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I. Compton Effect

$$\mu + k_0 = E + k_1 \qquad \vec{k_0} = \vec{p} + \vec{k_1}$$

$$(\mu + k_0 - k_1)^2 = (\vec{k_0} - \vec{k_1})^2 + \mu^2$$

$$-k_0 k_1 + \mu k_0 - \mu k_1 = -\cancel{2}\, k_0 k_1 \cos\vartheta$$

$$k_1 = \frac{k_0}{1 + (1-\cos\vartheta)\frac{k_0}{\mu}}$$

Zwischenzustand 1) k_0: absorbiert $\qquad \vec{p}' = \vec{k_0}$

k_1: emittiert

2) k_1: emittiert $\qquad \vec{p}'' = -\vec{k_1}$

k_0: absorbiert

Sekundärquant sei $d\Omega_1$ ins Raumwinkel zu emittieren, eins diff. Wirkungsquerschnitt ist

$$d\Phi = \frac{2\pi}{hc} |H|^2 \frac{k_1^2 d\Omega_1}{(2\pi hc)^3} \frac{E k_1}{\mu k_0}$$

$$\because \left(\frac{\partial k_1}{\partial \mathcal{E}}\right)_\vartheta = \frac{E k_1}{\mu k_0} \qquad \mathcal{E} = E + k_1 = \sqrt{(\vec{k_1} - \vec{k_0})^2 + \mu^2} + k_1$$

$$\frac{\partial \mathcal{E}}{\partial k_1} = \frac{(k_1 + k_0\cos\vartheta)}{\sqrt{\;''\;}} + 1 = \frac{k_1 + k_0 \cos\vartheta + E}{E}$$

$$(\mathcal{E} - k_1)^2 = k_1^2 + k_0^2 - 2k_0k_1\cos\vartheta + \mu^2 \qquad \cancel{\frac{k_1}{E k_1}}$$

$$\mathcal{E}^2 - 2\mathcal{E}k_1 = k_0^2 - 2k_0k_1\cos\vartheta + \mu^2$$

$$k_1 = \frac{\mathcal{E}^2 - k_0^2 - \mu^2}{2(\mathcal{E} - k_0\cos\vartheta)} \qquad \frac{\partial k_1}{\partial \mathcal{E}} = \frac{\mathcal{E}}{(\mathcal{E} - k_0\cos\vartheta)} - \frac{\mathcal{E}^2 - k_0^2 - \mu^2}{2(\quad)^2}$$

$$= \frac{2\mathcal{E}^2 - 2\mathcal{E}k_0\cos\vartheta - \mathcal{E}^2 + k_0^2 + \mu^2}{(\quad)^2} = \cancel{\frac{E^2 + k_1^2 - 2Ek_1 - 2Ek_0\cos\vartheta \mp 2k_0k_1\cos\vartheta + k_0^2 + \mu^2}{2(E + k_1 - k_0\cos\vartheta)}}$$

$\mathcal{E} = \mu + k_0$

$$= \frac{\cancel{2}\mu^2 + k_0^2 + \cancel{2}\mu k_0 - \cancel{2}\mu k_0\cos\vartheta - k_0^2\cos\vartheta}{\cancel{2}\{\mu + k_0(1-\cos\vartheta)\}} =$$

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$$d\Phi = \frac{2\pi}{\hbar c}|H|^2 \frac{k_1^2 d\Omega_1}{(2\pi\hbar c)^3}\frac{E k_1}{\mu k_0}$$

$$\mathcal{E} = E + k_1 = \sqrt{(\vec{k}_1 - \vec{k}_0)^2 + \mu^2} + k_1$$

$$(\mathcal{E} - k_1)^2 = k_1^2 + k_0^2 - 2k_0 k_1 \cos\vartheta + \mu^2$$

$$k_1 = \frac{\mathcal{E}^2 - k_0^2 - \mu^2}{2(\mathcal{E} - k_0\cos\vartheta)}$$

$$\left(\frac{\partial k_1}{\partial \mathcal{E}}\right)_\vartheta = \frac{2(\mathcal{E} - k_0\cos\vartheta)\mathcal{E} - \mathcal{E}^2 + k_0^2 + \mu^2}{2(\mathcal{E} - k_0\cos\vartheta)^2}$$

$$\mathcal{E} = \mu + k_0 \qquad \mathcal{E} - k_0\cos\vartheta = \frac{k_0\mu}{k_1}$$

$$\left(\frac{\partial k_1}{\partial \mathcal{E}}\right)_\vartheta = \frac{(\mathcal{E} - k_0\cos\vartheta)\mathcal{E} - \cancel{2}\mu k_0}{(\mathcal{E} - k_0\cos\vartheta)^2}$$

$$= \frac{\frac{k_0\mu}{k_1}\cdot(\mu + k_0) - \mu k_0}{\left(\frac{k_0\mu}{k_1}\right)^2} = \frac{k_1(\mu + k_0 - k_1)}{k_0\mu}$$

$$= \frac{k_1 E}{k_0\mu}.$$

$$H = \sum_{\text{spin}}\left(\frac{H_{AI}H_{IE}}{E_A - E_I} + \frac{H_{AII}H_{IIE}}{E_A - E_{II}}\right)$$

