Mavzu: Alfa, betta va gamma nurlarning modda orqali o'tishi

Topshiruvchilar:Davlatov Sunnat, Botirova Flyura, Jumaboyeva Shohina.

Alfa nurlar.

- **Alfa zarrachasi** bu ikki proton va ikkita neytrondan tashkil topgan, radioaktiv parchalanish yoki yadro bo'linishida chiqadigan musbat zaryadlangan zarracha; geliy atomining yadrosi hisoblanadi.

- Alfa zarralarning modda orqali o'tish jarayoni:

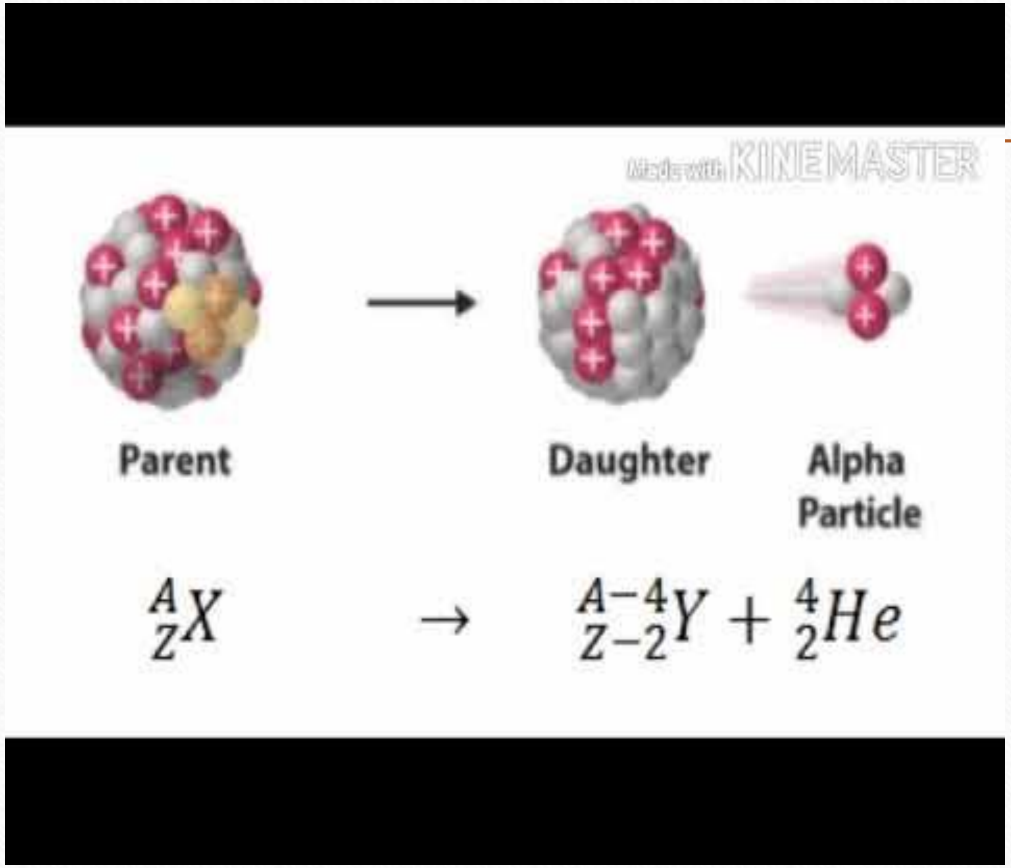
1.Ionlanish: Alfa zarralar modda orqali o'tganda, o'z yo'lida atomlarning elektronlarini chiqarib, ionlashish jarayonini boshlaydi. Bu ularning asosiy energiya yo'qotish usuli hisoblanadi.

2. O'tish masofasi: Alfa zarralar nisbatan katta massaga ega bo'lganligi va modda bilan kuchli o'zaro ta'sirga kirishganligi sababli, ular qisqa masofada energiyasini yo'qotib, tezda to'xtaydi. Alfa zarralarning o'tish masofasi odatda bir necha mikrometrdan millimetrgacha (moddaning zichligi va tarkibiga bog'liq).

3. To'xtash: Alfa zarralar modda ichida energiyasini yo'qotgach, geliy yadrosiga aylanadi va to'xtaydi. Ular havoda taxminan 2-10 sm masofani bosib o'tishi mumkin, qog'oz yoki terining yupqa qatlamidan esa o'ta olmaydi.

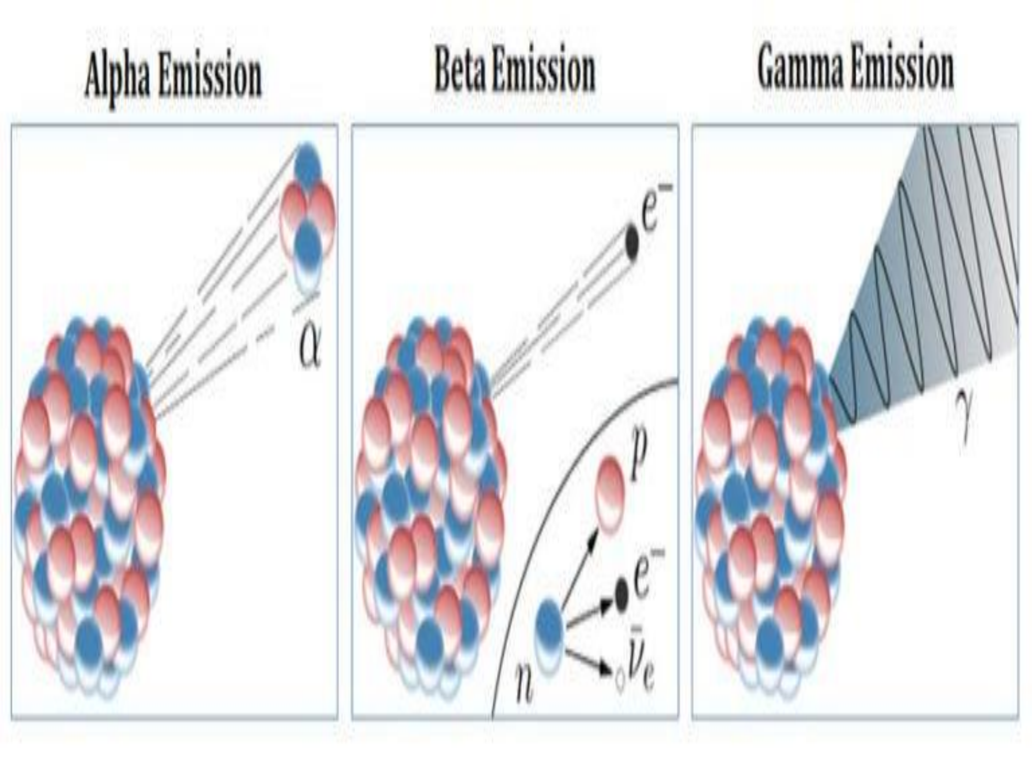
4. Sochilish: Moddadagi atomlar bilan to'qnashuv natijasida alfa zarralar yo'nalishini biroz o'zgartirishi mumkin. Biroq, ularning yo'nalishi katta darajada o'zgarmaydi.

