Şimdi ~~Halen bu~~ küçük · aşağı yukarı bölüm, her sınıfa uygun olacak ~~şekilde~~
~~mahiyette~~ ve ~~mühim~~ yeni ufukları açacak mahiyette ve
bir faaliyetlerinin programının faydalanabileceği kaynakların
bir listesini çıkarmakla meşguldür.

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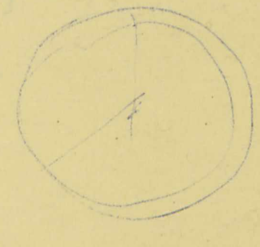
in-service

cross-country

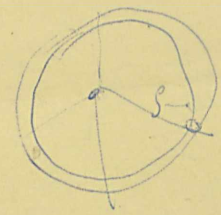
Cam

mood pieces

$$m_i = \int_0^R \frac{\overbrace{4\pi\rho^2 d\rho\, \rho_0}^{m_i}}{|r-\rho|}$$



$$4\pi \frac{KT}{2\, 4\pi} = \pm\frac{2}{R^2}$$



$$\frac{KT}{6} = \frac{2}{R^2} = 4\pi$$

$$R^2 = \frac{12}{KT} \qquad \frac{1}{(t+r)(t-r)} = \frac{1}{2t}\left(\frac{1}{t+r} + \frac{1}{t-r}\right)$$

$$-G\,\frac{4\pi\rho^2 d\rho}{\rho}$$

$$4\pi G\int_0^R \rho\, d\rho = 2\pi G R^2$$

$$\frac{1}{t^2 - r^2} = \frac{1}{2t^2}\left[\frac{1}{1+\frac{r}{t}} + \frac{1}{1-\frac{r}{t}}\right]$$

[illegible] of outgoing and ingoing waves.

$$\int \nabla^2 \Phi\, d^3 x$$

$d\tau^2 = \gamma_{\mu\nu}\, dx^\mu dx^\nu$

$-\frac{1}{4} + 1 + \cancel{\frac{1}{2}} - \frac{1}{2}$

$\Box \phi = -4\pi K' \mathcal{T} = \frac{+2}{R^2}\phi^3$

$-(4\pi K' T)\phi^3 =$

$$M(t) = 4\pi R^2 \int_0^\infty \frac{2 r^2\, dr}{\left(1 - \frac{c^2 t^2}{2R^2} + \frac{r^2}{2R^2}\right)^3}$$

$$\int_0^\infty \frac{2 r^2\, dr}{(a + b r^2)^3} =$$

$r^2 = \xi \qquad r = \xi^{\frac{1}{2}}$

$2r\,dr = d\xi$

$$\int_0^\infty \frac{\xi^{\frac{1}{2}}\, d\xi}{(a + b\xi)^3}$$

$R \dfrac{1 + \frac{\vec{x}'}{2R}}{1 - \frac{\vec{x}'}{2R}} = R e^{\frac{\vec{a}}{2R}} \dfrac{1 + \frac{\vec{x}}{2R}}{1 - \frac{\vec{x}}{2R}} e^{\frac{\vec{a}}{2R}} = 1 +$

$R \dfrac{1 + \frac{\vec{Y}}{2R}}{1 - \frac{\vec{Y}}{2R}} = X_5 + \vec{X}$

$e^{\frac{\vec{x}'}{R}} = e^{\frac{\vec{a}}{R} + \frac{\vec{x}}{R}}$

$x' = \vec{x} + \vec{a}$

$X'_5 + \vec{X}' = e^{\frac{\vec{a}}{2R}} (X_5 + \vec{X}) e^{\frac{\vec{a}}{2R}}$

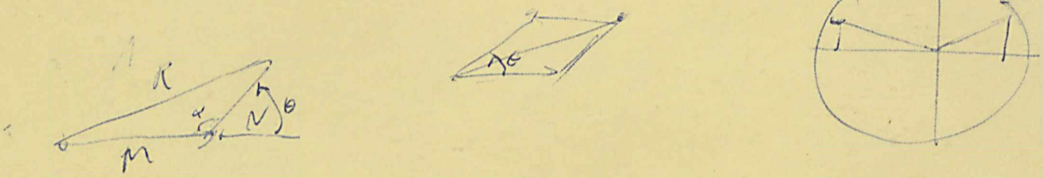
$1 + X = Y - XY \qquad X(1+Y) = Y - 1$

$X = \frac{Y-1}{Y+1}$

$\frac{1+X}{1-X} = Y$

$\frac{X'}{2R} =$

$MN \cos \vec{M}\vec{N}$



$R^2 = M^2 + N^2 + MN \cos \alpha.$

$= M^2 + N^2 + MN \cos(180 - \theta)$

$M^2 + N^2 - MN \cos\theta.$

$$f(\vec{x} + \vec{a}) = f(\vec{x}) + a_m \partial_m f(\vec{x}) = (1 + i\vec{p}\cdot\vec{a}) f(\vec{x})$$

$$i\vec{p} = \vec{\nabla}$$

$$f \qquad R \frac{1 + \frac{\vec{x}'}{2R}}{1 - \frac{\vec{x}'}{2R}} = R e^{\frac{\vec{a}}{2R}} \frac{1 + \frac{\vec{x}}{2R}}{1 - \frac{\vec{x}}{2R}} e^{\frac{\vec{a}}{2R}} = 1 +$$

$$R \frac{1 + \frac{\vec{x}}{2R}}{1 - \frac{\vec{x}}{2R}} = X_5 + \vec{X}$$

$$e^{\frac{\vec{x}'}{R}} = e^{\frac{\vec{a}}{R} + \frac{\vec{x}}{R}} \qquad x' = \vec{x} + \vec{a}$$

$$X'_5 + \hat{X}' = e^{\frac{\vec{a}}{2R}} (X_5 + \vec{X}) e^{\frac{\vec{a}}{2R}}$$

$$1 + Y = Y - XY \qquad X(1+Y) = Y - 1$$

$$X = \frac{Y-1}{Y+1}$$

$$\frac{1 + X}{1 - X} = Y$$

$$\frac{X'}{2R} =$$

$$\frac{\xi}{(a+b\xi)^3} = \frac{1}{b}\left[\frac{1}{(a+b\xi)^2} - \frac{a}{(a+b\xi)^3}\right]$$

$$\frac{r^2}{(a+br^2)^3} = \frac{A}{(a+br^2)^3} + \frac{B}{(a+br^2)^2} + \quad \frac{1}{b}\left[a+b\xi \ - a\right]$$

$$\frac{\xi}{(a+b\xi)^3} = \frac{A}{(a+b\xi)^3} + \frac{B}{(a+b\xi)^2} + \cancel{\frac{C}{a+b\xi}}$$

$Ca^2+2Cab\xi + Cb^2\xi^2$

$$= \frac{A + B(a+b\xi) + C(a+b\xi)^2}{(a+b\xi)^3}$$

$$= \underbrace{A + aB + a^2C}_{(\ )} + (Bb + 2abC)\xi + Cb^2\xi^2$$

$C=0.$

$\cancel{b=0}.\quad A + aB = 0$

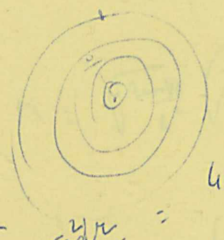
$Bb = 1$

$B = \frac{1}{b} \quad A = -\frac{a}{b}$

$$R_\mu{}^\nu - \frac{1}{2}\delta_\mu{}^\nu R = \phi^{-2}\left(R_\mu{}^\nu - \frac{1}{2}\delta_\mu{}^\nu R\right) - 4\phi^{-4}[\ \ ] + 2\phi^{-3}[\ \ ]$$

$$= \kappa\,\phi^{-3}\,\mathcal{T}_\mu{}^\nu$$

$$R_\mu{}^\nu - \frac{1}{2}\delta_\mu{}^\nu R = \kappa\,\phi^{-1}\mathcal{T}_\mu{}^\nu + 4\phi^{-2}[\ \ ] - 2\phi^{-1}[\ \ ]$$



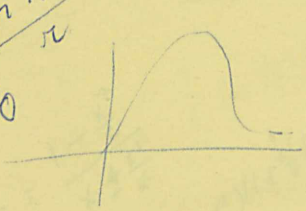
$$\kappa\int_0^R \frac{4\pi T r^2 dr}{r} = 4\pi\kappa T\int_0^R r\,dr = 4\pi\kappa T\frac{R^2}{2}$$

$$= 2\pi\kappa T R^2 = \phi$$

$$M = \frac{4\pi}{3}TR^3$$

$$\frac{M}{R} = \frac{4\pi}{3}TR^2 = \frac{2}{3\kappa}(2\pi\kappa TR^2) = \frac{2}{3\kappa}\phi$$

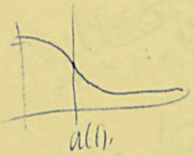
$$\phi = \frac{3\kappa M}{2R}$$



$$g = \phi^8\gamma$$

$$\sqrt{-g} = \phi^4\sqrt{-\gamma}$$

$$\phi\,\partial_\mu\partial_\mu\phi = \partial_\mu(\phi\,\partial_\mu\phi) - (\partial_\mu\phi)(\partial_\mu\phi)$$



a(t)

$$\int\phi\,\Box\phi\,d^4x = -\int(\partial_\mu\phi)(\partial_\mu\phi) + \phi$$

$$\phi = \frac{1}{1 - \frac{r^2}{2R^2}} + \frac{\kappa M}{r} \qquad \frac{\sum m_i}{R} \qquad \phi^{-3} \quad \phi^{-4}\frac{d\phi}{dr}$$

$$\left(-\frac{3}{2}+\frac{2}{2}\right)\frac{r^2}{R^2} - 3 +$$

$$\frac{7}{2}\frac{r^2}{R^2} = 1 - \frac{c r^2}{2R^2}$$

$$r^2 = \frac{2}{7}R^2\left(1 - \frac{cr^2}{2R^2}\right) \qquad \frac{7}{2}\frac{r^2}{R^2} + \frac{cr^2}{2R^2} - 1 = 0$$

$$r = \sqrt{\frac{2}{7}}\,R\sqrt{1-\frac{cr^2}{2R^2}}$$

$$\phi = \frac{3}{R^2(\ )^5}\left[4\frac{r^2}{R^2} - \frac{1}{2}\frac{r^2}{R^2} - 1 + \frac{cr^2}{2R^2}\right]$$

$$\frac{1}{\left(1 - \frac{cr^2}{2R^2} + \frac{r^2}{2R^2}\right)^3}$$

$$\frac{d\mathcal{T}}{dr} = -\frac{3}{R^2}\frac{r}{(\ \ )^4}$$

$$\frac{d^2\mathcal{T}}{dr^2} = \frac{12}{R^2}\frac{\frac{r^2}{R^2}}{(\ \ )^5} - \frac{3}{R^2}\frac{1 - \frac{cr^2}{2R^2} + \frac{r^2}{2R^2}}{(\ \ )^5}$$

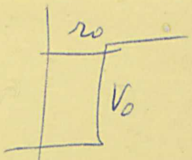
3 × 4

u

$L_0 = k\cot\delta_0$

$k = \frac{\sqrt{2mE}}{\hbar}$

$k^2 = \frac{2mE}{\hbar^2}$



$\kappa = \frac{1}{\hbar}\sqrt{2m(E+V_0)} = \sqrt{\frac{2mE}{\hbar^2}+\frac{2mV_0}{\hbar^2}} = \sqrt{k^2+\frac{2mV_0}{\hbar^2}}$

$K r_0 = \frac{r_0}{\hbar}\sqrt{2mV_0} = \kappa(0) r_0$

$$k\cot\delta_0 = \frac{k\sin kr_0 + \kappa(\cot\kappa r_0)\cos kr_0}{\cos kr_0 - \kappa\cot\kappa r_0 \frac{\sin kr_0}{k}}$$

$k = 0 \quad \kappa = K.$

$K = \frac{\sqrt{2mV_0}}{\hbar}$

$\kappa = \sqrt{k^2 + \frac{2mV_0}{\hbar^2}}$

$= k\sin kr_0 + \frac{1}{k}\sqrt{}$

$$\kappa = \sqrt{\frac{2mV_0}{\hbar^2}}\left(\sqrt{1+\frac{k^2}{\hbar\sqrt{\frac{2mV_0}{\hbar^2}}}}\right. = K\sqrt{1+\frac{k^2}{K^2}} \sim K\left(1+\frac{1}{2}\frac{k^2}{K^2}\right) = K + \frac{1}{2}\frac{k^2}{K}$$

$$k\cot\delta_0 = \frac{K\cot Kr_0}{1 - r_0 K\cot Kr_0} = \frac{1}{\frac{1}{K\cot Kr_0} - r_0} = \frac{1}{a}$$

$$\frac{\cos x}{\sin x} = \frac{1-\frac{x^2}{2}}{x - \frac{x^3}{6}} = \frac{1}{x}\frac{\left(1-\frac{x^2}{2}\right)}{1-\frac{x^2}{6}} = \frac{1}{x}\left(1-\frac{x^2}{2}\right)\left(1+\frac{x^2}{6}\right) = \frac{1}{x}\left(1-\frac{3x^2}{6}+\frac{x^2}{6}\right) = \frac{1}{x}\left(1-\frac{x^2}{3}\right)$$

$$a = \frac{r_0 K\cot Kr_0 - 1}{K\cot Kr_0} = r_0 - \frac{1}{K\cot Kr_0} = r_0\left(1 - \frac{1}{r_0 K\cot Kr_0}\right)$$

