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1.

Lösung der Wellengleichung für das Elektron in Gegenwart einer ebenen Lichtwelle.

$$A = a e^{i\nu(t - \frac{(nx)}{c})} + \bar{a} e^{-i\nu(t - \frac{(nx)}{c})} \quad (1)$$

Wellengl. $\left\{ \frac{E}{c} + \rho_1(\sigma p) + \rho_3 mc + \frac{e}{c}\rho_1(\sigma A) \right\} \psi = 0 \quad (2)$

$$\varphi \left\{ \frac{E}{c} + \rho_1(\sigma p) + \rho_3 mc + \frac{e}{c}\rho_1(\sigma A) \right\} = 0 \quad (2a)$$

$$\sigma_1 \sigma_2 = i\sigma_3 \ \text{etc} \quad (3)$$

$$\rho_1 \rho_2 = i\rho_3 \ \text{etc} \quad (3a)$$

Kontinuitätsgl.

$$\frac{\partial(\varphi\psi)}{\partial t} + \operatorname{div}(-c\varphi\rho_1\sigma\psi) = 0 \quad (4)$$

in übereinstimmung mit

$$\rho = -e\varphi\psi, \quad J = ec\varphi\rho_1\sigma\psi \quad (5)$$

$$\psi_0 = u e^{\frac{i}{h}[-Et + (px)]}, \quad \varphi_0 = v e^{-\frac{i}{h}[-Et + (px)]} \quad (6)$$

$$-\frac{E^2}{c^2} + p^2 + m^2c^2 = 0 \quad (7)$$

oder $E = \pm c\sqrt{p^2 + m^2c^2}$

$$\left.\begin{aligned} \psi &= (1 + f e^{i\nu(\,)} + \tilde{f} e^{-i\nu(\,)}) \cdot \psi_0 \\ \varphi &= \varphi_0 (1 + g e^{i\nu(\,)} + \tilde{g} e^{-i\nu(\,)}) \end{aligned}\right\} \quad (8)$$

$$\left.\begin{aligned}
f &= -\frac{e}{2h\nu\left(\frac{E}{c}-(np)\right)}\left[2(ap)+h(\alpha\eta)+ih\rho_1(\alpha\varepsilon)\right]\\
\tilde f &= \frac{e}{2h\nu\left(\frac{E}{c}-(np)\right)}\left[2(\tilde a p)+h(\alpha\tilde\eta)+ih\rho_1(\alpha\tilde\varepsilon)\right]\\
g &= \frac{e}{2h\nu\left(\frac{E}{c}-(np)\right)}\left[2(ap)+h(\alpha\eta)-ih\rho_1(\alpha\varepsilon)\right]\\
\tilde g &= -\frac{e}{2h\nu\left(\frac{E}{c}-(np)\right)}\left[2(\tilde a p)+h(\alpha\tilde\eta)-ih\rho_1(\alpha\tilde\varepsilon)\right]
\end{aligned}\right\} \quad (9)$$

$$\left.\begin{aligned}
\mathfrak{E} &= \varepsilon\, e^{i\nu\left(t-\frac{(nx)}{c}\right)}+\tilde\varepsilon\, e^{-i\nu\left(t-\frac{(nx)}{c}\right)}\\
H &= \eta\, e^{i\nu\left(t-\frac{(nx)}{c}\right)}+\tilde\eta\, e^{-i\nu\left(t-\frac{(nx)}{c}\right)}
\end{aligned}\right\} \quad (10)$$

Allgemeine Lösung $\int \psi(p)\,dp, \quad \int \varphi(p)\,dp.$

Wahrscheinlichkeitsdichte $\iint \overline{\varphi(p)\,\psi(p')\,dp\,dp'}$

$$\varphi(p)\psi(p') = \varphi_0(p)\psi_0(p') + v(p)\Big\{\left[f(p')+g(p)\right] e^{\frac{i}{h}\left[-(E'-E-h\nu)t+(p'-p-n\frac{h\nu}{c})x\right]}$$
$$+\left[\tilde f(p')+\tilde g(p)\right] e^{\frac{i}{h}\left[-(E'-E+h\nu)t+(p'-p+n\frac{h\nu}{c})x\right]}\Big\}\,u(p')$$

Nach Weglassung von $\varphi_0\,\psi_0$

$$\iint dp\,dp'\Big\{ v(p)\left[f(p')+g(p)\right]u(p')\,e^{\frac{i}{h}\left[-\overset{-(E+h\nu-E')}{(E'-E-h\nu)}t+(p'-p-n\frac{h\nu}{c})x\right]}$$
$$+\,v(p')\left[\tilde f(p)+\tilde g(p')\right]u(p)\,e^{-\frac{i}{h}\left[-\underset{(E+h\nu-E')}{(E'-E-h\nu)}t+(p'-p-n\frac{h\nu}{c})x\right]}$$

Elektrische Dichte

$$P(p) = -\epsilon\int dp'\Big\{ v(p)\left[f(p')+g(p)\right]u(p')\,e^{-\frac{i}{h}\left[-(E+h\nu-E')t+(p-p'+n\frac{h\nu}{c})x\right]}$$
$$+\,v(p')\left[\tilde f(p)+\tilde g(p')\right]u(p)\,e^{\frac{i}{h}\left[-(E+h\nu-E')t+(p-p'+n\frac{h\nu}{c})x\right]} \quad (11)$$

Strahlausdruck

$$J(p) = ee\int dp' \left\{ v(p)\left[\rho_1\alpha f(p') + g(p)\rho_1\alpha\right] u(p')\, e^{-\frac{i}{h}[\ \ ]} + v(p')\left[\rho_1\alpha \tilde{f}(p) + \tilde{g}(p')\rho_1\alpha\right] u(p)\, e^{\frac{i}{h}[\ \ ]} \right\} \qquad (12)$$

$$A'(p) = \frac{ee}{c\,r}\int dp' \left\{ e^{\frac{i}{h}[E+h\nu-E')(t-\frac{r}{c})}\int dx\, e^{-\frac{i}{h}\left[p-p'+n\frac{h\nu}{c}-n'\frac{(E+h\nu-E')}{c}\right]x}\, v(p)\left[\rho_1\alpha f(p') + g(p)\rho_1\alpha\right]u(p') + e^{-\frac{i}{h}(E+h\nu-E')(t-\frac{r}{c})}\int dx\, e^{\frac{i}{h}\left[p-p'+n\frac{h\nu}{c}-n'\frac{E+h\nu-E'}{c}\right]x}\, v(p')\left[\rho_1\alpha\tilde{f}(p)+\tilde{g}(p')\rho_1\alpha\right]u(p) \right.$$

wobei $\int dx = \int dx_1 \int dx_2 \int dx_3$

$$A' = \frac{(2\pi h)^3 e}{r}\left\{ v(p)\left[\rho_1\alpha f(p') + g(p)\rho_1\alpha\right]u(p')\, e^{i\nu'(t-\frac{r}{c})} + v(p')\left[\rho_1\alpha\tilde{f}(p)+\tilde{g}(p')\rho_1\alpha\right]u(p)\, e^{-i\nu'(t-\frac{r}{c})}\right\} \qquad (13)$$

wobei
$$\left.\begin{aligned} E+h\nu &= E'+h\nu' \\ p+n\frac{h\nu}{c} &= p'+n'\frac{h\nu'}{c} \end{aligned}\right\} \qquad (14)$$

$$H' = -\frac{i\nu'}{c}[n'A'] \qquad (15)$$

$$p = 0\,, \quad E = mc^2 \qquad (16)$$

$$\therefore\ g(p) = \frac{e}{2\nu mc}\left[(\alpha\eta) - i\rho_1(\alpha\varepsilon)\right]$$

$$+\ \text{da}\quad (\alpha\eta)\alpha = \eta + i[\alpha\times\eta]$$

$$\therefore\ g(p)\rho_1\alpha = \frac{e}{2\nu mc}\left\{\rho_1(\eta + i[\alpha\times\eta]) - i(\varepsilon + i[\alpha\varepsilon])\right\}$$

Ersetzung von ρ_1 + $\rho_1 \sigma$ durch 1 + σ

$$\left.\begin{aligned} &v(p)(1+\rho_3)=0 \\ &\left[\frac{E'}{c}+\rho_1(\sigma p')+\rho_3 mc\right]u(p')=0 \end{aligned}\right\} \quad (16)$$

$$\therefore \left.\begin{aligned} &v(p)(\rho_1+i\rho_2)=0 \\ &\left(\frac{E'}{c}\rho_1+(\sigma p')-i\rho_2 mc\right)u(p')=0 \end{aligned}\right\} \quad (16')$$

$$\therefore v(p)\rho_1 u(p') = -\frac{v(p)(\sigma p')u(p')}{\frac{E'}{c}+mc}$$

Setze

$$\left.\begin{aligned} &v(p)\sigma u(p') = S \quad \& \quad v(p')\sigma u(p) = \bar{S} \\ &v(p)u(p') = d \qquad\quad v(p')u(p) = \bar{d} \end{aligned}\right\} \quad (17)$$

$$\left.\begin{aligned} &\frac{E'}{c}+mc = \frac{h}{c}\left(\nu-\nu'+\frac{2mc^2}{h}\right) \\ &p' = \frac{h}{c}(n\nu - n'\nu') \end{aligned}\right\} \quad (18)$$

$$\therefore v(p)\rho_1 u(p') = \frac{-S(n\nu-n'\nu')}{\nu-\nu'+\frac{2mc^2}{h}} \quad (19)$$

Aus (16)

$$v(p)(\rho_1\sigma+i\rho_2\sigma)=0$$

$$\left\{\frac{E'}{c}\rho_1\sigma+\sigma(\sigma p')-i\rho_2\sigma mc\right\}u(p')=0$$

$$\therefore v(p)\rho_1\sigma u(p') = -\frac{v(p)\sigma(\sigma p')u(p')}{\frac{E'}{c}+mc} = -\frac{p'v(p)u(p')+i[p', v\sigma u]}{\frac{E'}{c}+mc}$$

$$= \frac{-(n\nu-n'\nu')d + i[(n\nu-n'\nu'), S]}{\nu-\nu'+\frac{2mc^2}{h}} \quad (20)$$

$$\therefore v(p)\, g(p)\, \rho_1 \alpha\, u(p')$$

$$= \frac{e}{2\nu mc}\left\{ \frac{-(S,(n\nu-n'\nu'))\,\eta + i\left[(n\nu-n'\nu')d + i[(n\nu-n'\nu'), S], \eta\right]}{\nu-\nu'+\frac{2mc^2}{h}} - i\left(d\mathcal{E} + i[S\mathcal{E}]\right)\right\}.$$

$$\therefore v(p)\,\rho_1\alpha f(p')u(p') = -\frac{e\, v(p)\rho_1\alpha}{2h\nu\left(\frac{E'}{c}-(np')\right)}\left[2(ap') + h(\alpha\eta) + ih\rho_1(\alpha\mathcal{E})\right]u(p')$$

Aus (14)

$$\frac{E'}{c} - (np') = mc\frac{\nu'}{\nu} \qquad (21)$$

Ferner

$$v(p)\rho_1\alpha(\alpha\eta)u(p') = v(p)\rho_1\left[\eta + i[\eta\times\alpha]\right]u(p')$$

$$= \frac{-(S, n\nu-n'\nu')\eta + i\left[\eta\times\left((n\nu-n'\nu')d + i[n\nu-n'\nu', S]\right)\right]}{\nu-\nu'+\frac{2mc^2}{h}}$$

$$\& \quad v(p)\alpha(\alpha\mathcal{E})u(p') = v(p)\left(\mathcal{E} + i[\mathcal{E}\alpha]\right)u(p') = \mathcal{E}d + i[\mathcal{E}S]$$

Also

$$v(p)\rho_1\alpha f(p')u(p') = \frac{e}{2mc\nu'}\left\{\frac{\frac{2}{c}(a, n\nu-n'\nu')\left((n\nu-n'\nu')d + i[n\nu-n'\nu', S]\right) + (S, n\nu-n'\nu')\eta + i\left[\eta, \left((n\nu-n'\nu')d + i[n\nu-n'\nu', S]\right)\right]}{\nu-\nu'+\frac{2mc^2}{h}} - i\mathcal{E}d + [\mathcal{E}S]\right\}$$

$$\therefore v(p)\left(\rho_1\alpha f(p') + g(p)\rho_1\alpha\right)u(p') = \frac{ie}{2mc}d\left\{-\frac{\frac{1}{\nu}\left[(n\nu-n'\nu')\eta\right]}{\nu-\nu'+\frac{2mc^2}{h}} - \frac{\mathcal{E}}{\nu} + \right.$$

$$\left. -\frac{\frac{1}{\nu'}\frac{2i}{c}(a, n\nu-n'\nu')(n\nu-n'\nu') + \frac{1}{\nu'}[\eta, n\nu-n'\nu']}{\nu-\nu'+\frac{2mc^2}{h}} - \frac{\mathcal{E}}{\nu'}\right\} +$$

$$+ \frac{e}{2mc}\left\{\frac{1}{\nu}\left(-\frac{(S, n\nu-n'\nu')\eta - [[n\nu-n'\nu', S], \eta]}{\nu-\nu'+\frac{2mc^2}{h}} + [S\mathcal{E}]\right) + \right.$$

$$+\ \frac{1}{\nu'}\Big(\frac{2i}{c}(a,\ n\nu-n'\nu')[n\nu-n'\nu';\ s]+(s,\ n\nu-n'\nu')\eta-[\eta,[n\nu-n'\nu';\ s]]\Big/\Big(\nu-\nu'+\frac{2mc^2}{h}\Big)\ +$$

$$+\ [\mathcal{E}\, s]\Big)\Big\} =$$

$$=\frac{eid}{2mc(\nu-\nu'+\frac{2mc^2}{h})}\Big\{\Big(\frac{1}{\nu}+\frac{1}{\nu'}\Big)[\eta,\ n\nu-n'\nu']-\frac{2(\mathcal{E}n')}{\nu}(n\nu-n'\nu')-\mathcal{E}\Big(\frac{1}{\nu}+\frac{1}{\nu'}\Big)\cdot\Big(\nu-\nu'+\frac{2mc^2}{h}\Big)\Big\}+\frac{e}{2mc(\nu-\nu'+\frac{2mc^2}{h})}\Big\{\Big(\frac{1}{\nu'}-\frac{1}{\nu}\Big)(s,\ n\nu-n'\nu')\eta+\Big(\frac{1}{\nu}+\frac{1}{\nu'}\Big)\Big([[n\nu-n'\nu'],\eta]\Big)$$

$$+\ \frac{\mathcal{E}}{\nu}(\mathcal{E}n')[n\nu-n'\nu';\ s]+\Big(\frac{1}{\nu}-\frac{1}{\nu'}\Big)[s\,\mathcal{E}]\Big(\nu-\nu'+\frac{2mc^2}{h}\Big)\Big\}$$

wo

$$(na)=0 \qquad \mathcal{E}=-\frac{i\nu}{c}a \qquad (22)$$

$$\eta=[n\mathcal{E}]$$

$$\therefore\ [n,\ n\nu-n'\nu']=\nu'(n'\mathcal{E})n+(\nu-\nu'(nn'))\mathcal{E}$$

mit Hilfe von (14)

$$=\frac{eid}{2mc(\nu-\nu'+\frac{2mc^2}{h})}\Big\{\frac{1}{\nu}(n'\mathcal{E})\big((\nu'-\nu)n+2\nu'n'\big)-\nu'\Big(\frac{1}{\nu}+\frac{1}{\nu'}\Big)^2\frac{mc^2}{h}\mathcal{E}\Big\}$$

$$+\ \frac{e}{2mc(\nu-\nu'+\frac{mc^2}{h})}\Big[\Big(\frac{1}{\nu'}-\frac{1}{\nu}\Big)\Big\{(s,\ n\nu-n'\nu')[n\mathcal{E}]+\frac{2\nu'}{\nu-\nu'}(\mathcal{E}n')[n\nu-n'\nu';\ s]-[s,\mathcal{E}]\Big(\nu-\nu'+\frac{2mc^2}{h}\Big)\Big\}-\Big(\frac{1}{\nu}+\frac{1}{\nu'}\Big)\Big((n[\mathcal{E}s])(n\nu-n'\nu')+\nu'(n'[n\mathcal{E}])s\Big)\Big]$$

Wenn wir die von Dirac für ρ und σ gegebenen Matrixausdrücke benutzen, so sind alle drei Komponenten von $\rho_1\,\sigma$ ebenso wie ρ_3 hermitische Matrizen. Wir können deshalb annehmen, dass $v(p)$ & $u(p)$ für alle Werte von p konjugiert komplex sind. Hieraus folgt auch, dass wir $\varphi(p)$ & $\psi(p)$ als konjugiert komplex annehmen können, was bei den Ausdrücken (8) in der Tat erfüllt ist

$\therefore\ v(p)[\rho_1\alpha f(p')+g(p)\rho_1\alpha]u(p')$ + $v(p')[\rho_1\alpha\tilde{f}(p)+\tilde{g}(p')\rho_1\alpha]u(p)$ konjugiert komplex sind, so dass der Ausdruck für das Vektorpotential reell ist. $H' = -\frac{i\nu'}{c}[n'A']$

$$H' = \frac{(2\pi h)^3 e^2\nu'}{2mc^2(\nu-\nu'+\frac{2mc^2}{h})r}\Bigg\{ d\left(\frac{1}{\nu}(n'\mathcal{E})(\nu'-\nu)[n'n] - \nu'\left(\frac{1}{\nu}+\frac{1}{\nu_1}\right)^2\frac{mc^2}{h}[n'\mathcal{E}]\right) -$$

$$-i\Bigg(\left(\frac{1}{\nu_1}-\frac{1}{\nu}\right)\Big[(S,n\nu-n'\nu')\big((n'\mathcal{E})n-(n'n)\mathcal{E}\big)+\left(\nu-\nu'+\frac{2mc^2}{h}\right)\big((Sn')\mathcal{E}-(n'\mathcal{E})S\big)\Big]$$

$$+\frac{2}{\nu}(\mathcal{E}n')\big((n'S)(n\nu-n'\nu')+(\nu'-(nn')\nu)S\big)-$$

$$-\left(\frac{1}{\nu_1}+\frac{1}{\nu}\right)\Big((n[\mathcal{E}S])\nu[n'n]+\nu'(n'[n\mathcal{E}])[n'S]\Big)\Bigg)\Bigg\}\, e^{i\nu'(t-\frac{r}{c})} +$$

$+$ konjugiert Komplexes Glied (23)

Für $p=0$, $\quad (1+\rho_3)u=0 \quad v(1+\rho_3)=0$.

$$1+\rho_3 = \begin{pmatrix} 2&0&0&0\\ 0&2&0&0\\ 0&0&0&0\\ 0&0&0&0 \end{pmatrix}$$

$\therefore\ u_1=u_2=v_1=v_2=0$, so dass u_3, u_4 + v_3, v_4 die allein übrigbleibenden Eigenfn sind. Da sich der Fall eines beliebigen p durch eine Lorentztransformation immer auf den Fall $p=0$ zurückführen lässt, so folgt, dass $u(p)$ + $v(p)$ immer nur je zwei unabhängigen Grössen enthalten. Insbesondere können wir im allgemeinen $u_1\ u_2$ durch $u_3\ u_4$ ausdrücken und ebenso $v_1\ v_2$ durch $v_3\ v_4$. Anstatt der konjugiert-komplexen Grösse u_3, v_3 + u_4, v_4 können wir folgende reelle unabhängige Grösse $a_1\ a_2\ b_1\ b_2$ in den ein[illegible]

$$\left.\begin{array}{ll} u_3 = a_1 e^{i\delta_1} , & u_4 = a_2 e^{i\delta_2} \\ v_3 = a_1 e^{-i\delta_1} ; & v_4 = a_2 e^{-i\delta_2} \end{array}\right\} \quad (24)$$

Das Vorhandensein der zwei unabhängig wählbaren entspricht den zwei Einstellungsmöglichkeit des Elektrons in einem Magnetfeld. Ohne wir auf eine nähere Untersuchung der Eigenfunktionen bei Anwesenheit eines Magnetfelds einzugehen wollen wir der doppelen Einstellungsmöglichkeit dadurch Rechnung tragen, dass wir die zu einem p gehörige Lösung auf 2 normieren. Dies bedeutet

$$\int \varphi_0(p') \psi_0(p'') dx = 2\delta(p'-p'')$$

wo $\delta(p'-p'')$ die von Dirac eingeführte singuläre Funktion bezeichnet. Durch Einsetzung der Ausdruck (6) & Vergleich mit dem Fourierschen Integraltheorem

$$v(p)\, u(p) = \frac{2}{(2\pi h)^3} \qquad (25)$$

Wir können leicht diese Bedingung in eine Beziehung für die Grösse a_1 & a_2 verwandeln

$$\left\{ \frac{E}{c} + \rho_1(\sigma p) + \rho_3 mc \right\} u(p) = 0$$

Multiplikation mit $v(p)\rho_3$

$$v(p) \left\{ \rho_3 \frac{E}{c} + i\rho_2(\sigma p) + mc \right\} u(p) = 0$$

ähnlich aus der adjungierten Gl.

$$v(p) \left\{ \rho_3 \frac{E}{c} - i\rho_2(\sigma p) + mc \right\} u(p) = 0$$

$$\therefore \quad v(p)\rho_3 u(p) = -\frac{mc^2}{E} v(p)\, u(p)$$

od. (auch) $\frac{1}{2} v(p)(1-\rho_3) u(p) = \frac{1}{2}\left(1 + \frac{mc^2}{E}\right) v(p)\, u(p)$

Die Grösse linker Hand ist aber eben $v_3 u_3 + v_4 u_4 = a_1^2 + a_2^2$;

$$\therefore \quad a_1^2 + a_2^2 = \frac{1}{(2\pi h)^3}\left(1 + \frac{mc^2}{E}\right) \qquad (26)$$

In dem Fall $p=0$ kann man leicht zeigen, dass die Anwesenheit eines magnetischen Felds eine Aufhebung der Entartung bewirkt, die wenn das Feld die Richtung von x_3 hat und wenn angenommen wird, dass σ_3 ebenso wie ρ_3 eine Diagonalmatrix ist, sich so ausdrücken lässt, dass nunmehr nur solche Lösungen existieren bei denen entweder u_3, v_3 od. u_4, v_4 allein von Null verschieden sind. Wir wollen als Anfangszustand ein solches in der x_3-Richtung "polarisiertes" Elektron annehmen, wo also entweder

$$u_3 v_3 = \frac{1}{(2\pi h)^3}, \quad u_4 = v_4 = 0$$

$$\text{od.} \quad u_4 v_4 = \frac{1}{(2\pi h)^3}, \quad u_3 = v_3 = 0$$

Auch bei beliebigen p führt die Anwesenheit eines Magnetfelds bestimmte Beziehungen mit sich, auf die wir jedoch hier nicht eingehen werden. Wie man aber leicht sieht, ~~x~~ bekommt man bei der erwähnten Polarisationsrichtung des Elektrons u. der getroffenen Matrixwahl nur dann bei allen Winkel (insbesondere $n'=n$) eine von dem Zeichen der Polarisation unabhängige Intensität der Streustrahlung, wenn die beiden Grösse $v_3(p')u_3(p')$ und $v_4(p')u_4(p')$ die den Endzustand charakterisieren einander gleich sind, d.h. wenn

$$a_1'^2 = a_2'^2 = \frac{1}{2(2\pi h)^3}\left(1 + \frac{mc^2}{E'}\right) = \gamma \qquad (27)$$

wie dies ja jedenfalls bei $p'=0$ der Fall sein würde.

Wenn wir die Grösse H'^2 berechnen, so bekommen wir wie ersichtlich einen bilinearen Ausdruck in den Grössen d, s und $\bar{d}, \bar{s}$, den wir sodann nach den Phasen von u & v im Anfangs- und Endzustand mitteln müssen. Wir können nun leicht mit Hilfe der Diracschen Matrixdarstellung der Grössen $\sigma_1 \sim \sigma_3$

$$\sigma_1 = \left(\quad \right) \qquad \sigma_2 = \left(\quad \right) \qquad \sigma_3 = \left(\quad \right) \qquad (28)$$

die Mittelwerte von $d\bar{S}_1$, $S_1\bar{S}_2$ etc. ermitteln. Nehmen wir erstens an, dass $v_3(p)\,u_3(p) = 1$, $v_4(p)\,u_4(p) = 0$, so folgt aus der Definition (7) der Grössen S & $\bar{S}$, d & $\bar{d}$

$$\left.\begin{aligned} S_1 &= v_3(p)\,u_4(p'), & S_2 &= -i\,v_3(p)\,u_4(p'), & S_3 &= v_3(p)\,u_3(p') \\ \bar{S}_1 &= v_4(p')\,u_3(p), & \bar{S}_2 &= i\,v_4(p')\,u_3(p), & \bar{S}_3 &= v_3(p')\,u_3(p) \end{aligned}\right\} (29)$$

$$d = v_3(p)\,u_3(p'), \quad \bar{d} = v_3(p')\,u_3(p)$$

Es folgt

$$\begin{aligned} \overline{(S\bar{S})} &= v_3(p)\,u_3(p)\left(2v_4(p')\,u_4(p') + v_3(p')\,u_3(p')\right) \\ &= \frac{3}{2(2\pi h)^6}\left(1 + \frac{mc^2}{E'}\right) = 3\gamma \qquad (30) \end{aligned}$$

Weiter

$$\begin{aligned} \overline{[S\bar{S}]_1} = \overline{[S\bar{S}]_2} = 0, \quad \overline{[S\bar{S}]_3} &= S_1\bar{S}_2 - S_2\bar{S}_1 = 2i\,v_3(p)\,u_3(p)\,v_4(p')\,u_4(p') \\ &= 2i\,\frac{1}{2(2\pi h)^6}\left(1 + \frac{mc^2}{E'}\right) = 2i\gamma \qquad (31) \end{aligned}$$

wo der Strich über die Grössen $[S\bar{S}]$ den Mittelwert nach den Phasen andeutet. Wenn wir mit l einen Einheitsvektor in der Richtung des polarisierenden Magnetfeldes bezeichnen (in dem eben betrachteten Fall die x_3-Richtung) so gilt also allgemein

$$\overline{[S\bar{S}]} = \frac{2i}{2(2\pi h)^6}\left(1+\frac{mc^2}{E'}\right)l \quad , \qquad (32)$$

wenn ~~Wir~~ wir den zu dem Eigenwert +1 von (αl) gehörige Lösung als Anfangszustand annehmen, und ebenso bei der anderen Lösung wo $(\alpha l) = -1$

$$\overline{[S\bar{S}]} = -\frac{2i}{2(2\pi h)^6}\left(1+\frac{mc^2}{E'}\right)l \qquad (32a)$$

also allgemein $\overline{[S\bar{S}]} = 2i(\alpha l)\gamma l$.

