NEYTRONLARNING MODDA BILAN TA'SIRI

FOR: RADIATION PHYSICS

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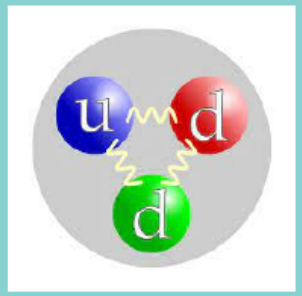
The neutron

M= 1
Q= 0

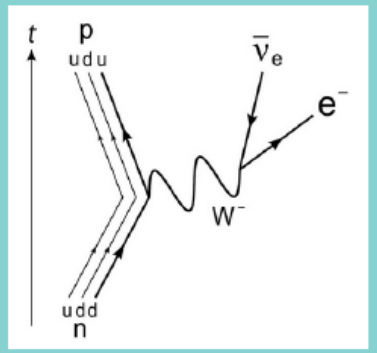
n $I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$

Mass $m = 1.0086649160 \pm 0.0000000005$ u
Mass $m = 939.5654205 \pm 0.0000005$ MeV [a]
$(m_n - m_{\bar{n}})/\ m_n = (9 \pm 6) \times 10^{-5}$
$m_n - m_p = 1.2933324 \pm 0.0000005$ MeV
$= 0.00138844919(45)$ u
Mean life $\tau = 878.4 \pm 0.5$ s (S = 1.8)
$c\tau = 2.6335 \times 10^8$ km
Magnetic moment $\mu = -1.9130427 \pm 0.0000005\ \mu_N$
Electric dipole moment $d < 0.18 \times 10^{-25}\ e$cm, CL = 90%
Mean-square charge radius $\langle r_n^2 \rangle = -0.1155 \pm 0.0017$ fm^2
Magnetic radius $\sqrt{\langle r_M^2 \rangle} = 0.864^{+0.009}_{-0.008}$ fm
Electric polarizability $\alpha = (11.8 \pm 1.1) \times 10^{-4}$ fm^3
Magnetic polarizability $\beta = (3.7 \pm 1.2) \times 10^{-4}$ fm^3
Charge $q = (-0.2 \pm 0.8) \times 10^{-21}\ e$
Mean $n\bar{n}$-oscillation time $> 8.6 \times 10^7$ s, CL = 90% (free n)
Mean $n\bar{n}$-oscillation time $> 4.7 \times 10^8$ s, CL = 90% [g] (bound n)
Mean nn'-oscillation time > 448 s, CL = 90% [h]