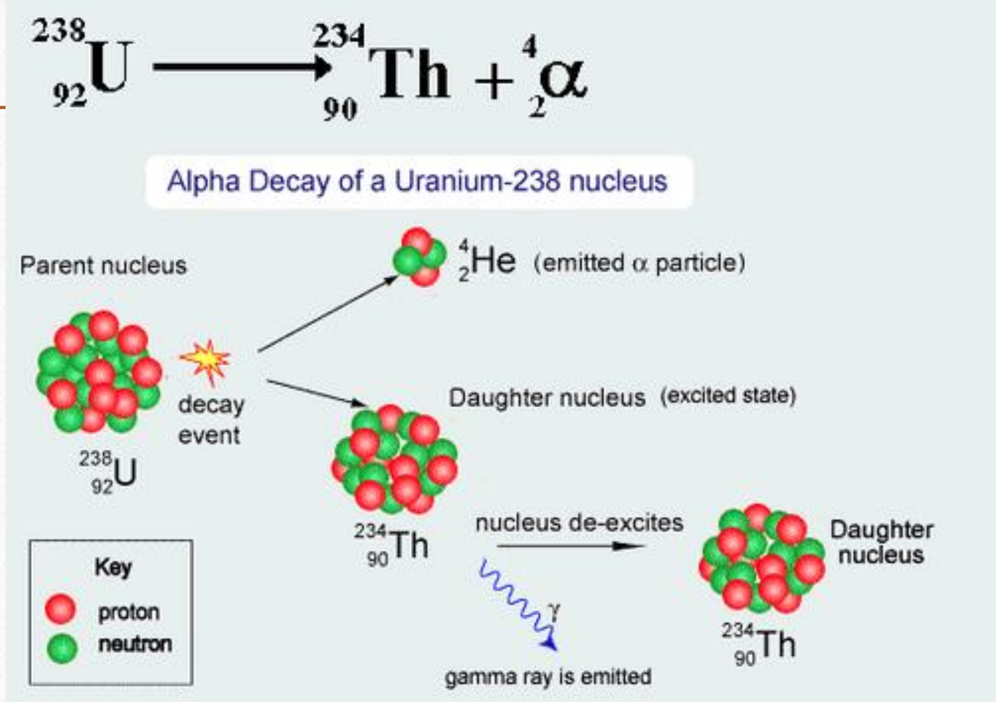
Radioktiv nurlarning o’tuvchanligi



Beta zarralarning modda orqali o’tishi

- Beta zarralar (β-zarralar) modda orqali o'tganda o'ziga xos xususiyatlarga ega bo'ladi. Beta zarralari elektron (β^-) yoki pozitron (β^+) shaklida bo'lib, radioaktiv parchalanish jarayonida hosil bo'ladi. Ularning modda bilan o'zaro ta'siri ionlanish va sochilish jarayonlari orqali yuzaga keladi.

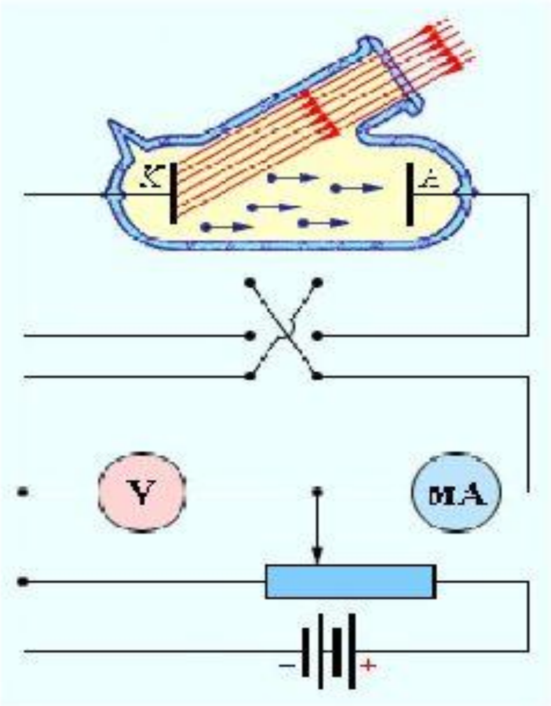

Alpha Emission
Beta Emission
Gamma Emission
α
e⁻
p
e⁻
n
γ


$^{238}_{92}U \longrightarrow ^{234}_{90}Th + ^{4}_{2}\alpha$
Alpha Decay of a Uranium-238 nucleus
Parent nucleus
$^{4}_{2}He$ (emitted α particle)
decay
event
$^{238}_{92}U$
Daughter nucleus (excited state)
$^{234}_{90}Th$
nucleus de-excites
γ
gamma ray is emitted
Daughter
nucleus
$^{234}_{90}Th$
Key
proton
neutron

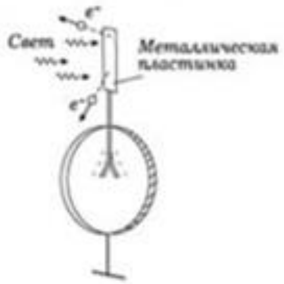
Gamma nurlarning modda bilan o’zaro ta’siri

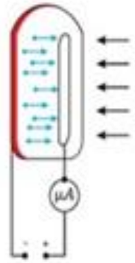
- Gamma nurlar (γ-nurlar) yuqori energiyali elektromagnit to‘lqinlar bo‘lib, zaryad va massa ega emas. Ular modda bilan kuchli o‘zaro ta'sir qilmaydi, shuning uchun nisbatan uzoq masofani bosib o‘tishi mumkin. Gamma nurlarning modda bilan o‘zaro ta'siri uchta asosiy jarayon orqali sodir bo‘ladi: fotoelektrik effekt, Kompton sochilishi va juftlik hosil bo‘lishi.

