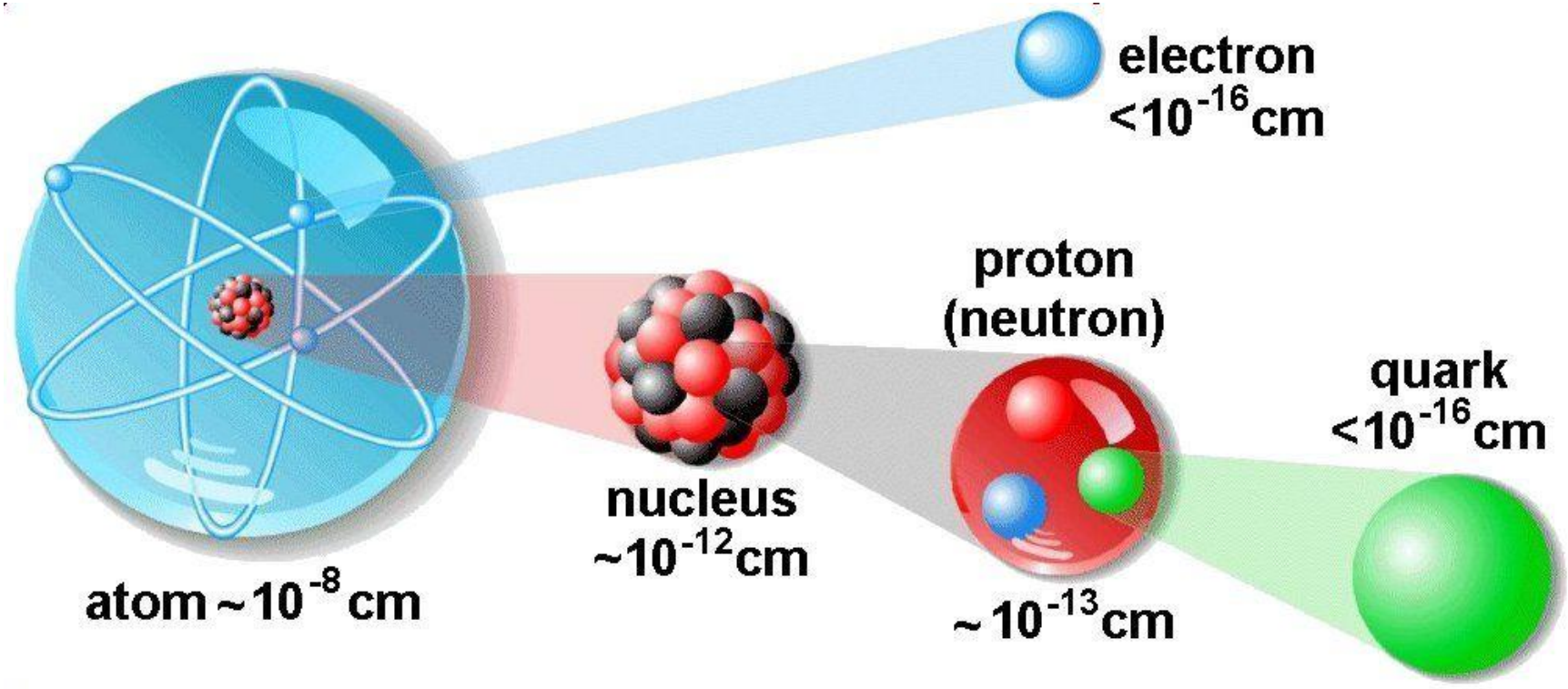
Neytronlarning modda bilan o’zaro ta’siri

Neytronning xossasi.

Neytronlar neytral zarralardir. Shuning uchun ular **to'g'ri chiziqlar** bo'ylab harakatlanadilar va faqat yadro bilan to'qnashganda yangi yo'nalishga tarqalish yoki so'riladilar. Yadroni o'rab turgan elektronlar (atom elektron buluti) ham, musbat zaryadlangan yadrodan kelib chiqadigan elektr maydoni ham neytronning parvoziga ta'sir qilmaydi. Qisqasi, neytronlar atomlar bilan emas, **yadrolar bilan to'qnashadi** .


electron
<10^-16 cm
proton
(neutron)
quark
<10^-16 cm
nucleus
~10^-12 cm
atom ~10^-8 cm
~10^-13 cm

Neytronlarning moddalar bilan o‘zaro ta’sir

Neytron yadro bilan to‘qnashganda uchta muhim o‘zaro ta’sir turlari kuzatiladi:

1.Neytronlarning elastik sochilishi

•2.Neytron1arning noelastik sochilishi

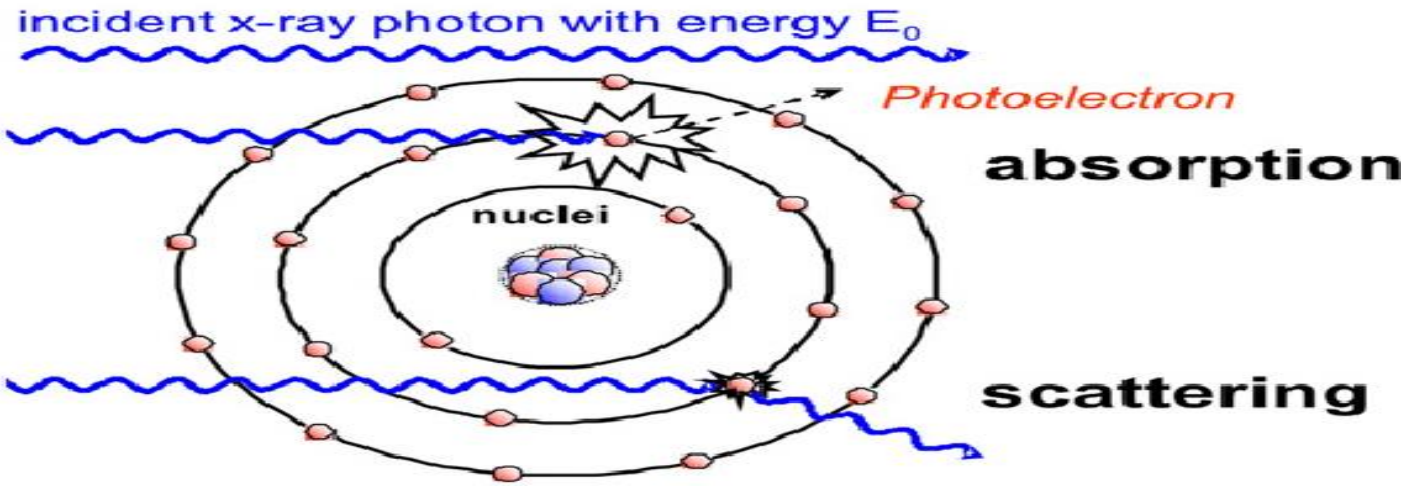
•3.Yadro reaksiyasi

•Yadro reaksiyasida ta’sirlashuvchi neytron nishon yadroda yutiladi va oraliq (kompound) yadro hosil bo‘ladi. Kompound yadro fotonlar (agar jarayon radiatsion qamrash bo‘lsa), protonlar, a-zarralar, ikki neytron va x.k.lar nurlaydi.