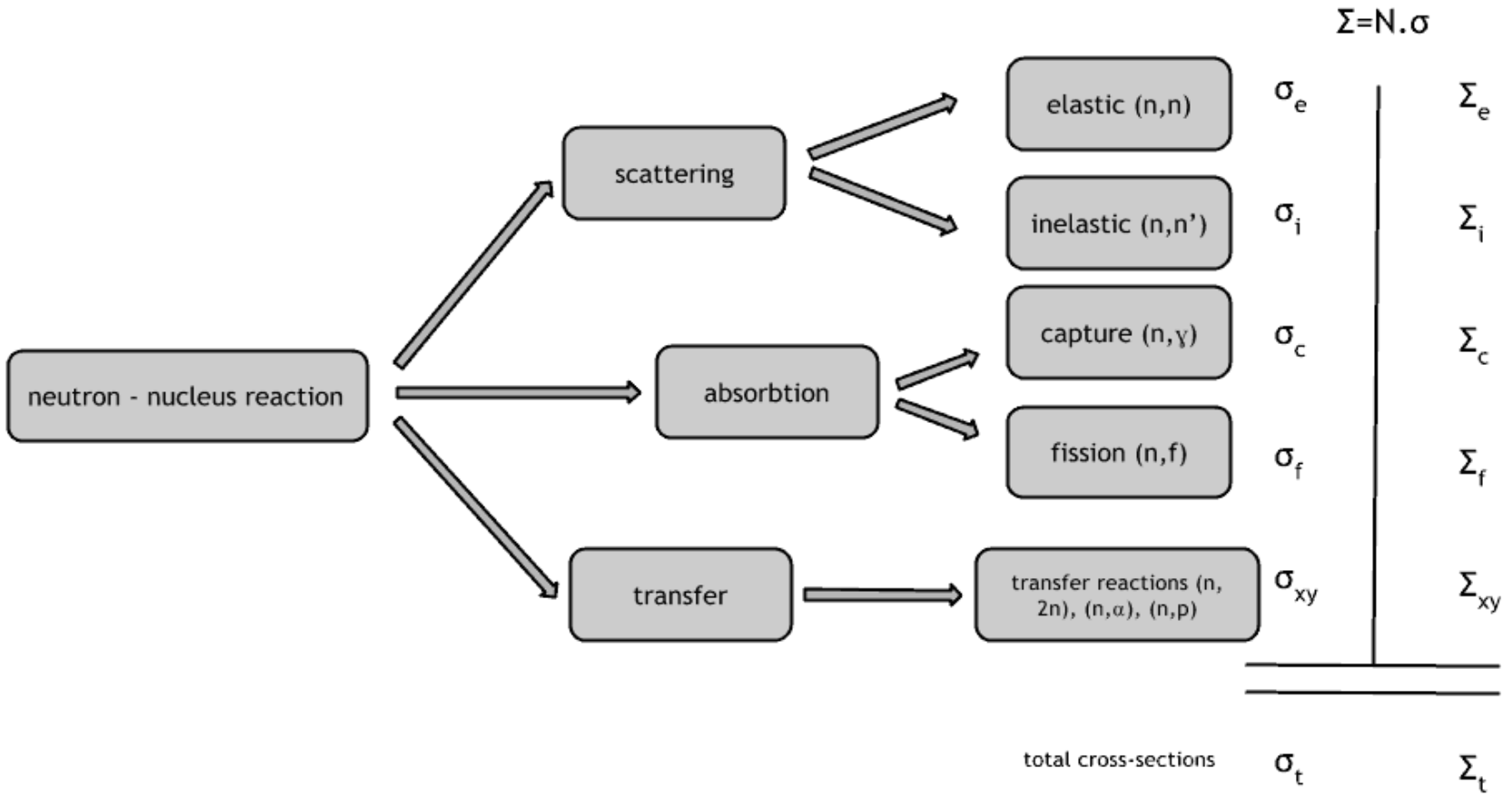
$T_{1/2}$= 10.14 min

$n \rightarrow p + e + \bar{\nu}_e$
(udd) (udu)