$x - \frac{x^3}{6}$

$x\left(1-\frac{x^2}{3}\right)$

$\cot x = \frac{1-\frac{x^2}{3}}{x}$

$\kappa = K + \frac{1}{2}\frac{k^2}{K}$

$\kappa^2 = K^2 + k^2$

$$\frac{k^2 r_0 + \left(K+\frac{1}{2}\frac{k^2}{K}\right)\frac{1-\frac{1}{3}(r_0^2K^2+r_0^2k^2)}{Kr_0+\frac{1}{2}\frac{r_0}{K}k^2}(1-k^2r_0^2)}{1-k^2r_0^2 - \left(K+\frac{1}{2}\frac{k^2}{K}\right)\frac{1-\frac{1}{3}(r_0^2K^2+r_0^2k^2)}{Kr_0+\frac{1}{2}\frac{r_0}{K}k^2}r_0\left(1-\frac{k^2r_0^2}{6}\right)}$$

$$= \frac{1}{\frac{1}{r_0} - \frac{1}{3}r_0K^2 - \frac{1}{3}r_0k^2 - r_0k^2 + \frac{1}{3}r_0^3K^2k^2}$$

$$\frac{1}{\cancel{K}r_0}\left(\cancel{K} + \cancel{\frac{1}{2}\frac{k^2}{K}}\right)\frac{1-\frac{1}{3}r_0^2K^2-\frac{1}{3}r_0^2k^2}{\cancel{1+\frac{1}{2}\frac{k^2}{K^2}}}\left(1-\cancel{\frac{1}{2}\frac{k^2}{K^2}}\right).$$

$$= \frac{1}{r_0}\left(1-\frac{1}{3}r_0^2K^2 - \frac{1}{3}r_0^2k^2\right) = \frac{1}{r_0} - \frac{1}{3}r_0K^2 - \frac{1}{3}r_0k^2$$

$(1-k^2r_0^2)$

$$\frac{1}{r_0} - \frac{1}{3} r_0 K^2 + r_0 k^2\left(-\frac{4}{3} + \frac{1}{3} r_0 K^2\right)$$

$$\frac{1}{r_0} - \frac{1}{3} r_0 K^2 - \frac{r_0 k^2}{3}\left(4 - r_0 K^2\right) + r_0 k^2$$

$-\frac{4}{3} + 1 = -\frac{4}{3} + \frac{3}{3} = -\frac{1}{3}$

$-\frac{1}{3} r_0 k^2 -$

$$\frac{\frac{1}{r_0} - \frac{1}{3} r_0 K^2 - \frac{r_0 k^2}{3}\left(1 - r_0 K^2\right)}{1 - k^2 r_0^2 + r_0\left(1 - \frac{1}{3} r_0^2 K^2 - \frac{1}{3} r_0^2 k^2\right)\left(1 - \frac{k^2 r_0^2}{6}\right)}$$

$\left(1 - \frac{1}{3} r_0^2 K^2 - \frac{1}{3} r_0^2 k^2\right) r_0\left(1 - \frac{k^2 r_0^2}{6}\right)$

$$1 - \frac{1}{3} r_0^2 K^2 - \frac{1}{3} r_0^2 k^2 - \frac{r_0^2}{6} k^2 + \frac{1}{18} r_0^4 K^2 k^2 - r_0^2 k^2$$

$$1 - \frac{3}{2} r_0^2 k^2 + \frac{1}{18} r_0^4 K^2 k^2 \Big/ -\frac{1}{3} - 1 - \frac{1}{6} = -\frac{2}{6} - \frac{1}{6} - 1 = -\frac{1}{2} - 1 = -\frac{3}{2}$$

2m

$$[ab, c] = [a, c]b + a[b, c].$$

$$\sigma_{\mu\nu} = i\,\frac{\gamma_\mu\gamma_\nu - \gamma_\nu\gamma_\mu}{2} = \frac{i}{2}[\gamma_\mu, \gamma_\nu]$$

$$[\sigma_{\mu\nu}, \gamma_\lambda] = \frac{i}{2}[\gamma_\mu\gamma_\nu, \gamma_\lambda] - \frac{i}{2}[\gamma_\nu\gamma_\mu, \gamma_\lambda]$$

$$= \frac{i}{2}[\gamma_\mu, \gamma_\lambda]\gamma_\nu + \frac{i}{2}\gamma_\mu[\gamma_\nu, \gamma_\lambda] -$$

$$abc - cab = abc + acb - acb - cab$$

$$= a\{bc\} - \{ac\}b.$$

$$[ab, c] = a\{bc\} - \{ac\}b$$

$$[\gamma_\mu\gamma_\nu, \gamma_\lambda] = \gamma_\mu\underbrace{\{\gamma_\nu\gamma_\lambda\}}_{2\delta_{\nu\lambda}} - \{\gamma_\mu\gamma_\lambda\}\gamma_\nu$$

$$S\gamma_\mu S^{-1} = \gamma_\mu + \gamma_\mu a$$

$$= 2\gamma_\mu\delta_{\nu\lambda} - 2\gamma_\nu\delta_{\mu\lambda}$$

$$\frac{i}{2}[\gamma_\mu\gamma_\nu, \gamma_\lambda] = i(\gamma_\mu\delta_{\nu\lambda} - \gamma_\nu\delta_{\mu\lambda})$$

$$[\sigma_{\mu\nu}, \gamma_\lambda] = 2i(\gamma_\mu\delta_{\nu\lambda} - \gamma_\nu\delta_{\mu\lambda}) - \cancel{\gamma_\nu}\,\delta$$

$$\gamma_\mu\partial_\mu\psi = m\psi \qquad \partial_\mu = \partial'_\mu + a_{\mu\nu}\partial'_\nu$$

$$\gamma_\mu\partial_\mu = \gamma_\mu\partial'_\mu + \gamma_\mu a_{\mu\nu}\partial'_\nu$$

$$\frac{d}{d\tau}\phi\frac{dx^\mu}{d\tau} = \partial^\mu\phi$$

$\phi = \phi(\sigma^2)$.

$\sigma^2 = x^\mu x_\mu$
$\frac{d}{d\tau}\sigma^2 = 2\frac{dx^\mu}{d\tau}x_\mu$

$\frac{d}{d\tau}\phi(\sigma^2) = \phi'(\sigma^2)\frac{d}{d\tau}\sigma^2$

$$\frac{d}{d\tau}\phi(\sigma^2)\frac{dx^\mu}{d\tau} = 2x^\mu\phi'(\sigma^2).$$

$\frac{\partial}{\partial x_\mu}\sigma^2 = \partial_\mu\sigma^2 = 2x_\mu$

$$\phi(\sigma^2)\frac{d^2x^\mu}{d\tau^2} + \phi'(\sigma^2)\,2x_\lambda\frac{dx^\lambda}{d\tau}\frac{dx^\mu}{d\tau} = 2x^\mu\phi'(\sigma^2).$$

$$\frac{d^2x^\mu}{d\tau^2} = 2\frac{\phi'}{\phi}\left[x^\mu - x_\lambda\frac{dx^\lambda}{d\tau}\frac{dx^\mu}{d\tau}\right]$$

$x^m - x_\lambda\frac{dx^\lambda}{d\tau}$

$$\frac{d^2x^\mu}{d\tau^2} = 2\frac{\phi'(\sigma^2)}{\phi(\sigma^2)}\left[x^\mu - \underbrace{x_\lambda\frac{dx^\lambda}{d\tau}}_{\left(\frac{1}{2}\frac{d}{d\tau}\sigma^2\right)}\frac{dx^\mu}{d\tau}\right].$$

$$d\tau^2 = dt^2\left(1-\frac{v^2}{c^2}\right).$$

Newline

$$\frac{d^2x^2}{dt^2} = \left(x^\mu - t\frac{dx^\mu}{dt}\right)\frac{\gamma}{\sigma^2}\,G(\xi)\left[\cancel{\left(\frac{1}{2}\frac{d}{dt}\sigma^2 \cdot \frac{dx}{dt}\right)^2}\right]$$

$\gamma = 1 - \frac{v^2}{c^2}$.

$$\xi = \frac{\left[\frac{1}{2}\frac{d\sigma^2}{dt}\right]^2}{\left(1-\frac{v^2}{c^2}\right)\sigma^2} = \frac{1}{\sigma^2}\left[\frac{d\,\sigma^2}{\sqrt{1-\frac{v^2}{c^2}}\,dt}\right]^2$$

$$\xi = \frac{1}{4\sigma^2}\left(\frac{d\sigma^2}{d\tau}\right)^2 = \frac{1}{4\sigma^2}\,4\sigma^2\left(\frac{d\sigma}{dt}\right)^2 = \left(\frac{d\sigma}{d\tau}\right)^2$$

$\frac{4\pi}{3} = 4$

$2\pi^2 = 20$

$$\xi = \left(\frac{d\sigma}{d\tau}\right)^2.$$

$$x^0\frac{dt}{d\tau} - x^m\frac{dx^m}{d\tau} = \frac{t}{\sqrt{1-v^2/c^2}} - \frac{x^m\,dx^m}{\sqrt{1-v^2/c^2}\,dt}$$

$$x^\mu - \frac{1}{\gamma}\left(t\frac{dx^\mu}{dt} - x^m\frac{dx^m}{dt}\frac{dx^\mu}{dt}\right). = \left(t - x^m\frac{dx^m}{dt}\right)\frac{1}{\sqrt{1-v^2/c^2}}\,\frac{dx^\mu}{dt\sqrt{1-v^2/c^2}}$$

$$X_\mu X_\mu + X_5^2 = R^2$$

$$X_\mu = \frac{x_\mu}{1 + \frac{x_\lambda x_\lambda}{4R^2}}$$

then we find . $X_5 = R \dfrac{1 - \frac{x_\lambda x_\lambda}{4R^2}}{1 + \frac{x_\lambda x_\lambda}{4R^2}} = R \dfrac{1 - \frac{\tau^2}{4R^2}}{1 + \frac{\tau^2}{4R^2}}$

$X_5 = R$ corresponds to $\tau^2 = 0$.

$$x = \frac{1+y}{1-y} \qquad \frac{\tau^2}{4R^2} = \frac{1 + \frac{X_5}{R}}{1 - \frac{X_5}{R}}$$

$$\frac{1-x}{1+x} = y$$

$x = -1 \quad y \to \infty$

$x = \infty \quad y = -1$

$$\tau^2 = 4R^2 \frac{1 + \frac{X_5}{R}}{1 + \frac{X_5}{R}}$$

$$ds^2 = dX_\mu dX_\mu + dX_5^2 = \frac{1}{\left(1 + \frac{\tau^2}{4R^2}\right)^2} d\sigma^2 \qquad d\sigma^2 = \eta_{\mu\nu} dx^\mu dx^\nu$$

$$\tau'^2 = f(\tau^2, a^2 \tau_\mu a_\mu)$$

$(x - a)$

$$\tau'^2 = \tau^2 + a^2 + 2\tau_\mu a_\mu$$

$$\gamma_5 X_5 + \gamma_\mu X_\mu = \gamma_\mu \frac{x_\mu}{1 + \frac{\tau^2}{4R^2}} + \gamma_5 R \frac{1 - \frac{\tau^2}{4R^2}}{1 + \frac{\tau^2}{4R^2}}$$

$$X'_5 + \gamma_\mu \gamma_5 X'_\mu = \mathrm{Tr}\,(X_5 + \gamma_\mu \gamma_5 X_\mu)\, e^{\gamma(\ldots)}$$

$$\gamma_5 X_5 + \gamma_\mu X_\mu = \frac{\gamma_\mu x_\mu + \gamma_5 R\left(1 - \frac{\tau^2}{4R^2}\right)}{1 + \frac{\tau^2}{4R^2}}$$

$$\gamma_5 X'_5 + \gamma_\mu X'_\mu = e^{\frac{i}{2}\gamma_5 \gamma_\mu a_\mu} (\gamma_5 X_5 + \gamma_\mu X_\mu)\, e^{-\frac{i}{2}\gamma_5 \gamma_\mu a_\mu}$$

$$X'_5 + \gamma_\mu \gamma_5 X'_\mu = e^{\frac{1}{2}\gamma_5 \gamma_\mu a_\mu} (X_5 + \gamma_\mu \gamma_5 X_\mu)\, e^{\frac{1}{2}\gamma_5 \gamma_\mu a_\mu}$$

$$X'_5 = \mathrm{Tr}\ S(\ )S \quad \mathrm{Tr}(\ )S^2$$

$$\frac{\gamma_\mu x'_\mu + \gamma_5 R\left(1-\frac{\tau'^2}{4R^2}\right)}{1+\frac{\tau'^2}{4R^2}} = e^{-\frac{1}{2}\gamma_5\gamma_\mu a_\mu}\,\frac{\gamma_\mu x_\mu + \gamma_5 R\left(1-\frac{\tau^2}{4R^2}\right)}{1+\frac{\tau^2}{4R^2}}\,e^{\frac{1}{2}\gamma_5\gamma_\mu a_\mu}$$

$$\frac{R\left(1-\frac{\tau'^2}{4R^2}\right) + \gamma_5\gamma_\mu x'_\mu}{1+\frac{\tau'^2}{4R^2}} = \frac{e^{-\frac{1}{2}\gamma_5\gamma_\mu a_\mu}\left[R\left(1-\frac{\tau^2}{4R^2}\right)+\gamma_5\gamma_\mu x_\mu\right]e^{\frac{1}{2}\gamma_5\gamma_\mu a_\mu}}{1+\frac{\tau^2}{4R^2}}$$

$$\cancel{X_\mu \frac{\partial}{\partial X_\nu} - X_\nu \frac{\partial}{\partial X_\mu}}$$

$$X_5 \frac{\partial}{\partial X_\mu} - X_\mu \frac{\partial}{\partial X_5}$$

$$\frac{\partial}{\partial X_\mu} = \frac{\partial x_\lambda}{\partial X_\mu}\frac{\partial}{\partial x_\lambda} \qquad X_5 = f(\tau^2)$$

$$\frac{\partial}{\partial X_5} = \frac{\partial x_\lambda}{\partial X_5}\frac{\partial}{\partial x_\lambda}$$