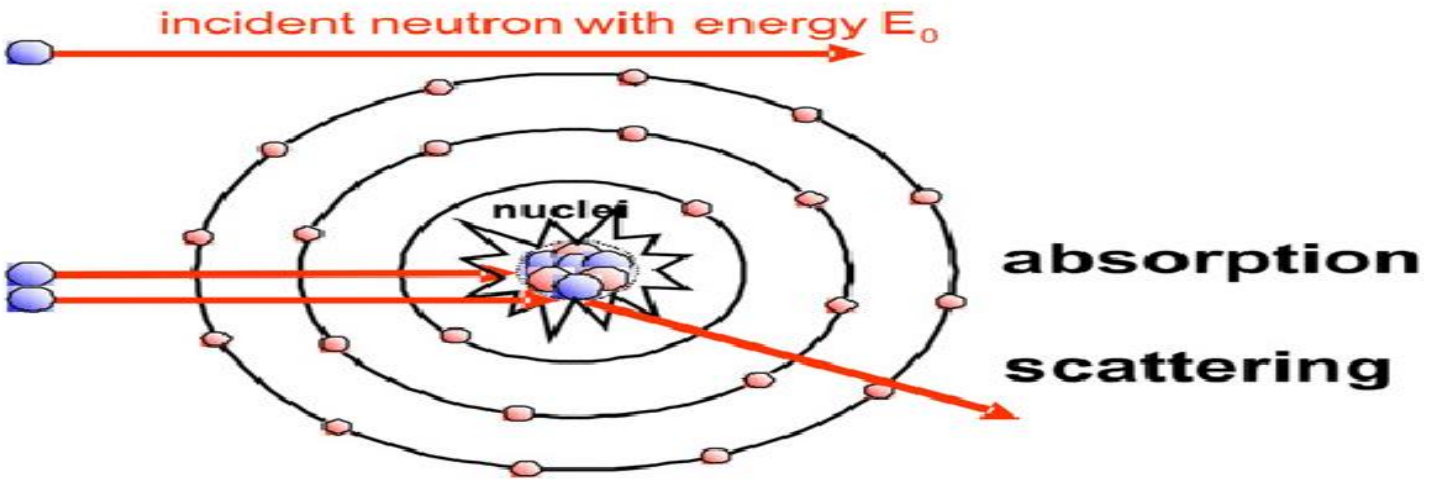
•Shuningdek, yadro bo‘linishi, yadro fragmentatsiyalanishi va yadro parchalanishi mumkin.

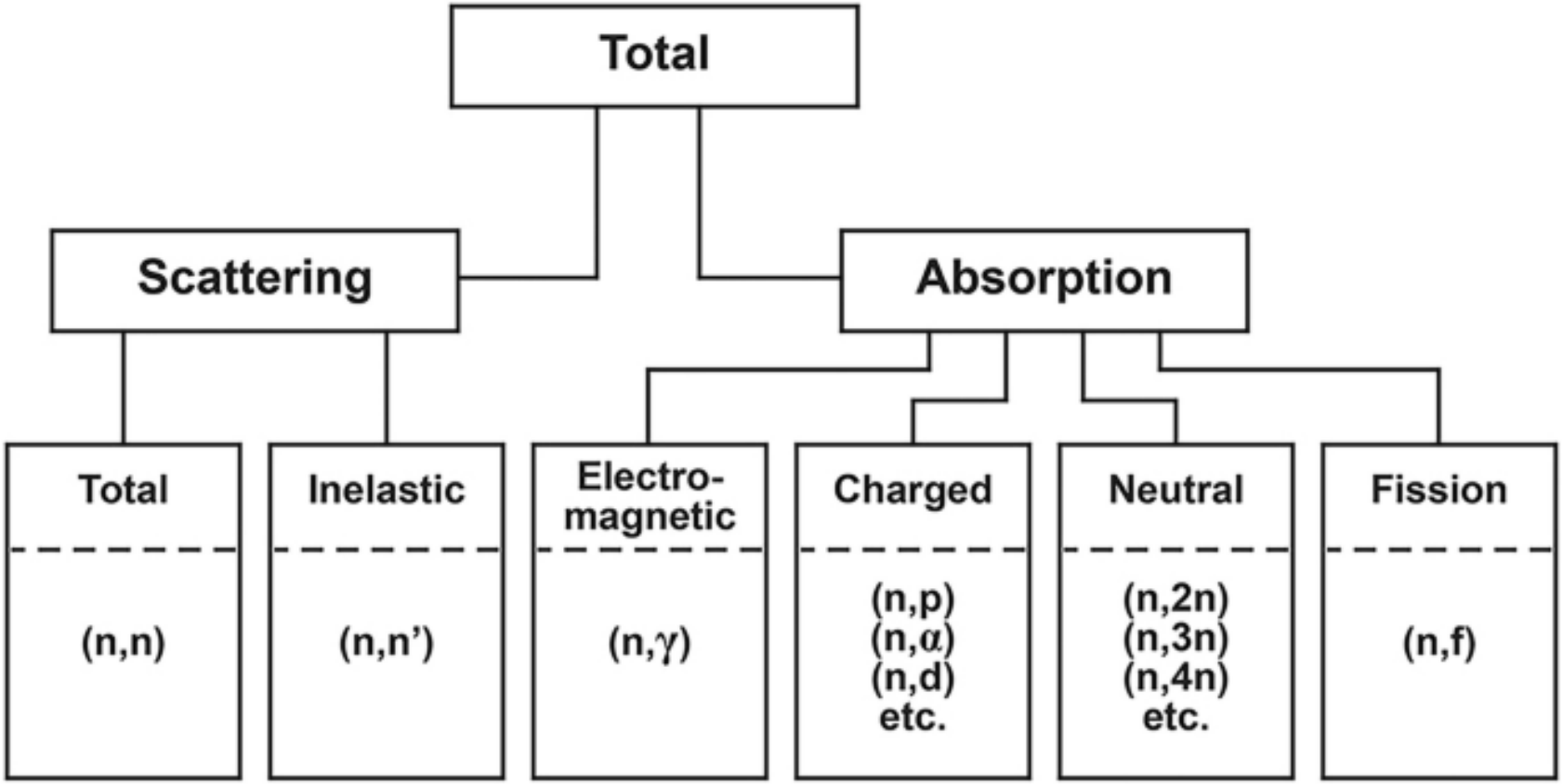
Neytronlarning moddalar bilan o‘zaro ta’siri reaksiyalari (n,p) , (n,a) , (n,y) ,(n,n) va (n,2n)