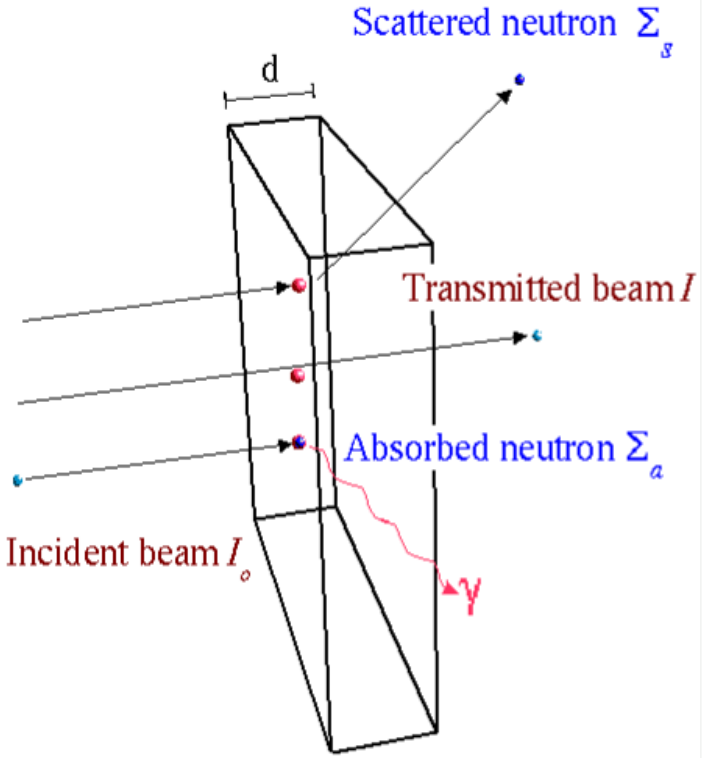
NEYTRONLAR KLASSIFIKATSIYA

1) High Energy neutrons:	$E_n > 100$ MeV
2) Fast Neutrons:	100 keV $< E_n < 10$ MeV
3) Epithermal Neutrons:	0.1 eV $< E_n < 100$ keV
4) Thermal/Slow Neutron:	$E_n = 1/40$ eV
5) Cold/Ultracold Neutrons:	$E_n <$ meV ... μeV

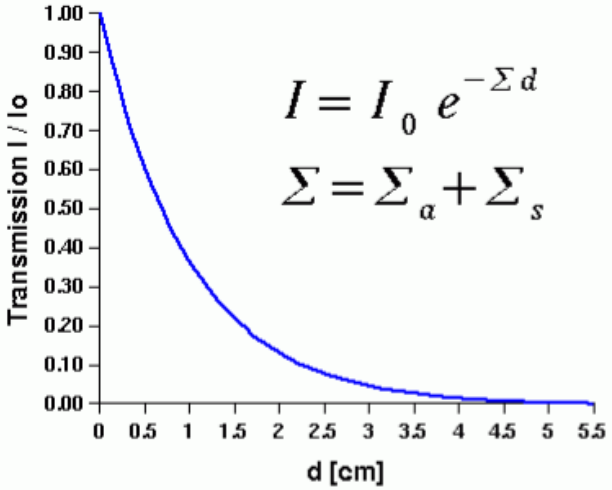

Σ=N.σ
neutron - nucleus reaction
scattering
absorbtion
transfer
elastic (n,n)
inelastic (n,n')
capture (n,γ)
fission (n,f)
transfer reactions (n, 2n), (n,α), (n,p)
σe
σi
σc
σf
σxy
σt
Σe
Σi
Σc
Σf
Σxy
Σt
total cross-sections