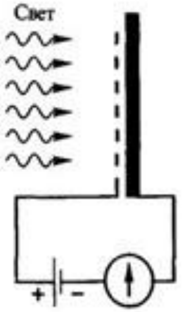
Фотоэффект



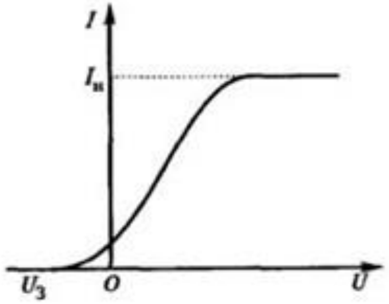
Фотоэффект

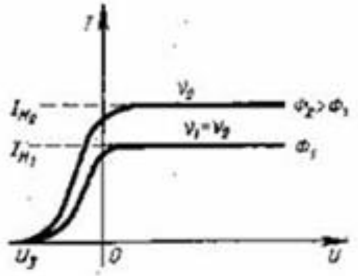






- *вырывание электронов из вещества под действием света*





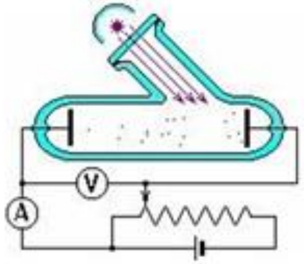
$$h\nu = A_{вых} + E_k$$

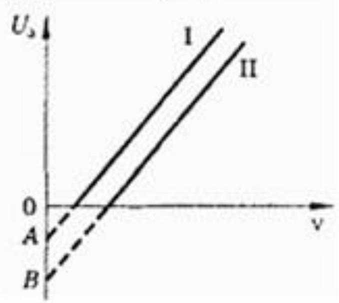
h=6,63·10^{-34} Дж с

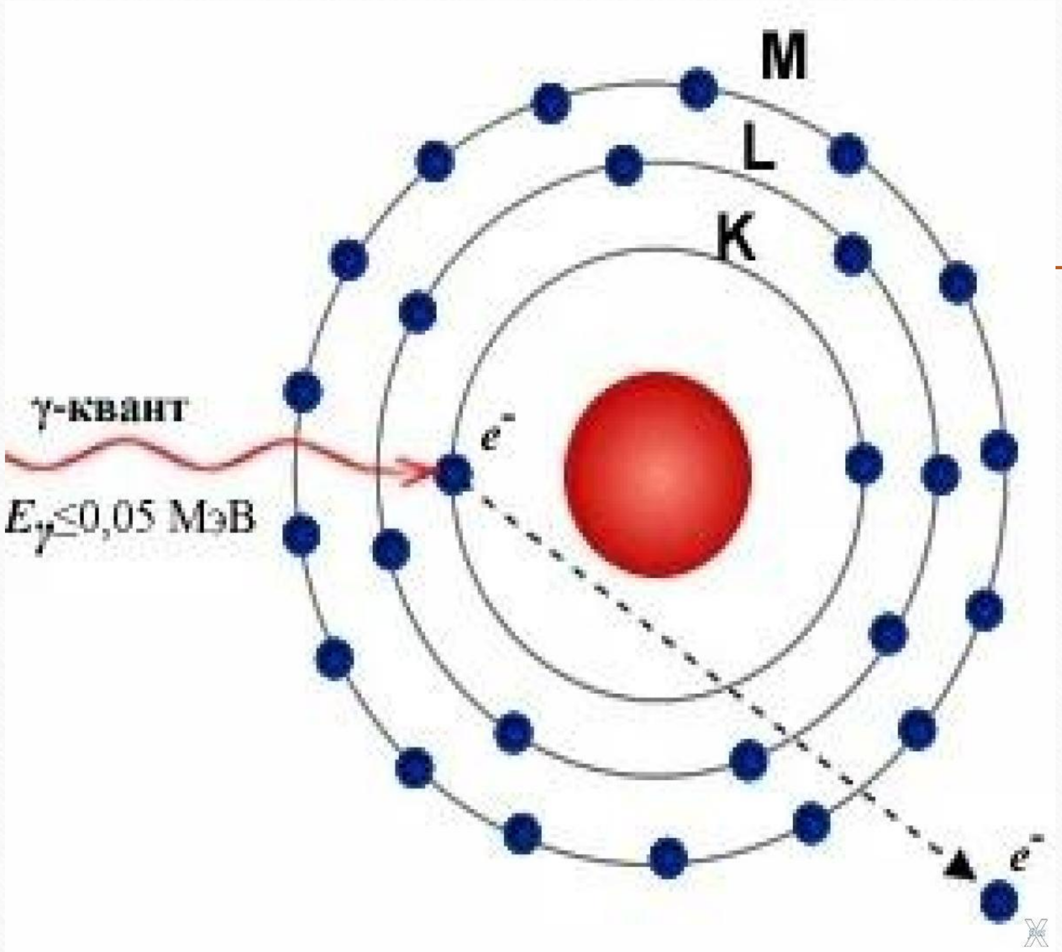
$$E_k = \left(\frac{mv^2}{2}\right)_{min} = eU_3$$