(a) x-rays



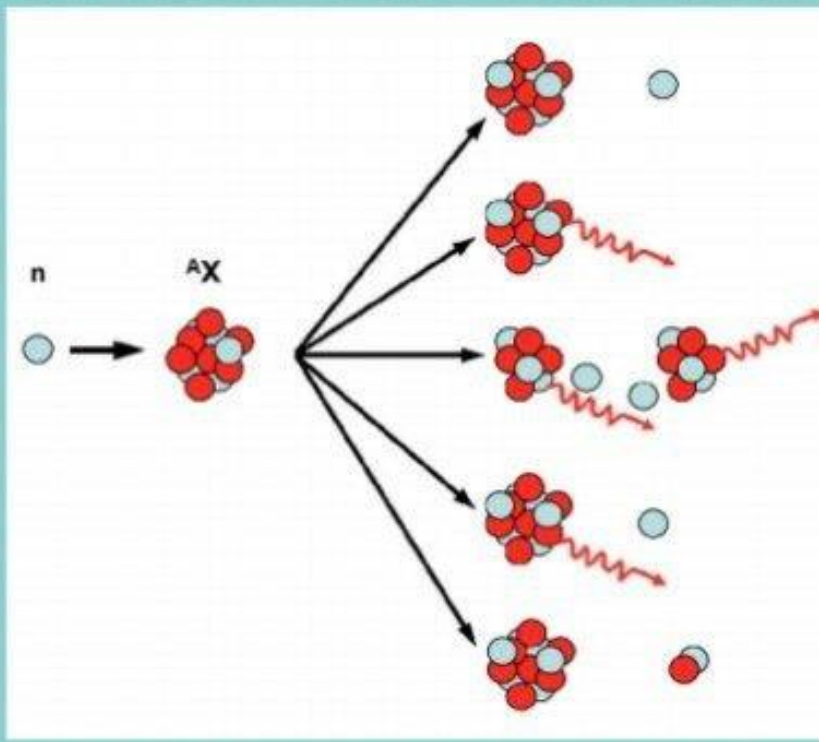
(b) neutrons




Total
Scattering
Absorption
Total
(n,n)
Inelastic
(n,n')
Electro-magnetic
(n,γ)
Charged
(n,p)
(n,α)
(n,d)
etc.
Neutral
(n,2n)
(n,3n)
(n,4n)
etc.
Fission
(n,f)

Reaction channels:

- elastic scattering: (n,n)
- inelastic scattering: (n,n')
- radiative capture: (n,γ)
- multiplication: (n,xn)
- charged particle production: (n,p), (n,α), …
- fission: (n,xn^{A1}Z1^{A2}Z2)
- …



All of these are used for neutron detection

Neytronlarning moddalar orqali o'tishi

Neytronlarning moddalar orqali o'tishi moddaning turli xususiyatlariga, ayniqsa uning zichligi va atom tuzilmasiga bog'liq. Neytronlar zaryadsiz bo'lgani uchun, ular moddaning elektron bulutiga ta'sir qilmaydi, lekin ular atom yadrolari bilan o'zaro ta'sir qilishlari mumkin. Neytronlarning moddalar orqali o'tishi jarayonida bir necha muhim omillar mavjud:

1. Neytronlarning modda bilan o'zaro ta'siri: Neytronlar modda orqali o'tganda, ular atom yadrolari bilan o'zaro ta'sir qilishlari mumkin. Bularning bir nechtasi quyidagilardir:

- Neytronlarni tutib olish: Ba'zi elementlar neytronlarni o'ziga tutib olish xususiyatiga ega. Masalan, bor, cadmium, va geksaflorid kabi elementlar neytronlarni o'z ichiga olishi mumkin. Neytronlar atom yadrosiga kirib, uni "qo'lga olish" jarayoni moddaning xususiyatlarini o'zgartirishi mumkin.

- Neytronlarning elastik tarqalishi: Neytronlar moddada, ayniqsa o'rtacha yoki yuqori energiyali neytronlar, atom yadrolaridan qaytishi yoki elastik tarzda tarqalishi mumkin. Bu jarayon neytronlarning energiyasi o'zgarmasdan qolganida sodir bo'ladi.
- Neytronlarning noelastik sochilish jarayoni, ya’ni ***(n,ri)*** og‘ir yadrolarda neytronlar kinetik energiyasi Tn>0,6 MeV bo‘lganda, yengil yadrolarda esa T>1 MeV energiyalarda sodir boiadi. Neytronlarning noelastik sochilish kesimi atom raqamiga va neytronlar energiyasiga bog‘liq bo'ladi. Yengil yadrolardan og‘ir yadrolar sohasiga o‘tganda va neytronlar energiyasi oshganda reaksiya kesimi ham oshadi.

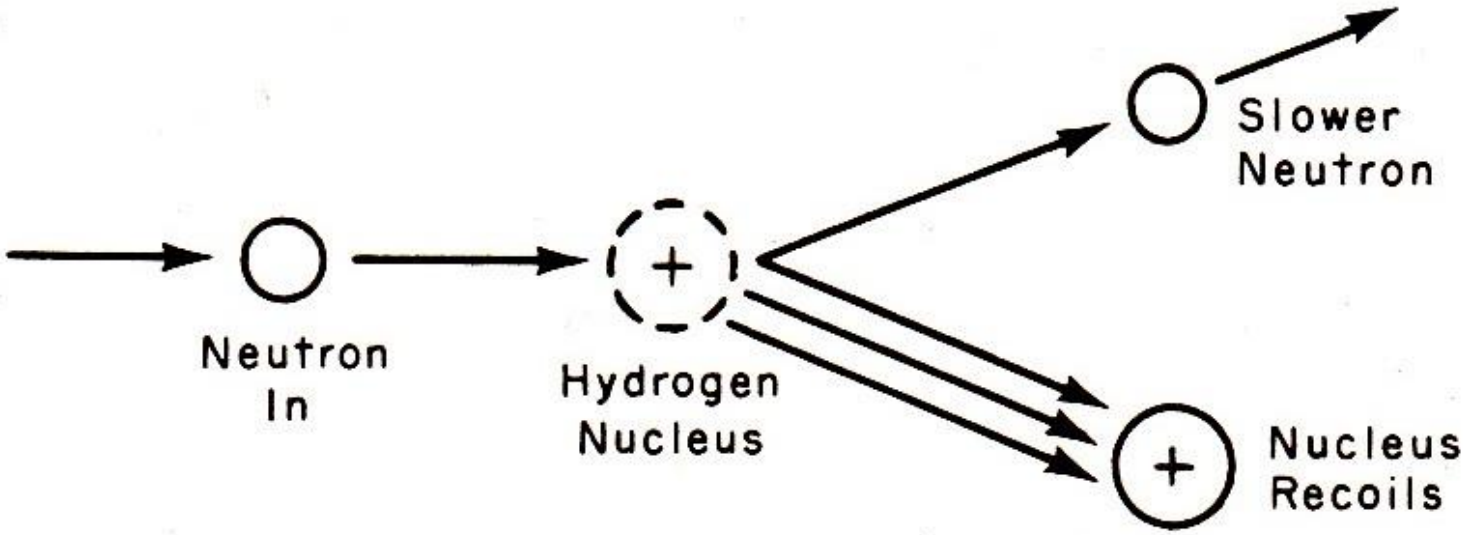


Fig. 6—Elastic scattering.

2. Neytronlarning energiyasiga bog'liq ta'sirlar: Turli energiyadagi neytronlar modda bilan turlicha ta'sir qiladi:

- Past energiyali neytronlar (termal neytronlar) odatda modda bilan juda ko'p o'zaro ta'sir qiladi va energiyasini yadro reaksiyalarida yo'qotadi. Ular kristall tuzilmasi yoki molekulalar bilan o'zaro ta'sir qilishda, masalan, neytron diffraksiyasi texnikasida qo'llaniladi.

- Yuqori energiyali neytronlar moddaning yuzasidan o'tishi mumkin, lekin ular atom yadrolari bilan juda kam ta'sir qiladi.