Narrow Beam Attenuation

$$I = I_o e^{-\Sigma d}$$



Exponential Attenuation Law



$$I = I_0 \, e^{-\Sigma d}$$

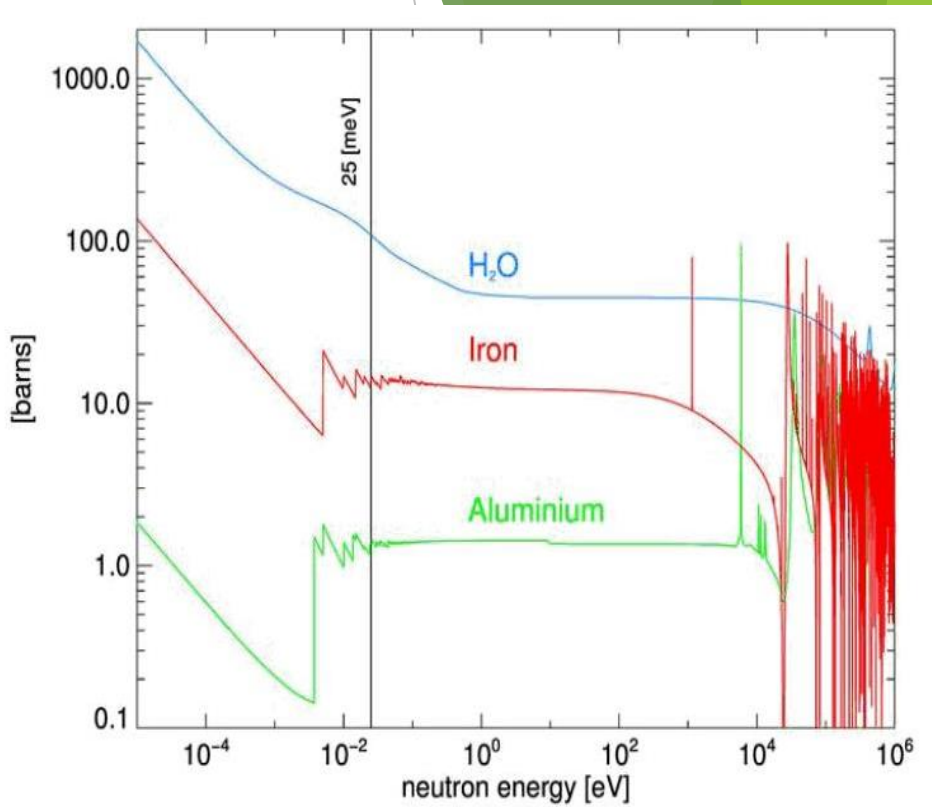
$$\Sigma = \Sigma_a + \Sigma_s$$

Macroscopic Cross Section Σ

$$\Sigma = N\sigma \quad [cm^{-1}]$$

$$N = \frac{\rho}{A} N_A \quad [cm^{-3}]$$

N := number density $[cm^{-3}]$
ρ := material density $[g\,cm^{-3}]$
A := atomic weight $[g\,mol^{-1}]$
N_A := Avogadro number $6.022\,10^{23}\,[mol^{-1}]$



Thermal neutron cross section at 0.025 eV			
Material	ρ	σ [barns]	Σ [1/cm]
Water	1	112	3.74
Iron	7.9	14	1.18
Aluminium	2.7	1.7	0.1

Common reactions used for neutron detection at low (and high) energies:

Elastic scattering:

- $n + {}^{1}H \rightarrow n + {}^{1}H$
- $n + {}^{2}H \rightarrow n + {}^{2}H$ (abund.=0.015%)

Charged particle:

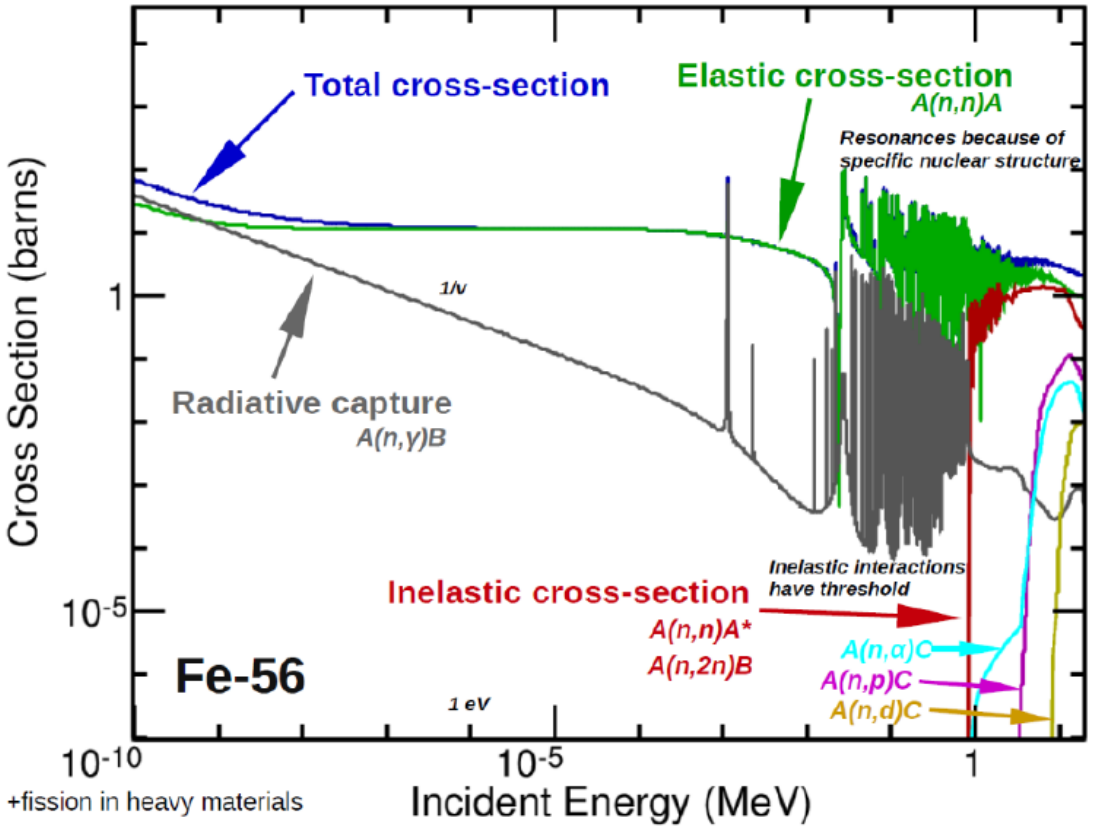
- $n + {}^{3}He \rightarrow {}^{3}H + {}^{1}H + 0.764$ MeV (abund.=0.00014%)
- $n + {}^{6}Li \rightarrow {}^{4}He + {}^{3}H + 4.79$ MeV (abund.=7.5%)
- $n + {}^{10}B \rightarrow {}^{7}Li^{*} + {}^{4}He \rightarrow {}^{7}Li + {}^{4}He + 0.48$ MeV γ +2.3 MeV (abund.=19.9%, b.r.=93%)

