$\psi(x'k')e^{\frac{2\pi i e}{c}\int_{x_0}^{x'} A_\mu dx_\mu}$

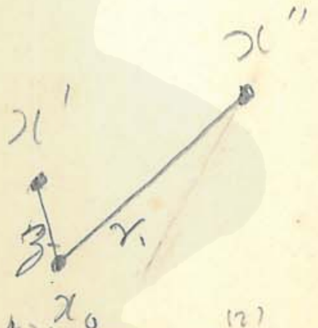
$e^{-\frac{2\pi i e}{c}\int_{x_0}^{x''} A_\mu dx_\mu} \cdot \psi^*(x''k'')x$

x' 又 x'' と x_0 の time が異つておれば、 $e^{+\cdots}$ は $e^{-\cdots}$ と $\psi^*(x'k')$

は $\psi^*(x''k'')$ とは non-commutative である。

所で、

$\exp\left\{\frac{2\pi i e}{hc}\int_{x_0}^{x} A_\mu dx_\mu\right\}$



なる operator は、 x_μ を discrete にとつて、

$\exp\left\{\sum_k \frac{2\pi i e}{hc} A_\mu(x_\mu^{(k)})\delta_\mu^{(k)}\right\} f(E_\mu(x_\mu^{(1)}), E_\mu(x_\mu^{(2)}), \cdots)$

$A_\mu = -\frac{ihc}{2\pi}\frac{\partial}{\partial E_\mu(x_\mu^{(k)})}$ $\delta(x^{(k)})$

$= f(E_\mu(x_\mu^{(k)}) + \frac{2\pi i e}{hc}\delta_\mu^{(k)}, \quad)$

一般に $f = \sum c_{\mu\nu}^{(k)} E_\nu(x^{(k)})$ なる形のものならば、 $x^{(k+1)} - x^{(k)}$

$\exp\{\quad\} f = \sum c_{\mu\nu}^{(k)}(E_\nu(x^{(k)}) \cancel{+\frac{2\pi i e}{hc}} - e\,\delta_{\mu\nu}^{(k)})$

$= f - e\sum c_{\mu\nu}^{(k)}\delta_{\mu\nu}^{(k)}$

$eE = \frac{e}{r}$ $\int^S$

$E = \frac{e}{r^2}$

$\delta_\mu^{(k)}$ を 0 にした limit をとれば、

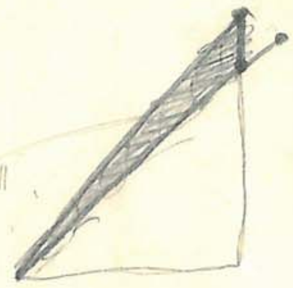
$= f - e\int_{x_0}^{x} C_{\mu\nu}(x_\mu)\,dx_\nu$

$$\psi \cdot e^{\frac{2\pi i e}{hc}\int_{x_0}(A\,dx - A_0\,dt)}$$

$$\parallel$$

$$\sum a_n e_n$$

$$a_m^* \; a_n$$



E_x^{H}

τ

$t,\ (t, x, y, z,)$

$$i\hbar\frac{\partial}{\partial t}e^{\cdots} = \frac{e}{hc}\frac{\partial}{\partial t}\int_{x_0}^{x_1}(A_0\,dt)\,e^{\cdots}$$

$$= e\,A_0 + \iint_{\text{面積}}(\mathrm{curl}\,A)^{4次元}\ \cdots\ S_i\,ds$$

t, s に垂直な comp.

$$\frac{\partial}{\partial s} = \frac{t}{S}\frac{\partial}{\partial t} + \cdots = $$

$+t(\mathrm{curl}\,A)$　t, s に垂直

$+x(\qquad)$　x, s に垂直

$+y(\qquad)$

$+z(\qquad)$　=

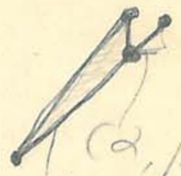
$$s = \sqrt{t\qquad}$$

$$(t \cdot \alpha x)\cdot(i\hbar\frac{\partial}{\partial t} + \alpha' c\, p' + \beta' m c^2)$$

