具体的な評課

半減期 $T_{1/2} = \sqrt{\frac{2m}{E}}\, a \log 2 \times \exp\left[\frac{\pi\sqrt{2mc^2}\,\gamma}{\sqrt{E}} - 4\sqrt{\frac{2mc^2\gamma a}{\hbar c}}\right]$

ポロニウム ($Z=84$) の場合 → 質量数 $A=218$.

自然単位系との変換

$1\,s = 1.52\times10^{15}\ \hbar\cdot eV^{-1} = 1.52\times10^{21}\ \hbar\cdot MeV^{-1}$

$1\,cm = 5.07\times10^{14}\ \hbar\cdot c\cdot eV^{-1}$

$1\,g = 5.61\times10^{32}\ eV\cdot c^{-1}$

また、$\hbar c = 197.3269\ MeV\cdot fm \simeq 200\ MeV\cdot fm$

α粒子は、原子量4より、

$m = \frac{4}{6.02\times10^{23}}\ g \simeq 3.73\times10^{9}\ eV\cdot c^{-2}$

$= 3.73\ GeV\cdot c^{-2}$

m ～ 1個あたりの質量

- 原子核半径 $a = 1.2\times218^{1/3}\ fm \simeq 7.22\ fm$
- $\log 2 \simeq 0.693$

① $\sqrt{\frac{2m}{E}}\, a \log 2 = \sqrt{\frac{2\times3.73\times10^{9}\,[eV]\cdot[c]^{-2}}{E}} \times 7.22\,fm \times 0.693$

$= \sqrt{\frac{7.46\times10^{3}\,[MeV][c]^{-2}}{E}} \times 7.22\times0.693 \times \frac{1}{200}\,[\hbar][c][MeV]^{-1}$

$= \frac{1}{1.52\times10^{21}}\,[s]$

$= \frac{\sqrt{0.746}\times10^{2}}{\sqrt{E}} \times \frac{7.22\times0.69}{200\times1.52} \times10^{-21}$

$\simeq \frac{1.4}{\sqrt{E}}\times10^{-22}\,[s]$

$\gamma = Z_a Z_b \alpha = 2 \cdot 82 \cdot \frac{1}{137}$

$\simeq 1.2$

② $\pi\sqrt{2mc^2\gamma}$

$= 3.14 \times \sqrt{2 \times 3.73 \times 10^9 [eV] [c]^{-2} \cdot [c]^2} \times 1.2$

$= 3.14 \times 1.2 \times \sqrt{7.46 \times 10^9 [eV]}$

$= 3.14 \times 1.2 \times \sqrt{0.746 \times 10^9 [MeV]}$

$= 3.14 \times 1.2 \times \sqrt{0.746} \times 10^2 [MeV]^{1/2}$

$= 3.25 \times 10^2 [MeV]^{1/2}$

③ $4\sqrt{\frac{2mc^2 \gamma a}{\hbar c}}$

$= 4\sqrt{\frac{2 \times 3.73 \times 10^9 eV \cdot c^{-2} \cdot c^2 \times 1.2 \times 7.22 fm}{\hbar c}}$

$= 4\sqrt{\frac{0.746 \times 10^9 [MeV] \times 1.2 \times 7.22 [fm]}{[\hbar c]}}$

$= 4\sqrt{\frac{0.746 \times 1.2 \times 7.22}{200} \times 10^2}$

$\simeq 71.9$

$\hbar c = 200 \, MeV \cdot fm$

$\leftrightarrow \frac{MeV \cdot fm}{\hbar c} = \frac{1}{200}$

①～③より、

$T_{1/2} = \frac{1.4 \times 10^{-22}}{\sqrt{E}} \exp\left[\frac{3.25 \times 10^2}{\sqrt{E}} - 71.9\right]$

E : [MeV]

$E = 4$ MeV のとき $T_{1/2} = 4.94 \times 10^9$ 年

$E = 5$ MeV のとき $T_{1/2} = 1.56 \times 10^2$ 年