Seien nun A & B 2 beliebige Vektoren, so bekommen wir ebenso

$$\overline{(AS)(B\bar{S})} = \left((AB) + i(A_1B_2 - A_2B_1)\right)\gamma$$

oder allgemein

$$\overline{(AS)(B\bar{S})} = \left\{(AB) + i(\alpha l)(l[AB])\right\}\gamma \qquad (33)$$

& $$\overline{[AS][B\bar{S}]} = \left\{2(AB) + i(\alpha l)(l[AB])\right\}\gamma$$

Ferner

$$\overline{(AS)\bar{d}} = A_3\gamma = (\alpha l)(Al)\gamma \quad \& \quad \overline{d(B\bar{S})} = (\alpha l)(Bl)\gamma \quad (34)$$

& also auch

$$\overline{s\bar{d}} = \overline{d\bar{s}} = \gamma l(\alpha l) \qquad (35)$$

& endlich: $\overline{d\bar{d}} = \gamma$ (36)

Mit Hilfe von diesen Rechnenregeln können wir nun den Ausdruck $\overline{H'^2}$ ausrechnen. Wir müssen dabei ~~den~~ den in (23) ausgeschriebenen Ausdruck mit seinem konj. kompl. Wert multiplizieren, der sich ergibt in dem wir erstens i durch $-i$, zweitens ε durch $\bar{\varepsilon}$ & drittens S & d durch $\bar{S}$ & $\bar{d}$ ersetzen. Wenn es sich um linear polarisierte

Licht handelt, wie wir zuerst annehmen wollen, können wir $\mathcal{E}$ als reell annehmen, so dass $\bar{\mathcal{E}} = \mathcal{E}$ wird. Es heben sich dann nach (35) alle Produktglieder von d mit $\bar{S}$ & $\bar{d}$ mit S weg. Dies bedeutet, dass der Teil der S-Glieder strahlung, welche mit der d-Gliedstrahlung kohärent ist senkrecht zu der letzteren polarisiert ist. Man sieht nun weiter aus den Ausdrücken (27), dass der Teil der Strahlung welche mit der Komponent von S nach der Richtung l polarisiert ist, mit der d-Strahlung kohärent ist, während der Teil der von den zu l senkrechten Komponenten von S abhängt mit der übrigen Strahlung ~~i~~inkohärent ist. Es ist deshalb zweckmässig S in zwei Komponenten S_1 und S_2 zu zerlegen, von denen erstere mit l parallel ist während letztere zu dieser Richtung senkrecht steht.
Wir setzen also

$$S = S_1 + S_2$$

wo $\quad S_1 = (S l)\, l, \qquad S_2 = S - (S l)\, l = [l[S l]]$

& entsprechend für $\bar{S}$.

Da der Ausdruck (23) in S & $\bar{S}$ linear ist, zerfällt er einfach in zwei Ausdrücken wo S bezw. durch S_1 & S_2 ersetzt ist. Um die entsprechenden Intensitäten berechnen zu können, müssen wir den Formeln (30) bis (36) entsprechende Rechnenregeln für $S_1, \bar{S}_1$, & $S_2, \bar{S}_2$ aufstellen. Es folgt unmittelbar

$$(S_1 \bar{S}_1) = (S l)(\bar{S} l) = \gamma \qquad (38)$$

$$(S_2 \bar{S}_2) = 2\gamma$$

Ferner $\overline{[S_1 \bar{S}_1]} = 0 \quad \overline{[S_2 \bar{S}_2]} = [S \bar{S}] = 2 i \gamma l (\sigma l)$ (39)

$$\overline{(A S_1)(B \bar{S}_1)} = (Al)(Bl)\gamma, \quad \overline{(A S_2)(B S_2)} = \overline{(AS)(B\bar{S})} - \overline{(A S_1)(B S_1)}$$

$$= \left\{ (AB) - (Al)(Bl) + i (\sigma l)(l [AB]) \right\} \gamma \qquad (40)$$

$$[A S_1][B \bar{S}_1] = \left\{ (AB) - (Al)(Bl) \right\} \gamma$$

$$[A S_2][B \bar{S}_2] = \left\{ (AB) + (Al)(Bl) + i (\sigma l)(l [AB]) \right\} \gamma .$$

$\boxed{191}$ 1.

$$\Big\{d\Big(\frac{1}{\nu}(n'\varepsilon)(\nu'-\nu)[n'n]-\nu'\Big(\frac{1}{\nu}+\frac{1}{\nu'}\Big)^2\frac{mc^2}{h}[n'\varepsilon]\Big)$$
$$-i\Big(\Big(\frac{1}{\nu'}-\frac{1}{\nu}\Big)\Big[(S,\,n\nu-n'\nu')\big((n'\varepsilon)n-(n'n)\varepsilon\big)+\Big(\nu-\nu'+\frac{2mc^2}{h}\Big)\big((Sn')\varepsilon-(n'\varepsilon)S\big)\Big]$$
$$+\frac{2}{\nu}(\varepsilon n')\Big((n'S)(n\nu-n'\nu')+\big(\nu'-(nn')\nu\big)S\Big)-$$
$$-\Big(\frac{1}{\nu'}+\frac{1}{\nu}\Big)\Big((n[\varepsilon S])\nu[n'n]+\nu'(n'[n\varepsilon])[n'S]\Big)\Big)\Big\}$$

$$\frac{1}{\nu}(\nu'-\nu)=\frac{-\beta}{1+\beta}$$

$S=v(p)\alpha u(p')$

$d=v(p)u(p')$

$\bar S=v(p')\alpha u(p)$

$\bar d=v(p')u(p)$

$\beta=\alpha(1-(nn'))$

$$\nu'\Big(\frac{1}{\nu}+\frac{1}{\nu'}\Big)^2\frac{mc^2}{h}=\nu'\frac{1}{\nu^2}(2+\beta)^2\frac{\nu}{\alpha}=\frac{\nu'}{\nu}(2+\beta)^2\frac{1}{\alpha}=\frac{(2+\beta)^2}{(1+\beta)\alpha}$$

$$d\Big(\frac{1}{\nu}(n'\varepsilon)(\nu'-\nu)[n'n]-\nu'\Big(\frac{1}{\nu}+\frac{1}{\nu'}\Big)^2\frac{mc^2}{h}[n'\varepsilon]\Big)$$
$$=d\Big((n'\varepsilon)\frac{\beta}{1+\beta}[n'n]-\frac{(2+\beta)^2}{\alpha(1+\beta)}[n'\varepsilon]\Big)$$
$$=\frac{d}{1+\beta}\Big\{[n',\,n\cdot\beta(n'\varepsilon)]-\Big[n',\,\frac{\varepsilon(2+\beta)^2}{\alpha}\Big]\Big\}=\frac{d}{1+\beta}\Big\{\Big[n',\,n\cdot\beta(n'\varepsilon)-\frac{\varepsilon(2+\beta)^2}{\alpha}\Big]\Big\}$$
$$=\frac{d(2+\beta)^2}{\alpha(1+\beta)}\Big\{\Big[n',\,\frac{\alpha\beta n}{(2+\beta)^2}(n'\varepsilon)-\varepsilon\Big]\Big\}$$
$$=-\frac{d\{2+\alpha(1-(nn'))\}^2}{\alpha\{1+\alpha(1-(nn'))\}}\Big[n',\,\varepsilon-n\cdot\frac{\alpha^2(1-(nn'))}{\{2+\alpha(1-(nn'))\}^2}(n'\varepsilon)\Big]=dA.$$

$$\Big(\frac{1}{\nu'}-\frac{1}{\nu}\Big)\Big\{(S,\,n\nu-n'\nu')\big((n'\varepsilon)n-(nn')\varepsilon\big)+\Big(\nu-\nu'+\frac{2mc^2}{h}\Big)\big((Sn')\varepsilon-(n'\varepsilon)S\big)\Big\}$$
$$=\frac{\beta}{\nu}\Big\{\nu\Big(S,\,n-n'\frac{1}{1+\beta}\Big)(n'\varepsilon)n+\Big(-\nu\Big(S,\,n-\frac{n'}{1+\beta}\Big)(nn')+k(Sn')\Big)\varepsilon-k(n'\varepsilon)S\Big\}$$

$$\frac{2}{\nu}(\varepsilon n')\Big((n'S)(n\nu-n'\nu')+\big(\nu'-(nn')\nu\big)S\Big)$$
$$=\frac{2}{\nu}(n'\varepsilon)\Big\{\nu(n'S)\Big(n-\frac{n'}{1+\beta}\Big)+\nu\Big(\frac{1}{1+\beta}-(nn')\Big)S\Big\}$$
$$=2(n'\varepsilon)\Big\{(n'S)\Big(n-\frac{n'}{1+\beta}\Big)+\Big(\frac{1}{1+\beta}-(nn')\Big)S\Big\}$$

$$-\Big(\frac{1}{\nu'}+\frac{1}{\nu}\Big)\Big((n[\varepsilon S])\nu[n'n]+\nu'(n'[n\varepsilon])[n'S]\Big)$$

$$= -\frac{1}{\gamma}(2+\beta)\Big(\big(S[n\mathcal{E}]\big)\gamma[n'n] + \gamma'\big(\mathcal{E}[n'n]\big)[n'S]\Big)$$

$$= -(2+\beta)\Big(\big(S[n\mathcal{E}]\big)[n'n] + \frac{1}{1+\beta}\big(\mathcal{E}[n'n]\big)[n'S]\Big)$$

$\therefore$ Total

$$= n\Big[\beta\big(S, n - \frac{n'}{1+\beta}\big)(n'\mathcal{E}) + 2(n'\mathcal{E})(n'S)\Big]$$

$$+\mathcal{E}\Big[\frac{\beta K}{\gamma}(Sn') - \beta\big(S, n - \frac{n'}{1+\beta}\big)(nn')\Big]$$

$$+S\Big[2(n'\mathcal{E})\Big(\frac{1}{1+\beta} - (nn')\Big) - \frac{3K}{\gamma}(n'\mathcal{E})\Big]$$

$$-\frac{2(n'\mathcal{E})(n'S)}{1+\beta}n' - [n'n](2+\beta)\big(S,[n\mathcal{E}]\big) - [n'S]\frac{2+\beta}{1+\beta}\big(\mathcal{E}[n'n]\big)$$

$\beta(Sn) - \frac{\beta}{1+\beta}(Sn') + 2(Sn')$

$$= n\Big[(n'\mathcal{E})\Big\{\beta(nS) + \frac{2+\beta}{1+\beta}(n'S)\Big\}\Big]$$

$$+\mathcal{E}\Big[\cancel{(Sn')\frac{\beta}{\alpha(1+\beta)}(2+\beta+\alpha+\alpha\beta)(Sn')}\ \frac{\beta}{\alpha(1+\beta)}(2+\beta+\alpha+\alpha\beta)(Sn') - \beta(nn')(Sn)\Big]$$

$$+S(n'\mathcal{E})\frac{\beta(2+\beta)}{1+\beta} - \frac{2(n'\mathcal{E})(n'S)}{1+\beta}n' - (2+\beta)\big(S,[n\mathcal{E}]\big)[n'n] - \frac{2+\beta}{1+\beta}[n'S]\big(\mathcal{E}[n'n]\big)$$

$$= (nS)\Big[n(n'\mathcal{E})\beta - \mathcal{E}(nn')\beta\Big]$$

$$+(n'S)\Big[n(n'\mathcal{E})\frac{2+\beta}{1+\beta} + \mathcal{E}\frac{\beta}{\alpha(1+\beta)}(2+\beta+\alpha+\alpha\beta) - \frac{2(n'\mathcal{E})}{1+\beta}n'\Big]$$

$$-\big([Sn]\mathcal{E}\big)(2+\beta)[n'n] - [n'S]\frac{2+\beta}{1+\beta}\big(\mathcal{E}[n'n]\big)$$

$$-S(n'\mathcal{E})\frac{\beta(2+\beta)}{1+\beta}.$$

1-Comp. $(n_1S_1 + n_2S_2 + S_3n_3)\Big[n_1(n'\mathcal{E})\beta + \mathcal{E}_1(nn')\beta\Big]$

$$+(n_1'S_1 + n_2'S_2 + n_3'S_3)\Big[n_1(n'\mathcal{E})\frac{\beta+2}{1+\beta} + \mathcal{E}_1\frac{\beta}{\alpha(1+\beta)}(2+\beta+\alpha+\alpha\beta) - \frac{2(n'\mathcal{E})}{1+\beta}n_1'\Big]$$

$$+\Big\{(S_2n_3 - S_3n_2)\mathcal{E}_1 + (S_3n_1 - S_1n_3)\mathcal{E}_2 + (S_1n_2 - S_2n_1)\mathcal{E}_3\Big\}(2+\beta)[n'n],$$

$$-(n_2' S_3 - n_3' S_2)\frac{2+\beta}{1+\beta}\left(\mathcal{E}[n'n]\right) - S_1 (n'\mathcal{E})\frac{\beta(2+\beta)}{1+\beta}$$

$$= (n_1S_1+n_2S_2)\left[n_1(n'\mathcal{E})\beta + \mathcal{E}_1(nn')\beta\right]$$

$$+ (n_1'S_1+n_2'S_2)\left[n_1(n'\mathcal{E})\frac{\beta+2}{1+\beta} + \mathcal{E}_1\frac{\beta}{\alpha(1+\beta)}(2+\beta+\alpha+\alpha\beta) - \frac{2(n'\mathcal{E})}{1+\beta}n_1'\right]$$

$$+\left\{S_2 n_3\mathcal{E}_1 - S_1 n_3 \mathcal{E}_2 + (S_1 n_2 - S_2 n_1)\mathcal{E}_3\right\}(2+\beta)[n'n],$$

$$+ n_3'\frac{2+\beta}{1+\beta}S_2\left(\mathcal{E}[n'n]\right) - S_1(n'\mathcal{E})\frac{\beta(2+\beta)}{1+\beta}$$

$$+ S_3\Big\{ n_3\left[n_1(n'\mathcal{E})\beta+\mathcal{E}_1(nn')\beta\right] + n_3'\left[n_1(n'\mathcal{E})\frac{\beta+2}{1+\beta} + \mathcal{E}_1\frac{\beta}{\alpha(1+\beta)}(2+\beta+\alpha+\alpha\beta) - \frac{2(n'\mathcal{E})}{1+\beta}\right]$$
$$+ n_1\mathcal{E}_2 - \mathcal{E}_1 n_2 - n_2'\frac{2+\beta}{1+\beta}\left(\mathcal{E}[n'n]\right)\Big\}.$$

$$\text{Total} = (n_1S_1+n_2S_2)\left[n(n'\mathcal{E})\beta \mp \mathcal{E}(nn')\beta\right]$$
$$+ (n_1'S_1+n_2'S_2)\left[n(n'\mathcal{E})\frac{\beta+2}{1+\beta} + \mathcal{E}\frac{\beta}{\alpha(1+\beta)}(2+\beta+\alpha+\alpha\beta) - \frac{2(n'\mathcal{E})}{1+\beta}n'\right]$$
$$+ \left(S_1[n\mathcal{E}]_1 + S_2[n\mathcal{E}]_2\right)(2+\beta)[n'n] - \frac{2+\beta}{1+\beta}\left(\mathcal{E}[n'n]\right) j S_1$$
$$- \frac{2+\beta}{1+\beta}\left(\mathcal{E}[n'n]\right) k S_2 - (n'\mathcal{E})\frac{\beta(2+\beta)}{1+\beta} x S_1 - (n'\mathcal{E})\frac{\beta(2+\beta)}{1+\beta} y S_2$$
$$+ S_3\Big\{ n_3\left[n(n'\mathcal{E})\beta \mp \mathcal{E}(nn')\beta\right] + n_3'\left[n(n'\mathcal{E})\frac{2+\beta}{1+\beta} + \mathcal{E}\frac{\beta}{\alpha(1+\beta)}(2+\beta+\alpha+\alpha\beta) - \frac{2(n'\mathcal{E})}{1+\beta}n'\right] - \frac{2+\beta}{1+\beta}\left(\mathcal{E}[n'n]\right) l - (n'\mathcal{E})\frac{\beta(2+\beta)}{1+\beta} z$$
$$+ [n\mathcal{E}]_3(2+\beta)[n'n]\Big\}$$

$x(1,0,0)$
$y(0,1,0)$
$z(0,0,1)$
$j(0, n_3', -n_2')$
$k(-n_3', 0, n_1')$
$l(n_2', -n_1', 0)$

* Suppose $u_3 v_3 = \frac{1}{(2\pi h)^3}$, $u_4 = v_4 = 0$.

$\therefore\ S_3 = d \qquad S_2 = -iS_1$

$\therefore$ Total $= S_1 C \mp i S_1 D + dB$

where
$$C = n_1\left[n(n'\mathcal{E})\beta - \mathcal{E}(nn')\beta\right]$$
$$+ n_1'\left[n(n'\mathcal{E})\frac{\beta+2}{1+\beta} + \mathcal{E}\frac{\beta}{\alpha(1+\beta)}(2+\beta+\alpha+\alpha\beta) - \frac{2(n'\mathcal{E})}{1+\beta}n'\right]$$
$$+ [n\mathcal{E}]_1(2+\beta)[n'n] - \frac{2+\beta}{1+\beta}(\mathcal{E}[n'n])j - (n'\mathcal{E})\frac{\beta(2+\beta)}{1+\beta}x$$

$$D = n_2\left[n(n'\mathcal{E})\beta - \mathcal{E}(nn')\beta\right]$$
$$+ n_2'\left[n(n'\mathcal{E})\frac{\beta+2}{1+\beta} + \mathcal{E}\frac{\beta}{\alpha(1+\beta)}(2+\beta+\alpha+\alpha\beta) - \frac{2(n'\mathcal{E})}{1+\beta}n'\right]$$
$$+ [n\mathcal{E}]_2(2+\beta)[n'n] - \frac{2+\beta}{1+\beta}(\mathcal{E}[n'n])k - (n'\mathcal{E})\frac{\beta(2+\beta)}{1+\beta}y$$

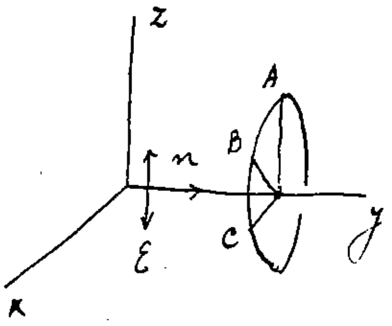
$$B = n_3\left[n(n'\mathcal{E})\beta - \mathcal{E}(nn')\beta\right] \cancel{+ n_3'[n(n'\mathcal{E})\beta\,2+\beta}$$
$$+ n_3'\left[n(n'\mathcal{E})\frac{2+\beta}{1+\beta} + \mathcal{E}\frac{\beta}{\alpha(1+\beta)}(2+\beta+\alpha+\alpha\beta) - \frac{2(n'\mathcal{E})}{1+\beta}n'\right]$$
$$+ [n\mathcal{E}]_3(2+\beta)[n'n] - \frac{2+\beta}{1+\beta}(\mathcal{E}[n'n])l - (n'\mathcal{E})\frac{\beta(2+\beta)}{1+\beta}z$$

$$H' = \cancel{\text{const}}\,\frac{(2\pi h)^3 e^2 \nu'}{2mc^2(\nu-\nu'+\frac{2mc^2}{h})h}\left\{d(A\mp iB) \mp S_1(D+iC)\right\} e^{i\nu'(t-\frac{r}{c})}$$
$+$ complex conjugate term

$$A = -\frac{\{2+\alpha(1-(nn'))\}^2}{\alpha\{1+\alpha(1-(nn'))\}}\left[n',\ \mathcal{E} - n\cdot\frac{\alpha^2(1-(nn'))}{\{2+\alpha(1-(nn'))\}^2}(n'\mathcal{E})\right]$$

For linearly polarised light A, B, C & D are real.

$\therefore$ $d(A-iB)$ & $S_1(D+iC)$, each constitutes ~~each~~ an elliptically polarised ~~[illegible]~~ light, which is incoherent each other.



$n_1=0,\ n_2=1,\ n_3=0$ $\mathcal{E}_x=0\ \ \mathcal{E}_y=0,\ \ \mathcal{E}_3=\mathcal{E}$.

Ⓐ $n_1'=0,\ n_2'=0,\ n_3'=1$

Ⓑ $n_1'=\frac{1}{\sqrt{2}},\ n_2'=0,\ n_3'=\frac{1}{\sqrt{2}}$. $\Big\}\ (nn')=0$.

Ⓒ $n_1'=1,\ n_2'=0,\ n_3'=0$.

Ⓐ.

$$A = -\frac{\{2+\alpha\}^2}{\alpha(1+\alpha)}\left[n', \mathcal{E} - n\,\frac{\alpha^2}{(2+\alpha)^2}(n'\mathcal{E})\right] \qquad [n', n]$$

$= +\frac{\alpha}{1+\alpha}\mathcal{E}$ in direction of x.

$$B = \mathcal{E}^y\frac{2+\alpha}{1+\alpha} + \mathcal{E}^z\frac{\alpha/}{1+\alpha}(2+2\alpha+\alpha^2) - \frac{2\mathcal{E}^z}{1+\alpha} - \mathcal{E}\frac{\alpha(2+\alpha)}{1+\alpha}{}_z.$$

$$= \left|\mathcal{E}\frac{2+\alpha}{1+\alpha}\right|_y + \left|\mathcal{E}\frac{\alpha(2+\alpha)}{1+\alpha}\right|_z - \left|\mathcal{E}\frac{\alpha(2+\alpha)}{1+\alpha}\right|_z = \left|\mathcal{E}\frac{2+\alpha}{1+\alpha}\right|_y.$$

$$C = |\mathcal{E}(2+\alpha)|_x\ \cancel{\frac{2+\alpha}{1+\alpha}} - \left|\mathcal{E}\frac{\alpha(2+\alpha)}{1+\alpha}\right|_x = \left|\mathcal{E}\frac{(2+\alpha)}{1+\alpha}\right|_x.$$

$$D = |\alpha\mathcal{E}|_y - \left|\mathcal{E}\frac{\alpha(2+\alpha)}{1+\alpha}\right|_y = \left|-\mathcal{E}\frac{\alpha}{1+\alpha}\right|_y$$

$$A - iB = \left|\frac{\alpha}{1+\alpha}\mathcal{E}\right|_x - i\left|\mathcal{E}\frac{2+\alpha}{1+\alpha}\right|_y.$$

$$-(D+iC) = \left|\frac{\alpha}{1+\alpha}\mathcal{E}\right|_y - i\left|\mathcal{E}\frac{2+\alpha}{1+\alpha}\right|_x.$$

Ⓒ

$$A = \left|+\frac{(2+\alpha)^2}{\alpha(1+\alpha)}\frac{\alpha^2}{(2+\alpha)^2}\mathcal{E}\right|_z = \cancel{\frac{\mathcal{E}\alpha}{1+\alpha}} - \left|\frac{(2+\alpha)^2}{\alpha(1+\alpha)}\mathcal{E}\right|_y + \left|\mathcal{E}\frac{\alpha}{1+\alpha}\right|_z =$$

$$-\left|\frac{(2+\alpha)^2}{\alpha(1+\alpha)}\mathcal{E}\right|_y +$$

$\frac{3.9}{1.7} = 2.35^2$

$\frac{1+(1.7)^2}{1.7}$ $\frac{.3}{2.3}$

$\alpha = 1.5$ $\frac{.16}{2.16}$

$\frac{1+(1.5)^2}{(1.5)}$ $\frac{3.25}{1.5} = 2.16$

$\frac{1+(1.3)^2}{1.3} = \frac{2.69}{1.3} = 2.07$

$+\frac{(1+\alpha)^2}{(1+\alpha)^4}\mathcal{E}^2 - 2\mathcal{E}^2$

$\frac{.07}{2.07}$ $= 1.67^2 - 1.35^2$ $\frac{.33}{1.67}$ $.65 - 2.$ $.65$

$\frac{1+(1.4)^2}{1.4}$ 1.96 $\frac{2.96}{1.4}$

$2.11 - 2$ $.2$ $.3$

1 4.5

$\frac{1+(1.45)^2}{1.45}$

$$B = \left|\varepsilon(2+\alpha)\right|_y + \left|\frac{2+\alpha}{1+\alpha}\varepsilon\right|_y = \varepsilon\left|\frac{(2+\alpha)^2}{1+\alpha}.\right|_y$$

$$C = \left|\varepsilon\,\frac{1}{1+\alpha}(2+2\alpha+\alpha^2)\right|_y .$$

$$D = -\left|\frac{2+\cancel{\alpha}}{1+\cancel{\alpha}}\,\varepsilon\right|_z$$

$$A - iB = -\left|\frac{(2+\alpha)^2}{\alpha(1+\alpha)}\varepsilon\right|_y + \left|\varepsilon\frac{\alpha}{1+\alpha}\right|_z - i\left|\varepsilon\,\frac{(2+\alpha)^2}{1+\alpha}\right|_y$$

$$-(D+iC) = \left|\frac{2+\alpha}{1+\alpha}\varepsilon\right|_z - i\left|\varepsilon\,\frac{2+2\alpha+\alpha^2}{1+\alpha}\right|_y .$$

$\mathcal{E}^2$-term $= \frac{4K}{\alpha\nu}\left\{\frac{\nu}{\nu'}+\frac{\nu'}{\nu}\right\}\mathcal{E}^2$

$(n'\mathcal{E})^2$-term $= -\frac{8K}{\alpha\nu}(n'\mathcal{E})^2$

$$\cancel{I = \frac{e^4}{2m^2c^4r^2}\left(\frac{\nu'}{\nu}\right)^3\left\{2\left(\frac{\nu}{\nu'}+\frac{\nu'}{\nu}\right)\mathcal{E}^2\right.}$$

$$I = \frac{e^4}{m^2c^4r^2}\left(\frac{\nu'}{\nu}\right)^3\cdot\frac{1}{8}\,\frac{\alpha\nu}{K}\left[\frac{4K}{\alpha\nu}\left(\frac{\nu}{\nu'}+\frac{\nu'}{\nu}\right)\mathcal{E}^2-\frac{8K}{\alpha\nu}(n'\mathcal{E})^2\right]$$

$$= \frac{e^4}{2m^2c^4r^2}\left(\frac{\nu'}{\nu}\right)^3\left[\left(\frac{\nu}{\nu'}+\frac{\nu'}{\nu}\right)\mathcal{E}^2-\cancel{\frac{2K}{\alpha}}\;2\,(n'\mathcal{E})^2\right]$$

$$\frac{\nu'}{\nu} = \frac{1}{1+\alpha(1-(nn'))} \qquad \frac{\nu}{\nu'} = 1+\alpha(1-(nn'))$$

$$\therefore\quad \frac{\nu'}{\nu}+\frac{\nu'}{\nu} = \frac{1+(1+\alpha(1-(nn')))^2}{1+\alpha(1-(nn'))}$$

$$\therefore\; I = \frac{e^4}{2m^2c^4r^2}\,\frac{1}{(1+\alpha(1-(nn')))^3}\left\{\frac{1+(1+\alpha(1-(nn')))^2}{1+\alpha(1-(nn'))}\mathcal{E}^2-2(n'\mathcal{E})^2\right\}$$

$\mathcal{E}^2$-term $= \frac{4k}{\alpha\nu}\left\{\frac{\nu}{\nu'}+\frac{\nu'}{\nu}\right\}\mathcal{E}^2$

$(n'\mathcal{E})^2$-term $= -\frac{8k}{\alpha\nu}(n'\mathcal{E})^2$

$$\cancel{I = \frac{e^4}{2m^2c^4r^2}\left(\frac{\nu'}{\nu}\right)^3\left\{2\left(\frac{\nu}{\nu'}+\frac{\nu'}{\nu}\right)\mathcal{E}^2\right.}$$

$$I = \frac{e^4}{m^2c^4r^2}\left(\frac{\nu'}{\nu}\right)^3\cdot\frac{1}{8}\frac{\alpha\nu}{k}\left[\frac{4k}{\alpha\nu}\left(\frac{\nu}{\nu'}+\frac{\nu'}{\nu}\right)\mathcal{E}^2-\frac{8k}{\alpha\nu}(n'\mathcal{E})^2\right]$$

$$= \frac{e^4}{2m^2c^4r^2}\left(\frac{\nu'}{\nu}\right)^3\left[\left(\frac{\nu}{\nu'}+\frac{\nu'}{\nu}\right)\mathcal{E}^2-\cancel{\frac{2k}{\alpha}}\,2\,(n'\mathcal{E})^2\right]$$

$$\frac{\nu'}{\nu} = \frac{1}{1+\alpha(1-(nn'))} \qquad \frac{\nu}{\nu'} = 1+\alpha(1-(nn'))$$

$$\therefore\quad \frac{\nu'}{\nu}+\frac{\nu'}{\nu} = \frac{1+(1+\alpha(1-(nn')))^2}{1+\alpha(1-(nn'))}$$

$$\therefore\quad I = \frac{e^4}{2m^2c^4r^2}\frac{1}{(1+\alpha(1-(nn')))^3}\left\{\frac{1+(1+\alpha(1-(nn')))^2}{1+\alpha(1-(nn'))}\mathcal{E}^2-2(n'\mathcal{E})^2\right\}$$

1.