$\psi(x_1, x_2, x_3, x_4)$

$x^2+y^2=R^2$

$x = R\frac{\xi/R}{1+\frac{\xi^2}{4R^2}} \qquad y = R\frac{1-\xi^2/4R^2}{1+\xi^2/4R^2}$

$x\,\partial_y - y\,\partial_x$

$x = r$

$y = r\,t$

$x = r\cos\varphi$

$y = r\sin\varphi$

$$\frac{\partial}{\partial x} = \frac{\partial r}{\partial x}\frac{\partial}{\partial r} + \frac{\partial\varphi}{\partial x}\frac{\partial}{\partial\varphi}$$

$$y\frac{\partial}{\partial x} = r\sin\varphi\,\frac{\partial r}{\partial x}\frac{\partial}{\partial r} + r\sin\varphi\,\frac{\partial\varphi}{\partial x}\frac{\partial}{\partial\varphi}$$

$\xi^2 + R^2\left(1+\frac{\xi^2}{4R^2}\right)^2$

$\frac{\xi^2}{R^2} + 1 + \frac{\xi^2}{2R^2} + \frac{\xi^4}{16R^4}$

$\left(1+\frac{\xi^2}{4R^2}\right)^2$

$1-x = y + xy$

$x(1-y) = 1+y \quad x = \frac{1-y}{1+y}$

$\frac{1-x}{1+x} = y$

$x^2 + y^2 = R^2$

$x = R\cos\varphi \quad y = R\sin\varphi$

$\frac{\xi^2}{4R^2} = \frac{1-\cos\varphi}{1+\cos\varphi} = \frac{\sin^2\frac{\varphi}{2}}{\cos^2\frac{\varphi}{2}}$

$\sin\varphi = \frac{\xi/R}{1+\frac{\xi^2}{4R^2}} \qquad \cos\varphi = \frac{1-\frac{\xi^2}{4R^2}}{1+\frac{\xi^2}{4R^2}} \qquad \varphi = \varphi(\xi^2)$

$x\partial_y - y\partial_x = \frac{\partial}{\partial\varphi} = \frac{d\xi}{d\varphi}\frac{\partial}{\partial\xi}$

$t = \xi_2$

$\frac{2t}{1+t^2}$

$\frac{\xi}{2R} = \operatorname{tg}\frac{\varphi}{2} \qquad \frac{\xi^2}{4R^2} = \operatorname{tg}^2\frac{\varphi}{2}$

$\xi = 4R\operatorname{tg}\frac{\varphi}{2}$

$x = \frac{\xi}{\left(1+\frac{\xi^2}{4R^2}\right)} \qquad y = R\,\frac{1-\xi^2/4R^2}{1+\xi^2/4R^2}$

$dx^2 + dy^2 =$

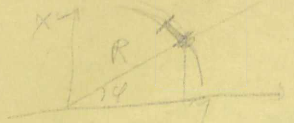
$\frac{dx}{d\xi} = \frac{1}{\left(1+\frac{\xi^2}{4R^2}\right)} - \frac{\xi \times 2\xi/4R^2}{(\ )^2} = \frac{1+\frac{\xi^2}{4R^2}-\frac{2\xi^2}{4R^2}}{(\ )^2} = \frac{1-\frac{\xi^2}{4R^2}}{(\ )^2}$

$\frac{dy}{d\xi} = R\,\frac{-\left(1+\frac{\xi^2}{4R^2}\right)\frac{2\xi}{4R^2} - \left(1-\frac{\xi^2}{4R^2}\right)\frac{2\xi}{4R^2}}{(\ )^2} = \frac{-\frac{2\xi}{4R^2}-\frac{2\xi}{4R^2}-\frac{2\xi^3}{16R^4}+\frac{2\xi^3}{16R^3}}{(\ )^2}$

$\frac{dy}{d\xi} = \frac{-\xi/R}{(\ )^2}$

$dx^2+dy^2 \left[\left(\frac{dx}{d\xi}\right)^2 + \left(\frac{dy}{d\xi}\right)^2\right] d\xi^2 = \frac{1+\frac{\xi^4}{16R^4}-\frac{\xi^2}{2R^2}+\frac{2\xi^2}{2R^2}}{(\ )^4} = \frac{\left(1+\frac{\xi^2}{4R^2}\right)^2}{\left(1+\frac{\xi^2}{4R^2}\right)^4} d\xi^2$

$dx^2 + dy^2 = \frac{d\xi^2}{\left(1+\frac{\xi^2}{4R^2}\right)^2}$



$$\xi = 2R\tan\frac{\varphi}{2}$$

$x^2+y^2=R^2$

$$ds = \frac{d\xi}{1+\frac{\xi^2}{4R^2}}$$

$0<\varphi<\pi$

$$x = R\sin\varphi \qquad y = R\cos\varphi$$

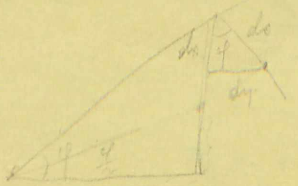
$$x = R\,\frac{\xi/R}{1+\frac{\xi^2}{4R^2}} \qquad y = R\,\frac{1-\frac{\xi^2}{4R^2}}{1+\frac{\xi^2}{4R^2}}$$

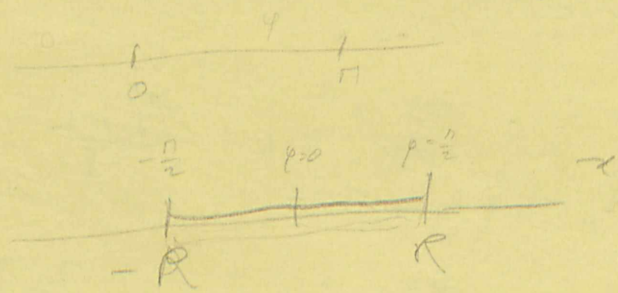
$$ds^2 = \frac{d\xi^2}{\left(1+\frac{\xi^2}{4R^2}\right)^2}$$

$0<\xi<\infty$

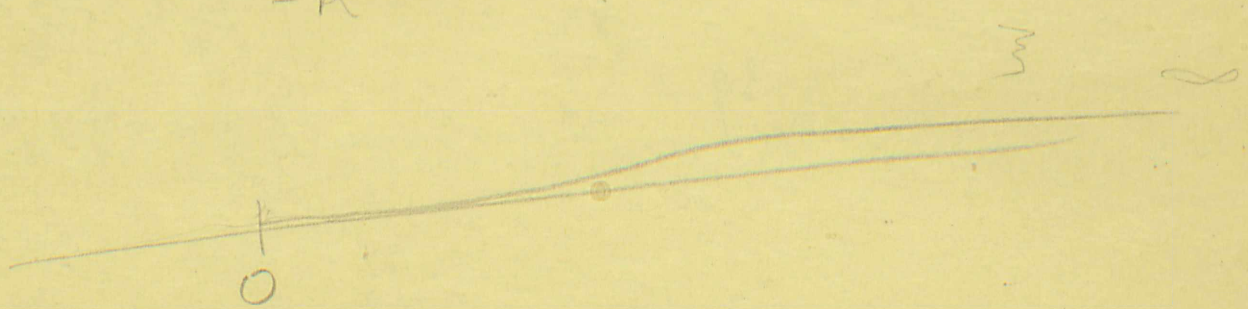
$$x\frac{\partial}{\partial y} - y\frac{\partial}{\partial x}$$

$$1+\frac{\xi^2}{4R^2} = 1+\tan^2\frac{\varphi}{2} = \frac{1}{\cos^2\frac{\varphi}{2}}$$





$$\frac{\frac{1}{R}d\xi}{1+\frac{\xi^2}{4R^2}} = d\varphi$$



$$\tan\frac{\varphi}{2} = \frac{\xi}{2R} \qquad \varphi = 2\tan^{-1}\frac{\xi}{2R} = \varphi(\xi)$$

$$\frac{\partial}{\partial\varphi} = \frac{d\xi}{d\varphi}\frac{\partial}{\partial\xi} \qquad \xi = 2R\,\frac{\sin\frac{\varphi}{2}}{\cos\frac{\varphi}{2}}$$

$$d\xi = 2R\,\frac{\cos^2\frac{\varphi}{2}+\sin^2\frac{\varphi}{2}}{\cos^2\frac{\varphi}{2}}\times\frac{1}{2}d\varphi = \frac{R\,d\varphi}{\cos^2\frac{\varphi}{2}}$$

$$x\partial_y - y\partial_x = \frac{\partial}{\partial\varphi}$$

$$d\xi = R\left(1+\tan^2\frac{\varphi}{2}\right)d\varphi$$

$$= R\left(1+\frac{\xi^2}{4R^2}\right)d\varphi$$

$$\frac{\partial}{\partial\varphi} = R\left(1+\frac{\xi^2}{4R^2}\right)\frac{\partial}{\partial\xi}$$

$$L_{54} = x\frac{\partial}{\partial y} - y\frac{\partial}{\partial x} = R\left(1+\frac{\xi^2}{4R^2}\right)\frac{\partial}{\partial \xi} - \sim R\frac{\partial}{\partial \xi}$$

$$\frac{1}{R}L_{54} = \left(1+\frac{\xi^2}{4R^2}\right)\frac{\partial}{\partial \xi}$$

$$X^2+Y^2+Z^2 = R^2, \qquad x^2+y^2=r^2$$

$$X = \frac{x}{\left(1+\frac{r^2}{4R^2}\right)} \qquad Y = \frac{y}{\left(1+\frac{r^2}{4R^2}\right)} \qquad Z = R\,\frac{1-\frac{r^2}{4R^2}}{\left(1+\frac{r^2}{4R^2}\right)}$$

$$X^2+Y^2+Z^2 = \frac{r^2 + R^2\left(1-\frac{r^2}{4R^2}\right)^2}{(\quad)^2} = R^2\,\frac{\frac{2r^2}{2R^2}+1+\left(\frac{r^2}{4R^2}\right)^2-\frac{r^2}{2R^2}}{(\quad)^2} = R^2$$

$$e_1X+e_2Y+e_3Z = \vec{q}.$$

$$|\vec{q}|=1 \qquad \frac{e_1x+e_2y+e_3R\left(1-\frac{x^2+y^2}{4R^2}\right)}{1+}$$

$$Re^{\vec{z}} + e^{-\vec{z}}$$

$$\left|\frac{1+i\alpha}{1-i\alpha}\right| = \qquad X\frac{\partial}{\partial Y} - Y\frac{\partial}{\partial X}$$

$$\frac{\partial}{\partial X}$$

$$Z\frac{\partial}{\partial X} - X\frac{\partial}{\partial Y} = Z(r^2)$$

$$2x^2\,dx+$$

$$\frac{\partial}{\partial X} = \frac{\partial x}{\partial X}\frac{\partial}{\partial x} + \frac{\partial y}{\partial X}\frac{\partial}{\partial y}$$

$$dr^2 = 2x\,dx + 2y\,dy$$

$$dX = \frac{\left(1+\frac{r^2}{4R^2}\right)dx - x \times \frac{2x\,dx+2y\,dy}{4R^2}}{(\quad)^2} =$$

$$X^2+Y^2 = \frac{r^2}{\left(1+\frac{r^2}{4R^2}\right)^2} \qquad x = \left(1+\frac{r^2}{4R^2}\right)X \qquad y = \left(1+\frac{r^2}{4R^2}\right)Y$$

$$\left(1+\frac{r^2}{4R^2}\right)^2(X^2+Y^2) = r^2$$

$$r^2\left(1-\frac{X^2+Y^2}{4R^2}\right) = X^2+Y^2 \qquad \frac{r^2}{4R^2} = \frac{(X^2+Y^2)/4R^2}{1-\frac{X^2+Y^2}{4R^2}}$$

$$\vec{q}\,' = e^{\frac{1}{2}\vec{\omega}}\, \vec{q}\, e^{-\frac{1}{2}\vec{\omega}}$$

$$\vec{q} = \frac{e_1 \rho \cos\varphi + e_2 \rho \sin\varphi + e_3 R\left(1 - \frac{\rho^2}{4R^2}\right)}{1 + \frac{\rho^2}{4R^2}}$$

$$\frac{e_1 \rho(\cos\varphi + e_3 \sin\varphi) + e_3 R(\quad)}{}$$

$$= \frac{e_1 \rho\, e^{-e_3\varphi} + e_3 R\left(1 - \frac{\rho^2}{4R^2}\right)}{1 + \frac{\rho^2}{4R^2}}$$

e_1

$$\left| R\frac{1+\vec{q}}{1-\vec{q}} \right| = R$$

$$X_1^2+X_2^2+X_3^2+X_4^2 = R^2$$

$$\frac{1+\vec{q}}{(1-\vec{q})}\frac{(1+\vec{q})}{(1+\vec{q})} = \frac{1\pm q^2+2\vec{q}}{1+q^2} = X_0+e_1X_1+e_2X_2+e_3X_3$$

$$R\cdot\frac{1+\frac{\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}} = X_5+e_1X_1+e_2X_2+e_3X_3$$

