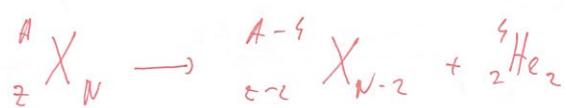


(1)

## $\alpha$ -koulass

Folyamat:



Energetikai feltétel:  $Q_\alpha \rightarrow \alpha$ -koulassban felszabadító energia

$$Q_\alpha = [n(z, A) - n(z-2, A-4) - M({}_2^4 He)] c^2$$

|| feltéti energiális kiegyenlítés

$$Q_\alpha = \underbrace{B({}_2^4 He)}_{28.3 \text{ MeV}} + B(z-2, A-4) - B(z, A) > 0$$

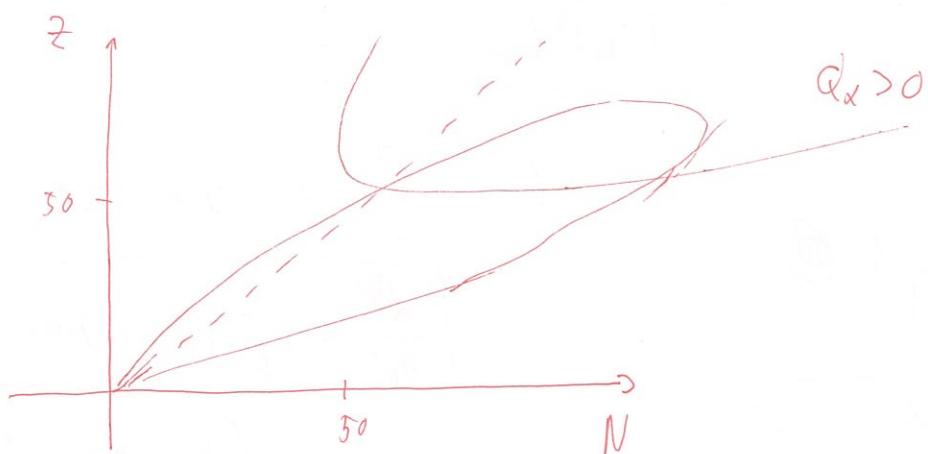
↓

↑  
Feltétel

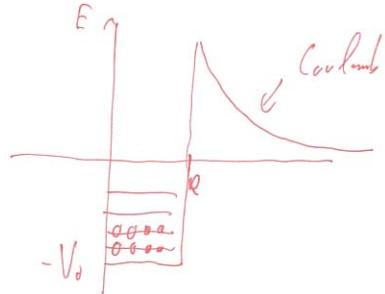
↓ Cseppmodell

||  
 $A \gtrsim 150$  ( $S_m$ )

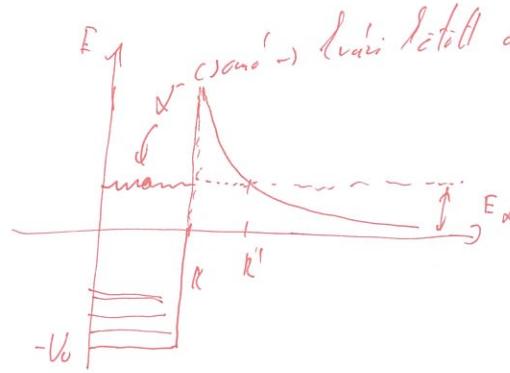
$$Q_\alpha \approx 28.3 \text{ MeV} - 4\alpha_v + \frac{8}{3} \frac{\alpha_s}{A^{1/3}} + 3 \frac{\alpha_c z}{A^{1/3}} \left(1 - \frac{z}{3A}\right) - 4\alpha_e \left(1 - \frac{z}{A}\right)^2$$



## Elein falazat



$\Rightarrow$



K. Elasztikus  
Vonatkozó  
a nukleon, mint  
a magból

$U > E_x$  esetén hozzájut ki az  $\lambda$ -re a  
magból?  $\Rightarrow$  Gamow - elágazástelephetős

Időegységek jelföldi váltás:

$$\lambda = \lambda_0 \frac{T}{\gamma} \quad \begin{array}{l} \text{transziszteri osztályhatás} \\ (\text{elágazás}) \end{array}$$