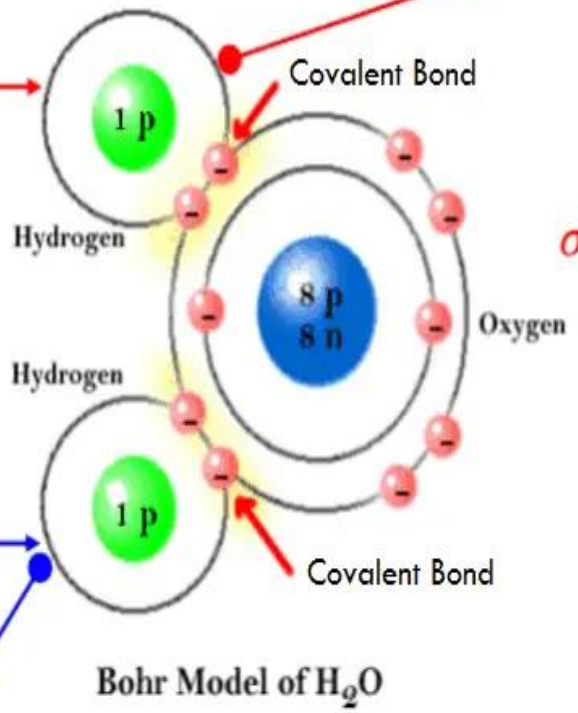
Fast neutron

Feels only H

$\tau_{coll} \sim 0$

$E_k \gg E_{chem}$

$\sigma_s(H_2O) = 2\sigma_s(H) + \sigma_s(O)$



Bohr Model of H_2O

Slow (thermal) neutron

Feels whole molecule

$\tau_{coll} \neq 0$

$E_k \sim E_{chem}$

3. Neytronlar va moddaning zichligi: Moddaning zichligi ham neytronlarning o'tishiga ta'sir qiladi. Yuqori zichlikdagi moddalar neytronlarni ko'proq tutib olishga moyil bo'ladi, chunki atom yadrolarining soni ko'proq va neytronlarning o'zaro ta'sir qilishi ehtimoli yuqori.

4. Neytronlarning o'tish tezligi: Neytronlar moddaning turli qatlamlaridan o'tayotganda tezligi o'zgarishi mumkin. Neytronlar modda orqali o'tayotganida energiyalarini yo'qotishi yoki tutib olinishi mumkin, bu ularning o'tish tezligini o'zgartiradi.

Neytronni aniqlash uchun ishlatiladigan umumiy reaksiyalar

Elastik sochilish :

- n + 1H= n + 1H
- n + 2H = n + 2H (abund.=0.015%)

Zaryadlangan zarracha:

- n + 3He = 3H + 1H + 0.764 MeV (abund.=0.00014%)
- n + 6Li = 4He + 3H + 4.79 MeV (abund.=7.5%)
- n + 10B = 7Li* + 4He=7Li + 4He + 0.48 MeV γ +2.3 MeV

(abund.=19.9%,
b.r.=93%)

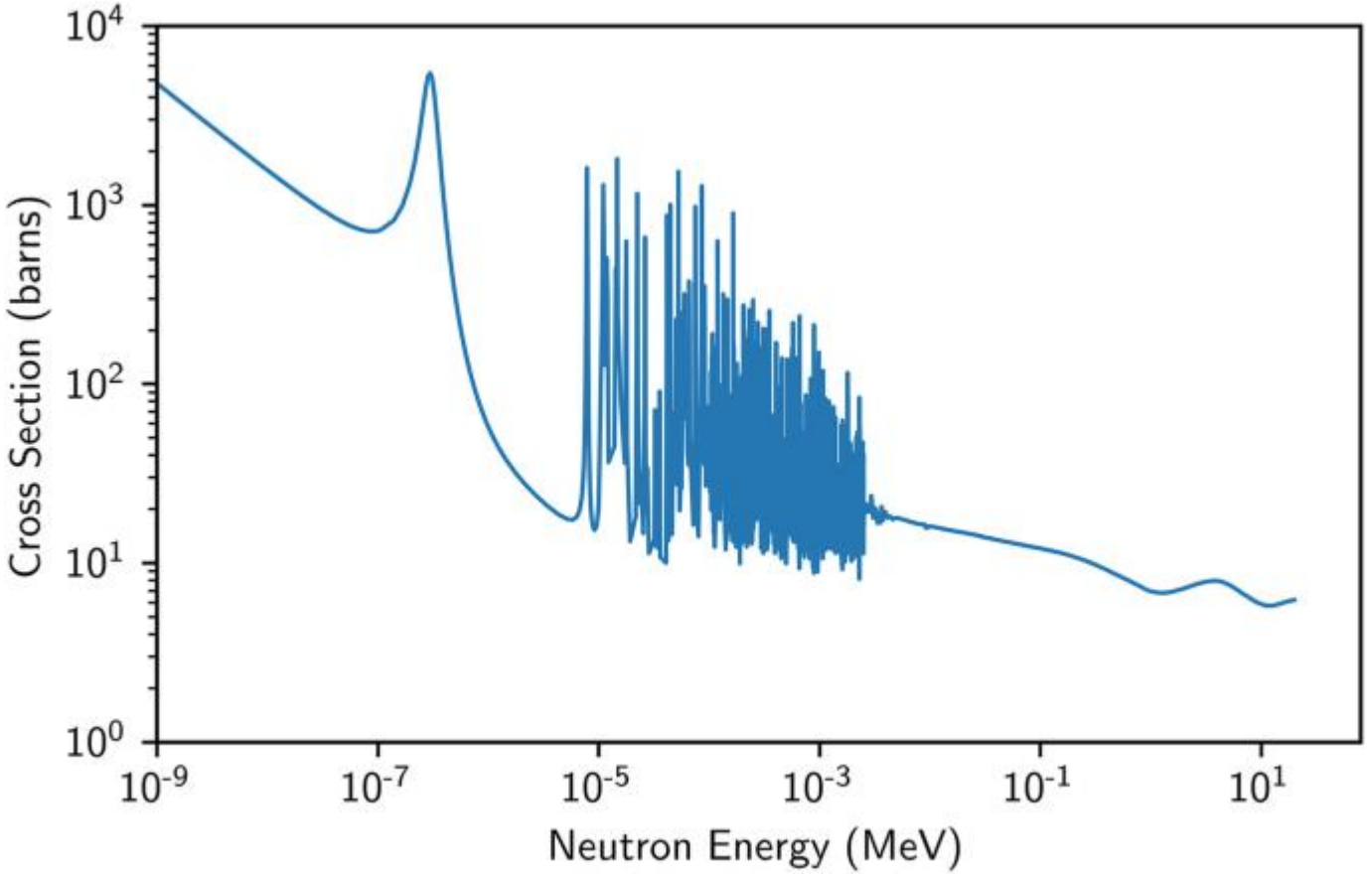
radiatsion suratga olish:

- n + 155Gd =156Gd* = γ-ray + CE spectrum (abund.=14.8%)
- n + 157Gd =158Gd* = γ-ray + CE spectrum (abund.=15.7%)

