

Einheiten der Kern- & Teilchenphysik & Raumwinkel

(a) $\Delta\phi = 1 \text{ V}; \quad q_e = e$

$$\Delta E = q_e \Delta\phi = 1.602 \times 10^{-19} \text{ C J/C} = \underline{\underline{1.602 \times 10^{-19} \text{ J} = 1 \text{ eV}}}$$

(b)

(i) $m_e = 0.510999 \text{ MeV}/c^2 = 0.510999 \frac{e}{c^2} \text{ J/C} = \underline{\underline{9.11 \times 10^{-31} \text{ kg}}}$

(ii) $m_p = 938.272 \text{ MeV}/c^2 = 938.272 \frac{e}{c^2} \text{ J/C} = \underline{\underline{1.67 \times 10^{-27} \text{ kg}}}$

(iii) $m_d = 1875.613 \text{ MeV}/c^2 = 1875.613 \frac{e}{c^2} \text{ J/C} = \underline{\underline{3.34 \times 10^{-27} \text{ kg}}}$

(c) Der Raumwinkel beschreibt das Verhältnis zwischen der Teilfläche einer Kugel zum Kugelradius r zum Quadrat.

$$d\Omega = \frac{dA}{r^2} = \underline{\underline{\sin(\theta) d\theta d\varphi}}$$

(d)

$$A = 2\pi r^2$$

$$\Omega = \frac{A}{r^2} = \underline{\underline{2\pi \text{ sr}}}$$

$$\Omega = 2\pi \left(\frac{180}{\pi} \right)^2 = \underline{\underline{\frac{64800}{\pi} \text{ deg}^2 = 20626.5 \text{ deg}^2}}$$

(e) $\theta = 1^\circ$

$$A = 2\pi r^2 \left(1 - \cos(\theta) + \frac{1}{2} \sin^2(\theta) \right)$$

$$\Omega = \frac{A}{r^2} = 2\pi \left(1 - \cos(\theta) + \frac{1}{2} \sin^2(\theta) \right) = \underline{\underline{5.11284 \text{ sr}}}$$

Relativistische Formel der Energie

$$(a) \quad p = \gamma m_0 v; \quad \gamma = \frac{1}{\sqrt{1-\beta^2}}; \quad \beta = \frac{v}{c}; \quad F = \frac{dp}{dt}$$

$$E_{\text{kin}} = \int_0^r F \, d\tilde{r} = \int_0^r \frac{dp}{dt} \, d\tilde{r} = \int_0^r \frac{d}{dt} \left(\frac{m_0 v}{\sqrt{1-\beta^2}} \right) d\tilde{r}$$

$$(b) \quad dp = m_0 \frac{d(\gamma v)}{dt} dt = m_0 \gamma (1 + \gamma^2 \beta^2) dv$$

$$E_{\text{kin}} = \int_0^r \frac{dp}{dt} d\tilde{r} = \int_0^p \frac{dr}{dt} d\tilde{p} = m_0 \int_0^v \gamma \tilde{v} (1 + \gamma^2 \beta^2) d\tilde{v} = \underline{\underline{m_0 c^2 (\gamma - 1)}}$$

$$(c) \quad \gamma \approx 1 + \frac{1}{2} \beta^2$$

$$E_{\text{kin}} = m_0 c^2 (\gamma - 1) \approx m_0 c^2 \left(1 + \frac{1}{2} \beta^2 - 1 \right) = \underline{\underline{\frac{m_0 v^2}{2}}}$$

Streuung an harter Kugel

$$(a) \quad 2\alpha + \theta = \pi; \quad R = R_1 + R_2$$

$$\frac{b}{R} = \sin(\alpha) = \sin\left(\frac{\pi}{2} - \frac{\theta}{2}\right) = \cos\left(\frac{\theta}{2}\right)$$

$$b = R \cos\left(\frac{\theta}{2}\right)$$

$$db = -\frac{R}{2} \sin\left(\frac{\theta}{2}\right) d\theta$$

$$(b)$$

$$\frac{d\sigma}{d\Omega} = \left| \frac{b \, db}{\sin(\theta) \, d\theta} \right| = \left| \frac{(R \cos(\frac{\theta}{2})) (-\frac{R}{2} \sin(\frac{\theta}{2}) \, d\theta)}{\sin(\theta) \, d\theta} \right| = \left| \frac{R^2 \cos(\frac{\theta}{2}) \sin(\frac{\theta}{2})}{2 \sin(\theta)} \right| = \underline{\underline{\frac{R^2}{4}}}$$

Da der differentielle Wirkungsquerschnitt nicht vom Winkel θ abhängt, treten alle Streuwinkel gleich häufig auf.

(c)

$$\sigma_{\text{tot}} = \int_0^\sigma d\tilde{\sigma} = \int_0^\Omega \frac{R^2}{4} d\tilde{\Omega} = \frac{R^2}{4} \int_0^\theta \sin(\tilde{\theta}) d\tilde{\theta} \int_0^{2\pi} d\phi = \underline{\underline{-\frac{R^2\pi}{2} (\cos(\theta) - 1)}}$$

Der totale Wirkungsquerschnitt hängt vom Winkel θ ab und nimmt Werte zwischen $-R^2\pi$ und $R^2\pi$ an.

(d) $\frac{\pi}{2} < \theta < \frac{3\pi}{2}$

$$\sigma_{\text{rück}} = \int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} -\frac{R^2\pi}{2} (\cos(\theta) - 1) d\theta = -\frac{R^2\pi}{2} \left[\sin(\theta) - \theta \right]_{\frac{\pi}{2}}^{\frac{3\pi}{2}} = \underline{\underline{R^2\pi(1 + \frac{\pi}{2})}}$$