$$R\frac{\vec{q}}{2} = \vec{x} \qquad \frac{\vec{q}}{2} = \frac{\vec{x}}{R}$$

$$X+iY = R\frac{1+i\frac{\xi}{2R}}{1-i\frac{\xi}{2R}} = R\frac{1-\frac{\xi^2}{4R^2}+i\frac{\xi}{R}}{1+\frac{\xi^2}{4R^2}}$$

$$R\frac{\cancel{1}+\vec{x}}{1-\frac{\vec{x}}{R}} =$$

$$R\frac{1-\frac{q^2}{4R^2}+\frac{\vec{q}}{R}}{1+\frac{q^2}{4R^2}} = \frac{R\left(1-\frac{q^2}{4R^2}\right)}{1+\frac{q^2}{4R^2}} + \frac{\vec{q}}{1+\frac{q^2}{4R^2}} = X_5+\vec{X}$$

$$\boxed{R\frac{1+\gamma_5\gamma_\mu\frac{x_\mu}{2R}}{1-\gamma_5\gamma_\mu\frac{x_\mu}{2R}} = X_5+\gamma_5\gamma_\mu X_\mu}$$

$$R\frac{2R\gamma_5+\gamma_\mu x_\mu}{2R\gamma_5\pm\gamma_\mu x_\mu} = X_5+\gamma_5\gamma_\mu X_\mu$$

$$\left(1-\frac{\gamma_5\gamma_\mu x_\mu}{2R}\right)\left(1+\frac{\gamma_5\gamma_\mu x_\mu}{2R}\right) = 1-\frac{\gamma_5\gamma_\mu\gamma_5\gamma_\nu x_\mu x_\nu}{4R^2}$$

$$R\frac{1+\gamma_5\gamma_\mu\frac{x_\mu'}{2R}}{1-\gamma_5\gamma_\mu\frac{x_\mu}{2R}} = e^{\frac{1}{2}\gamma_5\gamma_\mu\frac{a_\mu}{R}}(\quad)e^{-\frac{1}{2}\gamma_5\gamma_\mu\frac{a_\mu}{R}} \qquad 1+\frac{\gamma_\mu\gamma_\nu x_\mu x_\nu}{4R^2} \quad 1+\frac{x_\mu^2}{4R^2}$$

X

$$X_5 + \vec{X} = R\,\frac{1+\frac{i\vec{q}}{2R}}{1-\frac{i\vec{q}}{2R}} = R\,\frac{1-\frac{q^2}{4R^2}+i\frac{\vec{q}}{R}}{1+\frac{q^2}{4R^2}}$$

$$X_5 \to X_5 \qquad \vec{X} \to e^i$$

$$\frac{X_5+\vec{X}}{R} = \frac{1+\frac{i\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}}$$

$$\frac{X_5+\vec{X}}{R}\left(1-\frac{\vec{q}}{2R}\right) = \frac{X_5+\vec{X}}{R} - \left(\frac{X_5+\vec{X}}{R}\right)\frac{\vec{q}}{2R} = 1+\frac{\vec{q}}{2R}$$

$$\frac{X_5+\vec{X}}{R} - 1 = \left(\frac{X_5+\vec{X}}{R}+1\right)\frac{\vec{q}}{2R}$$

$$\frac{\vec{q}}{2R} = \frac{\frac{X_5+\vec{X}}{R}-1}{\frac{X_5+\vec{X}}{R}+1} = S\left(\frac{X_5+\vec{X}}{R}-1\right)S^{-1}S\left(\frac{X_5+\vec{X}}{R}+1\right)^{-1}S^{-1}$$

$$q' = SqS^{-1}$$

$$\frac{\vec{q}'}{2R} = \frac{S\frac{X_5+\vec{X}}{R}S^{-1}-1}{S\frac{X_5+\vec{X}}{R}S^{-1}+1} = S^{X}$$

Translation

$$\frac{\vec{q}'}{2R} = \cancel{S\left(\frac{X_5+\vec{X}}{R}-1\right)S}$$

$$\frac{1+\frac{\vec{x}'}{2R}}{1-\frac{\vec{x}'}{2R}} = e^{\frac{\vec{a}}{2R}}\,\frac{1+\frac{\vec{x}}{2R}}{1-\frac{\vec{x}}{2R}}\,e^{\frac{\vec{a}}{2R}}$$ translation

$\frac{1+x}{1-x}=y$ $\quad 1+x = y-yx$ $\quad x(1+y)=y-1$ $\quad x=\frac{y-1}{y+1}$

$$\frac{\vec{x}'}{2R} = \frac{e^{\frac{\vec{a}}{2R}}\,\frac{1+\frac{\vec{x}}{2R}}{1-\frac{\vec{x}}{2R}}\,e^{\frac{\vec{a}}{2R}} - 1}{e^{\frac{\vec{a}}{2R}}\,\frac{1+\frac{\vec{x}}{2R}}{1-\frac{\vec{x}}{2R}}\,e^{\frac{\vec{a}}{2R}} + 1}$$

Inf. limit $\quad a^2 \to 0$ $\qquad \Omega + \frac{\Omega\vec{a}}{2R} + \frac{\vec{a}}{2R}\Omega$

$$\frac{\vec{x}'}{2R} = \frac{\left(1+\frac{\vec{a}}{2R}\right)\Omega\left(1+\frac{\vec{a}}{2R}\right)-1}{\left(1+\frac{\vec{a}}{2R}\right)\Omega\left(1+\frac{\vec{a}}{2R}\right)-1} = \frac{\Omega+\left\{\frac{\vec{a}}{2R}\Omega\right\}-1}{\Omega+\left\{\frac{\vec{a}}{2R}\Omega\right\}-1}$$

$$\frac{1+\frac{\vec{x}'}{2R}}{1-\frac{\vec{x}'}{2R}} = \frac{1+\frac{\vec{a}}{4R}}{1-\frac{\vec{a}}{4R}}\;\frac{1+\frac{\vec{x}}{2R}}{1-\frac{\vec{x}}{2R}}\;\frac{1+\frac{\vec{a}}{4R}}{1-\frac{\vec{a}}{4R}}$$

$dr = \frac{\vec{x}\cdot d\vec{x}}{r}$

$$X+iY = R\,\frac{1+i\frac{\xi}{2R}}{1-i\frac{\xi}{2R}} \quad \text{or} \quad X+iY = Re^{i\frac{\xi}{R}}$$

$$dX+idY = \frac{i}{R}e^{i\frac{\xi}{R}}d\xi$$

$$X_5+\vec{X} = R\,e^{\frac{\vec{x}}{R}} = R\left(\cos\frac{r}{R}+\frac{\vec{x}}{r}\sin\frac{r}{R}\right)$$

$$d(X_5+\vec{X}) = R\left(-\frac{\vec{x}}{r}\cdot d\vec{x}\,\frac{1}{R}\sin\frac{r}{R} + \frac{d\vec{x}}{r}\sin\frac{r}{R}\right.$$

$$ds^2 = d\xi^2$$

$$\frac{\vec{q}}{2R} = \frac{\frac{X_5+\vec{X}}{R} - 1}{\frac{X_5+\vec{X}}{R} + 1} = \left(\frac{X_5+\vec{X}}{R} - 1\right)\left(\frac{X_5+\vec{X}}{R} + 1\right)^{-1}$$

$$X_5 + \vec{X} = Q \qquad Q = R\,\frac{1+\frac{\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}}$$

$$\frac{\vec{q}}{2R} = \left(\frac{Q}{R} - 1\right)\left(\frac{Q}{R} + 1\right)^{-1}$$

$$\frac{\vec{q}\,'}{2R} = \left(\frac{Q'}{R} - 1\right)\left(\frac{Q'}{R} + 1\right)^{-1}$$

$$Q' = e^{\frac{\vec{a}}{2R}}\, Q\, e^{\frac{\vec{a}}{2R}} = S Q S$$

$$|Q'| = |Q|$$

$$\frac{\vec{q}\,'}{2R} = \left(S \frac{Q}{R} S - 1\right)\left(S \frac{Q}{R} S + 1\right)^{-1}$$

$$\frac{1+\frac{\vec{q}\,'}{2R}}{1-\frac{\vec{q}\,'}{2R}} = S\,\frac{1+\frac{\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}}\,S = Q'$$

$$1 + \frac{\vec{q}\,'}{2R} = Q' - \frac{\vec{q}\,'}{2R} Q'$$

$$\frac{\vec{q}\,'}{2R}(1+Q') = Q' - 1 \qquad \frac{\vec{q}\,'}{2R} = \frac{Q'-1}{Q'+1}$$

$$\frac{\vec{q}\,'}{2R} = \frac{S\,\frac{1+\frac{\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}}\,S - 1}{S\,\frac{1+\frac{\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}}\,S + 1} \qquad S = e^{\frac{\vec{a}}{2R}}$$

$$\frac{\vec{q}\,'}{2R} = S\left[\frac{1+\frac{\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}} - S^{-2}\right] S\, S^{-1}\left[\frac{1+\frac{\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}} + S^{-2}\right]^{-1} S^{-1}$$

$$\frac{\vec{q}\,'}{2R} = S\left[\frac{1+\frac{\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}} - S^{-2}\right]\left[\frac{1+\frac{\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}} + S^{-2}\right]^{-1} S^{-1}$$

$$\frac{\vec{q}\,'}{2R} = S\left[\frac{1+\frac{\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}} - S^{-2}\right]\left(1-\frac{\vec{q}}{2R}\right)\left(1-\frac{\vec{q}}{2R}\right)^{-1}\left[\quad\right]^{-1} S^{-1}$$

$$= S\left\{\left[\quad\right](\,)\right\}\left\{\left[\quad\right]'(\,)\right\}^{-1} S^{-1}$$

$$= S\left[1+\frac{\vec{q}}{2R} - S^{-2}\left(1-\frac{\vec{q}}{2R}\right)\right]\left[1+\frac{\vec{q}}{2R} + S^{-2}\left(1-\frac{\vec{q}}{2R}\right)\right] S^{-1}$$

$$= \left[S\left(1+\frac{\vec{q}}{2R}\right) - S^{-1}\left(1-\frac{\vec{q}}{2R}\right)\right]\left[S\left(1+\frac{\vec{q}}{2R}\right) + S^{-1}\left(1-\frac{\vec{q}}{2R}\right)\right]^{-1}$$

$S = 1 + \frac{\vec{a}}{2R}$

$S^{-1} = 1 - \frac{\vec{a}}{2R}$

$S - S^{-1} = \frac{\vec{a}}{R}$

$S + S^{-1} = 2$

$$\cancel{S + \frac{S\vec{q}}{2R}}$$

$$\frac{\vec{q}\,'}{2R} = \frac{S - S^{-1} + (S + S^{-1})\frac{\vec{q}}{2R}}{S + S^{-1} + (S - S^{-1})\frac{\vec{q}}{2R}}$$

$$\frac{q'}{2R} = \frac{S - S^{-1} + (S + S^{-1})\frac{\vec{q}}{2R}}{(S + S^{-1}) + (S - S^{-1})\frac{\vec{q}}{2R}}$$

$$S - S^{-1} = \frac{\vec{a}}{R} \qquad S + S^{-1} = 2. \qquad a^2 \sim 0$$

$$\frac{q'}{\cancel{2}R} = \frac{\frac{\vec{a}}{\cancel{R}} + \frac{\vec{q}}{\cancel{R}}}{\cancel{2} + \frac{\vec{a}}{R}\frac{\vec{q}}{\cancel{2}R}}$$

$$\vec{q}\,' = \frac{\vec{q} + \vec{a}}{1 + \frac{\vec{a}\vec{q}}{R^2}} = (\vec{q} + \vec{a})\left(1 - \frac{\vec{a}\vec{q}}{R^2}\right)$$

$$\vec{q}\,' = \vec{q} + \vec{a} - \frac{\cancel{\vec{q}}\,\vec{a}\,\cancel{\vec{q}}}{R^2} = \vec{q} + \vec{a} + \frac{q^2}{R^2}\vec{a}$$

$$= \vec{q} + \left(1 + \frac{q^2}{R^2}\right)\vec{a}$$

$$\cancel{f(a} \qquad \vec{x}\,' = \vec{x} + \left(1 + \frac{r^2}{R^2}\right)\vec{a}$$

$$f\left(\vec{x} + \vec{a} + \frac{r^2}{R^2}\vec{a}\right) = f(\vec{x}) + \left(1 + \frac{r^2}{R^2}\right)\vec{a}\cdot\vec{\nabla} f$$

$$i\,\vec{p} = \left(1 + \frac{r^2}{R^2}\right)\vec{\nabla}.$$

$$L_{\mu\nu} = x_\mu \partial_\nu \pm x_\nu \partial_\mu$$

$$\Pi_\nu = \frac{1}{R} L_{5\nu} = \left(1 + \frac{r^2}{R^2}\right)\partial_\nu = \cancel{p_\nu} \left(1 + \frac{r^2}{R^2}\right) p_\nu$$

$$\frac{1}{R^2} L_{\mu\nu} L_{\mu\nu} + \frac{1}{R^2} L_{5\nu} L_{5\nu} = \Omega$$

$$\Omega = \left(1 + \frac{r^2}{R^2}\right) p_\nu \left(1 + \frac{r^2}{R^2}\right) p_\nu + \frac{1}{R^2} L(L+1)$$

$$=$$

$$\frac{\partial}{\partial x}(x^2+y^2) - (x^2+y^2)\frac{\partial}{\partial x} = 2x$$