=

$$\bar{R}(x, x') = \psi^\dagger(x)\,e^{\frac{2\pi i}{h}(x'-x)\mathbb{D}}\,\psi(x)$$

$$\mathbb{D} = \frac{h}{2\pi i}\frac{\partial}{\partial}\ \mathrm{grad} + \frac{e}{c}A$$



(α, β, γ)

ds

$$\int_{x_0}^{x} A_x\,dx$$

$$\frac{\delta(r-ct)}{r^2 - ct}$$

$$\frac{h}{2\pi i}\frac{\partial}{\partial x}\left(\psi e^{+\frac{2\pi i e}{hc}\int_{x_0}^{x}A\,ds}\right) = \frac{h}{2\pi i}\frac{\partial\psi}{\partial x}e^{\cdots} + \frac{e}{c}\frac{\partial}{\partial x}\left(\int_{x_0}^{x}A\,ds\right)e^{\cdots}$$

$$= \frac{h}{2\pi i}\frac{\partial\psi}{\partial x}e^{\cdots} - \frac{e}{c}A_x - \frac{e}{c}\int_{x_0}^{x}\frac{\partial A_y}{\partial x}dy\Big\{ -\frac{e}{c}\int_{x_1}^{x}\frac{\partial A_z}{\partial x}dz$$

$$+ \frac{e}{c}\iint_{x_0}^{x}\{(\mathrm{curl}\,A)_{\perp x, s}\,dx\,dy\,ds\}$$

$$\parallel$$

$$\int_{x_0}^{x}(\mathrm{curl}\,A)\frac{s}{S}ds$$

$$H_\perp$$

$$R^{r'r}_{kl} R^{r''r'''}_{mn} \pm R_{ml} R_{kn}$$

$$R^{(0)}(r,r')\, R^{(0)}(r'' r''') \pm R^{(0)}(r,r''')\, R^{(0)}(r'' r')$$

$$= \psi^\dagger(r)\psi(r')\psi^\dagger(r'')\psi(r''') \pm \psi^\dagger(r)\psi(r''')\psi^\dagger(r'')\psi(r')$$

$$= \psi^\dagger(r)\left(\delta(r'r'') \mp \psi^\dagger(r'')\psi(r')\right)\psi(r''')$$

$$= \pm R_{mk}\delta_{mn} + R_{ml}\delta_{kn}$$

$$\pm \psi^\dagger(r)\left(\delta(r''r''') \mp \psi^\dagger(r''')\psi(r'')\right)\psi(r')$$

$$= \psi^\dagger(r)\psi(r''')\,\delta(r'r'') \pm \psi^\dagger(r)\psi(r')\,\delta(r''r''')$$

$$R^{(0)}(r,r')\, R^{(0)}(r'' r''') \pm R^{(0)}(r,r''')\, R^{(0)}(r'' r')$$

$$= \psi\, e^{-\frac{2\pi i e}{hc}\int_{r_0}^{r} A\, ds}\, \psi^\dagger(r) \quad - \; -$$

$$R_{kl}(R_{mn} \mp \delta_{mn}) \pm R_{ml}(R_{kn} \mp \delta_{kn}) = 0$$

$$= R^{(0)}(r,r''')\,\delta(r'r'') \pm R^{(0)}(r,r')\,\delta(r'',r''')$$

$$R^{(0)}(r,r')\left(R^{(0)}(r''r''') \mp \delta(r'',r''')\right)$$

$$\mp R^{(0)}(r,r''')\left(\delta(r'r'') \mp R^{(0)}(r''r')\right)$$

$$N_k(N_k - 1) + R_{mk}(R_{km} - \delta_{km}) = 0$$

$$N_m(N_k - 1) + R_{km}(R_{mk} - \delta_{km}) = 0$$

$$\left(R^{(0)}(r^4 r^5) \pm \delta(r^4 r^5)\right) R^{(0)}(r,r')\left(R^{0}(r''r''') \mp \delta(r''r''')\right)$$

$$- R^{(0)}(r^4 r^5)$$

$$N_k(N_k \mp \delta 1) = 0.$$

$$\cancel{= R_k(R_k \mp 1)}$$

$$R_{\lambda l}(R_{\mu m} - \delta_{\mu m}) + R_{\lambda m}(R_{\mu l} - \delta_{\mu l}) = 0.$$