$\boxed{192}$

$n = E \times H$ $\quad J = ce\varphi'\alpha\psi$

$'J = cs = ce\varphi'\alpha\psi$

$$J_{\mathfrak{M}} = ce\int d\mathfrak{M}'\Big[\{G_2\alpha u' + v\alpha F_1'\}e^{\frac{i}{\hbar}[(E+h\nu-E')t-(\mathfrak{M}+\frac{h\nu}{c}n-\mathfrak{M}')r]}$$
$$+\{G_1'\alpha u + v'\alpha F_2\}e^{-\frac{i}{\hbar}[(E+h\nu-E')t-(\mathfrak{M}+\frac{h\nu}{c}n-\mathfrak{M}')r]}\Big]$$

$$\mathfrak{A}_{\mathfrak{M}} = \frac{e}{R}\int dv\int d\mathfrak{M}' \ldots$$
$$= \frac{e}{R}(2\pi\hbar)^3\Big\{(G_2\alpha u' + v\alpha F_1')e^{i\nu'(t-\frac{R}{c})} + (G_1'\alpha u + v'\alpha F_2)e^{-i\nu'(t-\frac{R}{c})}\Big\}$$

$$G_2 = \frac{e}{2mch\nu}v[(QH)-(PE)] \qquad Q = h\alpha \quad P = ih\alpha$$

$$F_1' = \frac{-e}{2mch\nu'}[2(aM') + (QH) + (P\mathcal{E})]u.$$

$$G_2\alpha u' = \frac{e}{2mch\nu}v[h(\alpha H) - ih(\alpha\mathcal{E})]\alpha u'$$
$$= \frac{e\hbar}{2mch\nu}v[(\alpha H)\alpha - i(\alpha\mathcal{E})\alpha]u'$$

$$v\alpha F_1' = \frac{-e\,v\alpha}{2mch\nu'}[2(aM') + h(\hat{\alpha}H) + ih(\alpha\mathcal{E})]u'$$
$$= \frac{-e\hbar v}{2mch\nu'}\Big[\frac{2(aM')}{h}\alpha + \alpha(\alpha H) + i\alpha(\alpha\mathcal{E})\Big]u'$$

$$\Big[\frac{E'}{c} + \rho_1(\alpha M') + \rho_3 mc\Big]u' = 0.$$

$$v\Big[\frac{E'}{c}(\alpha H)\alpha + (\alpha H)\alpha(\alpha M') + (\alpha H)\alpha\rho_3 mc\Big]u' = 0. \qquad \rho_1\hat{\alpha}(\alpha H) \quad -\alpha(\alpha H)\rho_3.$$

$$v[1+\rho_3] = 0 \qquad \therefore\ v[(H\hat{\alpha})\alpha - (\alpha H)\alpha\rho_3] = 0 \qquad \therefore\ v(\alpha H)\alpha\rho_3 = +v(H\hat{\alpha})\alpha$$

$$\therefore\ v\Big[\Big(\frac{E'}{c}+mc\Big)(\alpha H)\alpha\Big]u' = -v\big[(\alpha H)\alpha(\alpha M')\big]u'$$

$$(\alpha H)\alpha_1 = (\alpha_1 H_1 + \alpha_2 H_2 + \alpha_3 H_3)\alpha_1 = H_1 - i\alpha_3 H_2 + i\alpha_2 H_3 = H_1 + i[\alpha H]_1$$

$$\underline{(\alpha H)\alpha = H + i[\alpha H]}$$

$$\underline{\alpha(\alpha H) = H - i[\alpha H]}$$

$$\therefore\ (\alpha H)\alpha + \alpha(\alpha H) = 2H.$$

$$\therefore\ [(\alpha H)\,\alpha(\alpha M')] = [\{2H - \alpha(\alpha H)\}(\alpha M')] = 2H(\alpha M') - \alpha(\alpha H)(\alpha M')$$

$$= 2H(\alpha M') - \alpha(HM') - i\alpha(\alpha, H\times M')$$

$$= 2H(\alpha M') - \alpha(HM') - i[H\times M'] - [\alpha, [H\times M']]$$

$$= 2H(\alpha M') - \alpha(HM') - i[H\times M'] - H(\alpha M') + M'(\alpha H).$$

$$= H(\alpha M') - \alpha(HM') - i[H\times M'] + M'(\alpha H)$$

$$\otimes\ \therefore\ v'[(\alpha H)\alpha]u' = \frac{+1}{\frac{E'}{c} + mc}\, v'\left[-H(\alpha M') + \alpha(HM') + i[H\times M'] - M'(\alpha H)\right]u'$$

$$-v\left[\left(\frac{E'}{c} + mc\right)\alpha(\alpha H)\right]u' = +v[\alpha(\alpha H)(\alpha M')]u'$$

$$\otimes\ \therefore -v[\alpha(\alpha H)]u' = \frac{1}{\frac{E'}{c} + mc}\, v\left[H(\alpha M') + \alpha(HM') + i[H\times M'] - M'(\alpha H)\right]u'$$

$$v\left[\frac{E'}{c}\alpha + \alpha(\alpha M') + \alpha\rho_1\rho_3 mc\right]u' = 0.$$

$$v[\alpha\rho_1 + \rho_3\alpha\rho_1] = 0$$

$$v(\alpha\rho_1) - v\rho_1\alpha\rho_3 = 0.$$

$$v(\alpha) = v\alpha\rho_3.$$

$$v\left[\left(\frac{E'}{c} + mc\right)\alpha\right] = -v[\alpha(\alpha M')]u'$$

$$= -v[M' - i[\alpha M']]$$

$$\otimes\ \therefore -v\alpha = \frac{1}{\frac{E'}{c} + mc}\left[-i[\alpha M'] + M'\right]$$

$$-i(\alpha\mathcal{E})\alpha = (\alpha\mathcal{E})\alpha = -i\mathcal{E} \pm \overset{\nu'}{} [\alpha\mathcal{E}]$$
$$-i\alpha(\alpha\mathcal{E}) = \alpha(\alpha\mathcal{E}) = -i\mathcal{E} \mp \underset{\nu}{} [\alpha\mathcal{E}]$$

$$-\frac{i\nu}{c}a = E$$
$$a\nu = +icE$$

$$G_2\alpha u' + v\alpha F_1' = \frac{e}{2mc\nu\nu'} v\Big[\nu'(\alpha H)\alpha - \nu\alpha(\alpha H) - i\nu'(\alpha\mathcal{E})\alpha - i\nu\alpha(\alpha\mathcal{E}) - 2\frac{\nu(aM')}{h}\alpha\Big]u'$$

$$= \frac{e}{2mc\nu\nu'} v\Big[\frac{1}{\frac{E'}{c}+mc}\Big\{H(\alpha M')(\nu-\nu') + \alpha(HM')(\nu+\nu') + i[H\times M'](\nu+\nu') - M'(\alpha H)(\nu+\nu') + \frac{2(aM')\nu}{h}(M' - i[\alpha\times M'])\Big\} - i\mathcal{E}(\nu+\nu') - [\alpha\mathcal{E}](\nu-\nu')\Big]u'$$

$$\frac{1}{\frac{E'}{c}+mc}\Big[i[H\times M'](\nu+\nu') + \frac{2ic(\mathcal{E}M')M'}{h} - i\left(\frac{E'}{c}+mc\right)\mathcal{E}(\nu+\nu')\Big]$$

$$[H\times M'] = \Big[H\times\left(\frac{h\nu}{c}n - \frac{h\nu'}{c}n'\right)\Big] = \frac{h\nu}{c}[H\times n] - \frac{h\nu'}{c}[H\times n'] = \frac{h\nu}{c}E - \frac{h\nu'}{c}[H\times n']$$
$$= \frac{h\nu}{c}\mathcal{E} + \frac{h\nu'}{c}\{n(n'\mathcal{E}) - \mathcal{E}(nn')\}.$$

$$\left(\frac{E'}{c}+mc\right)\mathcal{E} = \left(2mc + \frac{h\nu}{c} - \frac{h\nu'}{c}\right)\mathcal{E} = 2mc\mathcal{E} + \frac{h\nu}{c}\mathcal{E} - \frac{h\nu'}{c}\mathcal{E}.$$

$$(\mathcal{E}M')M' = \left(\mathcal{E}, \frac{h\nu}{c}n - \frac{h\nu'}{c}n'\right)M' = -\frac{h\nu'}{c}(n'\mathcal{E})\left(\frac{h\nu}{c}n - \frac{h\nu'}{c}n'\right)$$
$$= -\frac{h^2}{c^2}\nu\nu' n(n'\mathcal{E}) + \frac{h^2}{c^2}\nu'^2 n'(n'\mathcal{E}).$$

$$[H\times M'](\nu+\nu') = \frac{h\nu}{c}\mathcal{E}(\nu+\nu') + \frac{h\nu'}{c}(\nu+\nu')\{n(n'\mathcal{E}) - \mathcal{E}(nn')\}$$

$$\frac{h\nu'\nu}{c}n(n'\mathcal{E}) + \frac{h\nu'^2}{c}n(n'\mathcal{E})$$

$$\int_0^x dx$$

8.4

$$-\left(\frac{E'}{c}+mc\right)\mathfrak{E}(\nu+\nu') = -2mc(\nu+\nu')\mathfrak{E} - \frac{h\nu}{c}(\nu+\nu')\mathfrak{E} + \frac{h\nu'}{c}(\nu+\nu')\mathfrak{E}$$

$$\frac{2c(\mathfrak{E}\mathfrak{M}')\mathfrak{M}'}{h} = -\cancel{2}\frac{h\nu'\cancel{\nu}}{c}n(n'\mathfrak{E}) + 2\frac{h\nu'^2}{c}n'(n'\mathfrak{E})$$

$$\therefore \frac{i}{\frac{E'}{c}+mc}\left[[H\times M'](\nu+\nu') + \frac{2c(\mathfrak{E}M')M'}{h} - \left(\frac{E'}{c}+mc\right)\mathfrak{E}(\nu+\nu')\right]$$

$$= \frac{i}{\frac{E'}{c}+mc}\left[\frac{h\nu'}{c}n(n'\mathfrak{E})(\overset{\nu'-\nu}{\cancel{\nu+\nu'}}) + (\nu+\nu')\left\{\frac{h\nu'}{c} - \frac{h\nu'}{c}(nn') - 2mc\right\}\mathfrak{E}\right]$$ 消してある.

$$\frac{h\nu'}{c}(1-(nn')) - 2mc \qquad +2\frac{h\nu'^2}{c}n'(n'\mathfrak{E})$$

$$= \frac{i}{\frac{E'}{c}+mc}\left[\frac{h\nu'}{c}n(n'\mathfrak{E})(\nu'-\nu) - \frac{(\nu+\nu')^2}{\nu}mc\,\mathfrak{E}\right.$$

$$\left. + \frac{2h\nu'^2}{c}n'(n'\mathfrak{E})\right]:$$

$$\frac{2h\nu\nu'}{mc^2} + 2\frac{mc^2}{h}$$

$$\nu' = \frac{\nu}{1+\frac{h\nu}{mc^2}(1-(nn'))} \qquad \nu' + \frac{h\nu\nu'}{mc^2}(1-(nn')) = \nu$$

$$\frac{\nu'}{\nu}mc + \frac{h\nu'}{\cancel{m}c}(1-(nn')) = mc$$

$$\therefore \frac{h\nu'}{\cancel{m}c}(1-(nn')) - 2mc = -\left(\frac{\nu'}{\nu}+1\right)mc = -\left(\frac{\nu+\nu'}{\nu}\right)cm$$

$$\therefore \mathfrak{A}_m = \frac{e}{R}(2\pi h)^3\frac{e}{2mc\nu\nu'}\frac{\cancel{1}\,v}{\frac{E'}{c}+mc}\left[H(\alpha M')(\nu-\nu') + \alpha(HM')(\nu+\nu') - \right.$$

$$- M'(\alpha H)(\nu+\nu') - i\,2\frac{(\alpha M')\nu}{h}[\alpha\times M']$$

$$\left. -\left(\frac{E'}{c}+mc\right)(\nu-\nu')[\alpha\mathfrak{E}]\right] + u'$$

$$+ i\left\{\frac{h\nu'}{c}n(n'\mathfrak{E})(\nu'-\nu) - \frac{(\nu+\nu')^2}{\nu}mc\mathfrak{E} + \frac{2h\nu'^2}{c}n'(n'\mathfrak{E})\right\}$$

$$\overline{\mathfrak{A}_m} = \frac{e^2}{R}(2\pi h)^3\frac{i\ \ v}{2mc\nu\nu'\left(2mc+\frac{h}{c}(\nu-\nu')\right)}\left\{\frac{h\nu'}{c}n(n'\mathfrak{E})(\nu'-\nu) - \frac{(\nu+\nu')^2}{\nu}mc\mathfrak{E}\right.$$

$$\left. + 2\frac{h\nu'^2}{c}n'(n'\mathfrak{E})\right\}u'$$

$$\overline{H}_{\mathfrak{M}} = \frac{e^2}{2mc^2R}\;\frac{1 \qquad\quad \nu}{\nu\left(2mc+\frac{h}{c}(\nu-\nu')\right)}\left\{\frac{h\nu'}{c}[n'\times n](n'\mathcal{E})(\nu'-\nu^2) \pm mc\,[n'\times\mathcal{E}]\,\frac{(\nu+\nu')^2}{\nu}\right\}u'$$

$$H(\alpha M')(\nu-\nu') = (\nu-\nu')\left\{\frac{h\nu}{c}H(n\alpha) - \frac{h\nu'}{c}H(n'\alpha)\right\}$$

$$\alpha(HM')(\nu+\nu') = -(\nu+\nu')\,\frac{h\nu'}{c}\,\alpha(n'H).$$

$$-M'(\alpha H)(\nu+\nu') = -(\nu+\nu')\left\{\frac{h\nu}{c}n(\alpha H) - \frac{h\nu'}{c}n'(\alpha H)\right\}.$$

$$M_1'^2$$

$$-[\alpha\mathcal{E}]\left(\frac{E'}{c}+mc\right)(\nu-\nu') = -\frac{1}{h}[\alpha\mathcal{E}]M'^2 = -\left\{H(n\alpha)-n(\alpha H)\right\}\left(\left(\frac{h\nu}{c}\right)^2+\left(\frac{h\nu'}{c}\right)^2 - 2\frac{h^2\nu\nu'}{c^2}(nn')\right)$$

$$-i\,\frac{2(\alpha M')\nu}{h}[\alpha\times M'] = +\frac{i\,2\cancel{h}\nu\nu'}{\cancel{h}c}(\alpha n')[\alpha M'] = -2\nu'(n'E)[\alpha M']$$

$$G_1'\alpha u = \frac{-e}{2mch\nu'}\,v'\left\{2(\tilde{\alpha}\mathfrak{M}') - (P\tilde{\mathcal{E}}) + (Q\tilde{H})\right\}\alpha u$$

$$= \frac{-e}{2mch\nu'}\,v'\left\{2(\tilde{\alpha}\mathfrak{M}') - ih(\alpha\tilde{\mathcal{E}}) + h(\alpha\tilde{H})\right\}\alpha u$$

$$= \frac{-e}{2mc\nu'}\,v'\left\{2\frac{(\tilde{\alpha}\mathfrak{M}')}{h}\alpha - i(\alpha\tilde{\mathcal{E}})\alpha + (\alpha\tilde{H})\alpha\right\}u$$

$$v'\alpha F_2 = \frac{e}{2mch\nu}\,v'\alpha\left\{(P\tilde{\mathcal{E}}) + (Q\tilde{H})\right\}u$$

$$= \frac{e}{2mc\nu}\,v'\alpha\left\{i(\alpha\tilde{\mathcal{E}}) + (\alpha\tilde{H})\right\}u$$

$$= \frac{e}{2mc\nu}\,v'\left\{i\alpha(\alpha\tilde{\mathcal{E}}) + \alpha(\alpha\tilde{H})\right\}u.$$

$$v'\left[\frac{E'}{c} + \rho_1(\alpha M') + \rho_3 mc\right] = 0 \qquad [1+\rho_3]u = 0 \quad \left[(\alpha\tilde{H})\alpha - \rho_3(\alpha\tilde{H})\alpha\right]u = 0.$$

$$v'\left[\frac{E'}{c}(\alpha\tilde{H})\alpha + (\alpha M')(\alpha\tilde{H})\alpha + mc\,\rho_3(\alpha\tilde{H})\alpha\right]u = 0$$

$$v'\left[\left(\frac{E'}{c}+mc\right)(\alpha\tilde{H})\alpha + (\alpha M')(\alpha\tilde{H})\alpha\right]u = 0$$

$$\therefore -v'\nu\,[(\alpha\tilde{H})\alpha]u = \frac{1}{\frac{E'}{c}+mc}\,v'\left[(\alpha M')(\alpha\tilde{H})\alpha\right]u.$$

$$(\alpha M')(\alpha \tilde{H}) = (M'\tilde{H}) + i(\alpha, M' \times H)$$

$$\therefore (\alpha M')(\alpha \tilde{H})\alpha = \alpha(M'\tilde{H}) + i[M' \times \tilde{H}] - [\alpha[M' \times \tilde{H}]]$$

$$= \alpha(M'\tilde{H}) + i[M' \times \tilde{H}] - M'(\alpha\tilde{H}) + \tilde{H}(\alpha M').$$

$$\otimes \therefore -v'\nu[(\alpha\tilde{H})\alpha]u = \frac{\nu}{\frac{E'}{c}+mc} v'\left[\alpha(M'\tilde{H}) - i[H \times M'] - M'(\alpha\tilde{H}) + \tilde{H}(\alpha M')\right]$$

$$\otimes\, v'\left[\frac{E'}{c}\alpha(\alpha\tilde{H}) + (\alpha M')\alpha(\alpha\tilde{H}) + mc\rho_3\alpha(\alpha\tilde{H})\right]u = 0.$$

$$\therefore v'\nu'[\alpha(\alpha\tilde{H})]u = \frac{\nu'}{\frac{E'}{c}+mc} v'\left[-(\alpha M')\alpha(\alpha\tilde{H})\right]u.$$

$$-(\alpha M')\alpha(\alpha H) = -(\alpha M')\left(2H - (\alpha H)\alpha\right) = -2H(\alpha M') + (\alpha M')(\alpha H)\alpha$$

$$= -2\tilde{H}(\alpha M') + \alpha(M'\tilde{H}) - i[\tilde{H} \times M'] - M'(\alpha\tilde{H}) + \tilde{H}(\alpha M').$$

$$\otimes \therefore v'\nu'[\alpha(\alpha\tilde{H})]u = \frac{\nu'}{\frac{E'}{c}+mc} v'\left[-2\tilde{H}(\alpha M') + \alpha(M'\tilde{H}) - i[\tilde{H} \times M'] - M'(\alpha\tilde{H})\right]u$$

$$v'\left[\frac{E'}{c}\alpha + (\alpha M')\alpha + \rho_3\rho_1\alpha\, mc\right]u = 0.$$

$$\otimes\, -v'\nu[\alpha]u = \frac{\nu}{\frac{E'}{c}+mc} v'\left[(\alpha M')\alpha\right]u$$

$$= \frac{\nu}{\frac{E'}{c}+mc} v'\left[M' + i[\alpha M']\right].$$

$$\otimes\, i\nu v'(\alpha\tilde{\mathfrak{E}})\alpha u = i\nu v'(\alpha\tilde{\mathfrak{E}})\alpha = \nu v'\left\{i\tilde{\mathfrak{E}} - [\alpha\tilde{\mathfrak{E}}]\right\}u$$

$$\otimes\, i\nu' v'\alpha(\alpha\tilde{\mathfrak{E}}) = i\nu' v'\alpha(\alpha\tilde{\mathfrak{E}}) = \nu' v'\left\{i\tilde{\mathfrak{E}} + [\alpha\tilde{\mathfrak{E}}]\right\}u.$$

$$G_2\alpha u' + v\alpha F_1' = \frac{e\, v'}{2mc\nu\nu'}\left\{\nu'\alpha(\alpha\tilde{H}) - \nu(\alpha\tilde{H})\alpha + i\nu'\alpha(\alpha\tilde{\mathfrak{E}}) + i\nu(\alpha\tilde{\mathfrak{E}})\alpha - \frac{2\nu(\tilde{\alpha}M')}{h}\alpha\right\}u$$

$$= \frac{e}{2mc\nu\nu'}\nu'\Big[\frac{1}{\frac{E'}{c}+mc}\Big\{\tilde{H}(\alpha M')(\nu-\nu')+\alpha(M'\tilde{H})(\nu+\nu')-i[\tilde{H}\times M'](\nu+\nu')$$
$$-M'(\alpha\tilde{H})(\nu+\nu')+2\frac{\nu(\tilde{\alpha}M')}{h}\{M'+i[\alpha M']\}$$
$$+i\tilde{\mathfrak{E}}(\nu+\nu')-[\alpha\tilde{\mathfrak{E}}](\nu-\nu')\Big]u$$

$$\bar{\gamma} = \frac{c}{4\pi}[\mathfrak{E}H] = \frac{c}{4\pi}|H|^2 = \frac{c}{4\pi}\frac{\nu'^2}{c^2}\left([n'\mathfrak{A}][n'\tilde{\mathfrak{A}}]\right)$$
$$= \frac{\nu'^2}{4\pi c}\left\{(\mathfrak{A}\tilde{\mathfrak{A}})-(n'\mathfrak{A})(n'\tilde{\mathfrak{A}})\right\}$$

$$\mathfrak{A}_m = \mathfrak{A}e^{i\nu(t-\frac{R}{c})}+\tilde{\mathfrak{A}}e^{-i\nu(t-\frac{R}{c})}$$
$$\tilde{\mathfrak{A}}_m = \tilde{\mathfrak{A}}e^{-i\nu(t-\frac{R}{c})}+\mathfrak{A}e^{+i\nu(t-\frac{R}{c})}.$$

$$\therefore \overline{\mathfrak{A}_m\tilde{\mathfrak{A}}_m} = 2\mathfrak{A}\tilde{\mathfrak{A}}. \qquad (n'\mathfrak{A}_m)(n'\tilde{\mathfrak{A}}_m) = 2(n'\mathfrak{A})(n'\tilde{\mathfrak{A}}).$$

$$S = \chi + \xi k_1 + \eta k_2 + \zeta k_3 \qquad i k_r = \sigma_r \quad \text{or} \quad k_r = -i\sigma_r .$$

$$\therefore \quad S = \chi - i(\xi\sigma_1 + \eta\sigma_2 + \zeta\sigma_3)$$

Put $S = b_0 - i\sum_1^3 b_k \sigma_k \qquad S^{-1} = b_0 + i\sum_1^3 b_k\sigma_k \qquad \therefore SS^{-1} = b_0^2 + \sum_1^3 b_k^2 = 1.$

$$\left.\begin{aligned}
b_0 &= \cos\tfrac12\theta\cos\tfrac12(\psi+\varphi)\\
b_1 &= \sin\tfrac12\theta\sin\tfrac12(\psi-\varphi)\\
b_2 &= \sin\tfrac12\theta\cos\tfrac12(\psi-\varphi)\\
b_3 &= \cos\tfrac12\theta\sin\tfrac12(\psi+\varphi)
\end{aligned}\right\}$$