$\lambda$  spektroakciójának faktor

## T faktor

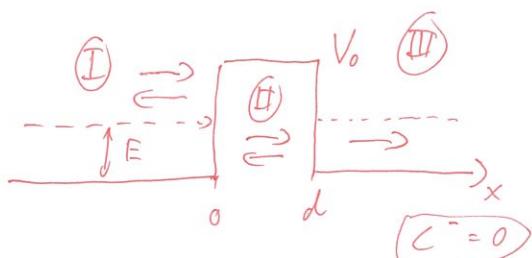
$$\text{def.: } T = \frac{j_{at}}{j_{be}}$$

$$j = \frac{\hbar}{2mi} (\psi^* \partial \psi - \psi \partial \psi^*) \approx |\psi|^2 v$$

$$p = mv = \hbar k$$

$$T = \frac{|\psi_{at}|^2 \lambda_{at}}{|\psi_{be}|^2 \lambda_{be}}$$

## 1 dim. □ potenciál



All. nevezetességek: normális

$$\psi^I = C e^{i \ell_I x} + A^- e^{-i \ell_I x}$$

$$\psi^{II} = B^+ e^{i \ell_{II} x} + B^- e^{-i \ell_{II} x}$$

$$\psi^{III} = C^+ e^{i \ell_{III} x}$$

$$\text{Soh.: } -\frac{\hbar^2}{2m} \Delta \psi + U \psi = E \psi$$

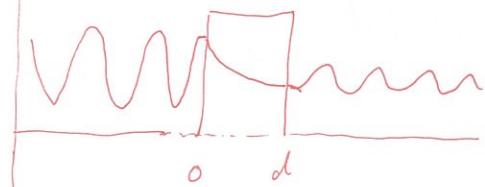
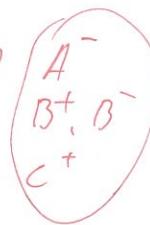
$$\boxed{\frac{d^2 \psi}{dx^2} + \frac{2m}{\hbar^2} (E - U) \psi = 0}$$

$$U = \begin{cases} V_0 & 0 \leq x \leq d \\ 0 & \text{másutt} \end{cases}$$

$$\text{ahol } \left\{ \begin{array}{l} \ell_I = \ell_{III} = \frac{\sqrt{2mE}}{\hbar} \\ \ell_{II} = \frac{\sqrt{2m(E-U_0)}}{\hbar} = i \frac{\sqrt{2m(V_0-E)}}{\hbar} = i \ell_{II}' \end{array} \right.$$

$$\ell_{II} = \frac{\sqrt{2m(E-U_0)}}{\hbar} = i \frac{\sqrt{2m(V_0-E)}}{\hbar} = i \ell_{II}'$$

+ Folgt aus  $\psi_1$  fiktiv:  $\psi_{\text{I}}(0) = \psi_{\text{II}}(0)$      $\psi_{\text{II}}(d) = \psi_{\text{III}}(d)$   
 $\psi'_{\text{I}}(0) = \psi'_{\text{II}}(0)$      $\psi'_{\text{II}}(d) = \psi'_{\text{III}}(d)$



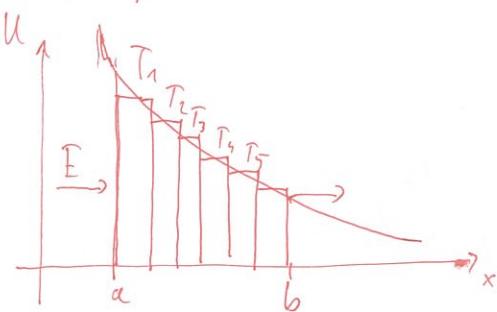
$$|C^+|^2 = \frac{1}{1 + \frac{A' k_I^2 k_{II}^2}{4 k_I^2 k_{II}^2} \sin^2(b k_2)}$$

( $b k_{II}$ )

$$T = \frac{|\psi_{\text{II}}|^2 \delta_{\text{III}}}{|\psi_{\text{I}}|^2 \delta_{\text{I}}} = \frac{|C^+|^2}{1} = |C^+|^2 \sim e^{-\frac{2}{\hbar} \sqrt{2m(V_0 - E)} d}$$

Gamow formula

Transversaler potenzial:



$$T = T_1 \cdot T_2 \cdot T_3 \cdot T_4 \cdots \approx e^{-\frac{2}{\hbar} \int_a^b \sqrt{2m(V(x) - E)} dx}$$

$$\approx e^{-\frac{2}{\hbar} \sum_i \sqrt{2m(V_i - E)} d_i}$$

$3D_s$  erst (zentraler potenzial)  $\rightarrow U(r)$

$$\psi(r, \vartheta, \varphi) = R(r) Y_l^m(\vartheta, \varphi)$$

Sch.:  $\partial_{rrr} \psi + \frac{2m}{\hbar^2} (E_{\text{Tot}} - u) \psi = 0$

|| Radiall. erzählt

$$\frac{1}{r^2} \frac{d^2}{dr^2} (r^2 R(r)) + \frac{2m}{\hbar^2} \left[ (E_{\text{Tot}} - u) - \underbrace{\frac{\ell(\ell+1)\hbar^2}{2mr^2}}_{\text{"Centrifugales - potenzial"}} \right] R(r) = 0$$