$$A_{вых} = h\nu_{min}$$

$$\nu_{min} = \frac{A_{вых}}{h}$$ - красная граница







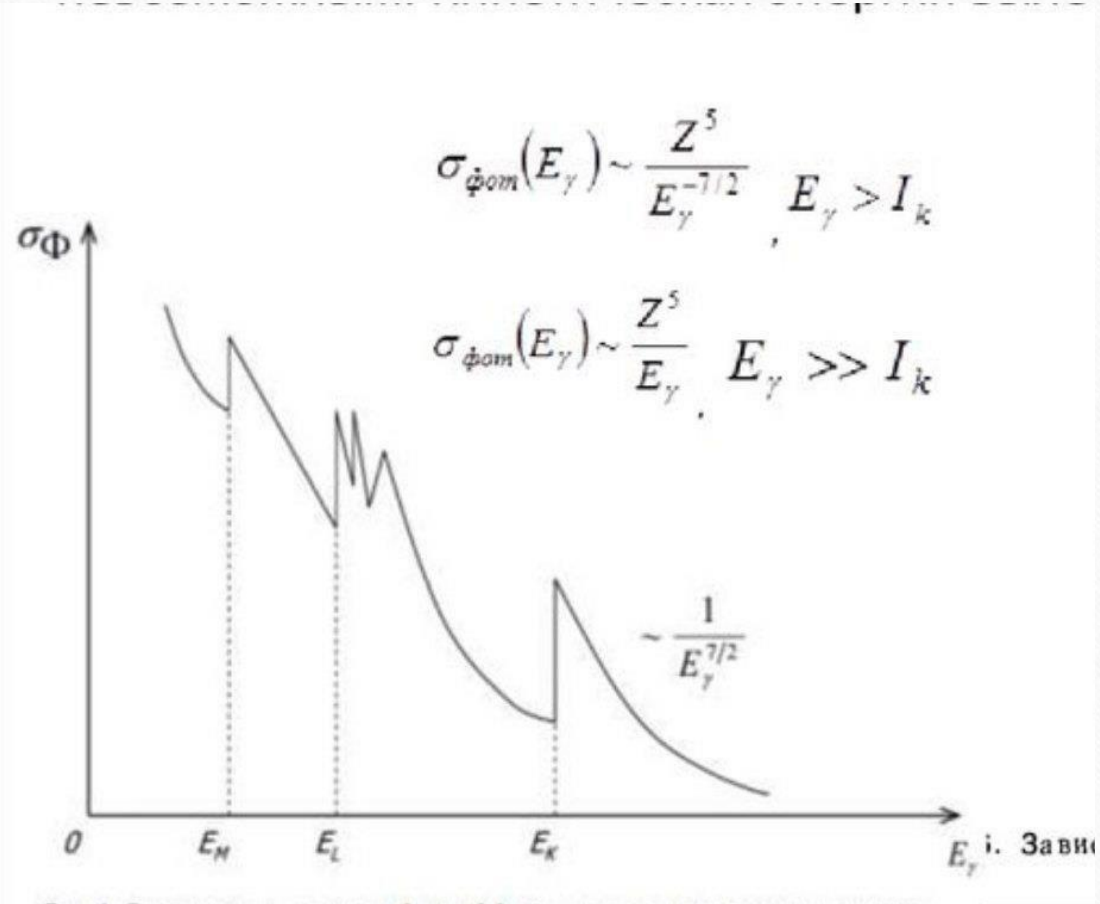
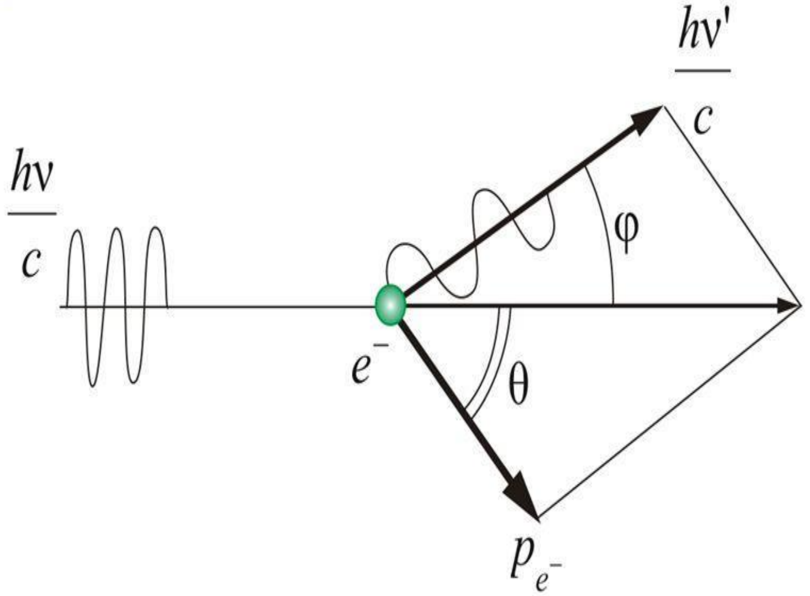
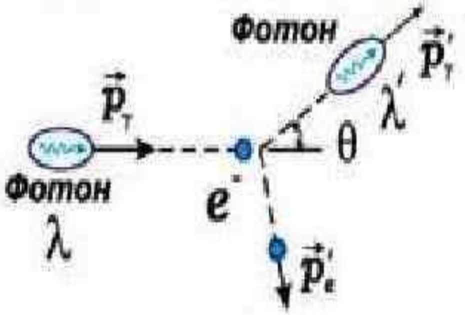


