

#2

原子力と放射線の物理  
第一歩  
PHYSICS OF  
NUCLEAR POWER & RADIATION  
(FIRST STEP)

大谷 暢夫  
OHTANI, Nobuo

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### Structure of Atom & Nuclear (原子と原子核の構造)

Crystal  
(結晶)

Atom (原子)

proton Neutron

Hydrogen  
P : 1  
N : 0  
(A=1)

Helium  
P : 2  
N : 2  
(A=4)

Uranium-235  
P : 92  
N : 143  
(A=235)  
(#2-2)

Nuclear model by N.Bohr (~1915)

Atom (原子)      原子核(nuclear)      電子(electron)

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### Weights & Dimensions(大きさと重さ)

	amu (atomic mass unit)	$m_e$	(gram)
nuclear of carbon	12		$9.1 \times 10^{-28}$
proton	1.0073	1836.1	
neutron	1.0087	1838.6	
electron	$5.49 \times 10^{-4}$	1	

Radius of Nuclear  
 $R = r_0 A^{1/3}$      $r_0 = 1.5 \times 10^{-13}(\text{cm})$

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### Nuclear Reaction (核反応)

reaction of radiation with nuclear(原子核と放射線の反応)

charged particle : electron, proton, alpha particle  
neutron(no electric charge)

charged particle  
(荷電粒子の反応)

neutron(中性子の反応)  
原子炉で重要

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### neutron reactions (中性子の反応)

neutron scattering (散乱)  
change of neutron energy, direction

neutron capture (中性子捕獲)  
(n,γ), (n,p),(n,α)  
.....> 放射化

fission (核分裂)  
multiplication of neutrons  
neutron energy, direction(isotropic)

transport of neutron (中性子輸送)

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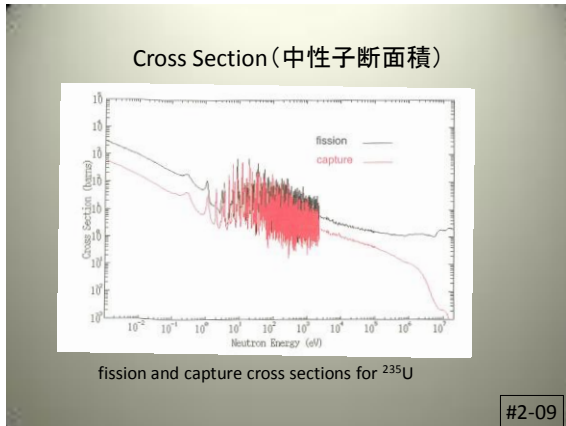
### Neutron Reaction Cross Section (中性子反応断面積)

nuclear radius(simple model by experiment)  
 $R = 1.5 \times 10^{-15} \times A^{1/3} (\text{m})$

U-235  
A = 235  
 $R \sim 9 \times 10^{-15} (\text{m})$   
 $S \sim 2.5 \times 10^{-28}(\text{m}^2)$

unit of reaction cross section  
barn : 1 barn =  $10^{-28} \text{m}^2$

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### 評価済み核データファイル Evaluated Nuclear Data File(ENDF)

ENDF : Name of Format  
: Name of U.S.A.\_Library

	Publish		Number of Nuclear
ENDF/B-IV.8	2001.10	U.S.A.	329
JENDL-3.3	2002.5	JAPAN	337
JEFF-3.0	2002.4	NEA	340

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### Fission (核分裂)

Fissile Nuclear  
 $U-235 \leftarrow U-238 + n$   
 $Pu-239 \leftarrow U-238 + n$   
 $U-233 \leftarrow Th-232 + n$

Production of Thermal Energy  
 $\sim 200\text{MeV}(FP, \beta, \gamma, n)$   
 $\sim 2\text{MeV}/n$

Example(statistical)  
 ${}_{92}U^{235} + {}_0n^1 \rightarrow {}_{57}La^{147} + {}_{35}Br^{87} + 2{}_0n^1$

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### Fission Products(FP) & FP Decay (核分裂片と核分裂片の崩壊)

Fission Products Mass Distribution

Fission Products Decay Chain Including 135-Xe

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### Fission Neutron (核分裂で発生する中性子)

Number of Fission Neutrons ( $\nu$ ):  $2.5 \pm 0.1$   
 (核分裂ででてくる中性子の個数)  
 uranium-235 fission by slow neutrons

Fission Neutron Energy Distribution

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### Criticality (臨界)

Chain Reaction & Criticality (連鎖反応と臨界)  
 mean number of neutrons ( $\nu$ )  $\sim 2.5$

- \* absorbed in material(iron, water, control material ...)
- \* leak\_out from the system
- 1.0 absorbed U-235 introducing next fission

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