Scattering of Cosmic

i) Elastic Scattering by Nuclei

Coulomb force による diff. cross section は

~~$d\Omega(\theta) = 2$~~

$$d\sigma = \frac{2\pi Z^2 e^4}{4 m_0^2 v^4} \frac{\sin\theta\, d\theta}{\sin^4 \frac{\theta}{2}} \quad \text{(non-relativistic)}$$

$$= Z^2 r_0^2 \cdot \frac{2\pi}{4} \left(\frac{mc^2}{m_0 v^2}\right)^2 \cdot \frac{\sin\theta\, d\theta}{\sin^4 \frac{\theta}{2}}$$

$$\frac{\sin\theta\, d\theta}{\sin^4 \frac{\theta}{2}} = \int_\delta^1 \frac{4\, dx}{x^3} = \left(\frac{1}{\delta^4} - 1\right)$$

$$= (2.8)^2 Z^2 \times 10^{-26} \times \frac{2\pi}{4} \left(\frac{mc^2}{m_0 v^2}\right)^2$$

Z : 小 relativistic

$$d\sigma = \frac{2\pi Z^2 e^4}{4E^2} \left\{ \frac{1}{\sin^4 \frac{\theta}{2}} - \left(1 - \frac{1}{3^2}\right) \frac{1}{\sin^2 \frac{\theta}{2}} \right\} \sin\theta\, d\theta$$

$$= \frac{2\pi Z^2}{16} r_0^2 \cdot \left(\frac{2mc^2}{E}\right)^2 [\ \ ,\ ,\ ] \sin\theta\, d\theta$$

$$= Z^2 \times 3 \times 10^{-26} \times \left(\frac{2mc^2}{E}\right)^2 [\ \ ,\ ,\ ] \sin\theta\, d\theta$$

2.8
2.8
22.4
56
78.4

$E \sim 10^8$ eV : $\left(\frac{2mc^2}{E}\right)^2 = 10^{-4}$

$E \sim 10^9$ eV : $\ddots = 10^{-6}$

$$d\sigma \sim Z^2 \times 3 \times 10^{-30} \sim 10^{-32} [\ \ ] \sin\theta\, d\theta$$

$\delta = \frac{1}{\sqrt{2}}$: $\simeq$ 10^{-28} ~~10^{-29}~~ 10^{-30}

Nuclear (Short Range Field) の potential

$$V = G^2 \left(\frac{1}{r} + \frac{1}{a_0}\right) e^{-2r/a_0}$$

cross section $Q_0 = \dfrac{1024 \cdot \pi^5 \cdot m_u^2 G^4 (3\lambda^4 + 18\lambda^2 k^2 + 28 k^4)}{3 h^4 \lambda^2 (\lambda^2 + 4k^2)^3}$

$\lambda = \dfrac{2}{a_0}$

$$Q_0 = \frac{1024 \cdot \pi^5}{3} \left(\frac{m_u c}{h}\right)^4 \cdot \left(\frac{G^2}{m_u c^2}\right)^2 \cdot \left(\frac{m_u}{m}\right)^2 \cdot \left(\frac{G}{e}\right)^4 \times \frac{3\lambda^4 + 18\lambda^2 k^2 + 28 k^4}{\lambda^2 (\lambda^2 + 4k^2)^3}$$

$k = \dfrac{2\pi m v}{h}$.

$$\simeq \frac{10^3 \cdot \pi}{3} \cdot \left(\frac{mc}{h}\right)^4 (2.8)^2 \times 10^{-26}$$

$$\simeq \frac{10^3 \cdot \pi}{3} \left(\frac{10^{11}}{3.85}\right)^4 (2.8)^2 \times 10^{-26} \times 4 \times 10^4 \times \left(\frac{G}{e}\right)^4 \times \frac{3\lambda^4 + 18\lambda^2 k^2 + 28 k^4}{\lambda^2 (\lambda^2 + 4k^2)^3}$$

44
7
51
20
25

$$= \frac{3 \times (2.8)^2 \times 4}{(3.85)^4} 10^{25} \times \left(\frac{Q_0}{2}\right)^4 \times \left(\frac{G}{e}\right)^4$$

11
10^{-52}

$$\simeq 10^{-27} \times \left(\frac{G}{e}\right)^4$$

ii) Scattering by Orbital Electrons

Inelastic
iii) Scattering by Nuclei