$N_k \cdot N_l$ oo

$$\cancel{(\psi^\dagger(x')\psi(x') - \psi(x')\psi^\dagger(x'))(\psi^\dagger(x)\psi(x) \ldots)}$$

$$(\psi^\dagger_\lambda \psi_l - \psi_l \psi^\dagger_\lambda)(\psi^\dagger_\mu \psi_m - \psi_m \psi^\dagger_\mu) \pm (\psi^\dagger_\lambda \psi_m - \psi_m \psi^\dagger_\lambda) \times (\psi^\dagger_\mu \psi_l - \psi_l \psi^\dagger_\mu)$$

$$= \psi^\dagger_\lambda (\delta_{l\mu} - \psi^\dagger_\mu \psi_l)\psi_m + \cancel{\psi^\dagger_\lambda \psi_m \psi_l \psi^\dagger_\mu}$$

$$\pm \psi_l \psi^\dagger_\lambda \psi^\dagger_\mu \psi_m + \psi_l (\delta_{\lambda m} - \psi_m \psi^\dagger_\lambda)\psi^\dagger_\mu$$

$$+ \psi^\dagger_\lambda (\delta_{m\mu} - \psi^\dagger_\mu \psi_m)\psi_l - \cancel{\psi^\dagger_\lambda \psi_m \psi_l \psi^\dagger_\mu}$$

$$- \psi_m \psi^\dagger_\lambda \psi^\dagger_\mu \psi_l + \psi_m(\delta_{\lambda l} - \psi_l \psi^\dagger_\lambda)\psi^\dagger_\mu$$

$$\cancel{\psi_l \psi^\dagger_\mu \psi^\dagger_\lambda \psi_m = \psi_m \psi^\dagger_\lambda \psi^\dagger_\mu \psi_l = (\delta_{l\mu} - \psi^\dagger_\mu \psi_l)\psi^\dagger_\lambda \psi_m}$$

$$= \psi^\dagger_\lambda \psi_m \delta_{l\mu} + \psi_l \psi^\dagger_\mu \delta_{\lambda m}$$

$$+ \psi^\dagger_\lambda \psi_l \delta_{m\mu} + \psi_m \psi^\dagger_\mu \delta_{\lambda l}$$

$$\left(\psi^\dagger_\lambda \psi_l - \frac{\delta_{\lambda l}}{2}\right)\left(\psi^\dagger_\mu \psi_m - \frac{\delta_{\mu m}}{2}\right) + \left(\psi^\dagger_\lambda \psi_m - \frac{\delta_{\lambda m}}{2}\right) \times \left(\psi^\dagger_\mu \psi_l - \frac{\delta_{\mu l}}{2}\right)$$

$$= \psi^\dagger_\lambda (\delta_{l\mu} - \psi^\dagger_\mu \psi_l)\psi_m - \psi^\dagger_\mu \psi_m \frac{\delta_{\lambda l}}{2}$$

$$- \psi^\dagger_\lambda \psi_l \frac{\delta_{\mu m}}{2} + \frac{\delta_{\lambda l}}{2}\frac{\delta_{\mu m}}{2}$$

$$+ \psi^\dagger_\lambda (\delta_{m\mu} - \psi^\dagger_\mu \psi_m)\psi_l - \psi^\dagger_\mu \psi_l \frac{\delta_{\lambda m}}{2}$$

$$- \psi^\dagger_\lambda \psi_m \frac{\delta_{\mu l}}{2} + \frac{\delta_{\lambda m}}{2}\frac{\delta_{\mu l}}{2} \qquad \left(-\frac{\delta_{\mu l}\delta_{\lambda m}}{4}\right.$$