Radiative capture:

- $n + {}^{155}Gd \rightarrow {}^{156}Gd^{*} \rightarrow \gamma$-ray + CE spectrum (abund.=14.8%)
- $n + {}^{157}Gd \rightarrow {}^{158}Gd^{*} \rightarrow \gamma$-ray + CE spectrum (abund.=15.7%)

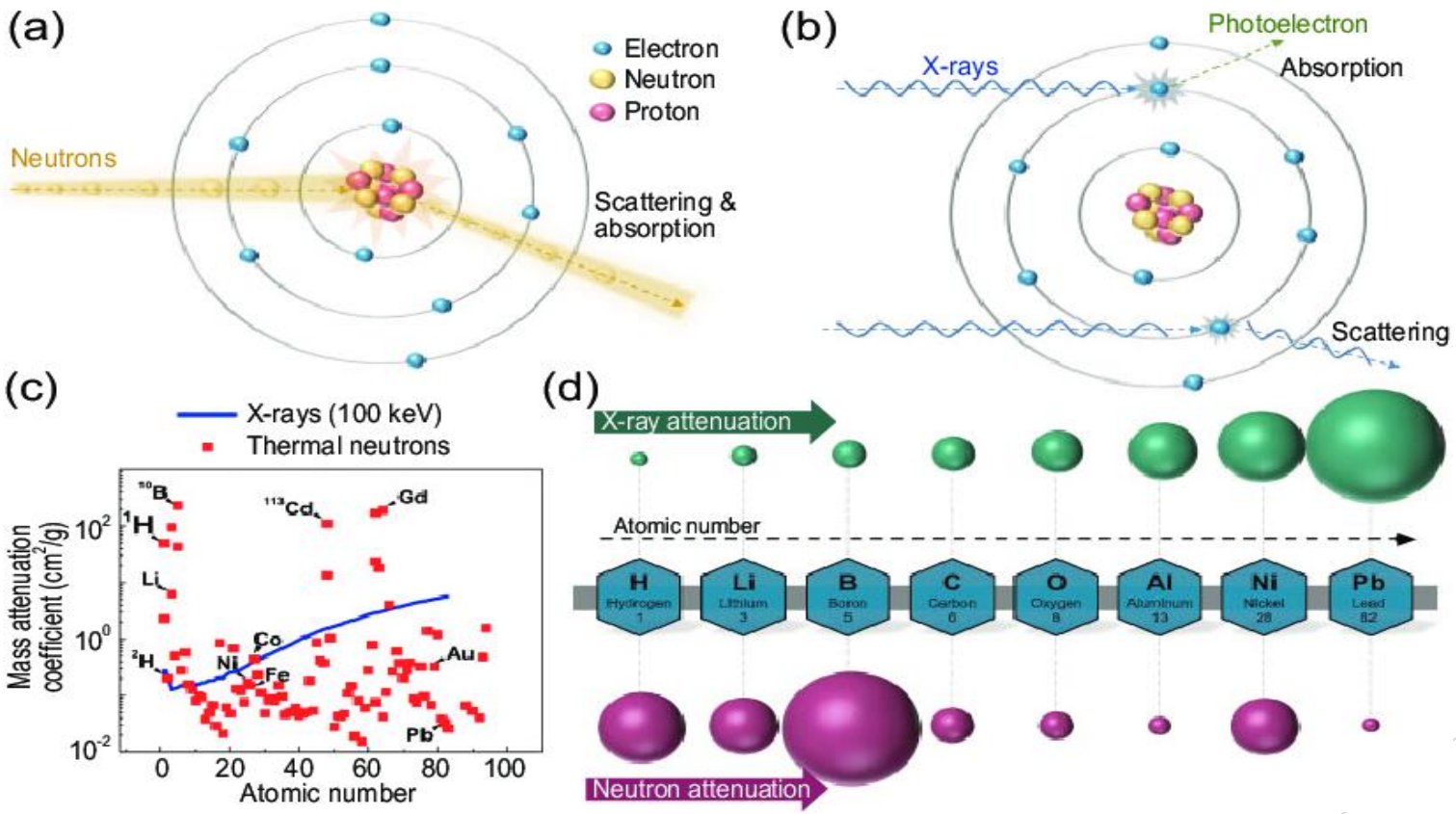
Fission:

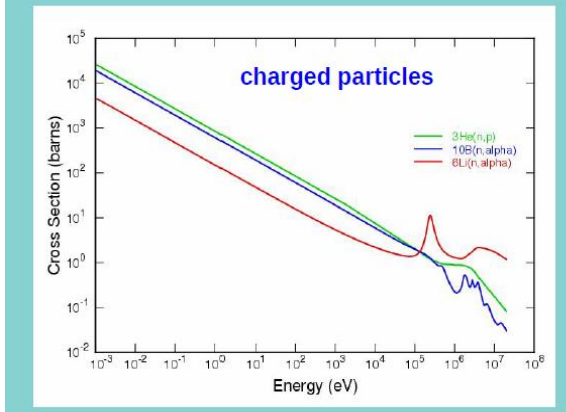
- $n + {}^{235}U \rightarrow$ fission fragments + ~160 MeV
- $n + {}^{239}Pu \rightarrow$ fission fragments + ~160 MeV
- $n + {}^{238}U \rightarrow$ fission fragments + ~160 MeV



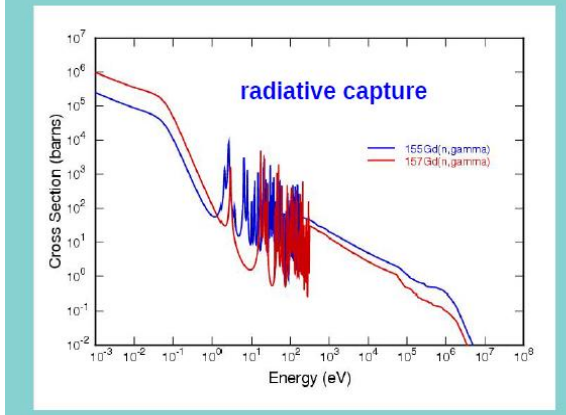
$$\sigma_{tot} = \sigma_{n,n} + \sigma_{n,\gamma} + \sigma_{n,n'} + \sigma_{n,\alpha} + \sigma_{n,p} + \ldots$$