$$p_\nu r^2 - r^2 p_\nu = 2 x_\nu$$

$$\Omega = \left(1 + \frac{r^2}{R^2}\right)^2 p_\nu p_\nu + \frac{2}{R^2}\left(1 + \frac{r^2}{R^2}\right) p_\nu x_\nu + \frac{1}{R^2} L(L+1)$$

$$\Omega = \left(1 + \frac{r^2}{R^2}\right)^2 p^2 + \frac{2}{R^2}\left(1 + \frac{r^2}{R^2}\right) X \cdot P + \frac{1}{R^2} L(L+1)$$

$$\left(1 + \frac{r^2}{R^2}\right)^{2} \frac{2}{R^2} x_m p_m$$

$$1 + r^2$$

$$\left(1 + \frac{r^2}{R^2}\right)^{2} \frac{2}{R^2} x_m p_m$$

$$J_{5n} = R\left(1 + \frac{r^2}{R^2}\right) p_n \qquad \Pi_n = \left(1 + \frac{r^2}{R^2}\right) p_n \qquad \frac{2}{R^2}\left(1 + \frac{r^2}{R^2}\right) J_{mn}$$

$$J_{5n} J_{5m} = R \qquad \left[\Pi_n, \Pi_m\right] = \left[\left(1 + \frac{r^2}{R^2}\right) p_n, \left(1 + \frac{r^2}{R^2}\right) p_m\right]$$

$$\left(1 + \frac{r^2}{R^2}\right) p_m, \left(1 + \frac{r^2}{R^2}\right) p_m \qquad = \frac{r^2}{R^2} p_m - \begin{array}{l} \left(1 + \frac{r^2}{R^2}\right) p_m \left(1 + \frac{r^2}{R^2}\right) p_m \\ - \left(1 + \frac{r^2}{R^2}\right) p_m \left(1 + \frac{r^2}{R^2}\right) p_m \end{array}$$

$$x = \cancel{R}\sin\theta\cos\varphi = \frac{\xi}{1+\frac{\rho^2}{4R^2}}$$

$$\rho^2 = \xi^2 + \eta^2$$

$$y = \cancel{R}\sin\theta\sin\varphi = \frac{\eta}{1+\frac{\rho^2}{4R^2}}$$

$$z = \cancel{R}\cos\theta = R\,\frac{1-\frac{\rho^2}{4R^2}}{1+\frac{\rho^2}{4R^2}}$$

$$\frac{\rho}{2R} = \tan\frac{\theta}{2} \quad , \varphi$$

$$\frac{y}{x} \quad \begin{cases} \frac{\eta}{\xi} = \tan\varphi \\ \frac{\rho}{2R} = \tan\frac{\theta}{2} \end{cases}$$

$$I_1 = \cos\varphi\,\frac{\partial}{\partial\theta}$$

$$x\frac{\partial}{\partial y} - y\frac{\partial}{\partial x}$$

$$\begin{cases} \frac{\sqrt{\xi^2+\eta^2}}{2R} = \tan\frac{\theta}{2} \\ \frac{\eta}{\xi} = \tan\varphi \end{cases}$$

$$\frac{\partial}{\partial\varphi} = \frac{\partial\eta}{\partial\varphi}\frac{\partial}{\partial\eta} + \frac{\partial\xi}{\partial\varphi}\frac{\partial}{\partial\xi}$$

$$L_x - iL_y = \hbar e^{-i\varphi}\left(-\frac{\partial}{\partial\theta} + i\cot\theta\frac{\partial}{\partial\varphi}\right)$$

$$L_x + iL_y = \hbar e^{i\varphi}\left(\frac{\partial}{\partial\theta} + i\cot\theta\frac{\partial}{\partial\varphi}\right)$$

$$L_z = -i\hbar\frac{\partial}{\partial\varphi}$$

$$\frac{\partial}{\partial\theta} = \frac{\partial}{\partial\rho}$$

$$2L_x = \hbar\frac{\partial}{\partial\theta}\left(e^{i\varphi}+e^{-i\varphi}\right) + 2i\hbar\cot\theta\frac{\partial}{\partial\varphi}$$

$$L_x = \hbar\cos\varphi\frac{\partial}{\partial\theta} + i\hbar\cot\theta\frac{\partial}{\partial\varphi}$$

$$\frac{\xi^2+\eta^2}{4R^2} = \tan^2\frac{\theta}{2}$$

$$\frac{\eta}{\xi} = \tan\varphi$$

$$\xi^2\left(1+\frac{\eta^2}{\xi^2}\right) = 4R^2\tan^2\frac{\theta}{2}$$

$$\xi^2\,(1+\tan^2\varphi) = 4R^2\tan^2\frac{\theta}{2}$$

$$\xi^2\,\frac{1}{\cos^2\varphi} = 4R^2\tan^2\frac{\theta}{2}$$

$$\xi = \left(2R\tan\frac{\theta}{2}\right)\cos\varphi = \rho\cos\varphi$$

$$\eta = \left(2R\tan\frac{\theta}{2}\right)\sin\varphi = \rho\sin\varphi$$

$$\frac{d}{d\theta}\tan\frac{\theta}{2} = \frac{1}{2}\left(1+\tan^2\frac{\theta}{2}\right)$$

$$\frac{d}{d\theta}\left(2\tan\frac{\theta}{2}\right) = \left(1+\tan^2\frac{\theta}{2}\right)$$

$$\frac{\partial\xi}{\partial\varphi} = -\rho\sin\varphi = -\eta \quad , \quad \frac{\partial\eta}{\partial\varphi} = \xi.$$

$$\frac{\partial}{\partial\varphi} = \frac{\partial\eta}{\partial\varphi}\frac{\partial}{\partial\eta} + \frac{\partial\xi}{\partial\varphi}\frac{\partial}{\partial\xi} = \xi\frac{\partial}{\partial\eta} - \eta\frac{\partial}{\partial\xi}$$

$$\frac{\partial}{\partial\theta} = \frac{\partial\eta}{\partial\theta}\frac{\partial}{\partial\eta} + \frac{\partial\xi}{\partial\theta}\frac{\partial}{\partial\xi}$$

$$\frac{\partial\eta}{\partial\theta} = (\cancel{1+R}\ R\left(1+\tan^2\frac{\theta}{2}\right)\cos\varphi$$

$$\frac{\partial\eta}{\partial\theta} = R\left(1+\tan^2\frac{\theta}{2}\right).\sin\varphi \qquad \frac{\partial\xi}{\partial\theta} = R\left(1+\tan^2\frac{\theta}{2}\right)\cos\varphi$$

$$-\frac{i}{\hbar} L_x = \sin\varphi \frac{\partial}{\partial\theta} + \cot\theta \cos\varphi \frac{\partial}{\partial\varphi}$$

$$\sin\varphi \frac{\partial}{\partial\theta} = R\left(1+\tan^2\frac{\theta}{2}\right)\sin^2\varphi \cancel{\cos\varphi} \frac{\partial}{\partial\eta}$$

$$+ R\left(1+\tan^2\frac{\theta}{2}\right)\sin\varphi\cos\varphi \frac{\partial}{\partial\xi}$$

$$\sin\varphi = \frac{\eta}{\rho} \qquad \cos\varphi = \frac{\xi}{\rho}$$

$$\tan\frac{\theta}{2} = \frac{\sqrt{\xi^2+\eta^2}}{2R} = \frac{\rho}{2R} \qquad \tan^2\frac{\theta}{2} = \frac{\xi^2+\eta^2}{4R^2}$$

$$\sin\varphi \frac{\partial}{\partial\theta} = R\left(1+\frac{\rho^2}{4R^2}\right)\left[\sin^2\varphi \frac{\partial}{\partial\eta} + \sin\varphi\cos\varphi \frac{\partial}{\partial\xi}\right]$$

$$\cancel{= R\,(}$$

$$= R\left(1+\frac{\rho^2}{4R^2}\right)\left[\frac{\eta^2}{\rho^2}\frac{\partial}{\partial\eta} + \frac{\eta\xi}{\rho^2}\frac{\partial}{\partial\xi}\right]$$

$$\cot\theta = \frac{\cos\theta}{\sin\theta} = \frac{\cos^2\frac{\theta}{2}-\sin^2\frac{\theta}{2}}{2\sin\frac{\theta}{2}\cos\frac{\theta}{2}} = \frac{1-\tan^2\frac{\theta}{2}}{2\tan\frac{\theta}{2}} = \frac{1-\frac{\rho^2}{4R^2}}{\rho/2R}$$

$$\cot\theta\cos\varphi\frac{\partial}{\partial\varphi} = 2R\,\frac{1-\frac{\rho^2}{4R^2}}{\rho}\,\frac{\xi}{\rho}\left(\xi\frac{\partial}{\partial\eta} - \eta\frac{\partial}{\partial\xi}\right)$$

$$= 2R\,\frac{1-\frac{\rho^2}{4R^2}}{\rho^2}\left(\xi^2\frac{\partial}{\partial\eta} - \xi\eta\frac{\partial}{\partial\xi}\right)$$

$$\sin\varphi\,\frac{\partial}{\partial\theta}+\cot\theta\cos\varphi\,\frac{\partial}{\partial\varphi}\Big) = \frac{R}{\rho^2}\left(1+\frac{\rho^2}{4R^2}\right)\left(\eta^2\frac{\partial}{\partial\eta}+\eta\xi\frac{\partial}{\partial\xi}\right)$$
$$+\frac{2R}{\rho^2}\left(1-\frac{\rho^2}{4R^2}\right)\left(\xi^2\frac{\partial}{\partial\eta}-\eta\xi\frac{\partial}{\partial\xi}\right)$$

$$\begin{cases}\xi = \rho\cos\varphi\\ \eta = \rho\sin\varphi\end{cases} \qquad \frac{\rho}{2R}=\tan\frac{\theta}{2}$$

$$L_x = \sin\varphi\,\frac{\partial}{\partial\theta}+\cot\theta\cos\varphi\,\frac{\partial}{\partial\varphi}$$

$$x = R\sin\theta\cos\varphi = \frac{\xi}{1+\rho^2/4R^2}$$
$$y = R\sin\theta\sin\varphi = \frac{\eta}{1+\rho^2/4R^2}$$
$$z = R\cos\theta = R\,\frac{1-\frac{\rho^2}{4R^2}}{1+\frac{\rho^2}{4R^2}}$$

$$\sin\theta = \frac{\rho/R}{1+\frac{\rho^2}{4R^2}} \qquad \sin\theta = 2\sin\frac{\theta}{2}\cos\frac{\theta}{2} = 2\tan\frac{\theta}{2}\cos^2\frac{\theta}{2} = \frac{2\tan\frac{\theta}{2}\cos^2\frac{\theta}{2}}{\sin^2\frac{\theta}{2}+\cos^2\frac{\theta}{2}} = \frac{2\tan\frac{\theta}{2}}{1+\tan^2\frac{\theta}{2}}$$

$$\cos\theta = \frac{1-\rho^2/4R^2}{1+\rho^2/4R^2} \qquad x = R\,\frac{\frac{\rho}{R}}{1+\frac{\rho^2}{4R^2}}\cos\varphi = \frac{\rho\cos\varphi}{1+\frac{\rho^2}{4R^2}} = \frac{\xi}{1+\rho^2/4R^2}$$

$$\cot\theta = \frac{\cos\theta}{\sin\theta} = \frac{1-\rho^2/4R^2}{\rho/R}$$

$$L_x = \frac{\eta}{\rho}\frac{\partial}{\partial\theta}+\frac{\xi}{\rho}\cot\theta\,\frac{\partial}{\partial\varphi} = \frac{\eta}{\rho}\frac{\partial}{\partial\theta}+\frac{\xi}{\rho}\,\frac{1-\rho^2/4R^2}{\rho/R}\,\frac{\partial}{\partial\varphi}$$

$$L_x = \frac{\eta}{\rho}\frac{\partial}{\partial\theta}+R\,\frac{\xi}{\rho^2}\left(1-\rho^2/4R^2\right)\frac{\partial}{\partial\varphi} \qquad \frac{\partial}{\partial\varphi} = \xi\frac{\partial}{\partial\eta}-\eta\frac{\partial}{\partial\xi}$$

$$L_x = \frac{\eta}{\rho}\frac{\partial}{\partial\theta}+R\,\frac{\xi}{\rho^2}\left(1-\frac{\rho^2}{4R^2}\right)\left(\xi\frac{\partial}{\partial\eta}-\eta\frac{\partial}{\partial\xi}\right)$$

$$\frac{\partial}{\partial\theta} = \frac{\partial\xi}{\partial\theta}\frac{\partial}{\partial\xi} + \frac{\partial\eta}{\partial\theta}\frac{\partial}{\partial\eta}$$

$$\xi = \rho\cos\varphi \qquad \eta = \rho\sin\varphi$$

$$\frac{\rho}{2R} = \tan\frac{\theta}{2} \qquad \rho = 2R\tan\frac{\theta}{2}$$

$$\cancel{\xi = 2R\tan\frac{\theta}{2}}$$

$$\frac{\partial\xi}{\partial\theta} = \frac{d\rho}{d\theta}\cos\varphi \qquad \frac{\partial\eta}{\partial\theta} = \frac{d\rho}{d\theta}\sin\varphi$$

$$\frac{\partial}{\partial\theta} = \frac{d\rho}{d\theta}\left(\cos\varphi\frac{\partial}{\partial\xi} + \sin\varphi\frac{\partial}{\partial\eta}\right)$$

$$= \frac{d\rho}{d\theta}\left(\frac{\xi}{\rho}\frac{\partial}{\partial\xi} + \frac{\eta}{\rho}\frac{\partial}{\partial\eta}\right)$$