$$= \left(\psi^\dagger_\lambda \psi_m - \frac{\delta_{\lambda m}}{2}\right)\frac{\delta_{\mu l}}{2} + \left(\psi^\dagger_\lambda \psi_l - \frac{\delta_{\lambda l}}{2}\right)\frac{\delta_{\mu m}}{2}$$

$$- \left(\psi^\dagger_\mu \psi_m - \frac{\delta_{\mu m}}{2}\right)\frac{\delta_{\lambda l}}{2} - \left(\psi^\dagger_\mu \psi_l - \frac{\delta_{\mu l}}{2}\right)\frac{\delta_{\lambda m}}{2} - \frac{\delta_{\mu m}\delta_{\lambda l}}{4}$$

$$\cancel{\Psi_x}\; R'_{\lambda m}\frac{\delta_{\mu l}}{2} + R'_{\lambda l}\frac{\delta_{\mu m}}{2}$$

$$- R'_{\mu m}\frac{\delta_{\lambda l}}{2} - R'_{\mu l}\frac{\delta_{\lambda m}}{2}$$

$$- \frac{\delta_{\mu m}\delta_{\lambda l}}{4} - \frac{\delta_{\mu l}\delta_{\lambda m}}{4}$$

$$= R'_{\lambda l}R'_{\mu m} + R'_{\lambda m}R'_{\mu l}$$

$$\left(R'_{\lambda l}+\frac{\delta_{\lambda l}}{2}\right)\left(R'_{\mu m}-\frac{\delta_{\mu m}}{2}\right)$$

$$+\left(R'_{\lambda m}+\frac{\delta_{\lambda m}}{2}\right)\left(R'_{\mu l}-\frac{\delta_{\mu l}}{2}\right) = 0$$

---

not quantised

$$\iint \underbrace{\psi(x'k'')}_{C_{k'k'''}} E \underbrace{\psi^\dagger(x'k'')}_{\tilde{C}_{k'k''}} = -\iint \underbrace{\psi^\dagger(x'k')}_{\tilde{C}_{k'k''}} \underset{C}{E} \underbrace{\psi(x'k'')}_{C_{k'k'''}}$$

ρ

$\iint$ ρ_1 ρ_3 $\boxed{C = \rho_2}$

$\iint$ α ρ

$$\boxed{\rho_2 \psi = \psi^\dagger}$$

$$\begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} + \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}\begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}$$

$$= \begin{pmatrix} 2a_{11} & 0 \\ 0 & 2a_{22} \end{pmatrix} = 0$$

$a_{11} = a_{22} = 0$,

$$\begin{pmatrix} 0 & a_{12} \\ a_{21} & 0 \end{pmatrix}^2 = \begin{pmatrix} a_{12}a_{21} & 0 \\ 0 & a_{21}a_{12} \end{pmatrix} = 1, \qquad a_{12}\cdot a_{21} = 1$$

$a_{12} = \tilde{a}_{21}$

$$\begin{pmatrix} 0 & e^{i\omega} \\ e^{-i\omega} & 0 \end{pmatrix}$$

$\alpha_x, \alpha_y, \alpha_z$ = real

β: imag. el.

$$\left(\frac{E}{c} + \alpha p + \beta \mu c\right)\psi_0 = 0,$$

$$\left(\frac{E}{c} + \alpha^* p + \beta^* \mu c\right)\psi_0^* = 0$$

$\mu = 0.$ $\quad \psi_0 = \psi_0^*,$

$$\left.\begin{array}{l}\left(\frac{E}{c} + \alpha p\right)\psi_0 = 0 \\ \left(\frac{E}{c} + \alpha p\right)\psi_0^* = 0.\end{array}\right\} \quad \begin{array}{l}\frac{E}{c} + \rho_1\sigma_z p_x + \rho_3 p_y + \rho_1 p_z \\ \quad + \rho_1\sigma_y \mu c = 0\end{array}$$