Рис.1 Зависимость сечения фотоэффекта от энергии гамма-излучения

Эффект Комптона



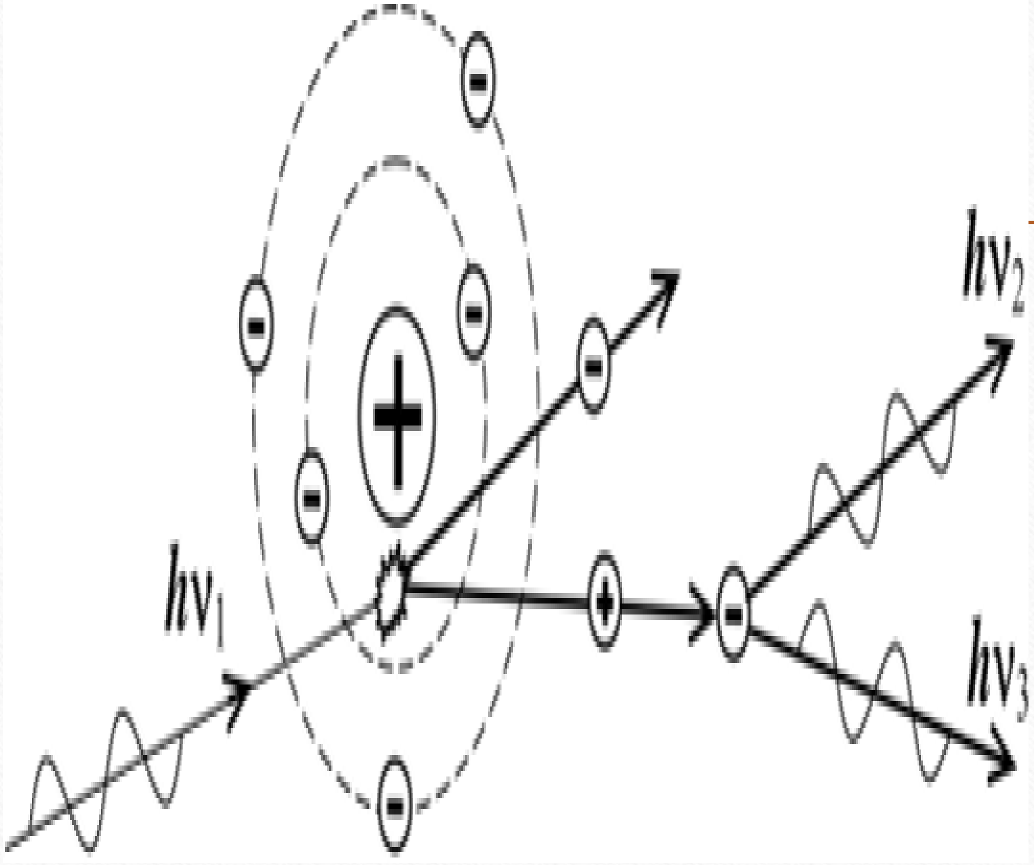
Эффект Комптона



$$\lambda' - \lambda = 2\,\frac{h}{m_e c}\sin^2\frac{\theta}{2}$$

$$\lambda_к = \frac{h}{m_e c} = \frac{2\pi\hbar}{m_e c}$$

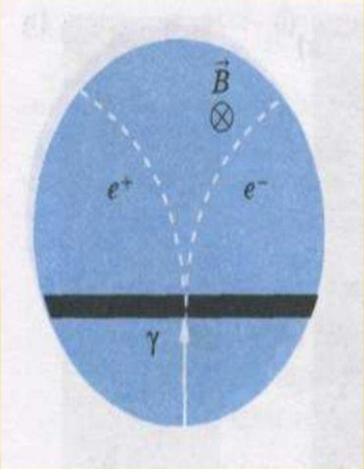
$$\lambda_к = 0{,}0243\ \overset{0}{A}$$ - Комптоновская длина волны