$$\begin{aligned}
S\sigma_1 S^{-1} &= (b_0 - ib_1\sigma_1 - ib_2\sigma_2 - ib_3\sigma_3)\sigma_1(b_0 + ib_1\sigma_1 + ib_2\sigma_2 + ib_3\sigma_3)\\
&= \sigma_1(b_0 - ib_1\sigma_1 + ib_2\sigma_2 + ib_3\sigma_3)(b_0 + ib_1\sigma_1 + ib_2\sigma_2 + ib_3\sigma_3)\\
&= \sigma_1\left\{b_0^2 + b_1^2 - b_2^2 - b_3^2 + 2ib_0b_2\sigma_2 + 2ib_0b_3\sigma_3 + 2ib_1b_2\sigma_3 - 2ib_1b_3\sigma_2\right\}\\
&= (b_0^2 + b_1^2 - b_2^2 - b_3^2)\sigma_1 - 2(b_0b_2 - b_1b_3)\sigma_3 + 2(b_0b_3 + b_1b_2)\sigma_2
\end{aligned}$$

$$\begin{aligned}
b_0^2 + b_1^2 - b_2^2 - b_3^2 &= \cos^2\tfrac12\theta\cos^2\tfrac12(\psi+\varphi) + \sin^2\tfrac12\sin^2\tfrac12(\psi-\varphi).\\
&\quad - \sin^2\tfrac12\theta\cos^2\tfrac12(\psi-\varphi) - \cos^2\tfrac12\sin^2\tfrac12(\psi+\varphi).\\
&= \cos^2\tfrac12\theta\left\{\cos^2\tfrac12(\psi+\varphi) - \sin^2\tfrac12(\psi+\varphi)\right\}\\
&\quad + \sin^2\tfrac12\theta\left\{\sin^2\tfrac12(\psi-\varphi) - \cos^2(\psi-\varphi)\right\}\\
&= \cos^2\tfrac12\theta\cdot\cos(\psi+\varphi) - \sin^2\tfrac12\theta\cos(\psi-\varphi)\\
&= \cancel{\cos\psi\cos\varphi}\ \cos\theta\cos\psi\cos\varphi - \sin\psi\sin\varphi
\end{aligned}$$

$$(b_0^2 + b_1^2 - b_2^2 - b_3^2)^2 = \cos^2\theta\cos^2\psi\cos^2\varphi + \sin^2\psi\sin^2\varphi - \tfrac12\cos\theta\sin2\psi\sin2\varphi$$

$$\overline{(\qquad\qquad)}^2 = \tfrac18 + \tfrac14 = \tfrac38 \quad \sigma_1$$

$$2(b_0b_2 - b_1b_3) = 2\Big(\sin\tfrac{1}{2}\theta\cos\tfrac{1}{2}\theta\,\sin\tfrac{1}{2}(\psi-\varphi)\cos\tfrac{1}{2}(\psi+\varphi)$$
$$-\sin\tfrac{1}{2}\theta\cos\tfrac{1}{2}\theta\,\cos\tfrac{1}{2}(\psi-\varphi)\sin\tfrac{1}{2}(\psi+\varphi)\Big)$$
$$= \cancel{2}-\sin\theta\sin\varphi$$
$$\therefore\ \overline{2(b_0b_2-b_1b_3)^2} = \frac{1}{4}. \qquad \sigma_3$$
$$2(b_0b_3+b_1b_2) = \cancel{\tfrac{1}{2}}\cos^2\tfrac{1}{2}\theta\,\sin(\psi+\varphi) + \cancel{\tfrac{1}{2}}\sin^2\tfrac{1}{2}\theta\,\sin(\psi-\varphi).$$
$$= \cancel{\tfrac{1}{2}}\sin\psi\cos\varphi + \cancel{\tfrac{1}{2}}\cos\theta\cos\psi\sin\varphi.$$
$$\overline{2(b_0b_3+b_1b_2)^2} = \sin^2\psi\cos^2\varphi + \cos^2\theta\cos^2\psi\sin^2\varphi + \tfrac{1}{2}\cos\theta\sin 2\psi\sin 2\varphi$$
$$\overline{2(b_0b_3+b_1b_2)^2} = \frac{3}{8}. \qquad \sigma_2$$

$$\therefore\ \text{Total} = 1.$$

$$\therefore (v\alpha u')(v'\alpha u) = (vu')(v'u).$$

$$(\mathfrak{A}\mathfrak{A}^2) = \frac{e^4}{4m^2c^2\nu^2\nu'^2R^2}(2\pi h)^6\frac{1}{\left(\frac{E'}{c}+mc\right)^2}\Big[\ H^2(\alpha M')^2(\nu-\nu')^2 + \cancel{(\alpha H)}\,M'\cdot 3(M'H)(M'\tilde{H})(\nu+\nu')^2$$
$$v(\alpha M')u'v'(\alpha M')$$
$$+M'^2\,{}^{v}(\alpha H)^{u'v'}(\alpha\tilde{H})^{u}(\nu+\nu')^2 + \frac{4\nu^2}{h^2}(aM')(\tilde{a}M')\ \ {}^{v}[\alpha M']^{u'v'}[\alpha M']^{u}$$
$$+\left(\frac{E'}{c}+mc\right)^2(\nu\pm\nu')^2\,{}^{v}[\alpha\mathfrak{E}]^{u'v'}[\alpha\tilde{\mathfrak{E}}]^{u} + {}_{v}\Big\{\underbrace{\frac{h\nu'}{c}n(n'\mathfrak{E})(\nu-\nu') - \frac{(\nu+\nu')^2}{\nu}mc\,\mathfrak{E}}_{X}$$
$$+\frac{2h\nu\nu'}{c}n'(n'\mathfrak{E})\Big\}_{u'v'}\Big\{\underbrace{\frac{h\nu'}{c}n(n'\tilde{\mathfrak{E}})(\nu-\nu') + \frac{(\nu+\nu')^2}{\nu}mc\,\tilde{\mathfrak{E}} + \frac{2h\nu\nu'}{c}n'(n'\tilde{\mathfrak{E}})}_{\tilde{X}}\Big\}_{u}$$
$$+\,{}^{v}(\alpha M')^{u'v'}(\alpha H)^{u}(M'\tilde{H})(\nu^2-\nu'^2) + {}^{v}(\alpha\tilde{H})^{u'v'}(\alpha M')^{u}(HM')(\nu^2-\nu'^2)$$
$$-\,{}^{v}(\alpha M')^{u'v'}(\alpha\tilde{H})^{u}(HM')(\nu^2-\nu'^2) - {}^{v}(\alpha H)^{u'v'}(\alpha M')^{u}(\tilde{H}M')(\nu^2-\nu'^2)$$
$$+i\frac{2\nu}{h}(\tilde{a}M')\,{}^{v}\Big(\cancel{\mathfrak{E}}(\alpha M')^{u'v'}H\cdot[\alpha M']\Big)^{u}(\nu-\nu') - 2i\frac{\nu}{h}(aM')\,{}^{v}\Big([\alpha M']\cdot\tilde{H}\Big)^{u'v'}(\alpha M')^{u}(\nu-\nu')$$

$$-\left(\frac{E'}{c}+mc\right)(\nu-\nu')^2\,(\alpha M')\left(H\cdot[\alpha\tilde{\mathcal{E}}]\right)-\left(\frac{E'}{c}+mc\right)(\nu-\nu')^2\left([\alpha\mathcal{E}]\cdot\tilde{H}\right)(\alpha M')$$

$$-i H(\alpha M')(\nu-\nu')(\tilde{X}H)+i\tilde{H}(\alpha M')(\nu-\nu')(X\tilde{H})$$

$$-(HM')(\nu+\nu')^2(\alpha M')(\alpha\tilde{H})-(\tilde{H}M')(\nu+\nu')^2(\alpha H)(\alpha M')$$

$$+\frac{2i\nu}{h}(\tilde{a}M')(HM')(\nu+\nu')\left(\alpha\cdot[\alpha M']\right)-\frac{2i\nu}{h}(aM')(M'\tilde{H})(\nu+\nu')\left([\alpha M']\alpha\right)$$

$$-\left(\frac{E'}{c}+mc\right)(\nu^2-\nu'^2)(HM')\left(\alpha\cdot[\alpha\tilde{\mathcal{E}}]\right)-\left(\frac{E'}{c}+mc\right)(\nu^2-\nu'^2)(M'\tilde{H})\left([\alpha\mathcal{E}]\alpha\right)$$

$$-i(HM')(\nu+\nu')(\alpha\tilde{X})+i(\tilde{H}M')(\nu+\nu')(\alpha X)$$

$$-\frac{2i\nu}{h}(\tilde{a}M')(\alpha H)\left(M'\cdot[\alpha M']\right)(\nu+\nu')+\frac{2i\nu}{h}(aM')\left([\alpha\times M']\cdot M'\right)(\alpha\tilde{H})$$

$$+i(\nu+\nu')(\alpha H)(M'\tilde{X})-i(\nu+\nu')(M'X)(\alpha\tilde{H})$$

$$+\left(\frac{E'}{c}+mc\right)(\nu^2-\nu'^2)(\alpha H)\left(M'\cdot[\alpha\tilde{\mathcal{E}}]\right)+\left(\frac{E'}{c}+mc\right)(\nu^2-\nu'^2)\left(M'\cdot[\alpha\mathcal{E}]\right)(\alpha\tilde{H})$$

$$+\frac{2i\nu}{h}(aM')\left(\frac{E'}{c}+mc\right)(\nu-\nu')\left([\alpha M']\cdot[\alpha\tilde{\mathcal{E}}]\right)-\frac{2i\nu}{h}(\tilde{a}M')\left(\frac{E'}{c}+mc\right)(\nu-\nu')\left([\alpha\mathcal{E}][\alpha M']\right)$$

$$-\frac{2(aM')\nu}{h}\left[[\alpha M']\cdot\tilde{X}\right]-\frac{2\nu}{h}(\tilde{a}M')\left(X\cdot[\alpha M']\right)$$

$$+i\left(\frac{E'}{c}+mc\right)(\nu-\nu')\left([\alpha\mathcal{E}]\cdot\tilde{X}\right)-i\left(\frac{E'}{c}+mc\right)(\nu-\nu')\left([\alpha\tilde{\mathcal{E}}]X\right)$$

$$+X\tilde{X}\ \Big]$$

$$(\mathfrak{A}\tilde{\mathfrak{A}}) = \frac{e^4}{4m^2c^2\nu^2\nu'^2 R^2 (2\pi h)^6} \frac{1}{\left(\frac{E'}{c}+mc\right)^2} \Big[H^2 (v(\alpha M')u)(v'(\alpha M')u)(\nu-\nu')^2$$
$$\cancel{3(M'H)(\tilde{M}\tilde{H})}(v\alpha u')(v'\alpha u)(HM')(\tilde{H}M')(\nu+\nu')^2$$
$$+ M'^2(\nu+\nu')^2 (v(\alpha H)u)(v'(\alpha\tilde{H})) + \frac{4\nu^2}{h^2}(aM')(\tilde{a}M')(v[\alpha M']u)(v'[\alpha M']u)$$
$$+ \left(\frac{E'}{c}+mc\right)^2(\nu-\nu')^2 (v[\alpha\mathfrak{E}]u)(v'[\alpha\tilde{\mathfrak{E}}]u) + (v\chi u')(v'\tilde{\chi}u)$$
$$+ (M'\tilde{H})(\nu^2-\nu'^2)(v(\alpha M')u')(v'(\alpha H)u) + (HM')(\nu^2-\nu'^2)(v(\alpha\tilde{H})u)(v'(\alpha M')u)$$
$$- (HM')(\nu^2-\nu'^2)(v(\alpha M')u')(v'(\alpha\tilde{H})u) - (\tilde{H}M')(\nu^2-\nu'^2)(v(\alpha H)u')(v'(\alpha M')u)$$
$$+ \frac{2i\nu}{h}(\tilde{a}M')(\nu^2-\nu')(v(\alpha M')u')(v'(H.[\alpha M'])u) - \frac{2i\nu}{h}(aM')(\nu-\nu')(v([\alpha M'].\tilde{H})u)(v'(\alpha M')u)$$
$$- \left(\frac{E'}{c}+mc\right)(\nu-\nu')^2(v(\alpha M')u)(v'(\cancel{H}.[\alpha\tilde{\mathfrak{E}}])u) - \left(\frac{E'}{c}+mc\right)(\nu-\nu')^2(v([\alpha\mathfrak{E}].\cancel{H})u')(v'(\alpha M')u)$$
$$- i(\nu-\nu')(v(\alpha M')u')(v'(\tilde{\chi}H)u') + i(\nu-\nu')(v(\chi\tilde{H})u')(v'(\alpha M')u)$$
$$- (HM')(\nu+\nu')^2(v(\alpha M')u')(v'(\alpha\tilde{H})u) - (\tilde{H}M')(\nu+\nu')^2(v(\alpha H)u')(v'(\alpha M')u)$$
$$+ \frac{2i\nu}{h}(\tilde{a}M')(HM')(\nu+\nu')(v(\alpha)u)(v'[\alpha M']u) - \frac{2i\nu}{h}(aM')(\tilde{H}M')(\nu+\nu')(v[\alpha M]u)(v'\alpha u)$$
$$- \left(\frac{E'}{c}+mc\right)(\nu^2-\nu'^2)(HM')(v(\alpha)u')(v'[\alpha\tilde{\mathfrak{E}}]u) - \left(\frac{E'}{c}+mc\right)(\nu^2-\nu'^2)(\tilde{H}M')(v[\alpha\mathfrak{E}]u')(v'\alpha u)$$
$$- i(HM')(\nu+\nu')(v\alpha u')(v'\tilde{\chi}u) + i(\tilde{H}M')(\nu+\nu')(v\chi u')(v'\alpha u)$$
$$- \frac{2i\nu}{h}(\tilde{a}M')(\nu+\nu')(v(\alpha H)u')(v'(\cancel{M}.[\alpha M'])u) + \frac{2i\nu}{h}(aM')(\nu+\nu')(v([\alpha M'] M')u')(v'(\alpha\tilde{H})u)$$
$$+ \left(\frac{E'}{c}+mc\right)(\nu^2-\nu'^2)(v(\alpha H)u')(v'(M'.[\alpha\tilde{\mathfrak{E}}])u) + \left(\frac{E'}{c}+mc\right)(\nu^2-\nu'^2)(v'(M'.[\alpha\mathfrak{E}])u)(v'(\alpha\tilde{H})u)$$
$$+ i(\nu+\nu')(v(\alpha H)u')(v'(M'\tilde{\chi})u) - i(\nu+\nu')(v(M'\chi)u')(v'(\alpha\tilde{H})u)$$
$$+ \frac{2i\nu}{h}(aM')\left(\frac{E'}{c}+mc\right)(\nu-\nu')(v[\alpha M']u')(v'[\alpha\tilde{\mathfrak{E}}]u) - \frac{2i\nu}{h}(\tilde{a}M)\left(\frac{E'}{c}+mc\right)(\nu-\nu')(v[\alpha\mathfrak{E}]u')(v'[\alpha M]u)$$
$$- \frac{2(aM')}{h}\nu(v[\alpha M']u')(v'\tilde{\chi}u) - \frac{2(\tilde{a}M')}{h}\nu(v\chi u')(v'[\alpha M']u)$$
$$+ i\left(\frac{E'}{c}+mc\right)(\nu-\nu')(v[\alpha\mathfrak{E}]u')(v'\tilde{\chi}u) - i\left(\frac{E'}{c}+mc\right)(\nu-\nu')(v\chi u)(v'[\alpha\tilde{\mathfrak{E}}]u)$$
$$+ \cancel{(v\chi u')(v'\tilde{\chi}u)} \Big]$$

$(v\sigma_1 u')(v'\sigma_2 u')$

$S\sigma_1 S^{-1} = (b_0^2+b_1^2-b_2^2-b_3^2)\sigma_1 - 2(b_0b_2-b_1b_3)\sigma_3 + 2(b_0b_3+b_1b_2)\sigma_2$

$S\sigma_2 S^{-1} = \sigma_2(b_0+ib_1\sigma_1-ib_2\sigma_2+ib_3\sigma_3)(b_0+ib_1\sigma_1+ib_2\sigma_2+ib_3\sigma_3)$

$= \sigma_2(b_0^2-b_1^2+b_2^2-b_3^2+2ib_0b_1\sigma_1+2ib_0b_3\sigma_3-2ib_1b_2\sigma_3+2ib_2b_3\sigma_1)$

$= (b_0^2-b_1^2+b_2^2-b_3^2)\sigma_2+2(b_0b_1+b_2b_3)\sigma_3+2(b_1b_2-b_0b_3)\sigma_1$

$b_0^2-b_1^2+b_2^2-b_3^2 = \cos^2\tfrac12\theta\cos^2\tfrac12(\psi+\varphi)-\sin^2\tfrac12\theta\sin^2\tfrac12(\psi-\varphi)$

$+\sin^2\tfrac12\theta\cos^2\tfrac12(\psi-\varphi)-\cos^2\tfrac12\theta\sin^2\tfrac12(\psi+\varphi).$

$= \cos^2\tfrac12\theta\cos(\psi+\varphi)+\sin^2\tfrac12\theta\cos(\psi-\varphi).$

$= \cancel{\cos\theta}\cos\psi\cos\varphi-\cos\theta\sin\varphi\sin\psi.$

$\overline{(\qquad)^2} = \frac38 \quad \sigma_2$

$2(b_0b_1+b_2b_3) = \sin\theta\cos\tfrac12(\psi+\varphi)\sin\tfrac12(\psi-\varphi)+\sin\theta\cos\tfrac12(\psi-\varphi)\sin(\psi+\varphi)$

$= \sin\theta\sin\psi.$

$\therefore \overline{2(b_0b_1+b_2b_3)} = \frac14. \quad \sigma_3$

$2(b_1b_2-b_0b_3) = \cancel{\sin\theta\{\cos\tfrac12(\psi+\varphi)}$

$\sin\psi\cos\varphi-\cos\psi\sin\varphi \qquad -\sin\psi\cos\varphi-\cos\psi\sin\varphi.$

$\sin^2\tfrac12\theta\sin(\psi-\varphi) - \cos^2\tfrac12\sin(\psi+\varphi)$

$= \cancel{-\sin\psi\cos\varphi+\cos\theta\cos\psi\sin\varphi} - \cos\psi\sin\varphi-\cos\theta\sin\psi\cos\varphi$

$\therefore \overline{2(b_1b_2-b_0b_3)} = \frac38 \quad \sigma_1$

$\therefore$ total $=1$.

$(S\sigma_1 S^{-1})(S\sigma_2 S^{-1})$

$= \{(b_0^2+b_1^2-b_2^2-b_3^2)\sigma_1 - 2(b_0 b_2 - b_1 b_3)\sigma_3 + 2(b_0 b_3 + b_1 b_2)\sigma_2\}$

$\{(b_0^2 - b_1^2 + b_2^2 - b_3^2)\sigma_2 + 2(b_0 b_1 + b_2 b_3)\sigma_3 + 2(b_1 b_2 - b_0 b_3)\sigma_1\}$

$= \{(\cos\theta\cos\psi\cos\varphi - \sin\psi\sin\varphi)\sigma_1 + (\sin\psi\cos\varphi + \cos\theta\cos\psi\sin\varphi)\sigma_2 - \sin\theta\sin\varphi\sigma_3\}$

$\{(\cancel{\cos\psi\cos\varphi - \cos\theta\sin\varphi\sin\psi})$

$(\sin\psi\cos\varphi \cancel{+\cos\theta\cos\psi\sin\varphi})\sigma_1 \mp (\cos\psi\cos\varphi - \cos\theta\sin\varphi\sin\psi)\sigma_2 + \sin\theta\sin\psi\sigma_3\}$

$-(\cos\theta\sin\psi\cos\varphi + \cos\psi\sin\varphi)$

$\therefore \ \overline{(S\sigma_1 S^{-1})(S\sigma_2 S^{-1})} = 0 \cdot \overline{(S\sigma_2 S^{-1})(S\sigma_1 S^{-1})} = 0.$

$S\sigma_3 S^{-1} = \sigma_3(b_0 + ib_1\sigma_1 + ib_2\sigma_2 - ib_3\sigma_3)(b_0 + ib_1\sigma_1 + ib_2\sigma_2 + ib_3\sigma_3).$

$= \sigma_3(b_0^2 - b_1^2 - b_2^2 + b_3^2 + 2ib_0 b_1\sigma_1 + 2ib_0 b_2\sigma_2 + 2ib_1 b_3\sigma_2 - 2ib_2 b_3\sigma_1)$

$= (b_0^2 - b_1^2 - b_2^2 + b_3^2)\sigma_3 + 2(b_2 b_3 - b_0 b_1)\sigma_2 + 2(b_0 b_2 + b_1 b_3)\sigma_1$

$b_0^2 - b_1^2 - b_2^2 + b_3^2 = \cos^2\frac{1}{2}\theta - \sin^2\frac{1}{2}\theta = \cos\theta. \quad \therefore \overline{(\quad)^2} = \frac{1}{2}. \quad \sigma_3$

$2(b_2 b_3 - b_0 b_1) = \sin\theta\{\sin\frac{1}{2}(\psi+\varphi)\cos\frac{1}{2}(\psi-\varphi) - \cos\frac{1}{2}(\psi+\varphi)\sin(\psi-\varphi)\}$

$= \sin\theta\sin\varphi. \quad \overline{(\quad)^2} = \frac{1}{4} \quad \sigma_2$

$2(b_0 b_2 + b_1 b_3) = \sin\theta\{\cos\frac{1}{2}(\psi+\varphi)\cos\frac{1}{2}(\psi-\varphi) + \sin\frac{1}{2}(\psi+\varphi)\sin\frac{1}{2}(\psi+\varphi)\}$

$= \sin\theta\cos\varphi. \quad \overline{(\quad)^2} = \frac{1}{4}. \quad \sigma_1$

$(S\sigma_2 S^{-1})(S\sigma_3 S^{-1})$

$= \{-(\cos\theta\sin\psi\cos\varphi + \cos\psi\sin\varphi)\sigma_1 + (\cos\psi\cos\varphi - \cos\theta\sin\varphi\sin\psi)\sigma_2 + \sin\theta\sin\psi\sigma_3\}$

$\times\{\sin\theta\cos\varphi\,\sigma_1 + \sin\theta\sin\varphi\,\sigma_2 + \cos\theta\,\sigma_3\}$

$$\therefore \overline{(S\alpha_3 S^{-1})(S\alpha_2 S^{-1})} = \overline{(S\alpha_2 S^{-1})(S\alpha_3 S^{-1})} = 0$$

$$\therefore \overline{\{v(\alpha M')u'\}\{v'(\alpha M')u\}}$$

$$= \overline{\{v(\alpha_1 M_1' + \alpha_2 M_2' + \alpha_3 M_3')u'\}\{v'(\alpha_1 M_1' + \alpha_2 M_2' + \alpha_3 M_3')u\}}$$

$$= \overline{(v(\alpha_1 M_1')u')(v'(\alpha_1 M_1')u)} + \overline{(v(\alpha_2 M_2')u')(v'(\alpha_2 M_2')u)} + \overline{(v(\alpha_3 M_3')u')(v'(\alpha_3 M_3')u')}$$

$$= \cancel{\alpha M} \quad \underbrace{\left(\overline{\alpha M'} \cdot \overline{\alpha M'}\right)}$$

$$= \cancel{\{M_1'^2 + M_2'^2 + M_3'^2\}\{(vu')(v'u)\}} = \underline{M'^2 (vu')(v'u)}.$$

$$= \cancel{M} \quad M'^2 (vu')(v'u).$$

$$(v\alpha u')(v'\alpha u) = (vu')(v'u)$$

$v \alpha u' = s \qquad v' \alpha u = \tilde{s}$

Voraussetzung $\quad s_1 \tilde{s}_1 = (vu')_{(v'u)} \; s_1 \tilde{s}_2 = \tilde{s}_2 \tilde{s}_1 = \cdots \quad = 0$

$(s\tilde{s}) = 3(vu')(v'u) \qquad (As)(B\tilde{s}) = (AB)(vu')(v'u).$

$([AsA][\tilde{s}B]) = (s\tilde{s})(AB) - (\tilde{s}A)(sB)$
$= \{3(AB) - AB\}(vu')(v'u)$
$= 2(AB)(vu')(v'u)$

$H^2(v(\alpha M')u')(v'(\alpha M')u)(v-v')^2 \cdot (v-v')^2$

$= \cancel{H^2(\alpha M')(\alpha}\; = |H|^2\{(sM')(\tilde{s}M')\} = |H|^2 M'^2 (vu')(v'u)_{(v-v')^2}$

$(v\alpha u')(v'\alpha u)(HM')(\tilde{H}M')(v+v')^2 \qquad (s[\tilde{s}M']) = ([s\tilde{s}]M') = 0$

$= 3(HM')(\tilde{H}M')(v+v')^2(vu')(v'u).$

$M'^2(v+v')^2(v(\alpha H)u')(v'(\alpha\tilde{H})) = M'^2(v+v')^2|H|^2(vu')(v'u)$

$\frac{4v^2}{h^2}(aM')(\tilde{a}M')(v[\alpha M']u')(v'[\alpha M']u) = \frac{4v^2}{h^2}(aM')(\tilde{a}M')M'^2(vu')(v'u)$

$(\frac{E'}{c}+mc)^2(v-v')^2(v[\alpha\mathfrak{E}]u')(v'[\alpha\tilde{\mathfrak{E}}]u) = 2(\frac{E'}{c}+mc)^2(v-v')^2|\mathfrak{E}|^2$

$(v\chi u')(v'\tilde{\chi}u) = |\chi|^2(vu')(v'u) \qquad (v(\alpha \overset{H}{M'})u')(v'(\overset{M}{H}.[\alpha \overset{\mathfrak{E}}{M'}]))$
$= (\overset{H}{s}M')(\overset{M}{H}.[\overset{\mathfrak{E}}{\tilde{s}}M']) = (s\overset{H}{M'})(\tilde{s}.[\overset{\mathfrak{E}}{M'}\overset{M}{H}])$
$= (\overset{H}{M'}[\overset{\mathfrak{E}}{M'}\overset{M}{H}])(vu')(v'u)$
$= (H[M'xM']) \cdots = 0$

$- (HM')(v+v')^2(v(\alpha M')u')(v'(\alpha\tilde{H})u) - (\tilde{H}M')(v+v')^2(v(\alpha H)u')(v'(\alpha M')u)$
$= \{-(HM')(\tilde{H}M') - (\tilde{H}M')(HM')\}(v+v')^2 = -2(HM')(\tilde{H}M')(v+v')^2(vu')(v'u)$