"Centrifugales - potenzial"

$$u(r) = r K(r)$$

~~Einf.~~

$$\frac{d^2}{dr^2} u(r) + \frac{2m}{\hbar^2} \left[ E_{\text{Tot}} - u(r) - \frac{\ell(\ell+1)\hbar^2}{2mr^2} \right] u(r) = 0$$

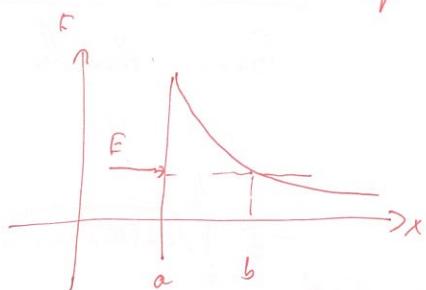
↪ analog a 1D-s erzählt

$$\text{Wahrscheinl.: } \mathcal{E}(r) = \frac{1}{\pi} \sqrt{2m(E - U(r) - \frac{\ell(\ell+1)\hbar^2}{2mr^2})}$$

$$T = \frac{\int |\Psi_{el}|^2 \ell_{el} r^2 dr}{\int |\Psi_{bc}|^2 \ell_{bc} r^2 dr} = \frac{\int \ell_{el}(r) |K_{el}(r)|^2 r^2 dr}{\int \ell_{bc}(r) |K_{bc}(r)|^2 r^2 dr} \frac{\left( \int |\Psi_{el}|^2 d\ell \right)}{\left( \int |\Psi_{bc}|^2 d\ell \right)} = 1$$

Coulomb-potential ( $\ell=0$  esat)  $\ell \leq l_m$  is ja' direkt

$$U(r) = \frac{z_1 z_2 e^2}{r} \Rightarrow \text{Virtua. an 1d. osetre}$$



$$T = \exp \left( -\frac{2}{\hbar} \int_a^b \sqrt{2m(E(r)-E)} dr \right) = e^{-G}$$

Gauß-faktor:  $G = \left( \frac{8m}{\hbar^2} \right)^{1/2} \int_a^b \left( \frac{z_1 z_2 e^2}{r} - E \right)^{1/2} dr =$

$$= \left( \frac{8 z_1 z_2 e^2 m b}{\hbar^2} \right)^{1/2} \left[ \arccos \left( \frac{k}{b} \right) - \sqrt{\frac{1}{b} - \left( \frac{k}{b} \right)^2} \right]$$

|     |                   |                              |        |                       |  |
|-----|-------------------|------------------------------|--------|-----------------------|--|
| Pl: | $^{212}\text{Po}$ | $T_{1/2}$                    | $E_x$  | $T_x$                 | $\log T_{1/2} \sim \frac{1}{\lambda} \sim e^G$ |
|     |                   | $0,3 \mu\text{s}$            | $8,77$ | $1,32 \cdot 10^{13}$  |  |
|     | $^{224}\text{Ra}$ | $3,6 \text{ nap}$            | $5,7$  | $5,9 \cdot 10^{-26}$  |  |
|     | $^{194}\text{Ud}$ | $2 \cdot 10^{18} \text{ ev}$ | $1,83$ | $2,18 \cdot 10^{-92}$ |  |

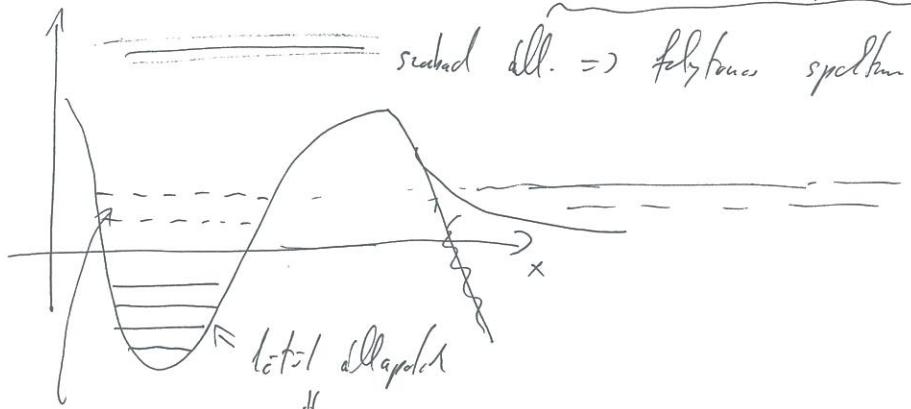
Geiger - Nutall (1911):  $\lambda_\alpha$  nimmt  $\propto$  proportional mit  $R_\alpha$

$$\log \lambda = a + b \log R_\alpha$$

$$\boxed{\log T_{1/2} = a + b \log E_x}$$

①

# Kvantitátsfölt allapotok leírása



diszkrét spektrum

Kvantitátsfölt  
all.

dönthetős  
folytonos esetek  $\Rightarrow$  bound allapot  $\Rightarrow$  diszkrét  $\rightarrow$  sebesség általat

$$\text{szellemháza: } \approx [s] \text{ ms}$$

Hogyan lehet kvantitációs allapotokat leírni?