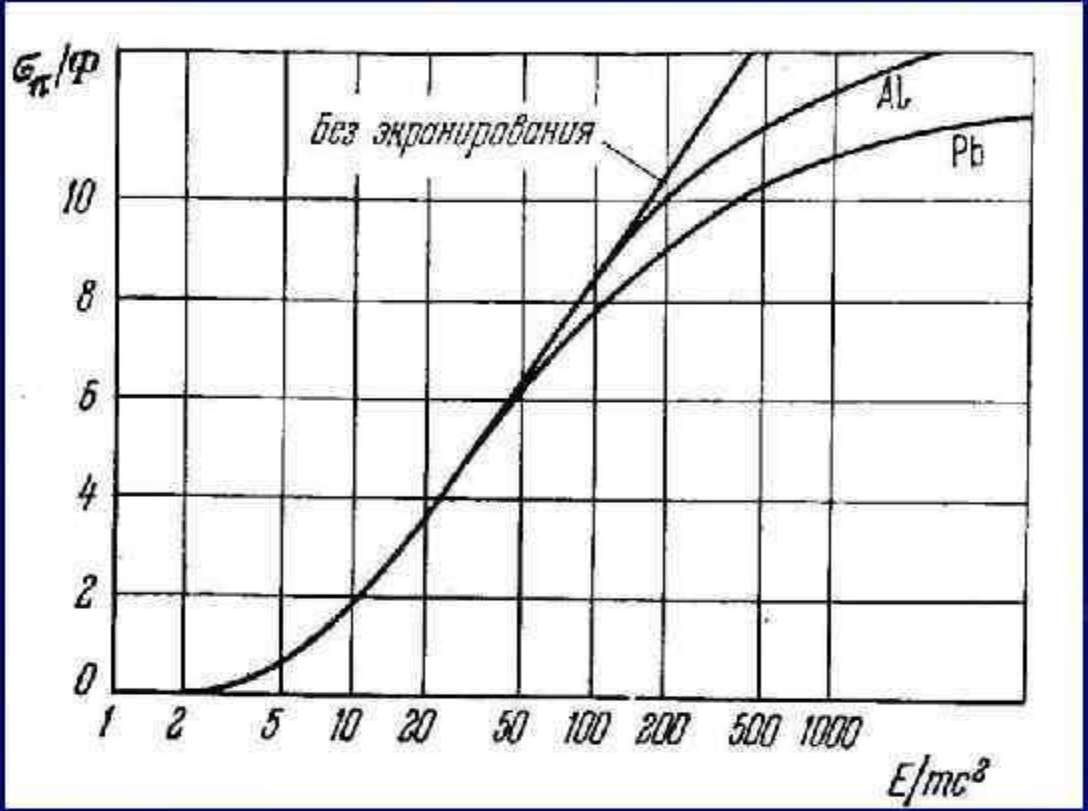
ЭЛЕКТРОН – ПОЗИТРОННАЯ ПАРА

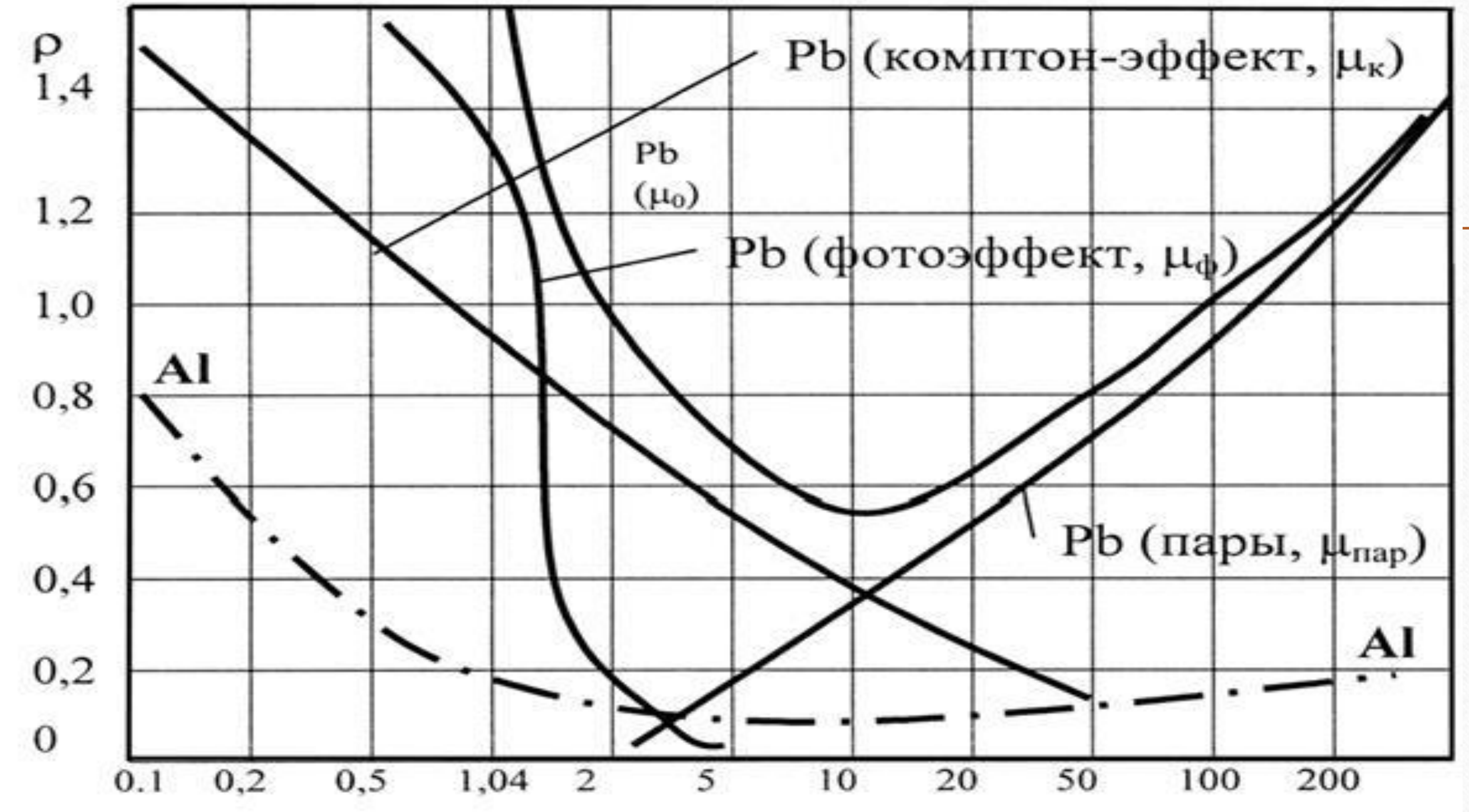
возникает при взаимодействии γ-кванта с веществом.

$\gamma \rightarrow e^- + e^+$



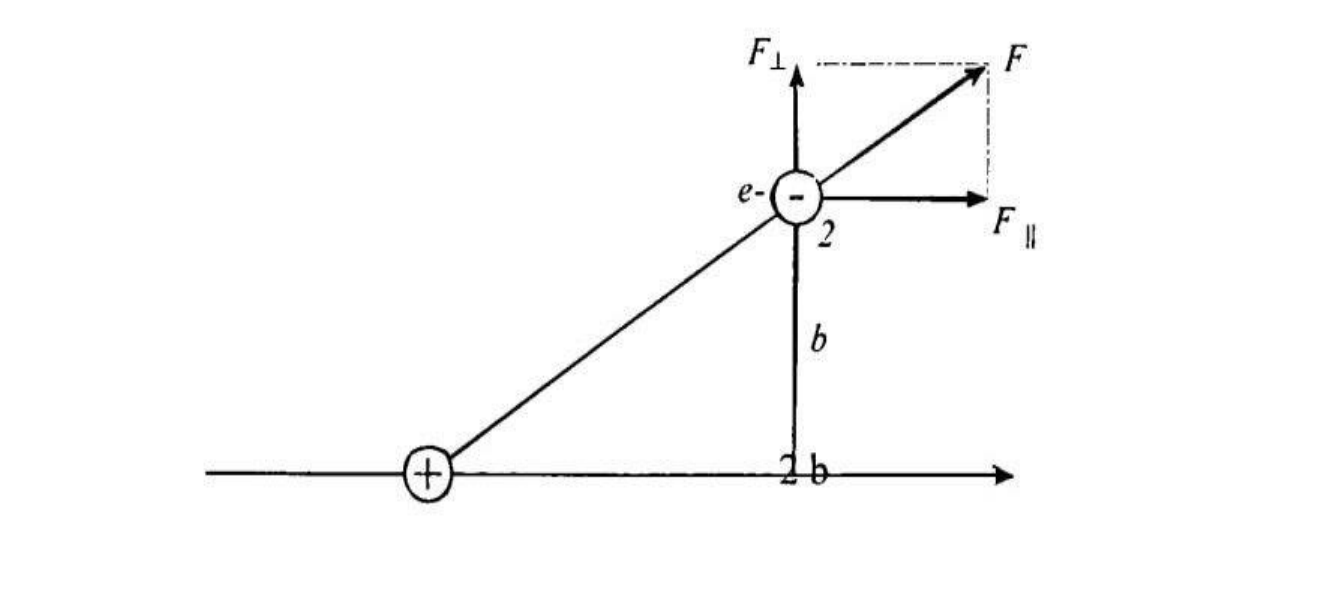
Зависимость сечения образования электрон-позитронных пар от энергии фотона





ρ
1,4
1,2
1,0
0,8
0,6
0,4
0,2
0
Pb (комптон-эффект, $\mu_к$)
Pb (μ_0)
Pb (фотоэффект, $\mu_ф$)
Pb (пары, $\mu_{пар}$)
Al
Al
0.1
0,2
0,5
1,04
2
5
10
20
50
100
200

Muhitga tushuvchi zarra zaryadi Ze, massasi M , tezligi v , elektronga eng yaqin kelish m asofasi b bo‘lsin. Zarra m assasi M » me elektron m assasidan katta bo‘ lgani uchun elektronlar bilan ta’sirlashuvda o‘z yo‘nalishini o‘zgartirmasdan to‘g‘ri chiziq bo‘yicha harakatlanib, zarraning elektron bilan ta ’sirlashuvi 2b m asofagacha bolsin.