$+\frac{4iv}{h}(aM')(\frac{E'}{c}+mc)(v-v')(\tilde{\mathfrak{E}}M') - \frac{4iv}{h}(\frac{E'}{c}+mc)(v-v')(\tilde{a}M')(\mathfrak{E}M').$

$= +\frac{4iv}{h}(\frac{E'}{c}+mc)(v-v')\{(aM')(\tilde{\mathfrak{E}}M') - (\tilde{a}M')(\mathfrak{E}M')\}(uv')(v'u).$

$\therefore (\mathfrak{O}\tilde{\mathfrak{O}}) = \frac{e^4}{4m^2c^4v^2v'^2R^2}(2\pi h)^6 \frac{1}{(\frac{E'}{c}+mc)^2}\Big[|H|^2M'^2(v-v')^2 + (HM')(\tilde{H}M')(v+v')^2 +$

$+|H|^2M'^2(v+v')^2 + \frac{4v^2}{h^2}(aM')(\tilde{a}M')M'^2 + 2(\frac{E'}{c}+mc)^2(v-v')^2|\mathfrak{E}|^2 + |\chi|^2$

$- \frac{8 c}{h}(\frac{E'}{c}+mc)(v-v')(\mathfrak{E}M')(\tilde{\mathfrak{E}}M')\Big](uv')(v'u)$

$$[n'X\mathfrak{R}] = \frac{e^2}{R}\,\frac{1}{2mc\nu\nu'}\,\frac{(2\pi h)^3}{\left(\frac{E'}{c}+mc\right)}\,\nu\Big[[n'H](\alpha M')(\nu-\nu') + [n'\alpha](HM')(\nu+\nu') -$$

$$-[n'M'](\alpha H)(\nu+\nu') - \frac{2i\nu}{h}(aM')\big[n'[\alpha M']\big] - \left(\frac{E'}{c}+mc\right)(\nu-\nu')\big[n'[\alpha\mathcal{E}]\big] + i[n'X]\Big]u'$$

$$[n'X\tilde{\mathfrak{R}}] = \frac{e^2(2\pi h)^3}{2mcR\nu\nu'\left(\frac{E'}{c}+mc\right)}\,\nu'\Big[[n'\tilde{H}](\alpha M')(\nu-\nu') + [n'\alpha](\tilde{H}M')(\nu+\nu') -$$

$$-[n'M'](\alpha\tilde{H})(\nu+\nu') + \frac{2i\nu}{h}(\tilde{a}M')\big[n'[\alpha M']\big] - \left(\frac{E'}{c}+mc\right)(\nu-\nu')\big[n'[\alpha\tilde{\mathcal{E}}]\big] - i[n'\tilde{X}]\Big]u$$

$$\overline{[n'X\mathfrak{R}][n'X\tilde{\mathfrak{R}}]} = \frac{e^4(2\pi h)^6}{4m^2c^2R^2\nu^2\nu'^2\left(\frac{E'}{c}+mc\right)^2}\,\nu\Big[\qquad\Big]u'\,\nu'\Big[\qquad\Big]u$$

$$= \frac{e^4(2\pi h)^6}{4m^2c^2R^2\nu^2\nu'^2\left(\frac{E'}{c}+mc\right)^2}\Big[\big\{|H|^2-(n'H)(n'\tilde{H})\big\}M'^2(\nu-\nu')^2 + 2(HM')(\tilde{H}M')(\nu+\nu')^2 +$$

$$+\big\{M'^2-(n'M')^2\big\}|H|^2(\nu+\nu')^2 + \frac{4\nu^2}{h^2}(aM')(\tilde{a}M')\cancel{(\quad)^2}\big\{M'^2+(n'M')^2\big\}\ \cancel{+\ldots}$$

$$+\left(\frac{E'}{c}+mc\right)^2(\nu-\nu')^2\big\{|\mathcal{E}|^2+(n'\mathcal{E})(n'\tilde{\mathcal{E}})\big\} + |X|^2-(n'X)(n'\tilde{X}) +$$

$$+\big\{(HM')(\tilde{H}M')-(n'H)(n'M')(\tilde{H}M')\big\}(\nu^2-\nu'^2) - \big\{(HM')(\tilde{H}M')-(n'H)(n'M')(\tilde{H}M')\big\}(\nu^2-\nu'^2)$$

$$+\big\{(\tilde{H}M')(HM')-(n'\tilde{H})(n'M')(HM')\big\}(\nu^2-\nu'^2) - \big\{(\tilde{H}M')(HM')-(n'\tilde{H})(n'M')(HM')\big\}(\nu^2-\nu'^2)$$

$$+\left(\frac{E'}{c}+mc\right)(\nu-\nu')^2(n'H)\big(n'[M'\tilde{\mathcal{E}}]\big) + \left(\frac{E'}{c}+mc\right)(\nu-\nu')^2(n'\tilde{H})\big(n'[M'\mathcal{E}]\big)$$

$$-\big\{(HM')(\tilde{H}M')-(n'\tilde{H})(n'M')(HM')\big\}(\nu+\nu')^2 - \big\{(\tilde{H}M')(HM')-(n'H)(n'M')(\tilde{H}M')\big\}(\nu+\nu')^2$$

$$+\frac{2i\nu}{h}(\nu+\nu')(\tilde{a}M')(n'M')\big(n'[M'H]\big) - \frac{2i\nu}{h}(\nu+\nu')(aM')(n'M')\big(n'[M'\tilde{H}]\big)$$

$$-\left(\frac{E'}{c}+mc\right)(n'M')\big(n'[H\tilde{\mathcal{E}}]\big)(\nu^2-\nu'^2) - \left(\frac{E'}{c}+mc\right)(n'M')\big(n'[\tilde{H}\mathcal{E}]\big)(\nu^2-\nu'^2)$$

$$+\frac{2i\nu}{h}(\nu-\nu')\left(\frac{E'}{c}+mc\right)(aM')\big\{(M'\tilde{\mathcal{E}})+(n'M')(n'\tilde{\mathcal{E}})\big\}$$

$$-\frac{2i\nu}{h}(\nu-\nu')\left(\frac{E'}{c}+mc\right)(\tilde{a}M')\big\{(M'\mathcal{E})+(n'M')(n'\mathcal{E})\big\}\Big]$$

$$(\cancel{\text{??}})\ \left([n'H][n'\tilde{H}]\right)(\alpha M')^2(\nu-\nu')^2$$
$$= \left\{|H|^2-(n'H)(n'\tilde{H})\right\} M'^2 (\nu-\nu')^2$$

$$[n'\alpha][n'\alpha](HM')(\tilde{H}M')(\nu+\nu')^2 = \left\{(\alpha)^2-(n'\alpha)(n'\alpha)\right\}(HM')(\tilde{H}M')(\nu+\nu')^2$$
$$= \cancel{3} \ 2(HM')(\tilde{H}M')(\nu+\nu')^2$$

$$[n'M'][n'M'](\alpha H)(\alpha\tilde{H})(\nu+\nu')^2 = \left\{M'^2-(n'M')^2\right\}|H|^2(\nu+\nu')^2$$

$$= \frac{4\nu^2}{h^2}(\alpha M')(\tilde{\alpha}M')\left[n'[\alpha M']\right]\left[n'[\alpha M']\right] = \cancel{\frac{4\nu^2}{h^2}(\ )(\ )\left\{(\alpha M')(\alpha M')\right.}$$
$$\cancel{-(n'[\alpha M'])(n'[\alpha M'])\Big\} = \frac{4\nu^2}{h^2}(\ )(\ )\left\{M'^2-(\alpha[M'n'])(\alpha[M'n'])\right\}}$$
$$\cancel{= \frac{4\nu^2}{h^2}(\ )(\ )\left\{M'^2-[M'n'][M'n']\right\}} = \frac{4\nu^2}{h^2}(\ )(\ )\left\{M'^2-M'^2+(n'M')^2\right\}$$

$$\left(\frac{E'}{c}+mc\right)^2(\nu-\nu')^2\left[n'[\alpha\mathcal{E}]\right]\cancel{\left[n'(\alpha\tilde{\mathcal{E}})\right] = (\ )(\ )^2}\left[\alpha[\mathcal{E}n']\right]$$

$$= \frac{4\nu^2}{h^2}(\ )(\ )\left\{([\alpha M'])([\alpha M'])-(n'[\alpha M'])(n'[\alpha M'])\right\}$$
$$= \frac{4\nu^2}{h^2}(\ )(\ )\left\{(\alpha)^2M'^2-(\alpha M')(\alpha M')-(\alpha[M'n'])(\alpha[M'n'])\right.$$
$$= \cdots \left\{3M'^2-M'^2-([M'n'])([M'n'])\right\}$$
$$= \cdots \left\{2M'^2-M'^2+(n'M')^2\right\} = \cdots \left\{M'^2+(n'M')^2\right.$$

$$([n'X])([n'\tilde{X}]) = |X|^2-(n'\tilde{X})(n'X)$$

$$\left(\frac{E'}{c}+mc\right)^2(\nu-\nu')\left(\left[n'[\alpha\mathcal{E}]\right]\right)\left(\left[n'[\alpha\tilde{\mathcal{E}}]\right]\right)$$
$$= \cdots \quad ([\alpha\mathcal{E}])([\alpha\tilde{\mathcal{E}}])-(n'[\alpha\mathcal{E}])(n'[\alpha\tilde{\mathcal{E}}])$$
$$= \cdots \quad \alpha^2|\mathcal{E}|^2-(\alpha\mathcal{E})(\alpha\tilde{\mathcal{E}})-(\alpha[\mathcal{E}n'])(\alpha[\tilde{\mathcal{E}}n'])$$
$$= \cdots \quad 3|\mathcal{E}|^2-|\mathcal{E}|^2-|\mathcal{E}|^2+(n'\mathcal{E})(n'\tilde{\mathcal{E}})$$
$$\cancel{2}\ |\mathcal{E}|^2+(n'\mathcal{E})(n'\tilde{\mathcal{E}})$$

$$[n'H][n'\alpha]\,(\alpha M')(\tilde H M')(\nu^2-\nu'^2) \underset{(\alpha M')}{=} \{(\alpha H)-(n'H)(n'\alpha)\}\,\cancel{(\alpha M')}\,(\tilde H M')(\nu^2-\nu'^2) \qquad 16''$$

$$\underset{(\alpha M')}{=} \{(HM')-(n'H)(n'M')\}(\tilde H M')(\nu^2-\nu'^2)$$

$$-([n'H][n'M'])(\nu^2-\nu'^2)(\alpha M')(\alpha\tilde H) = -\big((HM')-(n'M')(n'H)\big)(\nu^2-\nu'^2)(\tilde H M')$$

$$=\big(-(HM')(\tilde H M')+(n'M')(n'H)(\tilde H M')\big)(\nu^2-\nu'^2).$$

$$\frac{2i\nu}{h}(\tilde a M')(\nu-\nu')(\alpha M')\big([n'H][n'[\alpha M']]\big) = \cdot\cdot\big(H[\alpha M']\big)-(n'H)(n'[\alpha M'])$$

$$= \cdot\cdot \qquad (\alpha M')(\alpha[M'H])-(n'H)(\alpha M')(\alpha[M'n'])$$

$$= \cdot\cdot \qquad (M'[M'H]) - nH(M'[M'n']) = 0.$$

$$([n'\tilde H][n'\alpha])(\alpha M')(HM')(\nu^2-\nu'^2) = \{(\alpha\tilde H)-(n'\tilde H)(n'\alpha)\}(\alpha M')(HM')(\nu^2-\nu'^2)$$

$$= \{(\tilde H M')-(n'\tilde H)(n'M')\}(HM')(\nu^2-\nu'^2).$$

$$-[n'M'][n'\tilde H](\alpha H)(\alpha M')(\nu^2-\nu'^2) = -\{(M'\tilde H)-(n'\tilde H)(n'M')\}(HM') -$$

$$-\left(\frac{E'}{c}+mc\right)(\nu-\nu')^2(\alpha M')\{[n'H][n'[\alpha\tilde{\mathfrak{E}}]]\} = \cdot\cdot\big(H[\alpha\tilde{\mathfrak{E}}]\big)-(n'H)(n'[\alpha\tilde{\mathfrak{E}}])$$

$$= \cdot\cdot \qquad (M'[\tilde{\mathfrak{E}}H])-(n'H)(M'[\tilde{\mathfrak{E}}n']) = \left(\frac{E'}{c}+mc\right)(\nu^2-\nu')^2(n'H)(n'[M'\tilde{\mathfrak{E}}])$$

$$= \qquad 0 \qquad -(n'H)\left\{\left(\frac{h\nu}{c}n-\frac{h\nu'}{c}n'\right)\cdot[\tilde{\mathfrak{E}}n']\right\}.$$

$$-\left(\frac{E'}{c}+mc\right)(\nu-\nu')^2\,[n'\tilde H][n'[\alpha\mathfrak{E}]](\alpha M')$$

$$= \cdot\cdot \quad \{(\tilde H[\alpha\mathfrak{E}])-(n'\tilde H)(n'[\alpha\mathfrak{E}])\}(\alpha M')$$

$$= \cdot\cdot \quad \{\ 0 \quad -(n'\tilde H)(M'[\mathfrak{E}n']$$

$$n'[M'\mathfrak{E}]$$

(2-3')

$$-(HM')\left([n'\alpha][n'M']\right)(\alpha\tilde{H})(\nu+\nu')^2 = -(HM')\left\{(\alpha M')-(n'\alpha)(\alpha' M')\right\}\cdot\cdot$$

$$= -(HM')\left\{(M'\tilde{H})-(n'\tilde{H})(n'M')\right\}(\nu+\nu')^2$$

$$= -\left\{(HM')(\tilde{H}M')-(n'\tilde{H})(n'M')(HM')\right\}(\nu+\nu')^2.$$

(2'-3'')

$$-(\alpha H)\left([n'M'][n'\alpha]\right)(\tilde{H}M')(\nu+\nu')^2.$$

$$= -(\alpha H)\left((\alpha M')-(n'\alpha)(n'M')\right\} \cdot\cdot \quad = -\left((HM')(\tilde{H}M')+(n'H)(n'M')(\tilde{H}M')\right.$$

(2-4')

$$\frac{2i\nu}{h}(HM')(\nu+\nu')\left([\alpha M'][\alpha[M'n]]\right) = \cdot\cdot \quad \left\{3\underset{0}{\underset{\parallel}{M'[M'n]}} - \alpha M'[M'n]\right\} = 0.$$

(2-5')

$$-\left(\frac{E'}{c}+mc\right)(HM')(\nu^2-\nu'^2)\left|[\alpha n'][\alpha[\tilde{\mathcal{E}}n']]\right| = \cdot\cdot \quad 3\left(n'[\hat{\mathcal{E}}n']\right) - n'[\tilde{\mathcal{E}}n'] = 0.$$

(3-4')

$$-\frac{2i\nu}{h}(\tilde{a}M')(\alpha H)(\nu+\nu')\left([n'M'][n'[\alpha M']]\right) = -\frac{2i\nu}{h}(\tilde{a}M')(\nu+\nu')(\alpha H)\left(\underset{0}{\underset{\parallel}{(M'[\alpha M'])}}\right.$$

$$\alpha[M'n']$$

$$-(n'M')(n'[\alpha M'])\Big) = +\frac{2i\nu}{h}(\tilde{a}M')(\nu+\nu')(n'M')\left(H[n'M']\right)$$

(3'-4)

(3-5')

$$\left(\frac{E'}{c}+mc\right)(\nu^2-\nu'^2)(\alpha H)\,[n'M'][n'[\alpha\tilde{\mathcal{E}}]] \quad \alpha[\tilde{\mathcal{E}}n']$$

$$= \cdot\cdot \quad \Big\{ M'[\alpha\tilde{\mathcal{E}}]-(n'M')(n'[\alpha\tilde{\mathcal{E}}])\Big)$$

$$= \cdot\cdot \quad \underset{0}{\underset{\parallel}{M'(H\tilde{\mathcal{E}})}} - (n'M')\left(H[\tilde{\mathcal{E}}n']\right)$$

$$= -\left(\frac{E'}{c}+mc\right)(\nu^2-\nu'^2)(n'M')\left(n'[H\tilde{\mathcal{E}}]\right)$$

$$(5-3') = \left(\frac{E'}{c}+mc\right)(\nu^2-\nu'^2)\left[n'[\alpha\tilde{\mathcal{E}}]\right][n'M](\alpha\hat{H})$$

$$= \cdot\cdot \quad (M'[\alpha\mathcal{E}])-(n'M')(n'[\alpha\mathcal{E}_0] \; \alpha[\mathcal{E}n'] \; (\alpha\hat{H}). = -\cdot\cdot\,(n'M')(\hat{H}[\mathcal{E}n'])$$

$$n'[\hat{H}\mathcal{E}]$$

(4-5') $\frac{2i\nu}{h}(aM')\left(\frac{E'}{c}+mc\right)(\nu-\nu')\left[n'[\alpha M']\right]\left[n'[\alpha\tilde{\mathfrak{E}}]\right]$

$= \quad \cdot\cdot \quad \{ [\alpha M'][\alpha\tilde{\mathfrak{E}}] - (n'[\alpha M'])(n'[\alpha\tilde{\mathfrak{E}}])$

$\alpha^2(M'\tilde{\mathfrak{E}}) - (M'\tilde{\mathfrak{E}}) - [M'n'][\tilde{\mathfrak{E}}n']$

$2(M'\tilde{\mathfrak{E}}) - M'^2 + (n'M')^2$

$(M'\tilde{\mathfrak{E}}) + (n'M')(n'\tilde{\mathfrak{E}})$.

$(M'\tilde{\mathfrak{E}}) + (n'M')(n'\tilde{\mathfrak{E}})$

(4'-5) -

M'^2 $\quad$ $[\alpha n][\alpha n] = 3$

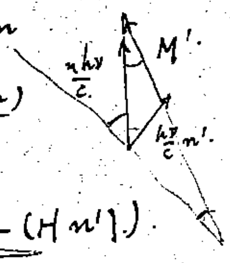
$\{|H'|^2 - (n'H)(n'\tilde{H})\} M'^2 = |H|^2 \sin^2(n'H)\left(\frac{E'^2}{c^2} - m^2c^2\right)$.

$2(HM')(\tilde{H}M') = 2\left(H, \frac{h\nu n}{c} - \frac{h\nu' n'}{c}\right)(\tilde{H}, \quad \cdots \quad) = 2|H|^2\left(\frac{h\nu'}{c}\right)^2\cos^2(n'H)$.

$= 2|H|^2|M'|^2\cos^2(H, M')$.

$\cos(n', M')$. $\quad M' = n' - n$

$\frac{\cos(n'n' - n'n)}{\cos n'n}$



$\{M'^2 - (n'M')^2\}|H|^2 = H^2$

$\cancel{\cos(H, M') = \cos((H, n) - (Hn'))}$.

$= \cancel{\cos(n'H)}$

$\frac{h\nu}{c}\left(\frac{h\nu}{c} - \frac{h\nu'}{c}(nn')\right)$

$M'^2 = \left(\frac{h\nu'}{c}\right)^2$. $\quad M'^2 = \left(\frac{h\nu}{c}n - \frac{h\nu'}{c}n'\right)^2 = \left(\frac{h\nu'}{c}\right)^2 + \left(\frac{h\nu}{c}\right)^2 - 2\left(\frac{h}{c}\right)^2\nu\nu'(nn')$

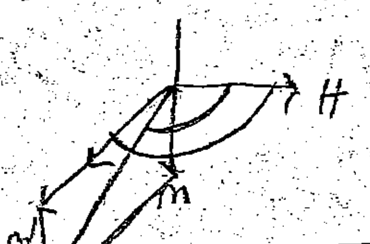
$= \left(\frac{h\nu'}{c}\right)^2 + \left(\frac{h}{c}\right)^2\{\nu^2 - 2\nu\nu'(nn')\}$.

$(HM') = |H||M'|\cos(HM') = |H||M'|\cos(n'H)$

$(HM')(\tilde{H}M') = |H|^2 M'^2 \cos^2(HM')$

$(HM') = |H||M'|\cos(HM') = -\frac{h\nu'}{c}(Hn') = -\frac{h\nu'}{c}|H|\cos(Hn')$

$|M'|\cos(HM') = -\frac{h\nu'}{c}\cos(Hn')$



$$\left\{\frac{h\nu'}{c} n(n'\mathfrak{E})(\nu-\nu') + mc\,\mathfrak{E}\,\frac{(\nu+\nu')^2}{\nu}\right\}\left\{\frac{h\nu'}{c} n(n'\tilde{\mathfrak{E}})(\nu-\nu') + mc\,\tilde{\mathfrak{E}}\,\frac{(\nu+\nu')^2}{\nu}\right\}$$

$$= \frac{h^2\nu'^2}{c^2}(\nu-\nu')^2(n'\mathfrak{E})(n'\tilde{\mathfrak{E}}) + m^2c^2|\mathfrak{E}|^2\frac{(\nu+\nu')^4}{\nu^2}$$

$$= \frac{h^2\nu'^2}{c^2}(\nu-\nu')^2|\mathfrak{E}|^2\cos^2(n'\mathfrak{E}) + m^2c^2|\mathfrak{E}|^2\frac{(\nu+\nu')^4}{\nu^2}$$

$$\left\{\frac{h\nu'}{c}(nn')(n'\mathfrak{E})(\nu-\nu') + mc\,(n'\mathfrak{E})\frac{(\nu+\nu')^2}{\nu}\right\}\left\{\frac{h\nu'}{c}(nn')(n'\tilde{\mathfrak{E}})(\nu-\nu') + mc\,(n'\tilde{\mathfrak{E}})\frac{(\nu+\nu')^2}{\nu}\right\}$$

$$= \frac{h^2\nu'^2}{c^2}|\mathfrak{E}|^2\cos^2(nn')\cos^2(n'\mathfrak{E})(\nu-\nu')^2 + m^2c^2|\mathfrak{E}|^2\frac{(\nu+\nu')^4}{\nu^2}\,\cancel{\sin}\cos^2(n'\mathfrak{E})$$

$$+\, 2\frac{h\nu'}{\nu}m\,(\nu+\nu')^2(\nu-\nu')|\mathfrak{E}|^2\cos^2(n'\mathfrak{E})$$

$$\nu' = \frac{\nu}{1+\frac{h\nu}{mc^2}(1-(nn'))}$$

$$\frac{h^2\nu'^2(\nu-\nu')^2}{c^2}|\mathfrak{E}|^2\cos^2(n'\mathfrak{E})\sin^2(n'n)$$

$$+\, \frac{m^2c^2(\nu+\nu')^4}{\nu^2}|\mathfrak{E}|^2\sin^2(n'\mathfrak{E})$$

$$\frac{\nu}{\nu'} = 1+\frac{h\nu}{mc^2}(1-(nn'))$$

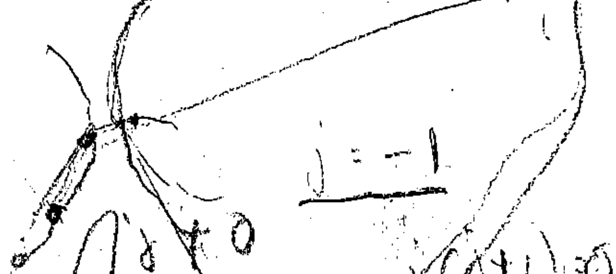
$$-\,2hm\frac{\nu'}{\nu}(\nu+\nu')^2(\nu-\nu')|\mathfrak{E}|^2\cos^2(n'\mathfrak{E})$$

$$\frac{\nu-\nu'}{\nu'} = \frac{h\nu}{mc^2}(1-(nn'))$$

$$\left\{ g_j\left(\frac{\cdot\, 6m}{\hbar}+\hbar\right)+1\right\}$$

$$j = -(j+1)$$

$$\frac{(\nu+\nu')}{\nu} = 2+\frac{h\nu}{mc^2}(1-(nn'))$$



$j=-1$

$j\neq 0$

$j(j+1)\neq 0$

$g_j = -4$

$-(j+1) = j$

12

12

$-\frac{e^2}{2m_0 c^2 \hbar^3}$

$\frac{e^2}{2m c^2 \hbar^3}(g_j+1)$

$\rho_1\left(\sigma \frac{1}{2}[Hr]\right) = \frac{1}{2}\rho_1 H[r\sigma] = \frac{i}{2}\rho_1\left((Hr) - (H\sigma)(r\sigma)\right)$

$i\sigma(\sigma r) = ir + \ell[\sigma r]$

$(a\sigma)(b\sigma) = (ab) + i(\sigma, b\times a) = (a b) - i(\sigma\times b)$

$\sigma(b\sigma) = b - i(\sigma\times b)$

$m\rho_1(\sigma p)$

$(\sigma m)(\sigma A) = (mA) + i(m\times A)$

$(\sigma A)(\sigma m) = (Am) + i(A\times m)$

$[HX] = \cancel{H_2X_3} - H_3X_2$

$m[HX] \quad [HX]m$

$-m[XH]$

$-H[mX] \quad H[Xm]$

$m_2X_3 - X_3m_2$

$(mH)X - X(mH) = i\hbar[XH]$

$[mX]_1 = m_2X_3 - m_3X_2 = i\hbar X_1$

$[mX] = i\hbar X$

$[Xm] = i\hbar X$

$(mX) = (Xm)$

$(mA)+(Am) = 0$

$m_3X_1 - X_1m_3 = i\hbar X_2$

$m_3X_2 - X_2m_3 = -i\hbar X_1$

$k \neq 3$

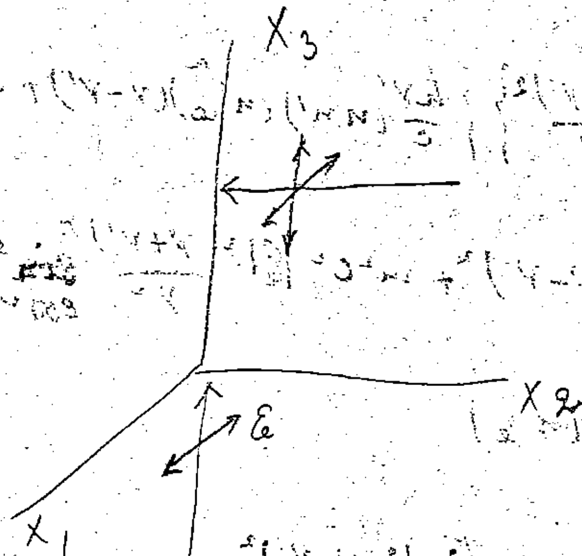
3/2

$[m\times[HX]] = H(mX) - (mH)X$

$[[HX]\times m] = -H(Xm) + X(mH)$

$\varphi_0 \sigma_2 \psi_0' = i\, \varphi_0 \sigma_1 \psi_0'$ $\qquad \varphi_0 \sigma_3 \psi_0' = -\varphi_0 \psi_0$

$\varphi_0 \rho_1 \psi_0' = -i\, \varphi_0 \rho_2 \psi_0'$



$\mathcal{E}_0 = (n \times H)$

② -18

1.