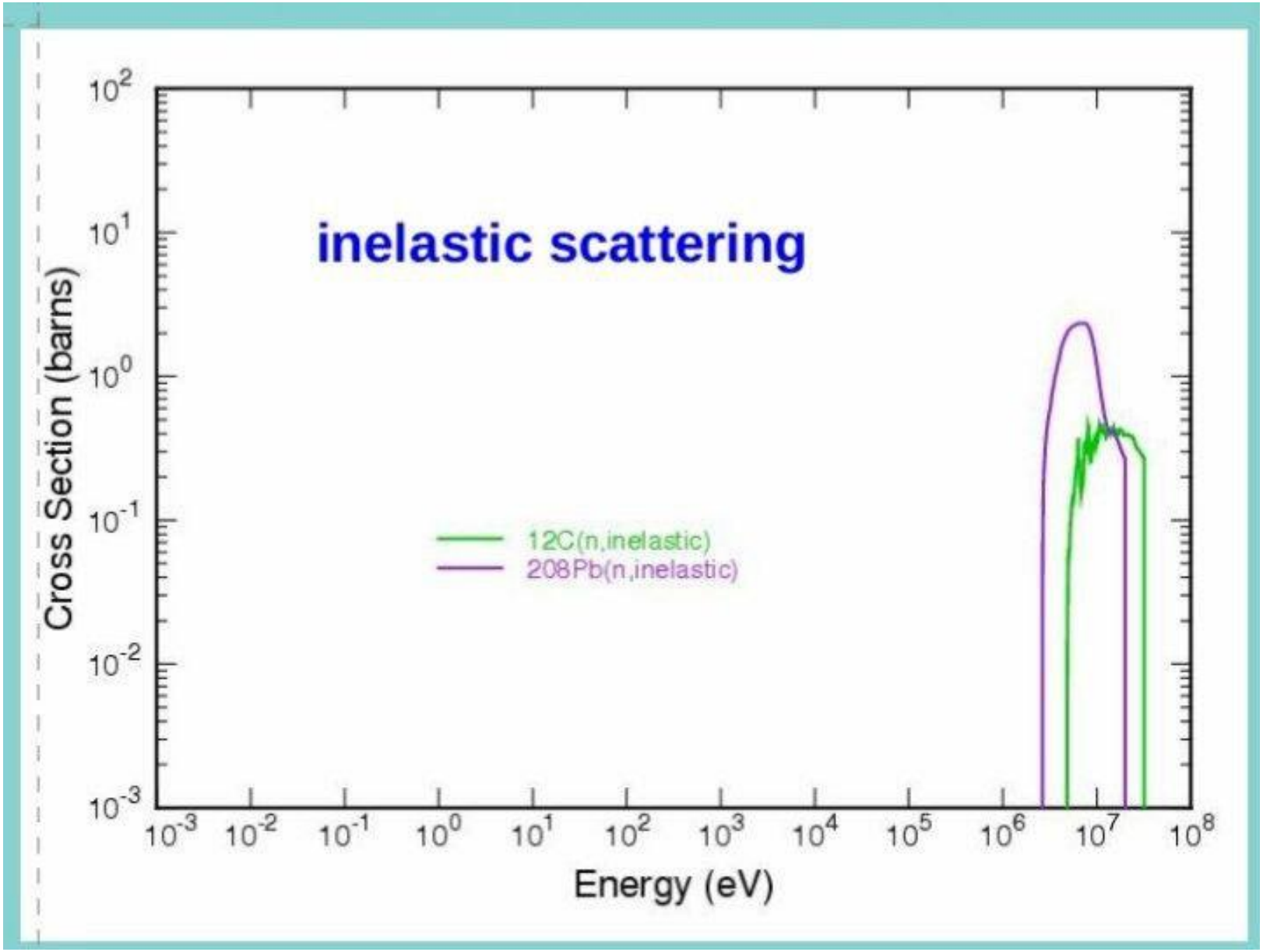
bo'linish:

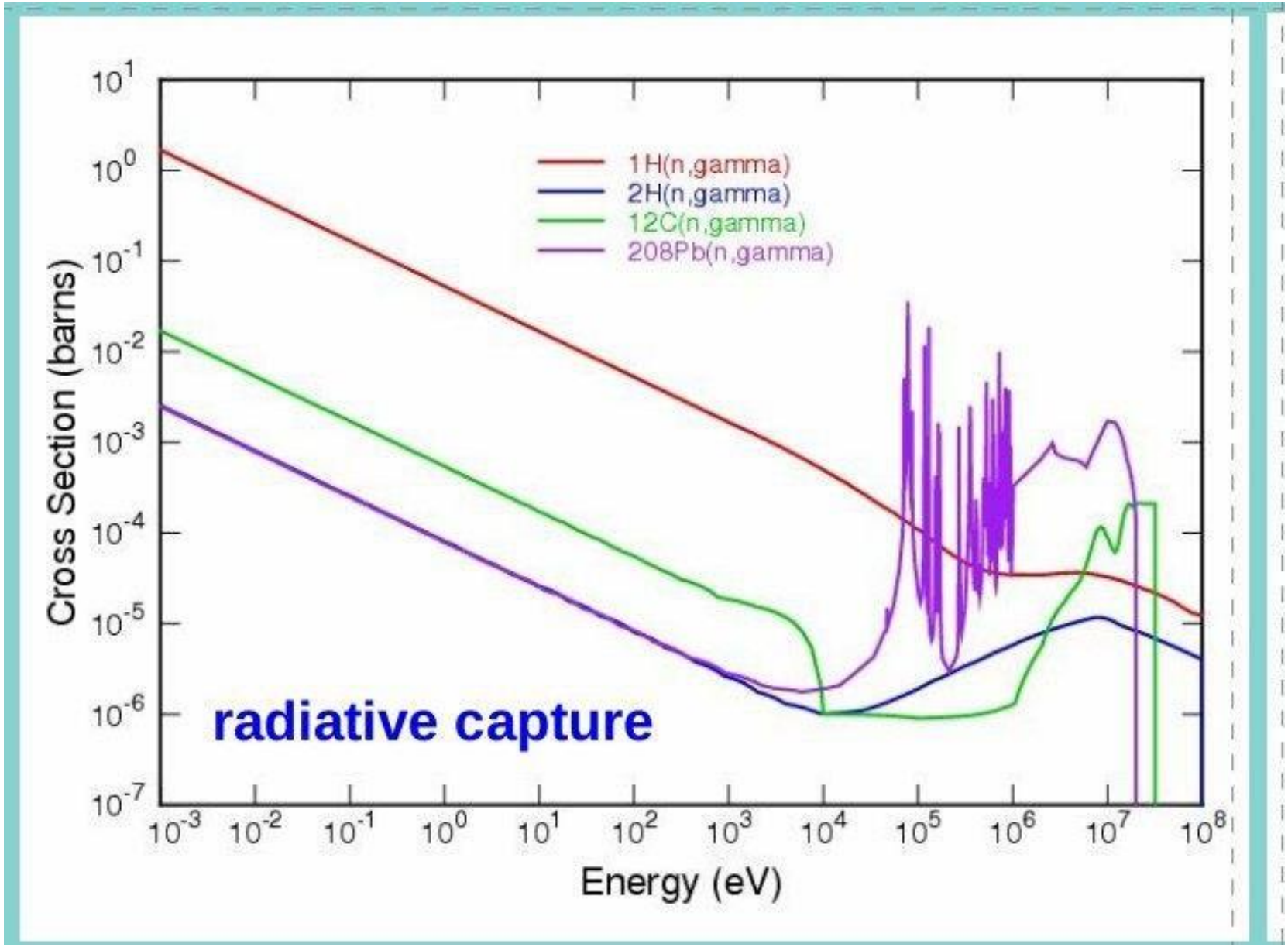
- n + 235U - fission fragments + ~160 MeV
- n + 239Pu -fission fragments + ~160 MeV
- n + 238U - fission fragments + ~160 MeV