Dastlab zarraning alohida elektron bilan o‘zaro ta’sirini ko‘rib chiqaylik. Zarraning harakat trayektoriyasiga tik yo‘nalishda elektronga bergan impulsi:

$$\Delta P_{\perp} = \int F_{\perp} dt.$$

bo‘ladi. Zarra elektronga yaqinlashganda va undan uzoqlashganda ta’sir kuchi yo‘nalishi qarama-qarshi bo‘lgani uchun zarra impulsining parallel tashkil etuvchisi nolga teng bo‘ladi:

$$\Delta P_{\parallel} = \int F_{\parallel} dt = 0.$$

Shuning uchun ionizatsiyani zarra impulsining tik $\Delta P_{\perp}$ tashkil etuvchisi vujudga keltiradi. O‘zaro ta’sir vaqti

$$\Delta t = \frac{2b}{\vartheta}.$$

zarracha tomonidan elektronni itaruvchi kulon kuchi:

$$F_{\perp} = \frac{Ze^2}{b^2}.$$

Elektronning zarracha tomonidan olgan impulsi:

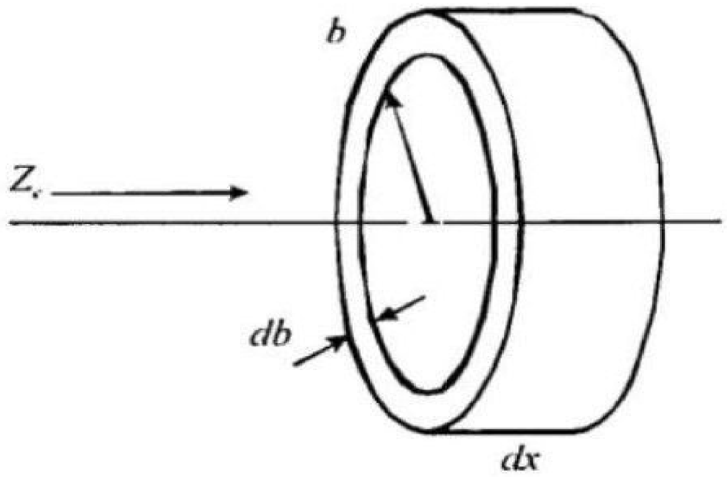
$$\Delta P_{\perp} = F_{\perp}\Delta t = \frac{Ze^2}{b^2}\frac{2b}{\vartheta} = \frac{2Ze^2}{b\vartheta} \quad .$$

Elektronning (6.1.5) impulsiga mos keluvchi olgan energiyasi:

$$\Delta E_1 = \frac{\Delta P_{\perp}^2}{2m_e} = \left(\frac{2Ze^2}{b\vartheta}\right)^2 \frac{1}{2m_e} = \frac{2Z^2e^4}{m_e\vartheta^2}\frac{1}{b^2}.$$

Shunday qilib, (6.1.6) ifoda zaryadli zarra trayektoriyasidan b masofada joylashgan atom elektronining olgan yoki zarraning elektronga bergan energiyasini ifodalaydi.

Zaryadli zarra muhitdan o‘tishda trayektoriyasidan b uzoqliqda db qalinlikda va *dx* uzunlikda joylashgan silindr ichidagi barcha elektronlar bilan ta’sirlashadi (



Ta'sirlashuvchi elektronlar soni: $Vn_e = 2\pi bdbdxn_e$, bu yerda $V = 2\pi bdbdx$ ko'rilayotgan silindr devorining hajmi, n_e – elektronlar konsentratsiyasi. Zarraning barcha elektronlar bilan ta'sirlashganda yo'qotgan energiyasi:

$$\Delta E = \Delta E_1 n_e V = \frac{4\pi n_e Z^2 e^4}{m_e \vartheta^2} \frac{db}{b} dx.$$

Uzunlik birligida yo‘qotgan zarraning solishtirma ionizatsiya energiyasi:

$$\left(\frac{dE}{dx}\right)_{ion}=\frac{4\pi n_e Z^2 e^4}{m\vartheta^2}\frac{db}{b}.$$

Zaryadli zarralar muhitdan o'tganda energiyalarini muhitni ionizatsiyalashdan tashqari radiatsion nurlashga ham sarflaydi.

Zaryadli zarralar muhit orqali o'tganda atom yadrosi va elektronlar maydonida tormozlanish natijasida radiatsion yoki tormozlanish nurlanish deb ataluvchi nurlanish hosil qiladi va o'z energiyasini shu nurlanishga yo'qota boradi.

Radiatsion nurlanish asosan yengil zarralarda kuchli bo'ladi. Chunki zarra qancha yengil bo'lsa, shuncha tez tormozlanadi. Haqiqatan, radiatsion nurlanishda zarraning yo'qotgan energiyasi, elektrodinamika qonuniga asosan, tormozlanayotgan zarraning tormozlanishda olgan tezlanishiga bog'liq. Elektrodinamika qonuniga ko'ra, muhitda α tezlanish bilan tormozlangan zarraning dt vaqt ichida radiatsion nurlash intensivligi

$$W = \frac{2}{3}\frac{Z^2e^2}{c^3}|a|^2,$$

bu yerda Ze – muhit zaryadi, α – zarraning tormozlanishda olgan tezlanishi. Ma'lumki, tezlanish

$$a = \frac{F}{m},$$

bunda F – zarraga ta'sir etuvchi kuch, m – zarra massasi.

ifodalardan bir xil zaryadli zarralar uchun radiatsion nurlash intensivligi zarra massasi kvadratiga teskari mutanosibligi kelib chiqadi:

$$\left(\frac{dE}{dx}\right)_{rad} \sim \frac{1}{m^2},$$

bundan radiatsion nurlash asosan yengil zarralarga xos ekanligi, haqiqatdan ham bir xil tormozlanuvchi muhitda protonning elektronga nisbatan radiatsion nurlanishi

$$\left(\frac{m_p}{m_e}\right)^2 = 1836^2 \approx 3,4 \cdot 10^6.$$

Zaryadli zarralarning ionizatsiya energiya yo'qotishi atom elektronlari bilan ta'sirlashuvga ko'ra, ro'y bersa, radiatsion nurlanish muhit yadrolari bilan ta'sirlashuvga ko'ra, bo'lishadi. Zarralarni tormozlovchi muhit yadrolarining kulon kuchi yadro zaryadi kvadrati Z^2 ga bog'liq.