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$K = \nu - \nu' + \frac{2mc^2}{h} = \frac{\nu^2+\nu'^2-2\nu\nu'(nn')}{\nu-\nu'}$ $\quad \frac{mc^2}{h} = \frac{\nu\nu'}{\nu-\nu'}\left(1-(nn')\right)$

$\omega^2 = (\nu-\nu')K \quad \omega = n\nu - n'\nu'$

$(n'\omega) = (nn')\nu - \nu' = (\nu-\nu')\left(1-\frac{mc^2}{h\nu'}\right)$ $\quad (nn')\nu = \nu - \frac{\nu-\nu'}{\nu'}\frac{mc^2}{h}$

$(n\omega) = \nu - (nn')\nu' = (\nu-\nu')\left(1+\frac{mc^2}{h\nu}\right)$ $\quad (nn')\nu' = \nu' - \frac{\nu-\nu'}{\nu}\frac{mc^2}{h}$

$(nn') = 1 - \frac{\nu-\nu'}{\nu\nu'}\frac{mc^2}{h} \quad 1-(nn') = \frac{\nu-\nu'}{\nu\nu'}\frac{mc^2}{h} \quad 1-(nn')^2 = \frac{2(\nu-\nu')}{\nu\nu'}\frac{mc^2}{h} - \frac{(\nu-\nu')^2m^2c^4}{\nu^2\nu'^2h^2}$

$(n'[n\mathfrak{E}])^2 = \mathfrak{E}^2\left(1-(nn')^2\right) - (n'\mathfrak{E})^2$ $\quad \frac{\nu'}{\nu-\nu'}\left(1-(nn')\right) = \frac{1}{\alpha}$

$\alpha = \frac{h\nu}{mc^2} \quad \beta = \frac{h\nu}{mc^2}\left(1-(nn')\right) = \alpha\left(1-(nn')\right) \quad \frac{mc^2}{h} = \frac{\nu}{\alpha}$

$\nu' = \frac{\nu}{1+\alpha(1-(nn'))} = \frac{\nu}{1+\beta} \quad \nu-\nu' = \beta\nu' = \frac{\beta\nu}{1+\beta} \quad \nu+\nu' = \nu\left(\frac{2+\beta}{1+\beta}\right)$

$\nu\nu' = \frac{\nu^2}{1+\beta} \quad (nn') = 1-\frac{\beta}{\alpha} \quad 1-(nn')^2 = \frac{\beta}{\alpha}\left(2-\frac{\beta}{\alpha}\right) \quad \because \; 1-(nn') = \frac{\beta}{\alpha}, \; 1+(nn') = 2-\frac{\beta}{\alpha}$

$K = \frac{\nu(2+2\beta+\alpha\beta)}{\alpha(1+\beta)} \quad \gamma = \frac{1}{2(2\pi h)^6}\left(1+\frac{mc^2}{E'}\right) \quad \frac{E'}{mc^2}\frac{\nu'}{\nu}$ factor

$\frac{1}{\nu'} - \frac{1}{\nu} = \frac{\beta}{\nu} \quad \frac{1}{\nu'} + \frac{1}{\nu} = \frac{1}{\nu}(2+\beta)$

$\overline{[S\tilde{S}]} = 2i\gamma n \quad \overline{(AS)(B\tilde{S})} = \gamma\{(AB)+i(n[AB])\}$

$\overline{(AS)\bar{d}} = (An)\gamma \quad \overline{\bar{d}(B\tilde{S})} = (Bn)\gamma \quad (S\tilde{S}) = 3\gamma$

$\overline{S\bar{d}} = \overline{d\tilde{S}} = \gamma n \quad d\bar{d} = \gamma.$

$\frac{\alpha(1+\beta)}{\nu(2+2\beta+\alpha\beta)}$

$\left(1+\frac{1}{1+\beta}\right)^3$

$\frac{1}{\alpha} = \frac{\nu'}{\nu-\nu'}\left(1-(nn')\right)$
$= \frac{1}{\frac{\nu}{\nu'}-1}\left(1-(nn')\right) = \frac{1}{\beta}\left(1-(nn')\right)$

$$H' = \frac{(2\pi h)^3 e^2 \nu'}{2mc^2\left(\nu - \nu' + \frac{2mc^2}{h}\right) r} \Bigg\{ d\left(\frac{1}{\nu}(n'\mathcal{E}_e)(\nu' - \nu)[n'n] - \nu'\left(\frac{1}{\nu} + \frac{1}{\nu'}\right)^2 \frac{mc^2}{h}[n'\mathcal{E}_e] \right)$$

$$- i\Bigg(\left(\frac{1}{\nu'} - \frac{1}{\nu}\right)\Big[(S, n\nu - n'\nu')\big((n'\mathcal{E}_e)n - (n'n)\mathcal{E}_e\big) + \left(\nu - \nu' + \frac{2mc^2}{h}\right)\big((Sn')\mathcal{E}_e - (n'\mathcal{E}_e)S\big)\Big]$$

$$+ \frac{2}{\nu}(\mathcal{E}_e n')\big((n'S)(n\nu - n'\nu') + (\nu' - (nn')\nu)S\big) - \left(\frac{1}{\nu'} + \frac{1}{\nu}\right)\Big((n[\mathcal{E}_e S])\overset{\cancel{\nu'}}{\nu}[n'n]$$

$$+ \nu'(n'[n\mathcal{E}_e])[n'S]\Big)\Bigg)\Bigg\} e^{i\nu'\left(t - \frac{r}{c}\right)} + \cdots$$

$=$

$$A' = \frac{e}{r}(2\pi h)^3 \frac{e}{2mc\nu\nu'}\Big[\Big\{H(SM')(\nu-\nu') + S(HM')(\nu+\nu') - M'(SH)(\nu+\nu')$$

$$- 2i\frac{(aM')\nu}{h}[S\times M'] - \left(\frac{E'}{c}+mc\right)(\nu-\nu')[S\times\mathfrak{E}]\Big\}$$

$$+ id\Big\{[H\times M'](\nu+\nu') + \frac{2c(\mathfrak{E}M')M'}{h} - \left(\frac{E'}{c}+mc\right)\mathfrak{E}(\nu+\nu')\Big]\cdot$$

$$\cdot\frac{1}{\frac{E'}{c}+mc} \qquad \text{wobei} \quad s = v \sim u' \quad d = v u'$$

$$= \frac{e^2}{r}(2\pi h)^3 \frac{1}{2mc\nu\nu'\left(2mc+\frac{h}{c}(\nu-\nu')\right)}\frac{h}{c}\Big[(\nu-\nu')\Big\{(n\times\mathfrak{E})(S, n\nu-n'\nu')$$

$$-(S\times\mathfrak{E})\left(\nu-\nu'+\frac{2mc^2}{h}\right)\Big\} - (\nu+\nu')\Big\{S\nu'(n\times\mathfrak{E}, n')$$

$$+(n\nu-n'\nu')(S, n\times\mathfrak{E})\Big\} - 2\nu'(n'\mathfrak{E})[S\times(\nu n-\nu' n')]$$

$$- i\Big\{n\nu'(n'\mathfrak{E})(\nu-\nu') + \frac{(\nu+\nu')^2}{\nu}mc\,\mathfrak{E} - \frac{2h\nu'^2}{c}n'(n'\mathfrak{E})\Big\}d\Big]$$

$$= \frac{e^2}{r}(2\pi h)^3 \frac{1}{2mc\nu\nu'\left(\frac{2mc^2}{h}+\nu-\nu'\right)}\Big[(\nu-\nu')\Big\{(n\times\mathfrak{E})(S,\omega) - [S\times\mathfrak{E}]\left(\nu-\nu'+\frac{2mc^2}{h}\right)\Big\}$$

$$-(\nu+\nu')\Big\{S\nu'(n\times\mathfrak{E}, n') + \omega(S, n\times\mathfrak{E})\Big\} - 2\nu'(n'\mathfrak{E})[S\times\omega]$$

$$- i\Big\{n\nu'(n'\mathfrak{E})(\nu-\nu') + \frac{(\nu+\nu')^2}{\nu}mc\,\mathfrak{E} - \frac{2h\nu'^2}{c}n'(n'\mathfrak{E})\Big\}d\Big]$$

$$H' = -\frac{i\nu'}{c}[n'\times A']$$

$$= -\frac{e^2}{r}(2\pi h)^3 \frac{i}{2mc^2\nu\left(\nu-\nu'+\frac{2mc^2}{h}\right)}\Big[(\nu-\nu')\Big\{[n'\times[n\times\mathfrak{E}]](S,\omega) - [n'\times[S\times\mathfrak{E}]]\cdot$$

$[n'\times n\nu - n'\nu']$ $= +\nu'[n'n']$

$$\cdot\left(\nu-\nu'+\frac{2mc^2}{h}\right)\Big\} - (\nu+\nu')\Big\{\nu'[n'\times S](n\times\mathfrak{E}, n') + [n'\times\omega](S, n\times\mathfrak{E})\Big\}$$

$$-2\nu'(n'\mathfrak{E})[n'\times[S\times\omega]] - i\Big\{\nu'[n'\times n](n'\mathfrak{E})(\nu-\nu') + \frac{(\nu+\nu')^2}{\nu}\frac{mc^2}{h}[n'\times\mathfrak{E}]\Big]$$

$-S(n'\omega)+\omega(n'S)$ $n'(n\nu'-n\nu)$

$$\frac{-i}{\nu\nu'}\Big\{(\nu-\nu')\big[(S\omega)\big((n'\mathcal{E})n-(n'n)\mathcal{E}\big)+K\big((Sn')\mathcal{E}-(n'\mathcal{E})S\big)\big]-(\nu+\nu')\big[(n[\mathcal{E}S])\nu[n'n]+\nu'(n'[n\mathcal{E}])[n'S]\big]$$
$$+2\nu'(n'\mathcal{E})\big[(n'S)\omega+S(\nu'\overset{-(n'\omega)}{-(nn')\nu})\big]\Big\}$$

$$\frac{i}{\nu\nu'}\Big\{(\nu-\nu')\big[(\tilde{S},\omega)\big((n'\mathcal{E})n-(nn')\mathcal{E}\big)+K\big((\tilde{S}n')\mathcal{E}-(n'\mathcal{E})\tilde{S}\big)\big]-(\nu+\nu')\big[(n[\mathcal{E}\tilde{S}])\nu[n'n]+\nu'(n'[n\mathcal{E}])[n'\tilde{S}]\big]$$
$$+2\nu'(n'\mathcal{E})\big[(n'\tilde{S})\omega+\tilde{S}(\nu'\overset{-(n'\omega)}{-(nn')\nu})\big]\Big\}$$

$$\nu^2\nu'^2\Big[(\nu-\nu')^2\Big\{\omega^2\big((n'\mathcal{E})^2+(nn')^2\mathcal{E}^2\big)+K^2\big(\mathcal{E}^2+3(n'\mathcal{E})^2-2\mathcal{E}^2\big)-2K\big((n'\omega)(nn')\mathcal{E}^2+(n\omega)(n'\mathcal{E})^2-(\omega\mathcal{E})(n'\mathcal{E})(nn')\big)$$
$$+(\nu+\nu')^2\Big\{\nu'^2\big(1-(nn')^2\big)\mathcal{E}^2+2\nu'^2(n'[n\mathcal{E}])^2-2\nu'^2(n'[n\mathcal{E}])^2(nn')\Big\}$$
$$4\nu'^2(n'\mathcal{E})^2\Big\{\omega^2+3(\nu'-(nn')\nu)^2+2(n'\omega)(\nu'-(nn')\nu)\Big\}$$
$$-(\nu^2-\nu'^2)\Big\{-2\nu'(nn')(n'[n\mathcal{E}])(\omega[n\mathcal{E}])+2\nu'(n'[n\mathcal{E}])\big\{(n'\mathcal{E})(\omega[nn'])-(nn')(\omega[\mathcal{E}n'])\big\}$$
$$+2K\nu'\big((\mathcal{E}[n'n])^2+(n'\mathcal{E})^2\big)\Big\}$$
$$+2\nu'(\nu-\nu')(n'\mathcal{E})\Big\{2K\big((\omega\mathcal{E})+(n'\mathcal{E})(n'\omega)\big)\Big\}$$
$$3(n'\omega)^2-2(n'\omega)^2$$
$$-2\nu'(\nu+\nu')(n'\mathcal{E})\Big\{2\nu'(n'[n\mathcal{E}])(\omega[n'n])+2\nu'(n'\omega)(n'\mathcal{E})\Big\}\Big]$$

$$\omega^2=(n\nu-n'\nu')^2$$
$$=\nu^2+\nu'^2-2\nu\nu'(nn')$$
$$=(\nu-\nu')^2+\frac{2mc^2}{h}(\nu-\nu')=(\nu-\nu')\Big\{\nu-\nu'+\frac{2mc^2}{h}\Big\}=(\nu-\nu')K$$

$$mc^2\frac{(\nu'-\nu)}{h}+\frac{h\nu\nu'}{mc^2}=\frac{h\nu\nu'}{mc^2}(nn')$$

$$5.\quad \frac{d\bar{d}\,\gamma}{(\nu\nu')^2}\Big\{ \nu'^2(n'\mathcal{E})^2(\nu'-\nu)^2\left(1-(nn')^2\right) + \frac{(\nu+\nu')^4}{\nu^2}\frac{m^2c^4}{h^2}\left(\mathcal{E}^2-(n'\mathcal{E})^2\right) + \frac{2}{\nu^2}(\nu+\nu')^2(\nu'-\nu)(nn')\frac{mc^2}{h}(n'\mathcal{E})^2 \Big\}$$

$$= \frac{\gamma}{(\nu\nu')^2}\Big[\mathcal{E}^2\,\frac{(\nu+\nu')^4 m^2c^4}{h^2\nu^2} + (n'\mathcal{E})^2\Big\{ \nu'^2(\nu'-\nu)^2\left(1-(n'n)^2\right) - \frac{(\nu+\nu')^4 m^2c^4}{h^2\nu^2} - \frac{2}{\nu^2}(\nu+\nu')^2(\nu-\nu')(nn')\frac{mc^2}{h}\Big\}\Big]$$

$$\frac{2\nu'}{\nu}$$

S-terms

$$\frac{\gamma}{(\nu\nu')^2}\Big[(\nu-\nu')^2\Big\{ K(\nu-\nu')\left((n'\mathcal{E})^2+(nn')^2\mathcal{E}^2\right) + K^2\left(\mathcal{E}^2+(n'\mathcal{E})^2\right) - 2K\left(+(nn')(n'\omega)\mathcal{E}^2 + \nu'(nn')(n'\mathcal{E})^2\nu\right)\Big\}$$

$$+(\nu+\nu')^2\Big\{ \mathcal{E}^2\nu^2\left(1-(nn')^2\right) + 2\nu'^2\{\mathcal{E}^2(1-(nn')^2)-(n'\mathcal{E})^2\} - 2\nu\nu'(nn')\{\mathcal{E}^2(1-(nn')^2)-(n'\mathcal{E})^2\}\Big\}$$

$$+4\nu'^2(n'\mathcal{E})^2\Big\{ K(\nu-\nu') + (n'\omega)^2\Big\}$$

$$-2K\nu(\nu^2-\nu'^2)\Big\{ \mathcal{E}^2\left(1-(nn')^2\right) - (n\mathcal{E})^2 + (n\mathcal{E})^2\Big\}$$

$$+4K\nu'(\nu-\nu')(n'\mathcal{E})^2\Big\{(nn')\nu-2\nu'\Big\} - 4\nu\nu'(\nu+\nu')(n'\mathcal{E})^2\left((nn')\nu-\nu'\right)\Big]$$

$$\frac{\mathcal{E}^2}{(\nu\nu')^2}\Big[\frac{(\nu+\nu')^4}{\alpha^2} + (\nu-\nu')^2\{K(\nu-\nu')^{(nn')^2}+K^2-2K(nn')(n'\omega)\}$$
$$+(\nu+\nu')^2(1-(nn')^2)\{\nu^2+2\nu'^2-2\nu\nu'(nn')\} - 2K\nu\underbrace{(\nu^2-\nu'^2)}_{(1-(nn')^2)}\Big]$$

$$+\frac{(n'\mathcal{E})^2}{(\nu\nu')^2}\Big[-\frac{(\nu+\nu')^4}{\alpha^2} + \nu'^2(\nu'-\nu)^2(1-(nn')^2) - \frac{2\nu'}{\nu}(\nu+\nu')^2(\nu-\nu')(nn')\frac{mc^2}{h}$$
$$+(\nu-\nu')^2\{K(\nu-\nu')+K^2-2K\nu\}$$
$$+2(\nu+\nu')^2\{\nu\nu'(nn')-\nu'^2\} + 4\nu'^2(K(\nu-\nu')+(n'\omega)^2)$$
$$+4K\nu'(\nu-\nu')\{(nn')\nu-2\nu'\} - 4\nu\nu'(\nu+\nu')((nn')\nu-\nu')\Big].$$

$$=\frac{\mathcal{E}^2}{(\nu\nu')^2}\Big[\frac{(\nu+\nu')^4}{\alpha^2} + K(\nu-\nu')\{\nu^2(1-(nn')^2)+\nu'^2(1-nn')^2\}$$
$$+(\nu+\nu')\{(\nu+\nu')\nu'^2-K(\nu-\nu')^2\}(1-(nn')^2)\Big]$$

$$+\frac{(n'\mathcal{E})^2}{(\nu\nu')^2}\Big[-\frac{(\nu+\nu')^4}{\alpha^2} + (\nu-\nu')^2\{\nu'^2(1-(nn')^2)-2K(\frac{mc^2}{h}-\nu')\}$$
$$+2\nu'(\nu+\nu')^2\{(nn')(\nu-\nu')-\nu'(1-(nn')^2)\}$$
$$-4\nu\nu'^2((nn')\nu-\nu')(1+(nn'))\Big]$$

$\frac{4}{\alpha^2}(\frac{\nu'}{\nu})^2(\frac{1}{1-(nn')})$

$\frac{4}{\alpha}(\frac{\nu'}{\nu})^2\frac{1}{(\frac{\nu}{\nu'}-1)}$

$\cancel{\frac{4mc^2}{K4}}$

$((1+(\frac{\nu}{\nu'})^2)(1+\frac{\nu^2}{\nu'^2}-2\frac{\nu}{\nu'}(nn'))$

$$=\frac{\mathcal{E}^2}{(\nu\nu')^2}\Big[\underbrace{\frac{(\nu+\nu')^4}{\alpha^2} + (1-nn')\nu'^2\{2(\nu+\nu')^2+(\nu-\nu')^2(1+nn')\}}_{\frac{4}{\alpha^2}(\frac{\nu'}{\nu})^2\frac{(1+(\frac{\nu}{\nu'})^2)(1+\frac{\nu^2}{\nu'^2}-2\frac{\nu}{\nu'}(nn'))}{1-(nn')}}\Big]$$

$$+\frac{(n'\mathcal{E})^2}{(\nu\nu')^2}\Big[-\frac{(\nu+\nu')^4}{\alpha^2} + (\nu-\nu')^2\{\nu'^2(1-(nn')^2)-2K(\frac{mc^2}{h}-\nu')\}$$
$$+2\nu'(\nu+\nu')^2\{(nn')(\nu-\nu')-\nu'(1-(nn')^2)\}$$
$$-4\nu\nu'^2((nn')\nu-\nu')(1+(nn'))\Big]$$

$-\frac{8}{\alpha}\frac{\nu'}{\nu}\frac{1}{(\frac{\nu}{\nu'}-1)}$

$8/(1+\frac{\nu^2}{\nu'^2}-\frac{2\nu}{\nu'}(nn'))$

$+2(nn')(\frac{\nu'}{\nu}-(nn'))$

$$=\cancel{\mathcal{E}^2\Big[\frac{(\nu\nu')^2}{\alpha^2}}$$

$$\frac{(n'\mathcal{E})^2}{(\nu\nu')^2}\Big\{-(1-(nn'))^2\frac{\nu'^2(\nu+\nu')^4}{(\nu-\nu')^2}+\nu'^2(\nu'-\nu)^2(1-(nn')^2)-2\nu'^2(\nu+\nu')^2(nn')(1-(nn'))$$

$$X\ +(\nu-\nu')^2K(\nu-\nu'+K-2\nu) \qquad -2(\nu-\nu')\nu(-\nu'(nn')+\nu)K \to (n\omega)$$

$$+2(\nu+\nu')^2\nu'\{\nu(nn')-\nu'\} \qquad -(n'\omega)$$

$$X+4\nu'^2\{K(\nu-\nu')+(n'\omega)^2\}$$

$$\Delta\ +4K\nu'(\nu-\nu')\{(n'\omega)-\nu'\}-4\nu\nu'(\nu+\nu')(n'\omega)$$

$(\nu(nn') - \nu')^2$.
$\nu^2(nn')^2-2\nu\nu'(nn')+\nu'^2$.
$\nu^2+\nu'^2 - 2\nu\nu'(nn')$.

$$(\nu-\nu')K\Big\{-2(\nu-\nu')(n\omega)+\cancel{4\nu'^2}+4\nu'\{(n'\omega)-\cancel{\nu'}\}\Big\}$$

$$-2(\nu-\nu')(\nu-\nu'(nn'))+4\nu'(\nu(nn')-\nu'\}$$

$$=-2\nu^2+2\nu\nu'(nn')+2\nu\nu'-2\nu'^2(nn')$$

$$+4\nu\nu'(nn')-4\nu'^2=-2(\nu^2-\nu\nu'+2\nu'^2) \quad -2(nn')(\nu'^2-3\nu\nu').$$

$$2(\nu+\nu')\Big\{(\nu+\nu')\nu'(n'\omega)-2\nu\nu'(n'\omega).$$

$$\nu'^2(n'\omega)-\nu\nu'(n'\omega)$$

$$=2\nu\nu'(\nu+\nu')\Big\{\frac{\nu'}{\nu}((nn')\nu-\nu')-((nn')\nu-\nu')$$

$$k(\nu-\nu')\Big\{\quad(\nu-\nu')\Big\{$$

$$-3^4+1-2(5)-2(3)^2+4\times2$$

$$-81+1-10-18+8=-100$$

$-10\quad -10$

$$\overline{\ \ 4\ \ }$$

$\nu - \nu' + \frac{2mc}{h}$
$-\nu - \nu'$

$$(\nu-\nu')^2 k(\nu-\nu'+K-2\nu) + 4\nu'^2 k(\nu-\nu') + 4K\nu'(\nu-\nu')\{(n'\omega)-\nu'\}$$

$$= (\nu-\nu')K\left\{(\nu-\nu')\left(\frac{2mc^2}{h}-2\nu'\right) + 4\nu'^2 + 4\nu'\left((n'\omega)-\nu'\right)\right\}$$

$$= (\nu-\nu')k\left\{(\nu-\nu')\left\{\frac{2\nu\nu'}{\nu-\nu'}(1-nn')-2\nu'\right\} + \cancel{4\nu'^2} - \cancel{4\nu'^2} + 4\nu'(n'\omega)\right\}$$

$$= (\nu-\nu')K\left\{2\nu\nu'(1-nn') - 2\nu'(\nu-\nu') + 4\nu'\{(nn')\nu - \nu'\}\right\}$$

$$= (\nu-\nu')K\left\{2\nu\nu' - 2\nu\nu'(nn') - 2\nu\nu' + 2\nu'^2 + 4\nu\nu'(nn') - 4\nu'^2\right\}$$

$$= 2(\nu-\nu')k(n'\omega)\nu'$$

$$2(\nu+\nu')^2\nu'(n'\omega) + 4\nu'^2(n'\omega)^2 - 4\nu\nu'(\nu+\nu')(n'\omega)$$

$$= 2\nu'(n'\omega)\left\{(\nu+\nu')^2 + 2\nu'(n'\omega) - 2\nu(\nu+\nu')\right\}$$

$$= 2\nu'(n'\omega)\left\{\cancel{\nu^2} + \cancel{2\nu\nu'} + \cancel{\nu'^2} + 2\nu\nu'(nn') - 3\nu'^2 - 3\nu^2 - \cancel{2\nu\nu'}\right\}$$

$$= -2\nu'(n'\omega)K(\nu-\nu').$$

$$\therefore\ (\nu-\nu')^2 K(\nu-\nu'+K-2\nu) + \cancel{4\nu'^2 k(\nu-\nu')} + 2(\nu+\nu')^2\nu'\overset{(n'\omega)}{\{\nu(nn')-\nu'\}}$$

$$+4\nu'^2\{K(\nu-\nu') + (n'\omega)^2\} + 4k\nu'(\nu-\nu')\left((n'\omega)-\nu'\right) - 4\nu\nu'(\nu+\nu)(n'\omega) = 0.$$

$$-(1-(nn'))^2\frac{\nu'^2(\nu+\nu')^4}{(\nu-\nu')^2} + \nu'^2(\nu'-\nu)^2(1-(nn')^2) - 2\nu'^2(\nu+\nu')^2(nn')(1-(nn'))$$

$$= (1-(nn'))\nu'^2\left\{-(1-(nn'))\frac{(\nu+\nu')^4}{(\nu-\nu')^2} + (\nu'-\nu)^2\overset{(1+nn')}{} - 2(\nu+\nu')^2(nn')\right\}$$

$$= (1-(nn'))\nu'^2\left\{(nn')\left\{\frac{(\nu+\nu')^4}{(\nu-\nu')^2} - 2\underset{(\nu-\nu')^2}{(\nu+\nu')^2}\right\} - \frac{(\nu+\nu')^4}{(\nu-\nu')^2} + (\nu'-\nu)^2\right\}$$

$$= \frac{(1-(nn'))\nu'^2}{(\nu-\nu')^2}\left\{(nn')\left\{(\nu+\nu')^4 - 2(\nu^2-\nu'^2)^2 + (\nu'-\nu)^4\right\} + \underbrace{\{(\nu-\nu')^2-(\nu+\nu')^2\}}_{-4\nu\nu'}\underbrace{\{(\nu-\nu')^2+(\nu+\nu')^2\}}_{2(\nu^2+\nu'^2)}\right\}$$

$$\left\{(\nu+\nu')^2 - (\nu-\nu')^2\right\}^2 \qquad -8\nu\nu'(\nu^2+\nu'^2).$$

$$(4\nu\nu')^2 = 16\nu^2\nu'^2.$$

$$= 8\,\frac{(1-(nn'))\,\nu\nu'^3}{(\nu-\nu')^2}\left\{2\nu\nu'(nn') - \nu^2+\nu'^2\right\} = \frac{-8(1-(nn'))\,\nu\nu'^3}{(\nu-\nu')}\,K.$$

$$\frac{mc^2}{h\nu} = \frac{\nu'}{\nu-\nu'}(1-nn') = \frac{1}{\alpha}. \qquad \cancel{(\nu+\nu')^2-(\nu-\nu')^2}\Big\}\Big\{\cancel{(\nu+\nu')^2-(\nu-\nu')^2\}(nn')}$$