$$\frac{\sin\theta}{\cos\theta} \qquad \frac{\cos\theta}{\sin\theta}$$

$$\frac{d\rho}{d\theta} = \frac{1}{2}2R\,\frac{\sin^2\frac{\theta}{2} + \cos^2\frac{\theta}{2}}{\cos^2\frac{\theta}{2}} = R\left(1 + \tan^2\frac{\theta}{2}\right)$$

$$= R\left(1 + \frac{\rho^2}{4R^2}\right)$$

$$\frac{\partial}{\partial\theta} = \frac{R}{\rho}\left(1 + \frac{\rho^2}{4R^2}\right)\left(\xi\frac{\partial}{\partial\xi} + \eta\frac{\partial}{\partial\eta}\right)$$

$$\sin\varphi\frac{\partial}{\partial\theta} = \eta\frac{R}{\rho^2}\left(1 + \frac{\rho^2}{4R^2}\right)\left(\xi\frac{\partial}{\partial\xi} + \eta\frac{\partial}{\partial\eta}\right)$$

$$\cos\varphi\cot\theta\frac{\partial}{\partial\varphi} = \xi\frac{R}{\rho^2}\left(1 - \frac{\rho^2}{4R^2}\right)\left(\xi\frac{\partial}{\partial\eta} - \eta\frac{\partial}{\partial\xi}\right)$$

$$L_x = \frac{R}{\rho^2}\Big[\left(1+\frac{\rho^2}{4R^2}\right)\left(\eta\xi\frac{\partial}{\partial\xi}+\eta^2\frac{\partial}{\partial\eta}\right) + \left(1-\frac{\rho^2}{4R^2}\right)\left(-\eta\xi\frac{\partial}{\partial\xi}+\xi^2\frac{\partial}{\partial\eta}\right)\Big]$$

$$= \frac{R}{\rho^2}\left[\rho^2\frac{\partial}{\partial\eta} + \frac{\rho^2}{4R^2}2\eta\xi\frac{\partial}{\partial\xi} + (\eta^2-\xi^2)\frac{\rho^2}{4R^2}\frac{\partial}{\partial\eta}\right]$$

$$\frac{1}{R}L_x = \frac{\partial}{\partial\eta} + \frac{1}{4R^2}\left(2\eta\xi\frac{\partial}{\partial\xi} + (\eta^2-\xi^2)\frac{\partial}{\partial\eta}\right)$$

imag.

$$2\eta\xi\frac{\partial}{\partial\xi} - \xi^2\frac{\partial}{\partial\eta} =$$

$$\eta\xi\frac{\partial}{\partial\xi} + \eta\xi\frac{\partial}{\partial\xi} + \eta^2\frac{\partial}{\partial\eta} - \xi^2\frac{\partial}{\partial\eta}$$

$$\eta\left(\xi\frac{\partial}{\partial\xi}+\eta\frac{\partial}{\partial\eta}\right) + \xi\underbrace{\left(\eta\frac{\partial}{\partial\xi}-\xi\frac{\partial}{\partial\eta}\right)}_{\frac{\partial}{\partial\varphi}}$$

$$\sin\varphi \frac{\partial}{\partial\theta} + \cos\varphi \cot\theta \frac{\partial}{\partial\varphi}$$

$$\left\{\begin{array}{l} X = \dfrac{\xi}{1+\frac{\rho^2}{4R^2}} = \dfrac{\rho\cos\varphi}{1+\frac{\rho^2}{4R^2}} = R\sin\theta\cos\varphi \\[2ex] Y = \dfrac{\eta}{1+\frac{\rho^2}{4R^2}} = \dfrac{\rho\sin\varphi}{1+\frac{\rho^2}{4R^2}} = R\sin\theta\sin\varphi \\[2ex] Z = R\dfrac{1-\frac{\rho^2}{4R^2}}{1+\frac{\rho^2}{4R^2}} = R\cos\theta \end{array}\right.$$

$$\frac{\rho/R}{1+\frac{\rho^2}{4R^2}} = \sin\theta$$

$$\frac{1-\frac{\rho^2}{4R^2}}{1+\frac{\rho^2}{4R^2}} = \cos\theta$$

$$\xi\frac{\partial}{\partial\eta} - \eta\frac{\partial}{\partial\xi} = \frac{\partial}{\partial\varphi}$$

$$\cot\theta = \frac{1-\frac{\rho^2}{4R^2}}{\rho/R} = \frac{\cos\theta}{\sin\theta} = \frac{R}{\rho}\left(1-\frac{\rho^2}{4R^2}\right) = \frac{R}{\rho} - \frac{\rho}{4R}$$

$$= \frac{R}{\rho}\left(1-\frac{\rho^2}{4R^2}\right)$$

hence $\dfrac{-\sin^2\theta-\cos^2\theta}{\sin^2\theta}\,d\theta = \left(-\dfrac{R}{\rho^2} - \dfrac{1}{4R}\right)d\rho$

$$\left(1+\cot^2\theta\right)d\theta = \left(\frac{R}{\rho^2}+\frac{1}{4R}\right)d\rho \qquad 1+\cot^2\theta = \frac{1}{\sin^2\theta} = \frac{R^2}{\rho^2}\left(1+\frac{\rho^2}{4R^2}\right)^2$$

$$\frac{\partial}{\partial\theta} = \frac{\partial\xi}{\partial\theta}\frac{\partial}{\partial\xi} + \frac{\partial\eta}{\partial\theta}\frac{\partial}{\partial\eta} \qquad \begin{array}{l}\xi = \rho\cos\varphi \\ \eta = \rho\sin\varphi\end{array}$$

$$\frac{\partial\xi}{\partial\theta} = \frac{d\rho}{d\theta}\cos\varphi \qquad \frac{\partial\eta}{\partial\theta} = \frac{d\rho}{d\theta}\sin\varphi$$

$$\frac{R^2}{\rho^2}\left(1+\frac{\rho^2}{4R^2}\right)^2 d\theta = \frac{R}{\rho^2}\left(1+\frac{\rho^2}{4R^2}\right)d\rho \qquad R\left(1+\frac{\rho^2}{4R^2}\right)d\theta = d\rho$$

$$\frac{d\rho}{d\theta} = R\left(1+\frac{\rho^2}{4R^2}\right)$$

$$\frac{\partial}{\partial\theta} = R\left(1+\frac{\rho^2}{4R^2}\right)\left(\cos\varphi\frac{\partial}{\partial\xi}+\sin\varphi\frac{\partial}{\partial\eta}\right)$$

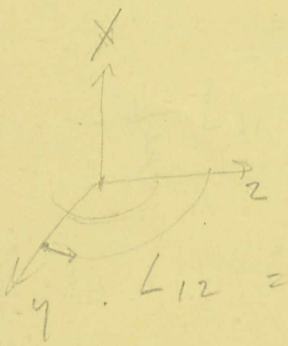
$$= \frac{R}{\rho}\left(1+\frac{\rho^2}{4R^2}\right)\left(\xi\frac{\partial}{\partial\xi}+\eta\frac{\partial}{\partial\eta}\right)$$

$$\sin\varphi\frac{\partial}{\partial\theta} = \frac{R}{\rho^2}\left(1+\frac{\rho^2}{4R^2}\right)\left(\eta\xi\frac{\partial}{\partial\xi}+\eta^2\frac{\partial}{\partial\eta}\right)$$

$$\cos\varphi\cot\theta\frac{\partial}{\partial\varphi} = \frac{\xi}{\rho}\frac{R}{\rho}\left(1-\frac{\rho^2}{4R^2}\right)\left(\xi\frac{\partial}{\partial\eta}-\eta\frac{\partial}{\partial\xi}\right)$$

$$= \frac{R}{\rho^2}\left(1-\frac{\rho^2}{4R^2}\right)\left(\xi^2\frac{\partial}{\partial\eta}-\eta\xi\frac{\partial}{\partial\xi}\right)$$

$$L_{23} : \quad \frac{L_x}{R} = \frac{1}{\rho^2}\left[\left(1+\frac{\rho^2}{4R^2}\right)\left(\eta\xi\frac{\partial}{\partial\xi}+\eta^2\frac{\partial}{\partial\eta}\right)+\left(1-\frac{\rho^2}{4R^2}\right)\left(\xi^2\frac{\partial}{\partial\eta}-\eta\xi\frac{\partial}{\partial\xi}\right)\right]$$



$$= \frac{1}{\rho^2}\left[\cancel{\eta\xi\frac{\partial}{\partial\xi}}+\eta^2\frac{\partial}{\partial\eta}+\xi^2\frac{\partial}{\partial\eta}-\cancel{\eta\xi\frac{\partial}{\partial\xi}}\right.$$
$$\left.+\frac{\rho^2}{4R^2}\left(\eta\xi\frac{\partial}{\partial\xi}+\eta^2\frac{\partial}{\partial\eta}-\xi^2\frac{\partial}{\partial\eta}+\eta\xi\frac{\partial}{\partial\xi}\right)\right]$$

$$L_{12} = \xi\frac{\partial}{\partial\eta}-\eta\frac{\partial}{\partial\xi}$$

$$\frac{1}{R}L_{23} = \frac{\partial}{\partial\eta}+\frac{1}{4R^2}\left[\eta\left(\eta\frac{\partial}{\partial\eta}+\xi\frac{\partial}{\partial\xi}\right)-\xi\left(\xi\frac{\partial}{\partial\eta}-\eta\frac{\partial}{\partial\xi}\right)\right]$$

$$\frac{1}{R}L_{31} =$$

$$\Pi_2 = p_2+\frac{1}{4R^2}\left[\xi_2\left(\xi_2 p_2+\xi_1 p_1\right)-\xi_1\frac{\partial}{\partial\varphi}\right]$$

$$X = \frac{\xi}{1+\frac{\rho^2}{4R^2}} \qquad Y = \frac{\eta}{1+\frac{\rho^2}{4R^2}} \qquad Z = R\,\frac{1-\frac{\rho^2}{4R^2}}{1+\frac{\rho^2}{4R^2}}$$

$$(X' + iZ') = e^{i\frac{a}{R}}(X + iZ)$$

$$Y' = Y$$

$$\frac{\xi' + iR\left(1-\frac{\rho'^2}{4R^2}\right)}{1+\frac{\rho'^2}{4R^2}} = e^{i\frac{a}{R}}\,\frac{\xi + iR\left(1-\frac{\rho^2}{4R^2}\right)}{1+\frac{\rho^2}{4R^2}}$$

$$Y' = Y \qquad \frac{\eta'}{1+\frac{\rho'^2}{4R^2}} = \frac{\eta}{1+\frac{\rho^2}{4R^2}}$$

$$-\frac{i}{\hbar}\Pi_2 = -\frac{i}{\hbar}\frac{1}{R}L_{23} = \frac{\partial}{\partial\xi_2} + \frac{1}{4R^2}\left[\xi_2\left(\xi_2\frac{\partial}{\partial\xi_2}+\xi_1\frac{\partial}{\partial\xi_1}\right)-\xi_1\left(\xi_1\frac{\partial}{\partial\xi_2}-\xi_2\frac{\partial}{\partial\xi_1}\right)\right]$$

$$-\frac{i}{\hbar}\frac{1}{R}L_{31} = -\cos\varphi\frac{\partial}{\partial\theta} + \sin\varphi\,\cot\theta\,\frac{\partial}{\partial\varphi}$$

$$\cos\varphi = \frac{\xi}{\rho} \qquad \frac{\partial}{\partial\theta} = \frac{R}{\rho}\left(1+\frac{\rho^2}{4R^2}\right)\left(\xi\frac{\partial}{\partial\xi}+\eta\frac{\partial}{\partial\eta}\right)$$

$$\sin\varphi = \frac{\eta}{\rho}$$

$$\cot\theta = \frac{R}{\rho}\left(1-\frac{\rho^2}{4R^2}\right)$$

$$\frac{\partial}{\partial\varphi} = \xi\frac{\partial}{\partial\eta} - \eta\frac{\partial}{\partial\xi}$$

$$-\frac{i}{\hbar}L_{31} = -\frac{\xi}{\rho}\frac{R}{\rho}\left(1+\frac{\rho^2}{4R^2}\right)\left(\xi\frac{\partial}{\partial\xi}+\eta\frac{\partial}{\partial\eta}\right)$$
$$+\frac{\eta}{\rho}\frac{R}{\rho}\left(1-\frac{\rho^2}{4R^2}\right)\left(\xi\frac{\partial}{\partial\eta}-\eta\frac{\partial}{\partial\xi}\right)$$

$$-\frac{i}{\hbar}\frac{1}{R}L_{31} = -\frac{1}{\rho^2}\left(1+\frac{\rho^2}{4R^2}\right)\left(\xi^2\frac{\partial}{\partial\xi}+\xi\eta\frac{\partial}{\partial\eta}\right)$$
$$+\frac{1}{\rho^2}\left(1-\frac{\rho^2}{4R^2}\right)\left(\eta\xi\frac{\partial}{\partial\eta}-\eta^2\frac{\partial}{\partial\xi}\right)$$
$$= +\frac{1}{\rho^2}\left(\eta\xi\frac{\partial}{\partial\eta}-\eta^2\frac{\partial}{\partial\xi}-\xi^2\frac{\partial}{\partial\xi}-\xi\eta\frac{\partial}{\partial\eta}\right)$$
$$+\frac{\rho^2}{4R^2}\left(-\eta\xi\frac{\partial}{\partial\eta}+\eta^2\frac{\partial}{\partial\xi}-\xi^2\frac{\partial}{\partial\xi}-\eta\xi\frac{\partial}{\partial\eta}\right)$$

$$-\frac{i}{\hbar}\frac{1}{R}L_{31} = -\frac{\partial}{\partial\xi} - \frac{1}{4R^2}\left[(\xi^2-\eta^2)\frac{\partial}{\partial\xi} + 2\eta\xi\frac{\partial}{\partial\eta}\right]$$