G.Bete va V.Geytlerlar elektronlar turli energiya sohalari uchun radiatsion nurlash formulalarini ishlab chiqdilar.

Umuman, radiatsion nurlanish muhit atomlarining tartib nomeri Z^2 ga, atom va elektronlari konsentratsiyasi n_e ga va zarra (elektron) kinetik energiyasi T_e ga bog'liq ekan:

$$\left(-\frac{dE}{dx}\right)_{rad} \sim Z^2 n_e T_e .$$

Zaryadli zarralarning ionizatsiya energiya yo‘qotish formulasi elektron uchun $\left(-\frac{dE}{dx}\right)_{ion} \sim n_e Z^2 \frac{1}{\vartheta^2}$ bog‘lanishda bo‘lib, ionizatsiya energiya yo‘qotish zarra energiyasi ortishi bilan kamayib boradi. Radiatsion energiya yo‘qotish esa energiya ortishi bilan otrib boradi. Ma’lum bir energiyada ionizatson va radiatsion energiya yo‘qotishlar tenglashadi. Bu turli muhit uchun har xil bo‘lib,bunga **kritik energiya** deyiladi. Uni quyidagi tenglamadan aniqlash mumkin:

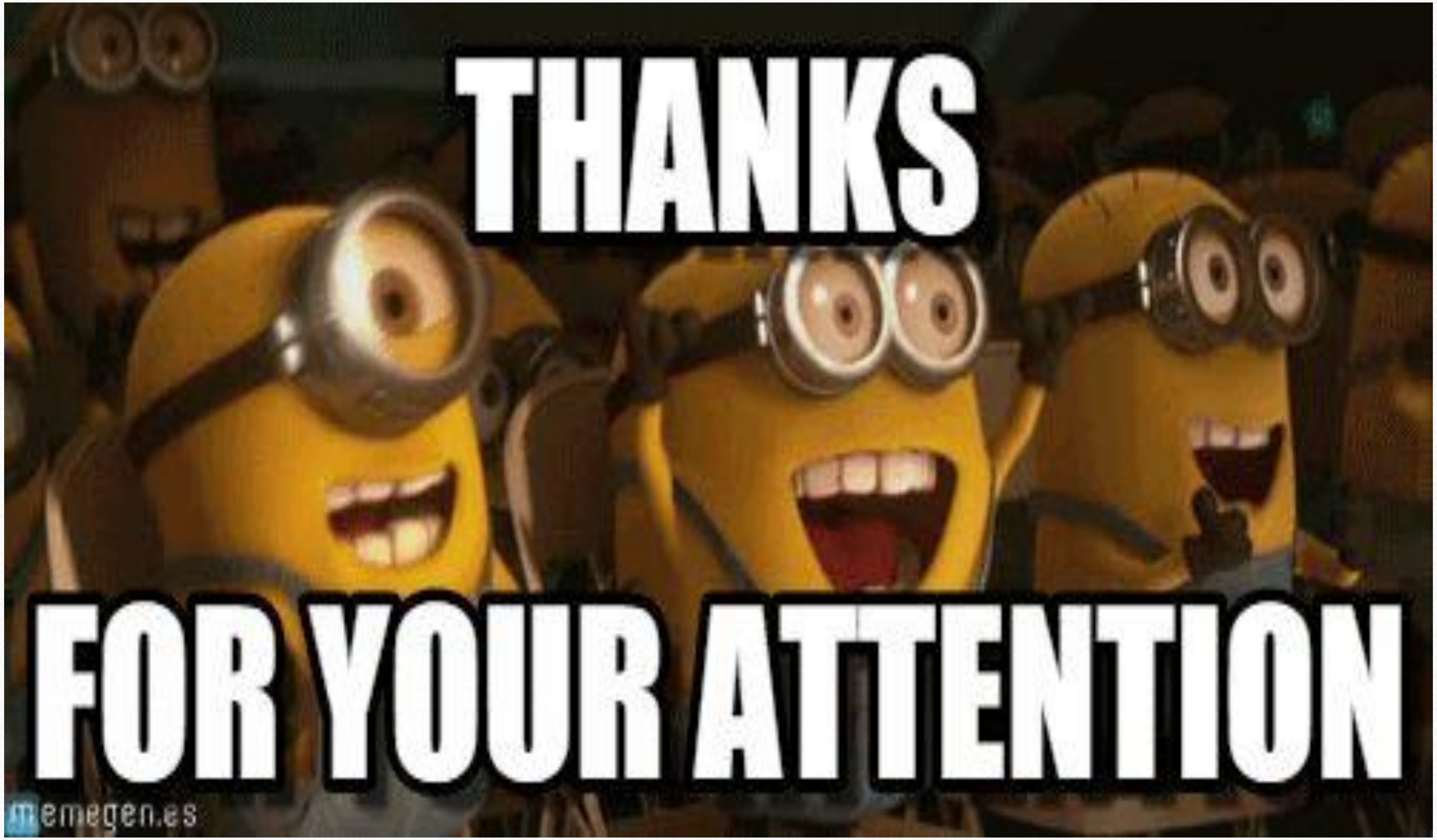
$$\left(\frac{dE}{dx}\right)_{rad} : \left(\frac{dE}{dx}\right)_{ion} \approx \frac{T_e Z}{800}$$

bu yerda T_e MeV larda olingan.

suvda ($\overline{Z} = 8$) energiyasi $T_e = 100\ MeV$ bo‘lgan elektronlar uchun $\left(\frac{dE}{dx}\right)_{ion} = \left(\frac{dE}{dx}\right)_{rad}$ bo‘ladi. Demak, suv uchun kritik energiya $T_{kr} = 100\ MeV$, qo‘rg‘oshin uchun Z = 82 va demak T_{kr} = 10 MeV. Elektronlar energiyasi kritik energiyadan yuqori bo‘lsa, energiya yo‘qotish asosan radiatsion yo‘qotishdan iborat bo‘lib,qoladi. Elektronning boshlang‘ich energiyasi E_0 bo‘lsa, radiatsion yo‘qotish natijasida energiyasi eksponensial qonun bo‘yicha o‘zgaradi:

$$\overline{E} = E_0 e^{-\frac{x}{x_0}}.$$

... dan $x = x_0$ masofada elektronning energiyasi *e* marta kamayadi. Bu $x = x_0$ turli muhitlar uchun har xil bo‘lib, **radiatsion uzunlik** deb ataladi.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