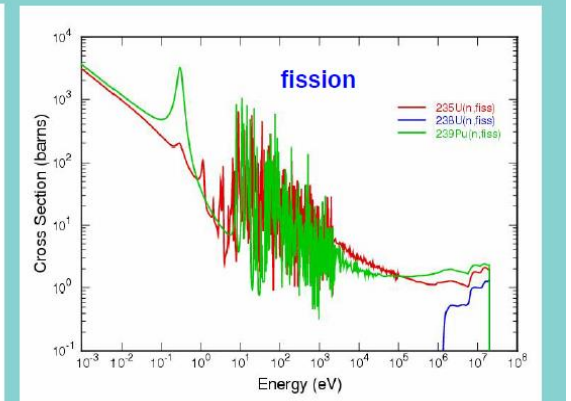
Elastic scattering and radiative capture channels are always open

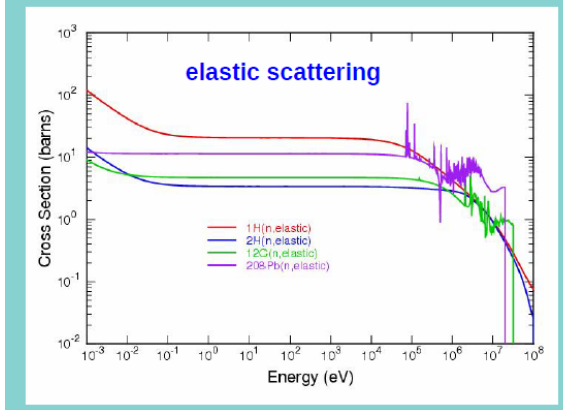

(a)
Electron
Neutron
Proton
Neutrons
Scattering &
absorption
(b)
Photoelectron
X-rays
Absorption
Scattering
(c)
X-rays (100 keV)
Thermal neutrons
Mass attenuation coefficient (cm²/g)
Atomic number
(d)
X-ray attenuation
Atomic number
H
Li
B
C
O
Al
Ni
Pb
Neutron attenuation