$+$

$$\cancel{\frac{1}{\alpha^2} = \frac{\nu'^2}{(\nu-\nu')^2}(1-nn')^2}$$

$$\cancel{= \frac{8\nu\nu'}{\alpha^2(1-nn')}\left\{2\nu\nu'(nn') - \nu^2+\nu'^2\right\}}.$$

$$= -\frac{8\nu\nu'^2}{\alpha}K.$$

$$\mathfrak{E}^2\text{ term} = \frac{4(1+(\frac{\nu}{\nu'})^2)}{\alpha^2(1-(nn'))}\left(1+\frac{\nu^2}{\nu'^2}-2\frac{\nu}{\nu'}(nn')\right)\frac{\nu'^4}{\cancel{\nu}}$$

$$= \frac{4(1+(\frac{\nu}{\nu'})^2)}{\alpha^2(1-(nn'))}\,K(\nu-\nu')\,\frac{\nu'^2}{\cancel{\nu}} \qquad , \qquad \frac{\nu-\nu'}{1-nn'} = \alpha\nu'$$

$$= \frac{4(1+(\frac{\nu}{\nu'})^2)}{\alpha}\,K\,\frac{\nu'^3}{\cancel{\nu}} \qquad\qquad \frac{\nu'}{\nu^2}\times\frac{}{\nu'^2\nu}$$

$$\text{Total} = \frac{1}{(\nu\nu')}\left(\mathfrak{E}^2\text{ term} + \frac{1}{2}(1-(nn')^2)\left((n'\mathfrak{E})^2\text{ term}\right)\right)$$

$$= \frac{1}{\cancel{\alpha\nu\nu'}}\left(4\frac{(1+(\frac{\nu}{\nu'})^2)}{\alpha}K\frac{\nu'^3}{\cancel{\nu}} - \frac{4\nu\nu'^2}{\alpha}K\,(1-(nn')^2)\right)$$

$$= \frac{4K}{\alpha}\frac{\nu'^2}{(\nu\nu')^2}\left\{(1+(\frac{\nu}{\nu'})^2)\nu' - \nu(1-(nn')^2)\right.$$

$$\nu(1+nn')(1-nn')$$

$$\frac{\nu^2+\nu'^2}{\nu'} - \nu(1-(nn')^2)$$

$$= \frac{4K}{\alpha}\frac{\nu'}{\nu'\nu^3}\left\{\frac{\nu}{\nu'}+\frac{\nu'}{\nu} - (1-(nn')^2)\right\}$$

Total

$$\frac{4}{\alpha}\left(1+\frac{\nu^2}{\nu'^2}\right) K \frac{\nu'}{\nu^2} - \left\{1-(nn')^2\right\} 4 \frac{\cancel{\nu\nu'}}{\alpha\nu} K$$

$$= \frac{4K}{\alpha\nu}\left\{ \frac{\nu'}{\nu}\left(1+\frac{\nu^2}{\nu'^2}\right) - \left(1-(nn')^2\right)\right\}$$

$$= \frac{4K}{\alpha\nu}\left\{ \frac{1}{\nu\nu'}\left(\nu^2+\nu'^2\right) - \left(1-(nn')^2\right)\right\}$$

$$= \frac{4K}{\alpha\nu}\left\{ \frac{\nu}{\nu'} + \frac{\nu'}{\nu} - \left(1-(nn')^2\right)\right\}$$

factor $\frac{e^4}{4m^2c^2\lambda^2}\left(\frac{\nu'}{\nu}\right)^3 \frac{\alpha\nu}{K}$

$1-(nn')^2 = \frac{\beta}{\alpha}\left(2-\frac{\beta}{\alpha}\right)$

$\frac{\nu'}{\nu} = \frac{1}{1+\beta}$ $\quad \frac{\nu}{\nu'} = 1+\beta$.

$\therefore \frac{2+2\beta+\beta^2}{(1+\beta)} - \frac{}{\alpha^2}$

$$K = \frac{\nu(2+2\beta+\alpha\beta)}{\alpha(1+\beta)}$$

$$\frac{\nu}{\nu'} = 1+\beta \qquad \frac{\nu'}{\nu} = \frac{1}{1+\beta}$$

$1-nn'^2$

$= 1-1+\frac{2\beta}{\alpha}-\frac{\beta^2}{\alpha^2}$

$= \frac{\beta}{\alpha}(2$

$-2\alpha\beta+\beta^2-2\alpha\beta^2+\beta^3$.

$$= 4\frac{(2+2\beta+\alpha\beta)}{\alpha^2(1+\beta)}\left\{1+\beta+\frac{1}{1+\beta}-\frac{\beta}{\alpha}\left(\frac{2\alpha-\beta}{\alpha}\right)\right\}$$

$$= \frac{4(2+2\beta+\alpha\beta)}{\alpha^2(1+\beta)}\left\{\frac{\alpha^2+2\beta\alpha^2+\beta\alpha^2-(2\alpha\beta-\beta^2)(1+\beta)}{\alpha^2(1+\beta)}\right\}$$

$$\times \frac{\alpha^2(1+\beta)}{8(2+2\beta+\alpha\beta)}$$

$\alpha^2(1+\beta)^2+\alpha^2$.

$2\alpha^2+2\alpha^2\beta+\alpha^2\beta^2$

$$\frac{\frac{2\alpha-\beta}{1+\beta}}{2\alpha-\beta+2\alpha\beta}$$

$1+(nn')^2 = 2-\frac{2\beta}{\alpha}+\frac{\beta^2}{\alpha^2}$

$= \frac{2\alpha^2-2\alpha\beta+\beta^2}{\alpha^2}$.

$$= \frac{1}{2}\left\{1+\frac{\beta(1+\beta)}{1+\beta}\ \beta+\frac{1}{1+\beta}-\frac{\beta}{\alpha}\left(\frac{2\alpha-\beta}{\alpha}\right)\right\}$$

$\beta(\alpha^2-2\alpha\beta+\beta^2)+\alpha^2\beta^2$

$$\frac{\alpha^2\beta(1+\beta)+\alpha^2-\beta(2\alpha-\beta)(1+\beta)}{\alpha^2(1+\beta)} = \alpha^2\beta+\alpha^2\beta^2+\alpha^2$$

$-2\alpha\beta+\beta^2-2\alpha\beta^2+\beta^3$

$(\alpha^2-2\alpha\beta+\beta^2)(1+\beta)+\alpha^2\beta^2$

$$\frac{\{1+\alpha(1-nn')\}}{(1+(nn')^2)}$$

(10の裏.)

$\lambda\nu = c$

$\nu = \frac{c}{\lambda}$

$\alpha = \frac{h\nu}{mc^2} = \frac{h}{mc\lambda} = \frac{6.54}{0.91\times3\times10^{10}\times2.2\times10^{-11}}$

$= \frac{6.54}{2.7\times2.2}$

$$I = \frac{(\cancel{4\pi}h)^6 e^4 \nu'^2}{4m^2c^4 K^2 r^2} \frac{1}{2(\cancel{2\pi}h)^6}\left(1+\frac{mc^2}{E'}\right)\frac{E'}{mc^2}\frac{\nu'}{\nu}\left[\overbrace{\mathcal{E}^2[\;]}^{\cancel{\times 2}} + \frac{1}{2}(1-(nn')^2)(n'\mathcal{E})^2\right]$$

$$= \frac{e^4}{m^2c^4r^2}\frac{\nu'^3}{\nu^3}\frac{1}{8}\left(\frac{E'}{mc^2}+1\right)\frac{1}{K^2}$$

$E' = h\nu - h\nu' + mc^2$

$= h(\nu-\nu') + mc^2$

$\frac{E'}{h} = (\nu-\nu') + \frac{mc^2}{h} = K - \frac{mc^2}{h}$

$$\frac{1}{8}\frac{4h}{mc^2}\frac{1}{K} \quad \frac{\alpha}{8}K$$

$E' + mc^2 = h(\nu-\nu') + 2mc^2$

$= Kh.$

$$= \frac{e^4}{m^2c^4r^2}\frac{\nu'^3}{\nu^3}\frac{\frac{1}{8}\alpha^2(1+\beta)}{(2+2\beta+\alpha\beta)}$$

$\frac{.17}{2.17}$ $.17$

$\frac{2.17}{2}$

$$\cancel{\text{Coeff}} = \frac{e^4}{m^2c^4r^2}\left(\frac{\nu'}{\nu}\right)^3 \cdot \frac{1}{8}\frac{\alpha\nu}{K}.$$

unpol. light

$$I = \frac{2I_D}{1+(nn')^2} \cdot \frac{1}{\cancel{8}\,2}\frac{\cancel{\alpha\nu}}{\cancel{K}} \times \frac{\cancel{4K}}{\cancel{\alpha\nu}}\left\{\frac{\nu}{\nu_1}+\frac{\nu'}{\nu} - (1-(nn')^2)\right\}$$

$$= I_D\left\{\frac{\nu}{\nu_1}+\frac{\nu'}{\nu} - (1-(nn')^2)\right\}\frac{1}{1+(nn')^2}$$

$1+(nn')^2-2$

$\frac{3.25}{1.5}$

$\frac{1+\frac{2.25}{1.5}-2.}{1+\frac{(1+\alpha)^2}{1+\alpha}}$

$\sin^2 = 1-\cos^2$

$1-(nn')^2$

$$= I_D\left\{1+\frac{\frac{\nu}{\nu_1}+\frac{\nu'}{\nu}-2}{1+(nn')^2}\right\}$$

$\frac{\nu'}{\nu} = \frac{1}{1+\alpha(1-(nn'))}.$

$\frac{\nu}{\nu_1} = 1+\alpha(1-(nn'))$ $\quad \frac{1.16}{.16}$

$$= I_D\left\{1+\frac{\alpha^2(1-nn')^2}{(1+(nn')^2)(1+\alpha(1-nn'))}\right\}$$

$\because \left(\frac{\nu}{\nu_1}\right)+\frac{\nu'}{\nu}-2$

$= \frac{1-2(1+\alpha(1-nn'))+(\;)^2}{1+\alpha(1-nn')}$

$$I = \frac{e^4}{m^2c^4r^2}\frac{\nu'^3}{\nu^3}\frac{1}{\cancel{4}}\frac{\alpha\nu}{K}\left[\mathcal{E}^2[\;] + \frac{1}{2}(1-(nn')^2)(n'\mathcal{E})^2\right]$$

$= \frac{1}{\cdot\cdot}\left\{\alpha^2(1-nn')^2\right\}$

$$\therefore\ I = I_D\left\{1+\frac{\alpha^2(1-nn')^2}{(1+(nn')^2)(1+\alpha(1-(nn')))}\right\}$$

③-1

$\boxed{197}$

1.

$$\left[p_0 + (\alpha, p+\tfrac{e}{c}A) + \overset{\rho_3}{\cancel{\beta_4}}\, mc\right]\psi = 0 \qquad p_0 = ih\frac{\partial}{c\partial t} \qquad p_r = -ih\frac{\partial}{\partial x_r}$$

$$\varphi\left[-p_0 + (\alpha, -p+\tfrac{e}{c}A) + \overset{\rho_3}{\cancel{\beta_4}}\, mc\right] = 0 \qquad p_0 = \frac{E}{c}$$

$$\left[p_0 + (\alpha p) + \overset{\rho_3}{\cancel{\beta_4}}\, mc\right]\psi = -\frac{e}{c}(\alpha A)\psi$$

$$\varphi\left[-p_0 - (\alpha p) + \overset{\rho_3}{\cancel{\beta_4}}\, mc\right] = -\frac{e}{c}\varphi(\alpha A)$$

$$\left[-p_0 + (\alpha p) + \overset{\rho_3}{\cancel{\beta_4}}\, mc\right]\left[p_0 + (\alpha p) + \overset{\rho_3}{\cancel{\beta_4}}\, mc\right]\psi = -\frac{e}{c}\left[-p_0 + (\alpha p) + \overset{\rho_3}{\cancel{\beta_4}}\, mc\right](\alpha A)\psi$$

$$\left[-p_0^2 + p^2 + m^2c^2\right]\psi = -\frac{e}{c}\left[-p_0 + (\alpha p) + \cancel{\beta_4}\, mc\right](\alpha A)\psi.$$

$$\varphi\left[p_0 - (\alpha p) + \overset{\rho_3}{\cancel{\beta_4}}\, mc\right]\left[-p_0 - (\alpha p) + \overset{\rho_3}{\cancel{\beta_4}}\, mc\right] = -\frac{e}{c}\varphi\overset{(\alpha A)}{\left[p_0 - (\alpha p) + \overset{\rho_3}{\cancel{\beta_4}}\, mc\right]}\cancel{(\alpha A)}$$

$$\varphi\left[-p_0^2 + p^2 + m^2c^2\right] = -\frac{e}{c}\varphi\overset{(\alpha A)}{\left[p_0 - (\alpha p) + \cancel{\beta_4}\, mc\right]}\cancel{(\alpha A)}.$$

$$\left[\frac{h^2}{c^2}\frac{\partial^2}{\partial t^2} - h^2\overset{(\mathrm{grad})^2}{\sum\frac{\partial^2}{\partial x_r^2}} + m^2c^2\right]\psi = \frac{e}{c}\left[ih\frac{\partial}{c\partial t} + ih\Big(\alpha\overset{\mathrm{grad}}{\frac{\partial}{\partial x}}\Big) - \overset{\rho_3}{\cancel{\beta_4}}\, mc\right](\alpha A)\psi$$

$$\psi_0 = u\, e^{-\frac{i}{h}[Et - (\mathfrak{M}r)]} \qquad \varphi_0 = v\, e^{\frac{i}{h}[Et - (\mathfrak{M}r)]}$$

$$\psi = \psi_0 + \sim f \qquad \varphi = \varphi_0 + \sim q. \qquad \sim A = \sim a\, e^{i\nu(t - \frac{(nr)}{c})} + \sim\tilde{a}\, e^{-i\nu(t-\frac{(nr)}{c})}$$

$$\therefore \left[\frac{h^2}{c^2}\frac{\partial^2}{\partial t^2} - h^2(\mathrm{grad})^2 + m^2c^2\right] f = \frac{e}{c}\left[ih\frac{\partial}{c\partial t} + ih(\alpha\,\mathrm{grad}) - \overset{\rho_3}{\cancel{\beta_4}}\, mc\right](\alpha A)\psi_0$$

$$(\alpha A)\psi_0 = (\alpha a)_u\, e^{-\frac{i}{h}[\underbrace{(E-h\nu)}_{E_1}t - (\underbrace{\mathfrak{M} - \frac{h\nu}{c}n}_{\mathfrak{M}_1})\cdot r]} + (\alpha\tilde{a})_u\, e^{-\frac{i}{h}[\underbrace{(E+h\nu)}_{E_2}t - (\underbrace{\mathfrak{M} + \frac{h\nu}{c}n}_{\mathfrak{M}_2})r]}$$

Setze: $f = F_1\, e^{-\frac{i}{h}[E_1t - \mathfrak{M}_1 r]} + F_2\, e^{-\frac{i}{h}[E_2t - \mathfrak{M}_2 r]}$

$$\therefore \left(-\frac{E_1^2}{c^2} + \mathfrak{M}_1^2 + m^2c^2\right)F_1 = \frac{e}{c}\left[\frac{E_1}{c} - (\alpha\mathfrak{M}_1) - \overset{\rho_3}{\cancel{\beta_4}}\, mc\right](\alpha a)u$$

$$\left(-\frac{E_2^2}{c^2}+\mathfrak{M}_2^2+m^2c^2\right)F_2 = \frac{e}{c}\left[\frac{E_2}{c}-(\alpha\mathfrak{M}_2)-\beta mc\right](\alpha\tilde{a})u$$

$$-\frac{E_1^2}{c^2}+\mathfrak{M}_1^2+m^2c^2 = -\frac{(E-h\nu)^2}{c^2}+\left(\mathfrak{M}-\frac{h\nu}{c}n\right)^2+m^2c^2$$

$$= -\left(\frac{E^2}{c^2}-\frac{2Eh\nu}{c^2}+\left(\frac{h\nu}{c}\right)^2\right)+\left(\mathfrak{M}^2+\left(\frac{h\nu}{c}\right)^2-2\frac{h\nu}{c}(n\mathfrak{M})\right)+m^2c^2$$

$$= \frac{2h\nu}{c}\left(\frac{E}{c}-(n\mathfrak{M})\right)$$

$$-\frac{E_2^2}{c^2}+\mathfrak{M}_2^2+m^2c^2 = -\frac{2h\nu}{c}\left(\frac{E}{c}-(n\mathfrak{M})\right)$$

$$\therefore\quad F_1 = \frac{e}{2h\nu\left(\frac{E}{c}-(n\mathfrak{M})\right)}\left[\frac{E_1}{c}-(\alpha\mathfrak{M}_1)-\beta mc\right](\alpha a)u$$

$$F_2 = \frac{-e}{2h\nu\left(\frac{E}{c}-(n\mathfrak{M})\right)}\left[\frac{E_2}{c}-(\alpha\mathfrak{M}_2)-\beta mc\right](\alpha\tilde{a})u$$

$$g\left[\frac{h^2\partial^2}{c^2\partial t^2}-h^2(\mathrm{grad})^2+m^2c^2\right] = -\frac{e}{c}\varphi_0^{(\alpha A)}\left[p_0-(\alpha p)+\cancel{\beta_4}mc\right]$$
$$-\frac{e}{c}\varphi_0^{(\alpha A)}\left[ih\frac{\partial}{c\partial t}+ih(\alpha\,\mathrm{grad})+\cancel{\beta_4}mc\right]\cancel{(\alpha A)}$$

$$\varphi_0(\alpha A) = v(\alpha a)\,e^{\frac{i}{h}\left[\overbrace{(E+h\nu)}^{E_2}t-(\overbrace{\mathfrak{M}+\frac{h\nu}{c}n}^{\mathfrak{M}_2})r\right]}+v(\alpha\tilde{a})\,e^{\frac{i}{h}\left[\underbrace{(E-h\nu)}_{E_1}t-(\underbrace{\mathfrak{M}-\frac{h\nu}{c}n}_{\mathfrak{M}_1})r\right]}$$

Setze $g = G_1\,e^{\frac{i}{h}[\cancel{(E-h\nu)t-(\mathfrak{M}}\;E_1t-(\mathfrak{M}_1r)]}+G_2\,e^{\frac{i}{h}[E_2t-(\mathfrak{M}_2r)]}$

$$G_1\left(-\frac{E_1^2}{c^2}+\mathfrak{M}_1^2+m^2c^2\right) = -\frac{e}{c}v^{(\alpha\tilde{a})}\left[-\frac{E_1}{c}+(\alpha\mathfrak{M}_1)+\overset{\rho_3}{\cancel{\beta_4}}mc\right]\cancel{(\alpha\tilde{a})}$$

$$G_2\left(-\frac{E_2^2}{c^2}+\mathfrak{M}_2^2+m^2c^2\right) = -\frac{e}{c}v^{(\alpha a)}\left[-\frac{E_2}{c}+(\alpha\mathfrak{M}_2)+\overset{\rho_3}{\cancel{\beta_4}}mc\right]\cancel{(\alpha a)}$$

(PE)

$$\therefore\quad G_1 = \frac{-e}{2h\nu\left(\frac{E}{c}-(n\mathfrak{M})\right)}v^{(\alpha\tilde{a})}\left[-\frac{E_1}{c}+(\alpha\mathfrak{M}_1)+\overset{\rho_3}{\cancel{\beta_4}}mc\right]\cancel{(\alpha\tilde{a})}$$

$$G_2 = \frac{e}{2h\nu\left(\frac{E}{c}-(n\mathfrak{M})\right)}v^{(\alpha a)}\left[-\frac{E_2}{c}+(\alpha\mathfrak{M}_2)+\overset{\rho_3}{\cancel{\beta_4}}mc\right]\cancel{(\alpha a)}$$

$$J = es = ice\varphi'\alpha\psi = ice\left(\varphi_0'\alpha\psi_0 + \alpha g'\alpha\psi_0 + \alpha\varphi_0'\alpha f\right)$$

$$\psi_0 = u\, e^{-\frac{i}{h}[Et-(\mathfrak{M}r)]} \qquad \varphi_0' = v' e^{\frac{i}{h}[E't-(\mathfrak{M}'r)]}$$

$$f = F_1 e^{-\frac{i}{h}[E_1t-(\mathfrak{M}_1r)]} + F_2 e^{-\frac{i}{h}[E_2t-(\mathfrak{M}_2r)]} \qquad g' = G_1' e^{\frac{i}{h}[E_1't-(\mathfrak{M}_1'r)]} + G_2' e^{\frac{i}{h}[E_2't-(\mathfrak{M}_2'r)]}$$

$$g'\alpha\psi_0 = G_1'\alpha u\, e^{-\frac{i}{h}[(E-E_1')t-(\mathfrak{M}-\mathfrak{M}_1')r]} + G_2'\alpha u\, e^{\frac{i}{h}[(E_2'-E)t-(\mathfrak{M}_2'-\mathfrak{M})r]}$$

$$\varphi_0'\alpha f = v'\alpha F_1\, e^{\frac{i}{h}[(E'-E_1)t-(\mathfrak{M}'-\mathfrak{M}_1)r]} + v'\alpha F_2\, e^{-\frac{i}{h}[(E_2-E')t-(\mathfrak{M}_2-\mathfrak{M}')r]}$$

$$\frac{J}{d\mathfrak{M}\; ice} = \int d\mathfrak{M}' \Big\{ (G_1'\alpha u + v'\alpha F_2)\, e^{-\frac{i}{h}[(E+h\nu-E')t-(\mathfrak{M}+\frac{h\nu}{c}n-\mathfrak{M}')r]}$$
$$+ (G_2'\alpha u + v'\alpha F_1)\, e^{\frac{i}{h}[(E'+h\nu-E)t-(\mathfrak{M}'+\frac{h\nu}{c}n-\mathfrak{M})r]}$$

$$\therefore \frac{J_m}{ice} = \int d\mathfrak{M}' \Big\{ (G_2'\alpha u' + v'\alpha F_1')\, e^{\frac{i}{h}[(E+h\nu-E')t-(\mathfrak{M}+\frac{h\nu}{c}n-\mathfrak{M}')r]}$$
$$+ (G_1'\alpha u + v'\alpha F_2)\, e^{-\frac{i}{h}[\quad \cdot\cdot \quad]} \Big\}$$

$$\mathfrak{A} = \frac{ie}{R}\int dv \int d\mathfrak{M}' \Big\{ (\ )\, e^{\frac{i}{h}[(E+h\nu-E')(t-\frac{R}{c}+\frac{(n'r)}{c})-(\mathfrak{M}+\frac{h\nu}{c}n-\mathfrak{M}')r]}$$
$$(\ )\, e^{-\frac{i}{h}[\quad \cdot\cdot \quad]} \Big\}$$

$$= \frac{ie}{R}(2\pi h)^3 \Big\{ (G_2\alpha u' + v\alpha F_1')\, e^{i\nu'(t-\frac{R}{c})} + (G_1'\alpha u + v'\alpha F_2)\, e^{-i\nu'(t-\frac{R}{c})} \Big\}$$

$$F_1' = \frac{e}{2h\nu\left(\frac{E'}{c}-(n\mathfrak{M}')\right)}\left[\frac{E_1'}{c}-(\alpha\mathfrak{M}_1')-\beta mc\right](\alpha a)u' \qquad F_2 = \frac{-e}{2mch\nu}\left[\frac{E_2}{c}-\frac{h\nu}{c}(n\alpha) - \beta mc\right](\alpha\tilde{a})u$$

$$= \frac{e}{2mch\nu'}\left[\frac{E_1'}{c}+\frac{h\nu'}{c}(n'\alpha)-\beta mc\right](\alpha a)u' \qquad G_2 = \frac{-e}{2mch\nu}v\left[+\frac{E_2}{c}-\frac{h\nu}{c}(n\alpha) - \beta mc\right](\alpha a)$$

$$G_1' = \frac{+e}{2mch\nu'}v'\left[+\frac{E_1'}{c}+\frac{h\nu'}{c}(n'\alpha)-\beta mc\right](\alpha\tilde{a})$$

$$G_2 \alpha u' = -\frac{e}{2mch\nu}\, v \left[\frac{E_2}{c} - \frac{h\nu}{c}(n\alpha) - \beta mc\right](\alpha a)\, \alpha u'$$

$$= -\frac{e}{2mch\nu}\, v \left[\frac{E_2}{c}(\alpha a)\alpha - \frac{h\nu}{c}(n\alpha)(\alpha a)\alpha - (\alpha a)\beta\alpha mc\right] u'$$

$$v\alpha F_1' = \frac{e}{2mch\nu'}\, v\alpha \left[\frac{E_1'}{c} + \frac{h\nu'}{c}(n'\alpha) - \beta mc\right](\alpha a)\, u'$$

$$= \frac{e}{2mch\nu'}\, v \left[\frac{E_1'}{c}\alpha(\alpha a) + \frac{h\nu'}{c}\alpha(n'\alpha)(\alpha a) - \alpha\beta mc(\alpha a)\right] u'$$

$$\frac{\nu E_1'}{c}\alpha_1(\alpha a) - \frac{\nu' E_2}{c}(\alpha a)\alpha_1$$

$$= \frac{\nu E_1'}{c}\alpha_1(\alpha_1 a_1 + \alpha_2 a_2 + \alpha_3 a_3) - \frac{\nu' E_2}{c}(\alpha_1 a_1 + \alpha_2 a_2 + \alpha_3 a_3)\alpha_1$$

$$= \frac{1}{c}\left\{\nu E_1' a_1 + iE_1'\nu(a_2\sigma_3 - a_3\sigma_2) - \nu' E_2 a_1 - iE_2\nu'(-a_2\sigma_3 + a_3\sigma_2)\right\}$$

$$= \frac{1}{c}\left\{ i(\nu E_1' + E_2\nu')[a\sigma]_1 + a_1(\nu E_1' - E_2\nu')\right\}$$

$$= \frac{1}{c}\left\{ i\, mc^2(\nu+\nu')[a\sigma]_1 + \cancel{ih(\nu\nu')[a\sigma]_1 - h(\nu+\nu')a_1} + (mc^2(\nu-\nu') - 2h\nu\nu')a_1\right\}$$

$$\frac{h\nu\nu'}{c}(n\alpha)(\alpha a)\alpha_1 + \frac{h\nu\nu'}{c}\alpha_1(n'\alpha)(\alpha a)$$

$$= \frac{h\nu\nu'}{c}\left\{(n_1\alpha_1 + n_2\alpha_2 + n_3\alpha_3)(a_1\alpha_1 + a_2\alpha_2 + a_3\alpha_3)\alpha_1 + \alpha_1(n_1'\alpha_1 + n_2'\alpha_2 + n_3'\alpha_3)(a_1\alpha_1 + a_2\alpha_2 + a_3\alpha_3)\right\}$$

$$= \frac{h\nu\nu'}{c}\left\{(n_1\alpha_1 + n_2\alpha_2 + n_3\alpha_3)(a_1 - ia_2\sigma_3 + ia_3\sigma_2) + (n_1'\alpha_1 - n_2'\alpha_2 - n_3'\alpha_3)(a_1 + ia_2\sigma_3 - ia_3\sigma_2)\right\}$$