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$$-\frac{i}{\hbar}\frac{1}{R}L_{13} = \frac{\partial}{\partial\xi} + \frac{1}{4R^2}\left[(\xi^2-\eta^2)\frac{\partial}{\partial\xi} + 2\eta\xi\frac{\partial}{\partial\eta}\right]$$

$$= \frac{i}{\hbar}\frac{1}{R}L_{31}$$

$$-\frac{i}{\hbar}\frac{1}{R}L_{23} = \frac{\partial}{\partial\eta} + \frac{1}{4R^2}\left[-(\xi^2-\eta^2)\frac{\partial}{\partial\eta} + 2\eta\xi\frac{\partial}{\partial\xi}\right]$$

$$= \frac{i}{\hbar}\frac{1}{R}L_{32}$$

$$+\frac{i}{\hbar}L_{12} = \xi\frac{\partial}{\partial\eta} - \eta\frac{\partial}{\partial\xi}$$

$$-i\hbar\frac{\partial}{\partial\xi} = p_1 \qquad \xi = \xi_1$$

$$L_{12} = \xi$$

$$-i\hbar\frac{\partial}{\partial\eta} = p_2 \qquad \eta = \xi_2$$

$$\cancel{-\frac{i}{\hbar}J_{12} = \xi}$$

$$J_{12} = \xi_1 p_2 - \xi_2 p_1 = J$$

$$\Pi_1 = \frac{1}{R}L_{31} \qquad \Pi_1 = p_1 + \frac{1}{4R^2}\left[(\xi_1^2-\xi_2^2)p_1 + 2\xi_1\xi_2 p_2\right]$$

$$\Pi_2 = \frac{1}{R}L_{32} \qquad \Pi_2 = p_2 + \frac{1}{4R^2}\left[-(\xi_1^2-\xi_2^2)p_2 + 2\xi_1\xi_2 p_1\right]$$

$$-\xi_1^2 p_2 + \xi_2^2 p_2 + \xi_1\xi_2 p_1 + \xi_1\xi_2 p_1 \qquad + \xi_1(\xi_2 p_1 - \xi_1 p_2)$$

$$\xi_1 p_1^2 - \xi_2^2 p_1 + \xi_1\xi_2 p_2 + \xi_1\xi_2 p_2 = \xi_2(\overbrace{\xi_1 p_2 - \xi_2 p_1}^{J_{12}}) + \xi_1(\xi_1 p_1 + \xi_2 p_2)$$

$$\Pi_1 = p_1 + \frac{1}{4R^2}\left[\xi_2 J_{12} + \xi_1(\xi_1 p_1 + \xi_2 p_2)\right]$$

$$\Pi_2 = p_2 + \frac{1}{4R^2}\left[-\xi_1 J_{12} + \xi_2(\xi_1 p_1 + \xi_2 p_2)\right]$$

$$\xi\frac{\partial}{\partial\xi} = \xi\frac{\partial J}{\partial\xi}\frac{\partial}{\partial J}$$

$$\frac{\partial}{\partial\rho}\psi = \frac{\partial\xi}{\partial\rho}\frac{\partial}{\partial\xi}\psi + \frac{\partial\eta}{\partial\rho}\frac{\partial}{\partial\eta}\psi$$

$$\xi = \rho\cos\varphi \qquad \eta = \rho\sin\varphi$$

$$\frac{\partial\xi}{\partial\rho} = \cos\varphi = \frac{\xi}{\rho}$$

$$\frac{\partial}{\partial\rho}\psi = \frac{\xi}{\rho}\frac{\partial}{\partial\xi}\psi + \frac{\eta}{\rho}\frac{\partial}{\partial\eta}\psi$$

$J_{12}\xi_1 + J_{12}\xi_2$

$$\rho\frac{\partial}{\partial\rho}\psi = \left(\xi\frac{\partial}{\partial\xi} + \eta\frac{\partial}{\partial\eta}\right)\psi \qquad -i\hbar\frac{\partial}{\partial\rho} = p_\rho$$

$$\text{Expr}\begin{cases}\Pi_1 = p_1 + \frac{1}{4R^2}\left[J_{12}\xi_2 + \xi_1\rho p_\rho\right] \\ \Pi_2 = p_2 + \frac{1}{4R^2}\left[-J_{12}\xi_1 + \xi_2\rho p_\rho\right]\end{cases}$$

$$\vec{\xi}\cdot\vec{p} = \rho p_\rho$$

Let $V_m = J_{mn}\xi_n$

$$V_1 = J_{1n}\xi_n = J_{12}\xi_2$$
$$V_2 = J_{2n}\xi_n = J_{21}\xi_1 = -J_{12}\xi_1$$

$$\Pi_m = p_m + \frac{1}{4R^2}\left[\xi_n J_{mn} + \xi_m\rho p_\rho\right] \qquad \rho p_\rho = \xi_n p_n$$

$$\Pi_m = \left(1 - \frac{\xi^2}{4R^2}\right)p_m + \frac{1}{2R^2}\xi_m(\vec{\xi}\cdot\vec{p}) = \left(1 - \frac{\xi^2}{4R^2}\right)p_m + \frac{1}{2R^2}\xi_m\rho p_\rho$$

$$J_{mn} = \xi_m p_n - \xi_n p_m$$

$1 + \xi_m p_m$

$$\boxed{\Pi_m = p_m + \frac{1}{4R^2}\xi_n\left[\underbrace{J_{mn} + \xi_m p_n}_{\xi_m p_n - \xi_n p_m}\right]}$$

$= 2\xi_m p_n - \xi_n p_m$

$\xi_n\left[2\xi_m p_n - \xi_n p_m\right]$

We need first $\left[\Pi_m, \Pi_n\right] = \frac{1}{R^2}J_{mn}$

$\xi_m \quad 2\xi_m\xi_n$

$1 + \vec{a}\cdot\vec{\rho} + \frac{1}{4R^2} +$

$$\Pi_m = \left(1 - \frac{\xi_n\xi_n}{4R^2}\right)p_m + \frac{1}{2R^2}\xi_m(\xi_n p_n)$$

~~Hatta bu~~ Şimdi küçük gruplar bölüm, her sınıfa uygun olacak ~~şekilde~~ ~~mahiyette~~ ve ~~muzg~~ yeni ufuklar açacak mahiyette münazara bir faaliyetlerimin programımın faydalanabileceği kaynakların bir listesini çıkartmakla meşgulüm.

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in-service

cross-country

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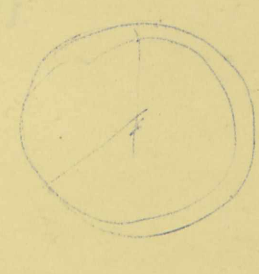
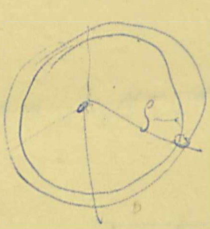
$$m_i = \int_0^R \frac{\overbrace{4\pi \rho^2 d\rho\, \rho_0}^{m_i}}{|r-\rho|}$$



$$4\pi \frac{KT}{2\cdot 4\pi} = \pm\frac{2}{R^2}$$



$$\frac{KT}{6} = \frac{2}{R^2} = 4\pi$$

$$R^2 = \frac{12}{kT} \qquad \frac{1}{(t+r)(t-r)} = \frac{1}{2t}\left(\frac{1}{t+r} + \frac{1}{t-r}\right)$$

$$-G\,\frac{4\pi\rho^2 d\rho}{\rho}$$

$$4\pi G\int_0^R \rho\, d\rho = 2\pi G R^2$$

$$\frac{1}{t^2-r^2} = \frac{1}{2t^2}\left[\frac{1}{1+\frac{r}{t}} + \frac{1}{1-\frac{r}{t}}\right]$$

mixture of outgoing and incoming waves.

$$\int \nabla^2 \Phi\, d^3 x$$

dr = [illegible]

$$-\frac{1}{4}+1+\cancel{\frac{1}{2}}-\frac{1}{2}$$

$$\Box\,\phi = -4\pi k' T = \frac{\pm c^2}{R^2}\phi^3$$

$$-(4\pi k' T)\,\phi^3 =$$

$$M(t) = \cancel{\pm}\,4\pi R^2 \int_0^\infty \frac{2r^2\,dr}{\left(1-\frac{c^2t^2}{2R^2}+\frac{r^2}{2R^2}\right)^3}$$

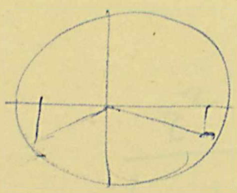
$$\int_0^\infty \frac{2r^2\,dr}{(a+br^2)^3} =$$

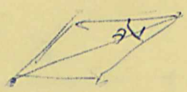
$r^2 = \xi$ $\quad r = \xi^{\frac{1}{2}}$

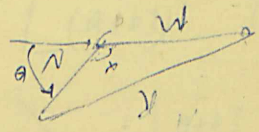
$2r\,dr = d\xi$

$$\int_0^\infty \frac{\xi^{\frac{1}{2}}\,d\xi}{(a+b\xi)^3}$$

$R^2 = M^2 + N^2 + MN\cos x$

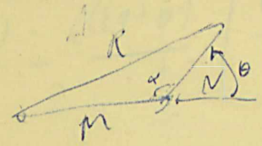


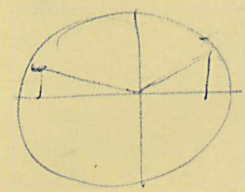




$MN\cos NW$

$MN \cos \vec{M}\vec{N}$





$R^2 = M^2 + N^2 + MN \cos \alpha$..

$= M^2 + N^2 + MN \cos(180 - \theta)$

$M^2 + N^2 - MN \cos\theta$.

$$f(\vec{x} + \vec{a}) = f(\vec{x}) + a_m \partial_m f(\vec{x}) = (1 + i\vec{p}\cdot\vec{a}) f(\vec{x})$$

$$i\vec{p} = \vec{\nabla}$$

$$f \qquad R\,\frac{1 + \frac{\vec{x}'}{2R}}{1 - \frac{\vec{x}'}{2R}} = R e^{\frac{\vec{a}}{2R}} \frac{1 + \frac{\vec{x}}{2R}}{1 - \frac{\vec{x}}{2R}} e^{\frac{\vec{a}}{2R}} = 1 +$$

$$R\,\frac{1 + \frac{\vec{x}}{2R}}{1 - \frac{\vec{x}}{2R}} = X_5 + \vec{X} \qquad e^{\frac{\vec{x}'}{R}} = e^{\frac{\vec{a}}{R} + \frac{\vec{x}}{R}} \qquad x' = \vec{x} + \vec{a}$$

$$X_5' + \vec{X}' = e^{\frac{\vec{a}}{2R}} (X_5 + \vec{X}) e^{\frac{\vec{a}}{2R}}$$

$1 + x = y - xy \qquad x(1+y) = y - 1$

$x = \frac{y-1}{y+1}$

$$\frac{1 + \ddot{x}}{1 - \ddot{x}} = y$$

$$\frac{x'}{2R} =$$

$$\frac{\xi}{(a+b\xi)^3} = \frac{1}{b}\left[\frac{1}{(a+b\xi)^2} - \frac{a}{(a+b\xi)^3}\right]$$

$$\frac{1}{b}\left[a+b\xi - a\right]$$

$$\frac{r^2}{(a+br^2)^3} = \frac{A}{(a+br^2)^3} + \frac{B}{(a+br^2)^2} +$$

$$\frac{\xi}{(a+b\xi)^3} = \frac{A}{(a+b\xi)^3} + \frac{B}{(a+b\xi)^2} + \cancel{\frac{C}{a+b\xi}}$$

$$Ca^2 + 2Cab\xi + Cb^2\xi^2$$

$$= \frac{A + B(a+b\xi) + C(a+b\xi)^2}{(a+b\xi)^3}$$

$$= A + aB + a^2C + (Bb + 2abC)\xi + Cb^2\xi^2$$

$C = 0$.