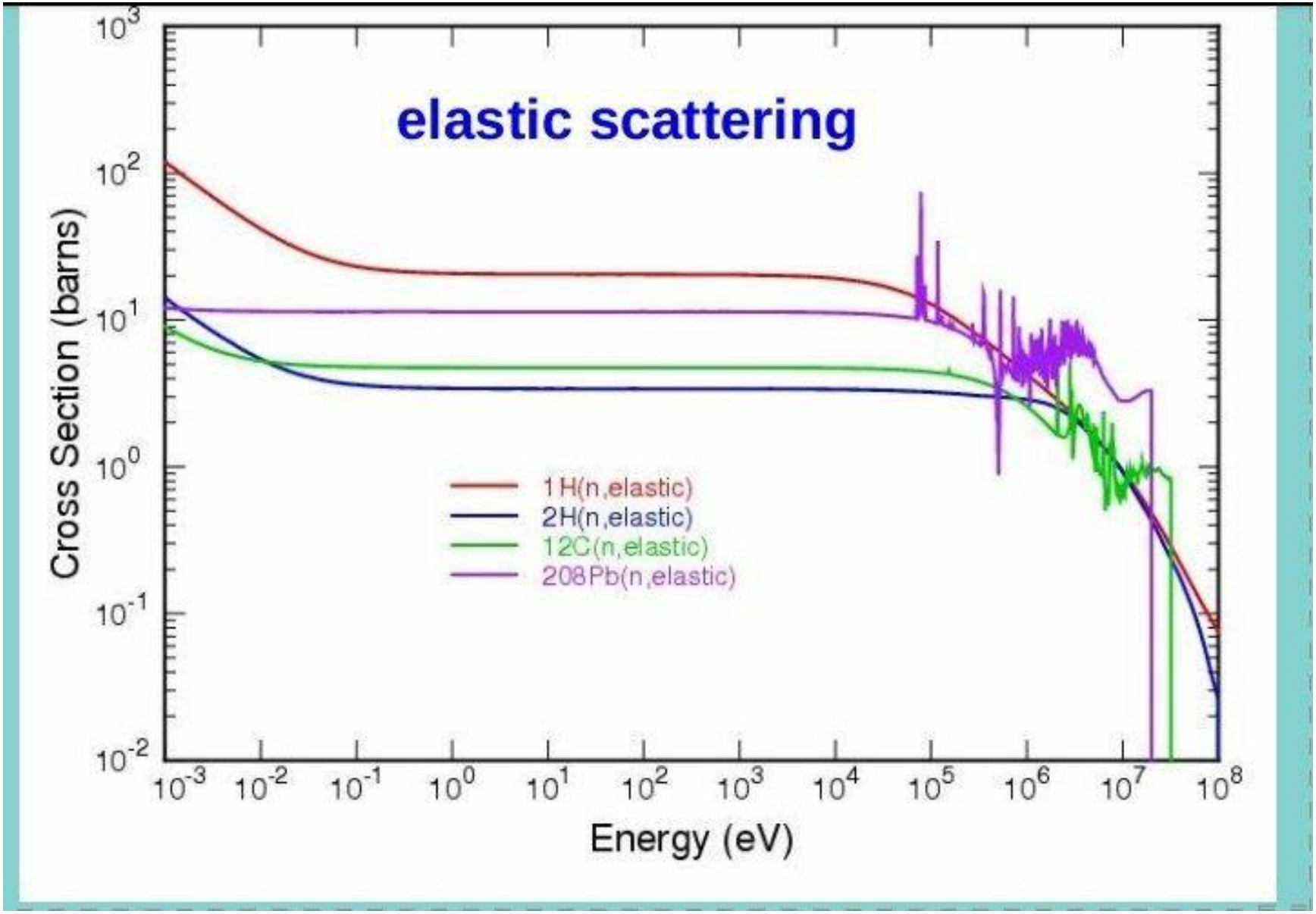
Neytronlarning yadrolar bilan o'zaro ta'sir qilish darajasi ko'ndalang kesimlar deb nomlanuvchi miqdorlarda tavsiflanadi . **Kesmalar tushayotgan neytron** va **maqsadli yadro** o'rtasidagi muayyan o'zaro ta'sir qilish **ehtimolini** ifodalash uchun ishlatiladi . Neytronning tezligi (kinetik energiya) kamayishi bilan termal neytronlar uchun (**1/v mintaqada**) yutilish kesmalari ortadi . Shuning uchun **1/v qonuni,** agar neytron atrofdagi muhit bilan