$$\left\{\rho_1\sigma_y \frac{E}{c} \pm i\sigma_x p_x - i\rho_2\sigma_y p_y \pm i\sigma_z p_z\right\}\psi_0 = 0$$

$$\{ \quad \text{''} \quad \text{''} \quad \}\psi_0^* = 0$$

$$\boxed{\psi_0 \equiv \psi_0^*.}$$

$$\psi_0 = \sum a_k \sin \cdots + \sum c_k \cos \cdots$$

$$\psi_0^* \psi_0 + \psi_0 \psi_0^* = \delta.$$

$$\psi_0 = \frac{1}{\sqrt{2}}(\varphi + \varphi^*)$$

$$\psi_0 \psi_0' + \psi_0' \psi_0 = \delta$$

$$\frac{1}{2}\{(\varphi+\varphi^*)(\varphi'+\varphi^{*\prime}) + (\varphi'+\varphi^{*\prime})(\varphi+\varphi^*)\}$$

$$= \frac{1}{2}\{(\varphi\varphi' + \varphi'\varphi) + (\varphi^*\varphi^{*\prime} + \varphi^{*\prime}\varphi^*) + (\varphi^*\varphi' + \varphi'\varphi^*)$$

$$+ (\varphi\varphi^{*\prime} + \varphi^{*\prime}\varphi)\} = \delta.$$

$$\psi_0 = \sum_{k} (a_k \varphi_k + \varphi_k^* + c_k \varphi_k^*)$$

$$\psi_- \rightleftarrows \psi_0 \rightleftarrows \psi_+$$

$\{ \quad \}\psi_0 = 0$

$$= \sum (a_k^* \varphi_k^* + c_k^* \varphi_k^*)$$

reduction

$$\left(\frac{\partial}{c\,\partial t} - \alpha\,\mathrm{grad}\right)\psi_0 = 0 \qquad \sigma_y(\rho_1\sigma_y + \rho_3) = (\rho_1 + \rho_3\sigma_y)$$

$$\psi_0 = A \exp i(\mathbf{k}\mathbf{r} - ck_0 t)$$

$\rho_1\sigma_y$

$$\{k_0 + (\alpha\,\mathbf{k})\}A = 0.$$

$\alpha_x\alpha_y(\alpha_y+\rho)\alpha_x$

$(\alpha_y+\rho)\alpha_{xy}$

$$\{k_0\delta_{\mu\lambda} + (\mathbf{k}\,\alpha_{\mu\nu})\}A_\nu = 0.$$

$= \alpha_y\rho$

$= \rho(\rho+\alpha_y)$

$$\| k_0\delta_{\mu\lambda} + \mathbf{k}\,\alpha_{\mu\nu} \| = 0.$$

$$\underline{k_0^2 = k^2}$$

$(\quad)\rho_1\sigma_y$

$$(k_0^2 - k^2)^2 = 0.$$

$$\psi_0^{*} = (A_{\mathbf{k}k_0} + A'_{\mathbf{k}k_0})\exp i(\cdots) + (A_{-\mathbf{k}k_0} + A)\exp -i(\cdots)$$

$$\psi_0^{*} = (A^{*}_{\mathbf{k}k_0} + A'^{*}_{\mathbf{k}k_0})\exp -i(\cdots)$$

$$A^{*}_{\mathbf{k}k_0} + A'^{*}_{\mathbf{k}k_0} = A_{-\mathbf{k}k_0} + A'_{-\mathbf{k}k_0}$$

$\boxed{\rho_3\sigma_y}$

$$A'^{*}_{\mathbf{k}k_0} = A_{\mathbf{k}k_0}$$

$$A'^{*}_{\mathbf{k}k_0} = A'_{\mathbf{k};k_0}$$

A's の意味は~~つけにくい、~~ ~~中方向の spin が +1 or -1.~~

つけにくい、~~pps spin~~ ス,リ,そこです方向の を一定でない、

或 disint をおこす様な process においても ~~elect~~ electron の spin も

生ずる neutrino の spin は一定でない。 従って

一定 ~~一定~~ である事。 ~~spin が一定でない~~ pps. interaction

spin をかへると

$\frac{1}{\sqrt{2}}(\rho_1+\rho_3\sigma_y)\{\frac{E}{c}+\rho_1(\sigma$ ...