Kvantitátsfölt allapot  $\Rightarrow$  véges v. végtelen esetben O-hoz tartó hullámhoz.

$\hookrightarrow$  O periodicitás  $\Rightarrow$  diszkrét spektrum:  $E_k$

Kvantitátsfölt allapot  $\Rightarrow$  illentés, e.g. Szenes zömb hullámhoz (limonál felbomlás)

$\hookrightarrow$  diszkrét hullámhoz (komplex)

komplex fr. periodikus!

$\hookrightarrow$  az energiarajzhoz komplex lesz

$$E \in \mathbb{C} : \operatorname{Re} E = \varepsilon$$

$$\operatorname{Im} E = -\frac{\Gamma}{2}$$

$$\text{Soh: } \left[ -\frac{\hbar^2}{2m} \frac{d^2}{dx^2} + V(x) \right] \psi(x) = E \psi(x)$$

$$\hookrightarrow időfüggős eset. \quad \psi(x,t) = e^{-\frac{i}{\hbar} (\operatorname{Re} E + i \operatorname{Im} E)t} \psi(x,0)$$

$$\text{vel. szabályz: } |\psi(x,t)|^2 = e^{\frac{1}{\hbar} \operatorname{Im}(E) \cdot t} |\psi(x)|^2 = e^{-\frac{t}{\tau}} |\psi(x)|^2$$

$$\boxed{\tau := -\frac{\hbar}{\operatorname{Im}(E)}}$$

$\Im(E) = \Gamma$  megadja a háríosztás alapján elhelyezkedést!

$$\downarrow \\ \Gamma = ?$$

$$\textcircled{1} \quad \psi^*(x) \left[ -\frac{\hbar^2}{2m} \frac{d^2}{dx^2} + V(x) \right] \psi(x) = E \psi^* \psi$$

$$\downarrow \int_0^\infty dx$$

$$\textcircled{1} \quad -\frac{\hbar^2}{2m} \int_0^\infty \psi^*(x) \frac{d^2}{dx^2} \psi(x) dx + \int_0^\infty \psi^*(x) V(x) \psi(x) dx = \Re E \int_0^\infty \psi^* \psi dx + i \Im E \int_0^\infty \psi^* \psi dx$$

$$\textcircled{2} \quad \left[ -\frac{\hbar^2}{2m} \frac{d^2}{dx^2} + V(x) \right] \psi^*(x) = (\Re E - i \Im E) \psi^*(x)$$

$$\downarrow \int_0^\infty \psi^*(x) dx$$

$$\textcircled{2} \quad -\frac{\hbar^2}{2m} \int_0^\infty \psi(x) \frac{d^2}{dx^2} \psi(x) dx + \int_0^\infty \psi^* V(x) \psi dx = \Re E \int_0^\infty \psi^* \psi dx - i \Im E \int_0^\infty \psi^* \psi dx$$

||

(II)-I:

$$\frac{\hbar^2}{2m} \underbrace{\left[ \int_0^\infty \left( \psi(x) \frac{d^2}{dx^2} \psi^* - \psi^* \frac{d^2}{dx^2} \psi \right) dx \right]}_{||} = 2i \Im(E) \int_0^\infty \psi^* \psi dx$$

||

$$= \frac{d}{dx} \left[ \psi(x) \frac{d}{dx} \psi^* - \psi^* \frac{d}{dx} \psi \right]$$

$$J = -\frac{\hbar}{2mi} \left[ \psi \frac{d}{dx} \psi^* - \psi^* \frac{d}{dx} \psi \right]$$

$$-\frac{\hbar}{2} \underbrace{\int_0^\infty \frac{d}{dx} J(x) dx}_{\lim_{\beta \rightarrow \infty} J(\beta) - J(0)} = \Im(E) \int_0^\infty \psi^* \psi dx$$

Gauss-fel.

$$\lim_{\beta \rightarrow \infty} J(\beta) - J(0) \underset{||}{=} 0 \quad \text{Kern felf.}$$

$$\int \psi_\Delta \psi^* - \psi^* \psi dV = \lim_{\beta \rightarrow \infty} \int J dV$$

$$-J = \psi \nabla \psi^* - \psi^* \nabla \psi$$

$$\boxed{\Im(E) = -\frac{\hbar}{2} \frac{\lim_{\beta \rightarrow \infty} J(\beta)}{\int_0^\infty \psi^* \psi dx}}$$