$n_2a_1 - n_1a_2$ $\quad$ $n_3a_1 - n_1a_3$ $\quad$ $n_2a_3 -$

$$= \frac{h\nu\nu'}{c}\left\{ (n_1+n_1')\alpha_1 a_1 + (n_2-n_2')\alpha_2 a_1 + (n_3-n_3')\alpha_3 a_1 - (n_1-n_1')\rho_1\overset{\alpha_2}{\sigma_2} a_2 + (n_2+n_2')\rho_1\overset{\alpha_1}{\sigma_1} a_2 - i(n_3+n_3')\rho_1 a_2 - (n_1-n_1')\rho_1\overset{\alpha_3}{\sigma_3} a_3 + i(n_2+n_2')\rho_1 a_3 + (n_3+n_3')\rho_1\overset{\alpha_1}{\sigma_1} a_3 \right\}$$

$$= \frac{h\nu\nu'}{c}\Big\{ \alpha_1(n'a_1) - [na]_3\alpha_2 + [n'a]_3\alpha_2 + [na]_2\alpha_3 - [n'a]_2\alpha_3$$

$$i\rho_1[na]_1 + i\rho_1[n'a]_1 \Big\}$$

$$= \frac{h\nu\nu'}{c}\Big\{ \alpha_1(n'a) + \big[[na]\alpha\big]_1 - \big[[n'a]\alpha\big]_1 + i\rho_1\big[(n+n')a\big]_1 \Big\}$$

$$= \frac{h\nu\nu'}{c}\rho_1\Big\{ \alpha_1(n'a) + \big[[na]\alpha\big]_1 - \big[[n'a]\alpha\big]_1 + i\big[(n+n')a\big]_1 \Big\}$$

$$+[\alpha[na]] \quad + [\alpha[n'a]] \quad + [\alpha[n'a]] - i[na] + i[na] \Big\}$$

$$n'(\alpha a) - a(n'\alpha)$$

$$mc\nu'\beta(\alpha a)\alpha_1 - mc\nu\alpha_1\beta(\alpha a)$$

$$= mc\Big\{ \nu'\beta(\alpha_1a_1 + \alpha_2a_2 + \alpha_3a_3)\alpha_1 - \nu\alpha_1\beta(\alpha_1a_1 + \alpha_2a_2 + \alpha_3a_3) \Big\}$$

$$= mc\Big\{ \nu\rho_3 a_1 - \nu\rho_3 a_1 - \nu' i\rho_3$$

$$= mc\Big\{ \nu'\rho_3a_1 + \nu\rho_3a_1 - i\nu'\rho_3\sigma_3a_2 + i\nu'\rho_3\sigma_2a_3 + i\nu\rho_3\sigma_3a_2 - i\nu\rho_3\sigma_2a_3 \Big\}$$

$$= mc\rho_3\Big\{ a_1(\nu+\nu') - i\nu'[a\sigma]_1 + i\nu[a\sigma]_1 \Big\}$$

$$= mc\rho_3\Big\{ a_1(\nu+\nu') + i[a\sigma]_1(\nu-\nu') \Big\}$$

$h\nu\nu \quad \nu_3u_3' \quad \nu_3u_1' \quad \nu_4u_2'$

$$mc + \frac{h\nu}{c} = \frac{h\nu'}{c} + \frac{h\nu'}{c}$$

$$\frac{i\nu}{e}(1-\frac{i}{k})$$

$$G_2\alpha u' + \nu\alpha F_1'$$

$$= \frac{e}{2mch\nu\nu'}\nu\Big[i mc[a\sigma](\nu+\nu') + mc\rho_3 a(\nu-\nu')$$

$$+ mc\,a(\nu-\nu') + imc\rho_3[a\sigma](\nu+\nu') - \frac{2h\nu\nu'}{c}a$$

$$+ \quad + \frac{h\nu\nu'}{c}\rho_1\Big\{ \sigma(n'a) + [[na]\sigma] - [[n'a]\sigma] - i[na] + i[n'a] \Big\}\Big]$$

$$[\sigma[na]] + [\sigma[n'a]] -$$

$$\nu\rho_3 u' = -\nu u'$$

$$[n[a\sigma]] = a(n\sigma) + \ldots$$

$$n(\sigma a) - a(n\sigma)$$

$$2[n \times a](n\sigma)\rho_1\frac{h\nu\nu'}{c}$$

$$-2a(n\sigma)\rho_1\frac{h\nu\nu'}{c} + 2imc\nu[a\sigma] + 2imc\nu\rho_3[a\sigma]$$

$$\therefore\ [n\times a]\rho_1\frac{h\nu\nu'}{c} = imc^2\nu a(1+\rho_3)$$

$$\frac{h\nu\nu'}{c}\Big\{(a_1\alpha_1+a_2\alpha_2+a_3\alpha_3)(n_1\alpha_1+n_2\alpha_2+n_3\alpha_3)\alpha_1$$
$$+\alpha_1(n_1'\alpha_1+n_2'\alpha_2+n_3'\alpha_3)(\alpha_1a_1+\alpha_2a_2+\alpha_3a_3)\Big\}$$

$$=\frac{h\nu\nu'}{c}\Big\{(a_1\alpha_1+a_2\alpha_2+a_3\alpha_3)(n_1-in_2\sigma_3+in_3\sigma_2)$$
$$+(n_1'+in_2'\sigma_3-in_3'\sigma_2)(\alpha_1a_1+\alpha_2a_2+\alpha_3a_3)\Big\}$$

$$=\frac{h\nu\nu'}{c}\Big\{(a\alpha)(n_1+n_1')-in_2\{-i\alpha_2a_1+i\alpha_1a_2+\rho_1a_3\}$$
$$+in_3\{i\alpha_3a_1+\rho_1a_2-i\alpha_1a_3\}$$
$$in_2'\{i\alpha_2a_1-i\alpha_1a_2+\rho_1a_3\}$$
$$-in_3'\{-i\alpha_3a_1+\rho_1a_2+i\alpha_1a_3\}\Big\}$$

$$=\frac{h\nu\nu'}{c}\Big\{(a\alpha)(n_1+n_1')+n_2[\alpha a]_3-n_3[\alpha a]_2-i\rho_1[na]_1$$
$$+n_2'[\alpha a]_3-n_3[\alpha a]_2+i\rho_1[n'a]_1\Big\}$$

$$=\frac{h\nu\nu'}{c}\Big\{(a\alpha)(n_1+n_1')+[n\times[\alpha a]]_1-i\rho_1[na]_1$$
$$+[n'\times[\alpha a]]_1+i\rho_1[n'a]_1\Big\}$$

$$=\frac{h\nu\nu'}{c}\rho_1\Big\{(a\sigma)(n+n')_1+\underbrace{[n[\sigma a]]+[n'[\sigma a]]}_{\sigma(na)-a(n\sigma)+\sigma(n'a)-a(n'\sigma)}-i[na]_1+i[n'a]\Big\}$$

$\boxed{-2a(n\sigma)}$

$-\cancel{2a(n\sigma)}$

$$\left.\begin{array}{l}
a_1n_1+ia_1n_2\sigma_3-ia_1n_3\sigma_2\\
-ia_2n_1\sigma_3+a_2n_2+ia_2n_3\sigma_1\\
+ia_3n_1\sigma_2-ia_3n_2\sigma_1+a_3n_3
\end{array}\right\}\alpha_1
\quad
\alpha_1\left\{\begin{array}{l}
a_1n_1'-ia_1n_2'\sigma_3+ia_1n_3'\sigma_2\\
ia_2n_1'\sigma_3+a_2n_2'-ia_2n_3'\sigma_1\\
-ia_3n_1'\sigma_2+ia_3n_2'\sigma_1+a_3n_3'
\end{array}\right.$$

$$=\alpha_1(an')+\alpha_2[na]_3-\alpha_3[na]_2+i\rho_1[na]+\alpha_2[n'a]_3-\alpha_3[n'a]_2+i\rho_1[n'a]$$
$$=\alpha_1(an')+[\alpha[na]]+[\alpha[n'a]]-i\rho_1[na]+i\rho_1[n'a]$$
$$=\rho_1\Big\{(an')\sigma+[\sigma[na]]+[\sigma[n'a]]-i[na]+i[n'a]\Big\}$$

$$mc\nu'(\alpha a)\beta\alpha - mc\nu\alpha\beta(\alpha a)$$

$$= mc\left\{\nu'(\alpha_1 a_1 + \alpha_2 a_2 + \alpha_3 a_3)\overbrace{\rho_3\rho_1}^{+i\rho_2}\cancel{\alpha}\sigma_1 - \nu\overbrace{\rho_1\sigma_1\rho_3}^{-i\rho_2}(\alpha_1 a_1 + \alpha_2 a_2 + \alpha_3 a_3)\right\}$$

$$= \cancel{mc}\ imc\left\{\nu'(a_1\rho_1 - i a_2\alpha_3 + i a_3\alpha_2)\rho_2 + \nu\rho_2(\rho_1 a_1 + i a_2\alpha_3 - i a_3\alpha_2)\right\}$$

$$= \cancel{imc\left\{\alpha_1 [a\alpha]_1 \rho_2 - \rho_2 [a\alpha]_1\right\} - mc\left\{[a\alpha]_1\rho_1\rho_2 - \rho_2\rho_1[a\alpha]_1\right\}}$$

$$= \cancel{imc\,\rho_3 [a\alpha]}$$

$$= imc\left\{-i\rho_3 a_1(\nu - \nu') - i[a\alpha]_1\rho_2\nu' \pm i\rho_2[a\alpha]\nu\right\}$$

$$= mc\left\{\rho_3 a_1(\nu - \nu') + i\rho_3[a\alpha]_1(\nu' + \nu)\right\}$$

$$\varphi(-p_0 - e'A_0) + \beta_1(\alpha, -p + e'A) + \beta_3 mc) = 0$$

$$\varphi^*(p_0 - e'A_0 + (\alpha, -p + e'A) + \beta_3 mc) = 0$$

$$\varphi[-(p_0 - e'A_0)^2 + (\alpha, -p + e'A)^2 + m^2c^2 + (-p_0 + e'A_0)(\alpha, -p + e'A) + (\alpha, -p + e'A)(p_0 - e'A_0)$$

$$(\alpha, -p + e'A)(\alpha, -p + e'A) = (-p + e'A)^2 + i\sum \alpha_3(-p_1 + e'A_1)(-p_2 + e'A_2) - (-p_2 + e'A_2)(-p_1 + e'A_1)$$

$$e'(-\overleftarrow{p_1}A_2 - A_1\overleftarrow{p_2} + \overleftarrow{p_2}A_1 + A_2\overleftarrow{p_1}) = ie'h\left(-\frac{\partial A_2}{\partial x_1} + \frac{\partial A_1}{\partial x_2}\right) = -i\, e'h H_3$$

$$= (-p + e'A)^2 + e'h\sum \alpha_3 H_3 = (-p + e'A)^2 + e'h(\alpha H)$$

$$(-p_0 + e'A_0)\{\alpha_1(-p_1 + e'A_1) + \alpha_2(-p_2 + e'A_2) + \alpha_3(-p_3 + e'A_3)\} + \{\ \}(p_0 - e'A_0)$$

$$e'\{-p_0A_1\alpha_1 - p_0A_2\alpha_2 - p_0A_3\alpha_3 - A_0\overleftarrow{p_1}\alpha_1 - A_0\overleftarrow{p_2}\alpha_2 - A_0\overleftarrow{p_3}\alpha_3$$
$$+ A_1\overleftarrow{p_0}\alpha_1 + A_2\overleftarrow{p_0}\alpha_2 + A_3\overleftarrow{p_0}\alpha_3 + p_1A_0\alpha_1 + p_2A_0\alpha_2 + p_3A_0\alpha_3\}$$

$$= e'\left\{+ih\frac{\partial A_1}{c\partial t}\alpha_1 + ih\frac{\partial A_2}{c\partial t}\alpha_2 + ih\frac{\partial A_3}{c\partial t}\alpha_3 + ih\frac{\partial A_0}{\partial x_1}\alpha_1 + ih\frac{\partial A_0}{\partial x_2}\alpha_2 + ih\frac{\partial A_0}{\partial x_3}\alpha_3\right\}$$

$$= \cancel{-ih}\ ihe\left\{\alpha_1\left(-\frac{\partial A_1}{c\partial t} - \frac{\partial A_0}{\partial x_1}\right) + \alpha_2\left(-\frac{\partial A_2}{c\partial t} - \frac{\partial A_0}{\partial x_2}\right) + \alpha_3\left(-\frac{\partial A_3}{\partial t} - \frac{\partial A_0}{\partial x_3}\right)\right\}$$

$$= -ihe\{\alpha_1E_1 + \alpha_2E_2 + \alpha_3E_3\} = -ih\,e(\alpha E) = -ihe\rho_1(\sigma E).$$

$$\therefore \varphi\left[-(p_0 - e'A_0)^2 + (-p + e'A)^2 + e'h(\sigma H) - ihe\rho_1(\sigma E)\right] = 0$$

$$\varphi\left[-(p_0 + e'A_0)^2 + (-p + e'A)^2 + e'(QH) - \cancel{ihe}(PE)\right] = 0$$

$$\varphi\left[-p_0^2 + p^2 - e'pA - e'Ap - e'(QH) - e'(PE)\right] = 0$$

$$\varphi\left[\frac{h^2\partial^2}{c^2\partial t^2} - \sum h^2\frac{\partial^2}{\partial x_k^2} + 2ihe(A\,\mathrm{grad}) + e'(QH) - e'(PE) + m^2c^2\right] = 0$$

$$g\left[\frac{h^2}{c^2}\frac{\partial^2}{\partial t^2} - \sum h^2 \frac{\partial^2}{\partial x_k^2} + m^2c^2\right] = -2ihe'(A\,\mathrm{grad})\varphi \pm e'\varphi(QH) \pm e'\varphi(P\mathcal{E})$$

$$g = \alpha(A\,\mathrm{grad}\,\varphi) + \beta\varphi(QH) + \gamma\varphi(P\mathcal{E}).$$

$$\mathrm{grad}\{\varphi(QH)\} = \mathrm{grad}\,\varphi\,(QH) + \varphi\,\mathrm{grad}(QH)$$

$$\Delta(\varphi(QH)) = \Delta\varphi.(QH) + \varphi\,\Delta(QH) + 2\,\mathrm{grad}\,\varphi\,\mathrm{grad}(QH).$$

$$\varphi = v e^{\frac{i}{h}(Et - (\mathfrak{M}r))}$$

$$H = He^{i\nu(t - \frac{nr}{c})} + \tilde{H}e^{-i\nu(t - \frac{nr}{c})}$$

$$\varphi H = \cdots e^{\frac{i}{h}(E_2 t - \mathfrak{M}_2 r)}.$$

$$A\varphi = \cdots e$$

$$\mathrm{grad}\,\varphi = -\frac{i}{h}\mathfrak{M}\varphi \qquad \frac{\partial\varphi}{\partial t} = \frac{i}{h}E\varphi$$

$$\mathrm{grad}(QH) = -\frac{i\nu n}{c}(QH) \qquad \frac{\partial(QH)}{\partial t} = i\nu(QH).$$

$$\Delta\varphi(QH) = \Delta\varphi\,(QH) + \varphi Q\Delta H - \frac{2\nu}{hc}(n\mathfrak{M})\varphi(QH).$$

$$\frac{\partial^2}{c^2\partial t^2}\varphi(QH) = \frac{1}{c^2}\frac{\partial^2\varphi}{\partial t^2}(QH) + \varphi Q\frac{\partial^2 H}{c^2\partial t^2} + 2\frac{\partial\varphi}{c^2\partial t}\left(Q\frac{\partial H}{\partial t}\right).$$

$$= \frac{1}{c^2}\frac{\partial^2\varphi}{\partial t^2}(QH) + \varphi\left(Q\frac{\partial^2 H}{c^2\partial t^2}\right) - 2\frac{\nu}{c^2h}E\varphi(QH).$$

$$\frac{h^2\partial^2}{c^2\partial t^2}\varphi(QH) - h^2\Delta(\varphi QH) = (-m^2c^2)\varphi(QH) - \frac{2h\nu}{c}\left(\frac{E}{c} - (n\mathfrak{M})\right)\varphi(QH).$$

$$\beta(-h^2\Box + m^2c^2)\varphi(QH) = -\beta\frac{2h\nu}{c}\left(\frac{E}{c} - (n\mathfrak{M})\right)\varphi(QH)$$

$$\gamma(-h^2\Box + mc^2)\varphi(PE) = -\gamma\frac{2h\nu}{c}\left(\frac{E}{c} - (n\mathfrak{M})\right)\varphi(P\mathcal{E}).$$

$$\alpha(-h^2\Box + mc^2)\varphi(A\,\mathrm{grad})\varphi = -\alpha\frac{2h\nu}{c}\left(\frac{E}{c} - (n\mathfrak{M})\right)\varphi(A\,\mathrm{grad})\varphi.$$

$$A\,\mathrm{grad}\,\varphi = -\frac{i}{h}(A\mathfrak{M})\varphi.$$

$$-\frac{i}{h}\times 2ih = 2$$

$$\therefore -\alpha\cdot\frac{2h\nu}{c}\left(\frac{E}{c} - (n\mathfrak{M})\right) = -2ih\frac{e'}{c} \qquad \therefore \alpha = \frac{e}{2h\nu\left(\frac{E}{c} - (n\mathfrak{M})\right)}\ 2ih.$$

$$-\beta \quad \cdot\cdot \quad = -\frac{e}{c} \qquad \beta = \frac{+e}{\cdot\cdot}$$

$$-\gamma \quad \cdot\cdot \quad = +\frac{e'}{c} \qquad \gamma = \frac{-e}{\cdot\cdot}$$

$$\therefore G_2 = K\left(2(\mathfrak{M}A) + (QH) \mp (P\mathcal{E})\right)$$

$$g = \alpha\,(\tilde{A}\,\mathrm{grad}\,\varphi) + \beta\,\varphi(Q\tilde{H}) + \gamma\,\varphi(P\tilde{\varepsilon}).$$

$$\mathrm{grad}\,\varphi = -\frac{i}{h}\mathfrak{M}\varphi \qquad \frac{\partial\varphi}{\partial t} = \frac{i}{h}E\varphi$$

$$\mathrm{grad}\,(Q\tilde{H}) = \frac{i\nu n}{c}(Q\tilde{H}) \qquad \frac{\partial(QH)}{\partial t} = -i\nu(QH).$$

$$\therefore \Delta\{\varphi(Q\tilde{H})\} = \Delta\varphi.(Q\tilde{H}) + \varphi.\Delta(Q\tilde{H}) + 2(n\mathfrak{M})\frac{\nu}{hc}\varphi(Q\tilde{H}).$$

$$\frac{\partial^2}{c^2\partial t^2}\varphi(Q\tilde{H}) = \frac{1}{c^2}\frac{\partial^2\varphi}{\partial t^2}(Q\tilde{H}) + \varphi\frac{\partial^2}{c^2\partial t^2}(Q\tilde{H}) + \frac{2\nu}{c^2h}E\varphi(Q\tilde{H}).$$

$$-h^2\Box\varphi(Q\tilde{H}) = -m^2c^2\varphi(Q\tilde{H}) + \left(\frac{2\nu h}{c^2}E - \frac{2h\nu}{c}(\mathfrak{M}n)\right)\varphi(Q\tilde{H}).$$

$$\beta\left(-h^2\Box\varphi(Q\tilde{H}) + m^2c^2\varphi(Q\tilde{H})\right) = \beta\frac{2h\nu}{c}\left(\frac{E}{c} - (\mathfrak{M}n)\right)\varphi(Q\tilde{H}).$$

$$\gamma\left(-h^2\Box + m^2c^2\right)(P\varepsilon) = \gamma\frac{2h\nu}{c}\left(\frac{E}{c} - (\mathfrak{M}n)\right)\varphi(P\tilde{\varepsilon}).$$

$$\alpha\left(\qquad\right)(\tilde{A}\,\mathrm{grad}\,\varphi) = \alpha\frac{2h\nu}{c}\left(\qquad\right)(\tilde{A}\,\mathrm{grad})\varphi. \qquad \frac{-i}{h}\mathfrak{M}.$$

$$\tilde{A}\,\mathrm{grad}\,\varphi.$$

$$\alpha\frac{2h\nu}{c}(\quad) = -2ih\frac{e}{c}. \qquad \therefore \alpha = \kappa(\cancel{-2ih}\; -2(\tilde{A}\mathfrak{M})$$

$$\beta\;.. \qquad = -\frac{e}{c} \qquad \beta = -\kappa$$

$$\gamma = +\kappa$$

$$\therefore G_1 = -\kappa\left(2(\tilde{A}\mathfrak{M}) + (Q\tilde{H}) \mp (P\tilde{\varepsilon})\right).$$

$$v\left[\frac{E}{c} + (\alpha\mathfrak{M}) + \beta_3 mc\right]\underset{=0}{(\alpha\tilde{A})}.$$

$$\cancel{v\left[\frac{E}{c}\right.}\quad \cancel{v(\alpha\tilde{A})}. \quad (\alpha_1\mathfrak{M}_1 + \alpha_2\mathfrak{M}_2 + \alpha_3\mathfrak{M}_3)(\alpha_1\tilde{A}_1 + \alpha_2\tilde{A}_2 + \alpha_3\tilde{A}_3)$$

$$= -\alpha_1\tilde{A}_1(\alpha_1\mathfrak{M}_1 + \alpha_2\mathfrak{M}_2 + \alpha_3\mathfrak{M}_3) + 2\tilde{A}_1\mathfrak{M}_1 \;\ldots$$

$$-\alpha_2\tilde{A}_2 \;\ldots$$

$$-\alpha_3\tilde{A}_3$$

$$(\alpha\mathfrak{M})(\alpha\tilde{A}) = -(\alpha_s\tilde{A}_s)(\alpha\mathfrak{M}) + 2(\tilde{A}\mathfrak{M}).$$

$$\nu(\alpha\tilde{A})\left[\frac{E}{c}\,\bar{\cdot}\,(\alpha\mathfrak{M}) - \rho_3 mc\right] = -2\nu(\tilde{A}\mathfrak{M}).$$

$$G_1 = -k\,\nu(\alpha\tilde{A})\left[-\frac{E_1}{c} + (\alpha\mathfrak{M}_1) + \rho_3 mc\right]$$

$$= k\,\nu(\alpha\tilde{A})\left[\frac{E_1}{c} - (\alpha\mathfrak{M}_1) - \rho_3 mc\right] = k\,\nu(\alpha\hat{A})\left[\frac{E}{c} - (\alpha\mathfrak{M}) - \rho_3 mc - \frac{h\nu}{c} + \frac{h\nu}{c}(\alpha n)\right]$$

$$= k\nu\left\{-2(\tilde{A}\mathfrak{M}) - \frac{h\nu}{c}(\alpha\tilde{A}) + \frac{h\nu}{c}(\alpha\tilde{A})(\alpha n)\right\}$$

$$= -k\nu\left\{(\tilde{A}\mathfrak{M}) + \frac{h\nu}{c}(\alpha\tilde{A}) - i\frac{h\nu}{c}(\tilde{\alpha}, A\times n)\right\}.$$

$$= -k\nu\left\{(\tilde{A}\mathfrak{M}) - ih(\alpha\tilde{E}) + h(\alpha, H)\right\} = -k\nu\left\{(\hat{A}\mathfrak{M}) + (QH) - (PE)\right\}$$

$$\frac{i\nu}{c}\tilde{A} = \tilde{E} \qquad \therefore\ \frac{\nu}{c}\tilde{A} = -i\tilde{E} \qquad \frac{i\nu}{c}[n\times A] = H.$$

$$\left(-(p_0 - e'A_0) + (\alpha_1^+, -p + e'A) + \beta_3^+ mc\right)\varphi = 0.$$

$$\left((p_0 - e'A) + (\alpha_1^+, -p + e'A) + \beta_3^+ mc\right)$$

$$\left[-(p_0 - e'A_0)^2 + (\alpha_1^+, -p + e'A)^2 + m^2c^2 + (p_0 - e'A)(\alpha_1^+, -p + e'A) + (\alpha_1^+, -p + e'A)(-p_0 + e'A_0)\right]\varphi = 0$$

$$(\alpha_1^+, -p + e'A)^2 = (-p + e'A)^2 + i\sum\alpha_3^+(\qquad) = (-p + e'A)^2 - e'h(\alpha^+H)$$

$$-ihe\rho_1^+(\alpha^+E).$$

$$\rho_1^+\alpha_1^+ = \tilde{\alpha}_1\rho_1 \qquad \therefore\ \rho_1^+(\alpha^+E) = \overline{(\sigma E)\rho_1}^+$$

$$\rho_2^+\alpha_2^+ = \tilde{\alpha}_2\rho_2$$