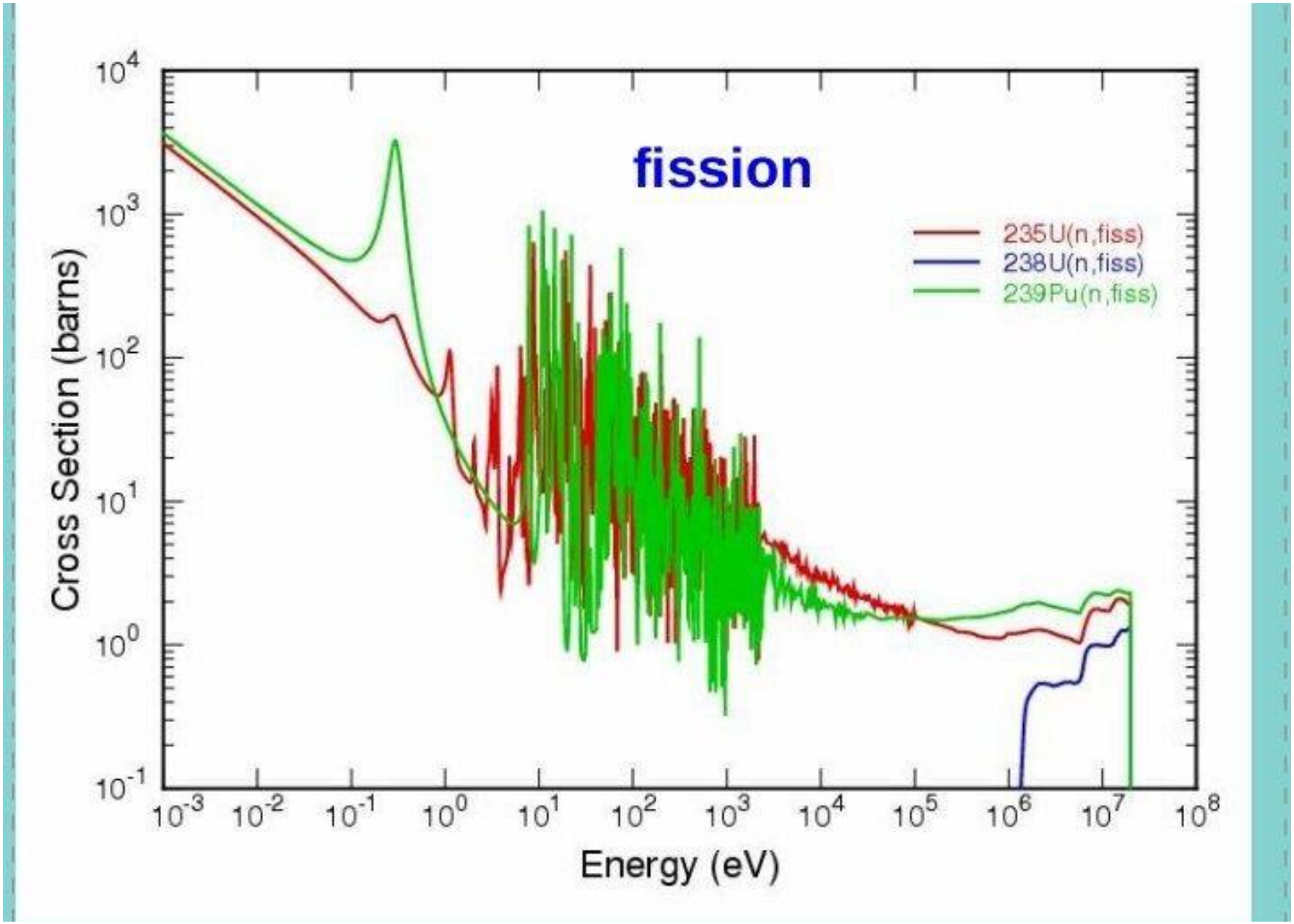


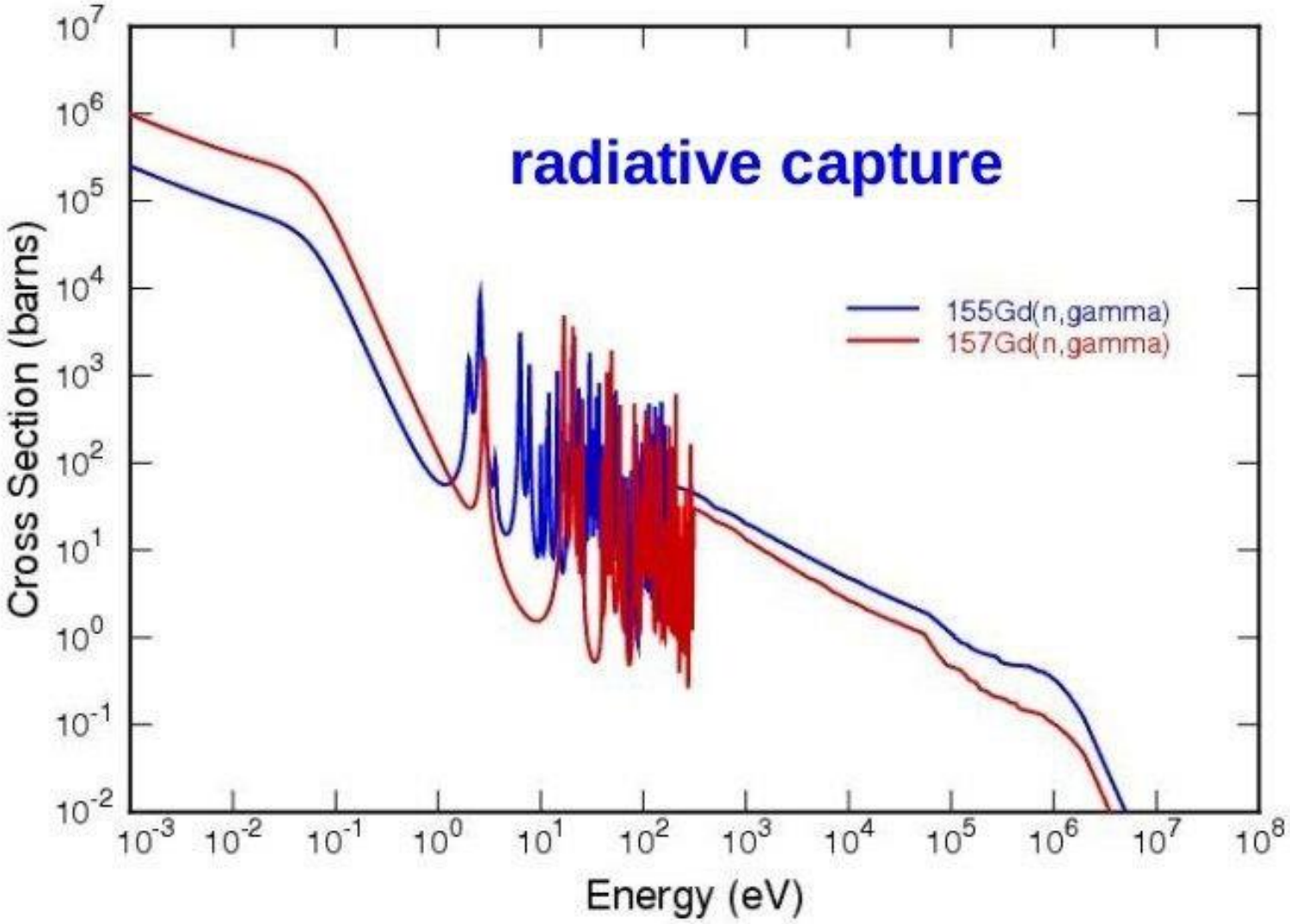
0,001 eV dan 10 MeV gacha energiyaga tushadigan neytronlar uchun ^{239} Pu uchun umumiy kesma tasvirlangan . Umumiy qoidaga ko'ra, energiya ortishi bilan kesma kamayadi. Past energiyalarda (1 MeV dan past) elastik kesma deyarli doimiy, elastik bo'lmagan sochiluvchi va yutilish kesimlari neytron tezligining o'zaro nisbatiga proportsionaldir (ya'ni, 1/v). Shunday qilib, past energiyalarda umumiy kesma deyarli doimiy bo'lishi yoki qaysi turdagi hodisa hukmron bo'lishiga qarab energiya bilan kamayishi mumkin.