$\frac{1}{\sqrt{2}}\{\frac{E}{c}+\rho_1\sigma_x p_x+\rho_1\sigma_y\rho_3 p_y+\rho_1\sigma_z p_z+\rho_1\sigma_y mc\}\frac{1}{\sqrt{2}}(\rho_1+\rho_3\sigma_y)\psi$

$\underline{\quad 20}$

$\because\ (\rho_1+\rho_3\sigma_y)\rho_1\sigma_x = \rho_1\sigma_x(\rho_1+\rho_3\sigma_y)$

$(\rho_1+\rho_3\sigma_y)\rho_1\sigma_y = \rho_3(\rho_3\sigma_y+\rho_1)$

$(\quad ,, \quad)\rho_1\sigma_z = \rho_1\sigma_z(\quad ,, \quad)$

$(\rho_1+\rho_3\sigma_y)\rho_3 = \rho_1\sigma_y(\rho_3\sigma_y+\rho_1)$

$\frac{1}{2}(\rho_1+\rho_3\sigma_y)^2 = 1$

$m=0$

$\frac{1}{\sqrt{2}}(\rho_1+\rho_3\sigma_y)\psi = \frac{1}{\sqrt{2}}(\rho_1+\rho_3\sigma_y)\psi^*$ X

$\frac{1}{\sqrt{2}}(\rho_1-\rho_3\sigma_y)$

$\rho_1\rho_3\sigma_y\ \psi = k\psi^*$

$i\rho_2\sigma_y$ $\quad -i\rho_2\sigma_y\ \psi = k\psi^*$

$\psi = k i\rho_2\sigma_y\psi^* = \psi$

$-k^{-1}i\rho_2\sigma_y\psi^* = \psi$ X

$\underline{\underline{\psi^* = \psi = 0}}$

pps $\quad \psi = \psi^*$

$\frac{1}{\sqrt{2}}(\rho_1+\rho_3\sigma_y)$

$\frac{1}{\sqrt{2}}(\rho_1-\rho_3\sigma_y)$

$$\left.\begin{aligned}\psi &= \frac{1}{\sqrt{2}}(\rho_1+\rho_3\sigma_y)\psi_0 \\ \psi^* &= \frac{1}{\sqrt{2}}(\rho_1-\rho_3\sigma_y)\psi_0^*\end{aligned}\right\}$$

$$= \frac{1}{\sqrt{2}}(\rho_1-\rho_3\sigma_y)\psi_0$$

$$\psi=\psi^*=0.$$

$$-i\rho_2\sigma_y\psi = \psi^*, \qquad \psi = i\rho_2\sigma_y\psi^*.$$

$$\underline{\underline{i\rho_2\sigma_y\,\psi^* = \psi}}$$

ψ_+

$\rho_3\sigma_y\,\psi_- = \psi_+^*$

$\cancel{(\psi_\lambda^\dagger \psi_l - \psi_\lambda \psi_l^\dagger)(\psi_\mu^\dagger \psi_m - \psi_\mu \psi_m^\dagger)}$

$+ (\psi_\lambda^\dagger \psi_m - \psi_\lambda \psi_m^\dagger)(\psi_\mu^\dagger \psi_l - \psi_\mu \psi_l^\dagger)$

$= \psi_\lambda^\dagger (\delta_{l\mu} - \psi_\mu^\dagger \psi_l) \psi_m + \psi_\lambda^\dagger \psi_\mu \psi_l (\delta_{\mu m} - \psi_m^\dagger \psi_\mu)$

$R_{\lambda l} R_{\mu m} + R_{\lambda m}$

$R^2 = 1,$

$\psi_\lambda^\dagger (\delta_{l\mu} - \psi_\mu^\dagger \psi_l)$

$\cancel{(R+1)(R-1) = 0}$

$(\psi_\lambda^\dagger \psi_l - \psi_\lambda \psi_l^\dagger)(\psi_l^\dagger \psi_m - \psi_m \psi_m^\dagger)$

