sistem $p_{2\mu}\, c = (E, pc)$

$p_{1\mu}\, p_{2\mu} = m_e^2 c^4 = E^2 - p^2 c^2$

$$\Rightarrow E = \sqrt{(mc^2)^2 + p^2c^2}$$

$p_0 c = 500\ MeV$

Zanima nas

$p'c = ?$

$T_{Cs} = ?$

$T_{Rb} = ?$

- pred

$$\left.\begin{aligned} p_U^\mu c^2 &= (E_U, p_0 c) \\ p_m^\mu c^2 &= (E_m, -p_0 c) \end{aligned}\right\} \quad p_z^\mu c^2 = (\underbrace{E_U + E_m}_{E^*}, 0)$$

E^* ... težiščna energija

$$E^* = \underbrace{\sqrt{(m_U c^2)^2 + (p_0 c)^2}}_{E_U} + \underbrace{\sqrt{(m_m c^2)^2 + (p_0 c)^2}}_{E_m} = 220'0\ GeV$$

- po reakciji

$$\left.\begin{aligned} p_{Rb}^\mu c^2 &= (E_{Rb}, p^2 c) \\ p_{Cs}^\mu c^2 &= (E_{Cs}, -p^2 c) \end{aligned}\right\} \quad p_k^\mu c^2 = (E_{Rb} + E_{Cs}, 0)$$

Poglejmo ohranitev energije

$p_x^\mu c = p_K^\mu c$

Da bo reakcija mogoča, more veljati $E^* > m_{Rb}c^2 + m_{Cs}c^2$

$$E^* = E_{Rb} + E_{Cs} = T_{Rb} + m_{Rb}c^2 + T_{Cs} + m_{Cs}c^2 = \not{4}$$

$$T = E - E_0 = \sqrt{(mc^2)^2 + (pc)^2} - mc^2$$

$$= mc^2 \left[\sqrt{1 + \left(\frac{pc}{mc^2}\right)^2} - 1 \right]$$

hitrost delcev

$pc \ll mc^2 \Rightarrow$ nerelativistično

mirovne mase približek

$$\approx mc^2 \left[1 + \frac{1}{2}\left(\frac{pc}{mc^2}\right)^2 - 1 \right] = \frac{1}{2}\frac{(pc)^2}{mc^2}$$

$$\not{4} = \frac{1}{2}\frac{(p'c)^2}{m_{Rb}c^2} + m_{Rb}c^2 + \frac{1}{2}\frac{(p'c)^2}{m_{Cs}c^2} + m_{Cs}c^2$$

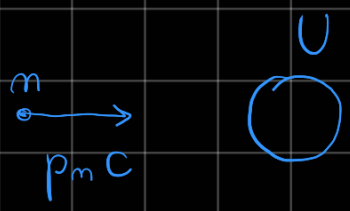
Izrazimo $p'c$: $p'c = \left(\frac{2\left[E - (m_{Rb} + m_{Cs})c^2\right]}{\frac{1}{m_{Rb}c^2} + \frac{1}{m_{Cs}c^2}} \right)^{\frac{1}{2}} = 5'63\ \text{GeV}$

$$T_{Rb} = \frac{1}{2}\frac{(p'c)^2}{m_{Rb}c^2} = 179\ \text{MeV}$$

$$T_{Cs} = \frac{1}{2}\frac{(p'c)^2}{m_{Cs}c^2} = 121\ \text{MeV}$$

c) Laboratorijski sistem z mirujočim uranom

$E_U = ?$ $\quad p_n c = ?$



Zapišimo četverca

$$\left.\begin{aligned} p_n^{\mu} c &= (E_n, p_n c) \\ p_U^{\mu} c &= (E_U, \varnothing) \end{aligned}\right\} \quad p_z^{\mu} c = (E_n + E_U, p_n c)$$

$$\underbrace{(p_T^{\mu} c)(p_{T\mu} c)}_{\text{težiščni}} = \overbrace{(p_L^{\mu} c)(p_{L\mu} c)}^{\text{laboratorijski}}$$

$$\Downarrow$$

$$E^{*2} = (E_n + E_U)^2 - (p_n c)^2$$

$$E^{*2} = E_n^2 + 2 E_n E_U + E_U^2 - (p_n c)^2$$

Razpišimo z invariantami $E = \sqrt{(mc^2)^2 + (pc)^2}$

$$E_n = \sqrt{(m_n c^2)^2 + (p_n c)^2}$$

$$E_U = m_U c^2$$

$$E^{*2} = (m_n c^2) + \cancel{(p_n c)^2} + (m_U c^2)^2 + 2 m_U c \sqrt{(m_n c^2)^2 + (p_n c)^2} - \cancel{(p_n c)^2}$$

$$p_n c = \left(\frac{E^{*2} - (m_n c^2)^2 - (m_U c^2)^2}{2 m_U c^2} - (m_n c^2)^2 \right)^{\frac{1}{2}} = 0{,}49\,\text{GeV}$$

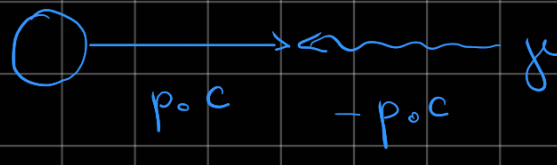
$$E_n = \sqrt{(m_n c^2)^2 + (p_n c)^2} = 1{,}06\,\text{eV}$$

Pliuski modul se ne dela (bo pri FJODu)

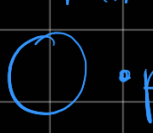
VI / 8

a) $\gamma + {}^{56}_{26}\text{Fe} \longrightarrow {}^{1}_{1}p + {}^{55}_{25}\text{Mn}$

Zanima na $E_\gamma^{min} = ?$



//pred reakcijo



$v_{Mn} = v_p = 0$