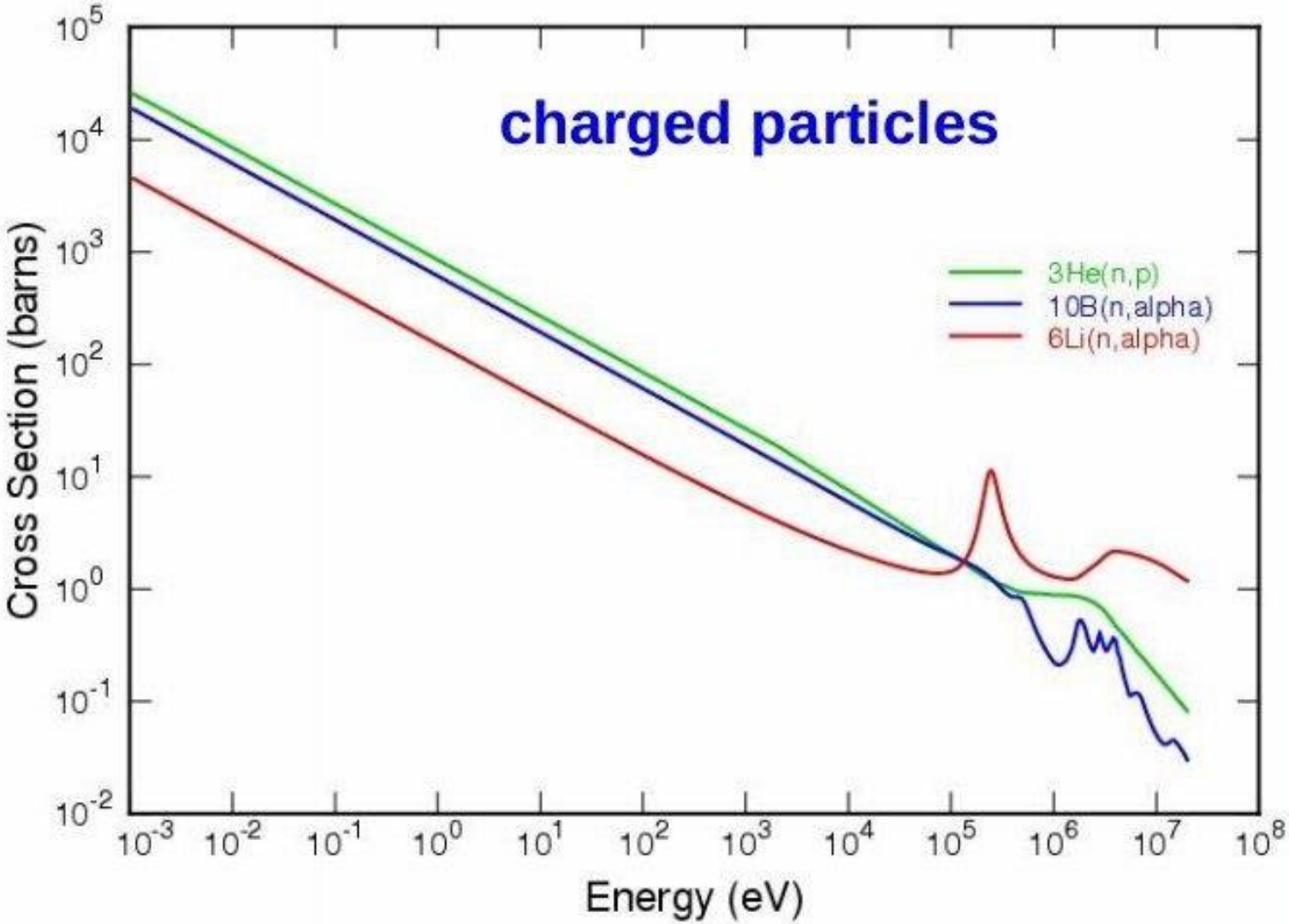

inelastic scattering
Cross Section (barns)
Energy (eV)
12C(n,inelastic)
208Pb(n,inelastic)
10^2
10^1
10^0
10^-1
10^-2
10^-3
10^-3 10^-2 10^-1 10^0 10^1 10^2 10^3 10^4 10^5 10^6 10^7 10^8

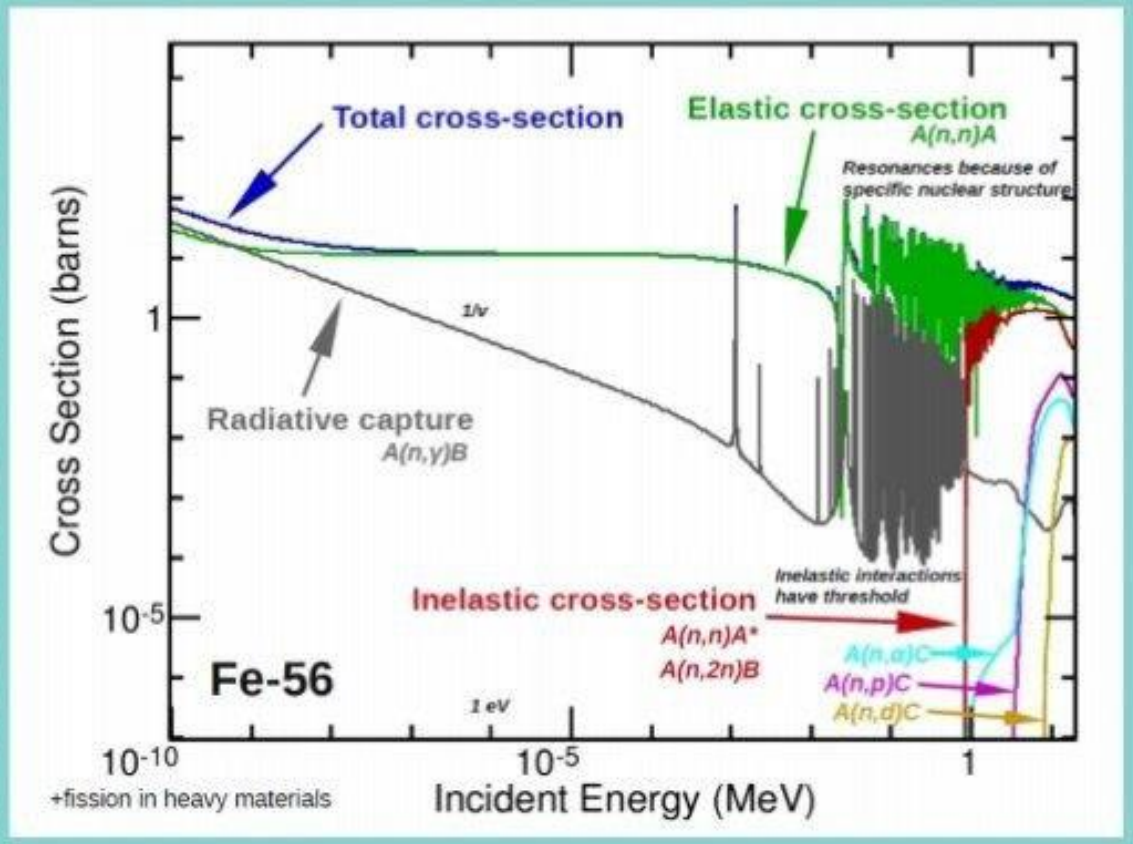

1H(n,gamma)
2H(n,gamma)
12C(n,gamma)
208Pb(n,gamma)
radiative capture
Cross Section (barns)
Energy (eV)
10^1
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
10^-3
10^-2
10^-1
10^0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8


elastic scattering
Cross Section (barns)
Energy (eV)
1H(n,elastic)
2H(n,elastic)
12C(n,elastic)
208Pb(n,elastic)
10^3
10^2
10^1
10^0
10^-1
10^-2
10^-3
10^-2
10^-1
10^0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8


fission
235U(n,fiss)
238U(n,fiss)
239Pu(n,fiss)
Cross Section (barns)
Energy (eV)
10^4
10^3
10^2
10^1
10^0
10^-1
10^-3
10^-2
10^-1
10^0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8


radiative capture
155Gd(n,gamma)
157Gd(n,gamma)
Cross Section (barns)
Energy (eV)
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4} 10^{5} 10^{6} 10^{7} 10^{8}


charged particles
3He(n,p)
10B(n,alpha)
6Li(n,alpha)
Cross Section (barns)
Energy (eV)
10^5
10^4
10^3
10^2
10^1
10^0
10^-1
10^-2
10^-3
10^-2
10^-1
10^0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8



$$\sigma_{tot} = \sigma_{n,n} + \sigma_{n,\gamma} + \sigma_{n,n'} + \sigma_{n,\alpha} + \sigma_{n,p} + \ldots$$

Elastic scattering and radiative capture channels are always open

E’tiboringz uchun raxmat!