$= \psi_\lambda^\dagger \delta_{l\mu} - \psi_\mu$

$(\psi_\lambda^\dagger \psi_\mu - \psi_\lambda \psi_\mu^\dagger)(\psi_\lambda^\dagger \psi_\mu - \psi_\lambda \psi_\mu^\dagger)$

$\cancel{= \psi_\lambda^\dagger (\psi_\mu \psi_\mu^\dagger + \psi_\mu^\dagger \psi_\mu) \psi_\nu}$

$\boxed{R^2 = 1,}$

$= \psi_\lambda^\dagger \psi (\delta_{\lambda\mu} - \psi_\lambda^\dagger \psi_\mu) \psi_\lambda$

$- \psi_\lambda \, \psi$

$\psi_\lambda^\dagger \psi_\mu \psi_\lambda$

$(a_\mu^\dagger a_m - a_{-\mu} a_{-m}^\dagger)$

$a_\mu^\dagger a_\mu - a_{-\mu} a_{-\mu}^\dagger) = 0$

$0 \quad - \quad 0$

$1 \quad - \quad 1$

Selbstenergie (V. Weisskopf, Z. f. Phys. 89, 27, 1934)

$$H = +c(\vec{\alpha}, \vec{p} \pm \tfrac{e}{c}\vec{A}) + \rho mc^2 + \frac{1}{8\pi}\int(\vec{E}^2 + \vec{H}^2)\,d\vec{r}.$$

$$E = -\int(\vec{i}\vec{A})\,d\vec{r} + \frac{1}{8\pi}\int(\vec{E}^2 + \vec{H}^2)\,d\vec{r}.$$

$$\vec{i} = e\vec{\alpha}.$$

~~Trans~~ rotationsfreier Teil $\vec{A}_l, \vec{E}_l\,(\vec{H}_l = 0)$

divergenzfreier Teil $\vec{A}_{tr}, \vec{E}_{tr}, \vec{H}_{tr}$

el. st. Energie: $E^S = -\int(\vec{i}\vec{A}_l)\,d\vec{r} + \frac{1}{8\pi}\int \vec{E}_l^2\,d\vec{r}$

$\vec{A}_l = \operatorname{grad}\lambda$, $\quad \Phi' = \Phi - \frac{1}{c}\frac{\partial\lambda}{\partial t}$ $\quad \vec{E}_l = -\operatorname{grad}\Phi'$

$$E^S = \frac{1}{2}\int \rho\,\Phi'\,d\vec{r}$$

$$\Phi(\vec{r}) = \int \frac{\rho(\vec{r}')}{|\vec{r} - \vec{r}'|}\,d\vec{r}'$$

el. dyn. Energie $E^D = -\int(\vec{i}_{tr}\vec{A}_{tr})\,d\vec{r} + \frac{1}{8\pi}\int(\vec{E}_{tr}^2 + H_{tr}^2)\,d\vec{r}$

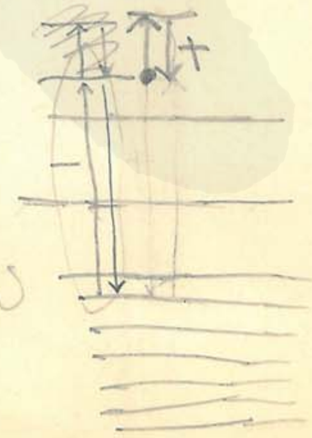
$$= -\frac{1}{2}\int(\vec{i}_{tr}\vec{A}_{tr})\,d\vec{r}$$

Löchertheorie: $E^S = \frac{1}{2}\iint \frac{[\rho(\vec{r}) - \tilde{\rho}(\vec{r})][\rho(\vec{r}') - \tilde{\rho}(\vec{r}')]}{|\vec{r} - \vec{r}'|}\,d\vec{r}\,d\vec{r}'$

$\tilde{\rho}, \tilde{\vec{i}}$: Ladungs- und Stromdichte der Elektronen in den negativen Zuständen.