Energievorzeichen

$$E_A - E_I = k_0 + \mu - E' ; \quad E_A - E_{II} = \mu - k_1 - E'',$$

$$E' = \pm\sqrt{p'^2 + \mu^2}. \text{ etc}$$

$$\alpha_0 = (\vec{\alpha}, \vec{e}_0)$$
$$\alpha_1 = (\vec{\alpha}, \vec{e}_1)$$

$$H_{AI} = \frac{e\sqrt{2\pi}\,\hbar c}{\sqrt{k_0}}(u_0 \alpha_0 u')$$

$$H = \frac{(\sqrt{2\pi}e\hbar c)^2}{\sqrt{k_0 k_1}}\sum\left\{\frac{(u_0\alpha_0 u')(u'\alpha_1 u)}{k_0 + \mu - E'} + \frac{(u_0\alpha_1 u'')(u''\alpha_0 u)}{\mu - k_1 - E''}\right\}$$

$$\alpha_1 (\vec{\alpha}\vec{e})(\vec{\alpha}\vec{k}) = (\vec{e}\vec{k}) + i(\vec{\sigma}, (\vec{e}\times\vec{k}))$$
$$= i\vec{\sigma}.$$

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$$H^2 = \frac{\pi^2 (hec)^4}{8\mu^2 k_0 k_1 E}\Big[Sp \frac{(1+\rho)\alpha_0 K'\alpha_1 (H+E)\alpha_1 K'\alpha_0}{k_0^2}$$
$$+ Sp\frac{(1+\rho)\alpha_1 K''\alpha_0 (H+E)\alpha_0 K''\alpha_1}{k_1^2} - 2Sp\frac{(1+\rho)\alpha_0 K'\alpha_1 (H+E)\alpha_0 K''\alpha_1}{k_0 k_1}\Big]$$

$$(1,0)$$

$$K' = \mu(1+\rho) + k_0 + (\vec{\alpha}\vec{k}_0)$$
$$K'' = \mu(1+\rho) - k_1 - (\vec{\alpha}\vec{k}_1)$$
$$H+E = E + \rho\mu + (\vec{\alpha}\vec{p})$$
$$d\Phi = \frac{r_0^2}{32}\left(\frac{k_1}{k_0}\right)^2 d\Omega_1 \frac{1}{\mu}[Sp(10)] \qquad r_0 = e^2/\mu$$

$$Sp\frac{(1+\rho)\alpha_0 (k_0 + \vec{\alpha}\vec{k}_0)\alpha_1 (E+\rho\mu + \vec{\alpha}\vec{p})\alpha_1 (k_0 + \vec{\alpha}\vec{k}_0)\alpha_0}{k_0^2}$$

$$= \frac{1}{k_0^2}(1-\rho)(k_0+\vec{\alpha}\vec{k}_0)\underbrace{\alpha_1(E+\rho\mu+\vec{\alpha}\vec{p})\alpha_1}_{(E-\rho\mu+\vec{\alpha}\vec{p}) + 2i(\vec{\sigma}(\vec{e}_1\times\vec{p}))\alpha_1}(k_0+\vec{\alpha}\vec{k}_0)$$

$$\cancel{(1-\rho)(k_0+\vec{\alpha}}$$
$$\cancel{k_0^2 E}$$

$$\frac{1}{\mu^2 k_0^2}$$

$$= \frac{1}{k_0^2}\Big\{(k_0+\vec{\alpha}\vec{k}_0)^2\{(E-\rho\mu+\vec{\alpha}\vec{p}) + 2i(\vec{\sigma}(\vec{e}_1\times\vec{p}))\alpha_1\}$$
$$-\beta(k_0-\vec{\alpha}\vec{k}_0)(k_0+\vec{\alpha}\vec{k}_0)\{ \quad " \quad " \quad \}\Big\}$$

$$= \frac{1}{k_0^2}\{2k_0^2 + 2\vec{\alpha}\vec{k}_0\cdot k_0\}\{(E-\rho\mu+\vec{\alpha}\vec{p}) + 2i(\vec{\sigma}(\vec{e}_1\times\vec{p}))\alpha_1\}$$
$$+2\beta\, k_0\cdot\vec{\alpha}\vec{k}_0\{ \quad " \quad " \quad \}$$
$$= \frac{2}{k_0}\{(k_0+\vec{\alpha}\vec{k}_0 + \rho\vec{\alpha}\vec{k}_0)\{ \qquad \}\}$$