Cross section energy dependence of important reactions







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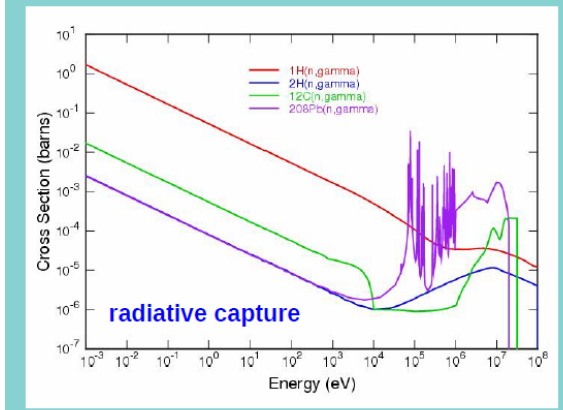
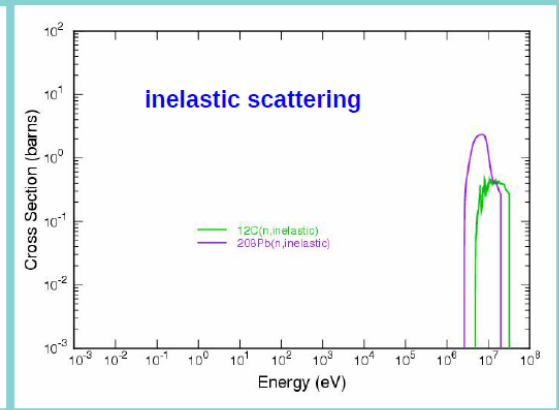
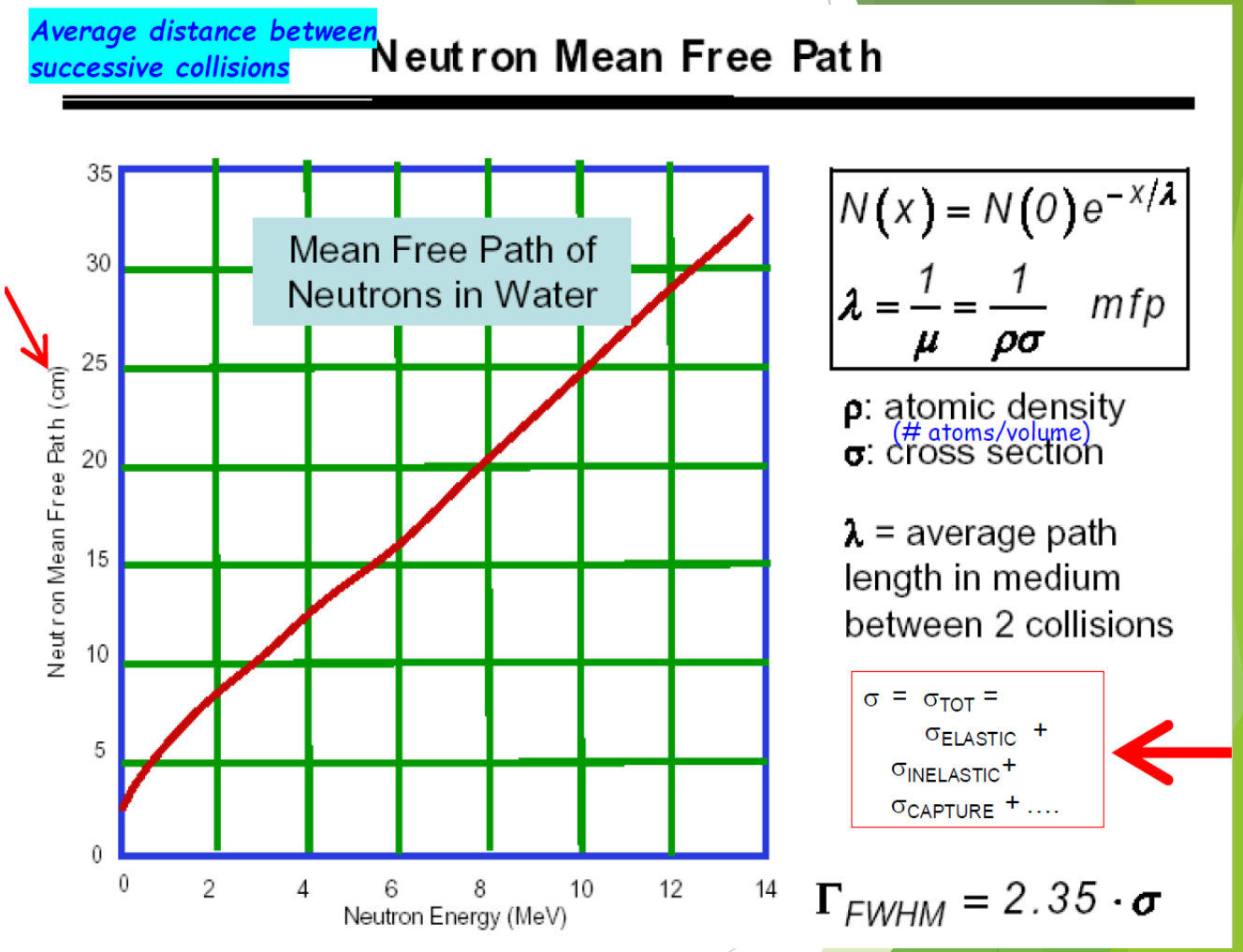




- **Neutronning O'rtacha Erkin Yo'li**
- **O'rtacha Erkin Yo'l:** Neutronlarning keyingi to'qnashuvlari orasidagi o'rtacha masofa
- **N(x) = N(0)e^(-x/λ)** – Bu formula orqali neutronning o'rtacha erkin yo'li hisoblanadi.
- **λ = 1/μ = 1/(ρσ)** – O'rtacha yo'l uzunligi.
  - ρ: atom zichligi
  - σ: kesishuv maydoni
  - λ: o'rtacha yo'l uzunligi



THANK YOU!