$\tilde{\vec{A}}$: deren erzeugtes Vektorpotential

$$E^D = -\frac{1}{2}\int(\vec{i}(\vec{r}) - \tilde{\vec{i}}(\vec{r}), \vec{A}(\vec{r}) - \tilde{\vec{A}}(\vec{r}))\,d\vec{r},$$



$$E^S = \frac{e^2}{h\sqrt{m^2c^2 + p^2}}(2m^2c^2 + p^2)\int_{p_0}^{\infty}\frac{dp}{p} + \text{end.}$$

$$E^D = \frac{e^2}{h\sqrt{m^2c^2 + p^2}}\cdot\left(m^2c^2 - \frac{4}{3}p^2\right)\int_{p_0}^{\infty}\frac{dp}{p} + \text{end.}$$

今一つのelectronが[illegible] charge current densityのために周囲にfieldを生ずる。このfieldのためにnegative energy stateのelectronsのwave function、従ってcharge, current densityも変化し、従って元のelectronに働くfieldが生ずる。このためにまた元のelectronのcharge, current densityが変化し、それがまた ~~pos.~~ energy electronsに影響を与へられる。この様にして結局、このprocessがconvergeするならば、one electron (in vacuum)の問題が解かれたことになる。

しかるに、このone electronによって生ずるfieldは

$$\Box V = -4\pi\rho$$

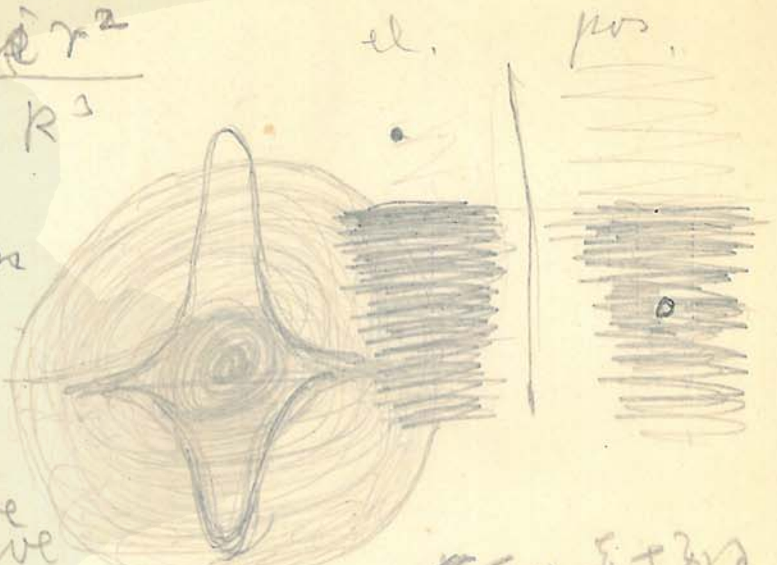
$$\Box A = -4\pi i$$

を解くことによって得られる。ρ, iとしては一定の ~~current~~ velocity, spinを持ったelectronのそれを入れると、それは場所によってかはらぬ、時間

今かりに electronは大きなsphere中の至る所にあるとすると、この中では V, A は

$$\frac{\rho \cdot r^3}{R^3}\cdot\frac{1}{r}=\frac{\rho r^2}{R^3},\quad \frac{i r^3}{R^3}\frac{1}{r}=\frac{i r^2}{R^3}$$

の形である。



すると、この内部の neg. ~~energy~~ energy electrons は attr. force ~~は harmonic な repulsive force,~~ ~~それ故 V がへれば、(pos. energy)~~

又 neg. energy ~~positrons~~ は harmonic な ~~attractive~~ repulsive force を受けたとは考へられない。中心に ~~働いて~~ 従って電荷は遠ざかる。外部ではCoulomb attractionがある様の考へである。之をつきあはすと、結局、~~positive~~ neg. chargeが中央に集って来ることになろう。元のelectronは ~~中央に集まろう~~ とする。之に反するであろう。