$\cancel{b=0}$. $A + aB = 0$

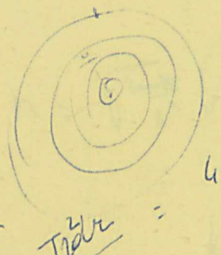
$Bb = 1$

$B = \frac{1}{b}$ $A = -\frac{a}{b}$

$$R_\mu{}^\nu - \tfrac{1}{2}\delta_\mu{}^\nu R = \phi^{-2}\left(R_\mu{}^\nu - \tfrac{1}{2}\delta_\mu{}^\nu R\right) - 4\phi^{-4}[\ ] + 2\phi^{-3}[\ ]$$

$$= \kappa\,\phi^{-3}\,T_\mu{}^\nu$$

$$R_\mu{}^\nu - \tfrac{1}{2}\delta_\mu{}^\nu R = \kappa\,\phi^{-1}T_\mu{}^\nu + 4\phi^{-2}[\ ] - 2\phi^{-1}[\ ]$$



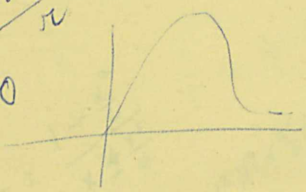
$$\kappa\int_0^R \frac{4\pi T r^2 dr}{r} = 4\pi\kappa T\int_0^R r\,dr = 4\pi\kappa T\frac{R^2}{2}$$

$$= 2\pi\kappa T R^2 = \phi$$

$$M = \frac{4\pi}{3}TR^3$$

$$\frac{M}{R} = \frac{4\pi}{3}TR^2 = \frac{2}{3\kappa}(2\pi\kappa T R^2) = \frac{2}{3\kappa}\phi$$

$$\phi = \frac{3\kappa M}{2R}$$

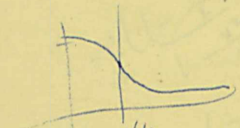


$$g = \phi^8\,\gamma$$

$$\sqrt{-g} = \phi^4\sqrt{-\gamma}$$

$$\phi\,\partial_\mu\partial_\mu\phi = \partial_\mu(\phi\,\partial_\mu\phi) - (\partial_\mu\phi)(\partial_\mu\phi)$$

$$\int \phi\,\Box\,\phi\,d^4x = -\int(\partial_\mu\phi)(\partial_\mu\phi) + \phi$$



$a(1)$.

$$\phi = \frac{1}{1 - \frac{r^2}{2R^2}} + \frac{\sum m_s}{r} \qquad \frac{\sum m_i}{R}. \qquad \phi^{-3} \quad \phi^{-4}\frac{d\phi}{dr}$$

$$\left(-\frac{3}{2} + \frac{2}{2}\right)\frac{r^2}{R^2} - 3 +$$

$$\frac{7}{2}\frac{r^2}{R^2} = 1 - \frac{ct^2}{2R^2}$$

$$\frac{7}{2}\frac{r^2}{R^2} + \frac{ct^2}{2R^2} - 1 = 0$$

$$r^2 = \frac{2}{7}R^2\left(1 - \frac{ct^2}{2R^2}\right)$$

$$r = \sqrt{\tfrac{2}{7}}\,R\sqrt{1 - \tfrac{ct^2}{2R^2}}$$

$$\phi =$$

$$\frac{3}{R^2(\ )^5}\left[4\frac{r^2}{R^2} - \frac{1}{2}\frac{r^2}{R^2} - 1 + \frac{ct^2}{2R^2}\right]$$

$$\frac{1}{\left(1 - \frac{ct^2}{2R^2} + \frac{r^2}{2R^2}\right)^3}$$

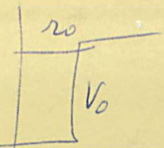
$$\frac{d\phi}{dr} = -\frac{3}{R^2}\frac{r}{(\ )^4}$$

$$\frac{d^2\phi}{dr^2} = \frac{12}{R^2}\frac{\frac{r^2}{R^2}}{(\ )^5} - \frac{3}{R^2}\frac{1 - \frac{ct^2}{2R^2} + \frac{r^2}{2R^2}}{(\ )^5}.$$

3×4

4

$$L_0 = k\cot\delta_0 \qquad k = \frac{\sqrt{2mE}}{\hbar} \qquad k^2 = \frac{2mE}{\hbar^2}$$



$$\kappa = \frac{1}{\hbar}\sqrt{2m(E+V_0)} = \sqrt{\frac{2mE}{\hbar^2}+\frac{2mV_0}{\hbar^2}} = \sqrt{k^2 + \dots}$$

$$K r_0 = \frac{r_0}{\hbar}\sqrt{2mV_0} = \kappa(0) r_0$$

$$k\cot\delta_0 = \frac{k\sin kr_0 + \kappa(\cot\kappa r_0)\cos kr_0}{\cos kr_0 - \kappa\cot\kappa r_0 \frac{\sin kr_0}{k}}$$

$$k = 0 \quad \kappa = K \qquad K = \frac{\sqrt{2mV_0}}{\hbar}$$

$$\kappa = \sqrt{k^2 + \frac{2mV_0}{\hbar^2}}$$

$$= k\sin kr_0 + \frac{1}{\hbar}\sqrt{}$$

$$\kappa = \sqrt{\frac{2mV_0}{\hbar^2}}\left(\sqrt{1+\frac{k^2}{\hbar\sqrt{\frac{2mV_0}{\hbar^2}}}}\right) = K\sqrt{1+\frac{k^2}{K^2}} \sim K\left(1+\frac{1}{2}\frac{k^2}{K^2}\right) = K + \frac{1}{2}\frac{k^2}{K}$$

$$k\cot\delta_0 = \frac{K\cot Kr_0}{1 - r_0 K\cot Kr_0} = \frac{1}{\frac{1}{K\cot Kr_0} - r_0} \simeq \frac{1}{a}$$

$$\frac{\cos x}{\sin x} = \frac{1-\frac{x^2}{2}}{x - \frac{x^3}{6}} = \frac{1}{x}\left(\frac{1-\frac{x^2}{2}}{1-\frac{x^2}{6}}\right) = \frac{1}{x}\left(1-\frac{x^2}{2}\right)\left(1+\frac{x^2}{6}\right) = \frac{1}{x}\left(1-\frac{3x^2}{6}+\frac{x^2}{6}\right) = \frac{1}{x}\left(1-\frac{x^2}{3}\right)$$

$$a = \frac{r_0 K\cot Kr_0 - 1}{K\cot Kr_0} = r_0 - \frac{1}{K\cot Kr_0} = r_0\left(1 - \frac{1}{r_0 K\cot Kr_0}\right)$$

$$\cot x = \frac{1-\frac{x^2}{3}}{x}$$

$$x - \frac{x^3}{6} \qquad x\left(1-\frac{x^2}{3}\right)$$

$$\kappa = K + \frac{1}{2}\frac{k^2}{K} \qquad \kappa^2 = K^2 + k^2$$

$$\frac{k^2 r_0 + \left(K + \frac{1}{2}\frac{k^2}{K}\right)\frac{1-\frac{1}{3}(r_0^2K^2 + r_0^2k^2)}{Kr_0 + \frac{1}{2}\frac{r_0}{K}k^2}\left(1-k^2r_0^2\right)}{1-k^2r_0^2 - \left(K+\frac{1}{2}\frac{k^2}{K}\right)\frac{1-\frac{1}{3}(r_0^2K^2+r_0^2k^2)}{Kr_0+\frac{1}{2}\frac{r_0}{K}k^2} r_0\left(1-\frac{k^2r_0^2}{6}\right)}$$

$$= \qquad \frac{1}{Kr_0}\left(K + \cancel{\frac{1}{2}\frac{k^2}{K^2}}\right)\frac{1-\frac{1}{3}r_0^2K^2 - \frac{1}{3}r_0^2k^2}{\cancel{1+\frac{1}{2}\frac{k^2}{K^2}}}\left(1 - \cancel{\frac{1}{2}}\frac{k^2}{K^2}\right)$$

$$\frac{1}{r_0} - \frac{1}{3}r_0K^2 - \frac{1}{3}r_0k^2$$
$$- r_0k^2 + \frac{1}{3}r_0^3K^2k^2$$

$$= \frac{1}{r_0}\left(1 - \frac{1}{3}r_0^2K^2 - \frac{1}{3}r_0^2k^2\right) = \frac{1}{r_0} - \frac{1}{3}r_0K^2 - \frac{1}{3}r_0k^2$$
$$\left(1 - k^2r_0^2\right)$$

$$\frac{1}{r_0} - \frac{1}{3} r_0 K^2 + r_0 k^2\left(-\frac{4}{3} + \frac{1}{3} r_0 K^2\right)$$

$$\frac{1}{r_0} - \frac{1}{3} r_0 K^2 - \frac{r_0 k^2}{3}\left(4 - r_0 K^2\right) + r_0 k^2$$

$$-\frac{4}{3} + 1 = -\frac{4}{3} + \frac{3}{3} = -\frac{1}{3}$$

$$-\frac{1}{3} r_0 k^2 -$$

$$\frac{\frac{1}{r_0} - \frac{1}{3} r_0 K^2 - \frac{r_0 k^2}{3}\left(1 - r_0 K^2\right)}{1 - k^2 r_0^2 + r_0\left(1 - \frac{1}{3} r_0^2 K^2 - \frac{1}{3} r_0^2 k^2\right)\left(1 - \frac{k^2 r_0^2}{6}\right)}$$

$$\left(1 - \frac{1}{3} r_0^2 K^2 - \frac{1}{3} r_0^2 k^2\right) r_0\left(1 - \frac{k^2 r_0^2}{6}\right)$$

$$1 - \frac{1}{3} r_0^2 K^2 - \frac{1}{3} r_0^2 k^2 - \frac{r_0^2}{6} k^2 + \frac{1}{18} r_0^4 K^2 k^2 - r_0^2 k^2$$

$$1 - \frac{3}{2} r_0^2 k^2 + \frac{1}{18} r_0^4 K^2 k^2 \Big/ -\frac{1}{3} - 1 - \frac{1}{6} = -\frac{2}{6} - \frac{1}{6} - 1 = -\frac{1}{2} - 1 = -\frac{3}{2}$$

2m

$$[ab, c] = [a, c]b + a[b, c].$$

$$\sigma_{\mu\nu} = i\,\frac{\gamma_\mu\gamma_\nu - \gamma_\nu\gamma_\mu}{2} = \frac{i}{2}[\gamma_\mu, \gamma_\nu]$$

$$[\sigma_{\mu\nu}, \gamma_\lambda] = \frac{i}{2}[\gamma_\mu\gamma_\nu, \gamma_\lambda] - \frac{i}{2}[\gamma_\nu\gamma_\mu, \gamma_\lambda]$$

$$= \frac{i}{2}[\gamma_\mu, \gamma_\lambda]\gamma_\nu + \frac{i}{2}\gamma_\mu[\gamma_\nu, \gamma_\lambda] -$$

$$abc - cab = abc + acb - acb - cab$$

$$= a\{bc\} - \{ac\}b$$

$$[ab, c] = a\{bc\} - \{ac\}b$$

$$[\gamma_\mu\gamma_\nu, \gamma_\lambda] = \gamma_\mu\underbrace{\{\gamma_\nu\gamma_\lambda\}}_{2\delta_{\nu\lambda}} - \{\gamma_\mu\gamma_\lambda\}\gamma_\nu$$

$$S\gamma_\mu S^{-1} = \gamma_\mu + \gamma_\mu a$$

$$= 2\gamma_\mu\delta_{\nu\lambda} - 2\gamma_\nu\delta_{\mu\lambda}$$

$$\frac{i}{2}[\gamma_\mu\gamma_\nu, \gamma_\lambda] = i(\gamma_\mu\delta_{\nu\lambda} - \gamma_\nu\delta_{\mu\lambda})$$

$$[\sigma_{\mu\nu}, \gamma_\lambda] = 2i(\gamma_\mu\delta_{\nu\lambda} - \gamma_\nu\delta_{\mu\lambda}) - \cancel{\gamma_\nu}\,\delta$$

$$\gamma_\mu\partial_\mu\psi = m\psi \qquad \partial_\mu = \partial'_\mu + a_{\mu\nu}\partial'_\nu$$

$$\gamma_\mu\partial_\mu = \gamma\partial'_\mu + \gamma_\mu a_{\mu\nu}\partial'_\nu$$

$$\frac{d}{d\tau}\phi\frac{dx^\mu}{d\tau} = \partial^\mu\phi \qquad \phi = \phi(\sigma^2). \qquad \sigma^2 = x^\mu x_\mu \quad \frac{d}{d\tau}\sigma^2 = 2\frac{dx^\mu}{d\tau}x_\mu$$

$$\frac{d}{d\tau}\phi(\sigma^2) = \phi'(\sigma^2)\frac{d}{d\tau}\sigma^2$$

$$\frac{d}{d\tau}\phi(\sigma^2)\frac{dx^\mu}{d\tau} = 2x^\mu\phi'(\sigma^2). \qquad \frac{\partial}{\partial x_\mu}\sigma^2 = \partial_\mu\sigma^2 = 2x_\mu$$

$$\phi(\sigma^2)\frac{d^2x^\mu}{d\tau^2} + \phi'(\sigma^2)\,2x_\lambda\frac{dx^\lambda}{d\tau}\frac{dx^\mu}{d\tau} = 2x^\mu\phi'(\sigma^2).$$

$$\frac{d^2x^\mu}{d\tau^2} = 2\frac{\phi'}{\phi}\left[x^\mu - x_\lambda\frac{dx^\lambda}{d\tau}\frac{dx^\mu}{d\tau}\right]$$

$$x^m - x_\lambda\frac{dx^\lambda}{d\tau}$$

$$\frac{d^2x^\mu}{d\tau^2} = 2\frac{\phi'(\sigma^2)}{\phi(\sigma^2)}\left[x^\mu - \underbrace{x_\lambda\frac{dx^\lambda}{d\tau}}_{\left(\frac{1}{2}\dot{\sigma}^2\right)}\frac{dx^\mu}{d\tau}\right].$$

$$d\tau^2 = dt^2\left(1-\frac{v^2}{c^2}\right).$$

Newline

$$\frac{d^2x^2}{dt^2} = \left(x^\mu - t\frac{dx^2}{dt}\right)\frac{\gamma}{\sigma^2}\,G(\xi)\left[\cancel{\frac{\frac{1}{2}\frac{d}{dt}\sigma^2}{\frac{1}{2}\frac{d\sigma^2}{dt}}}\right]^2$$

$$\gamma = 1 - \frac{v^2}{c^2}.$$

$$\xi = \frac{\left[\frac{1}{2}\frac{d\sigma^2}{dt}\right]^2}{\left(1-\frac{v^2}{c^2}\right)\sigma^2} = \frac{1}{\sigma^2}\left[\frac{d\sigma^2}{\sqrt{1-\frac{v^2}{c^2}}\,dt}\right]^2$$

$$\frac{4\pi}{3} \approx 4 \qquad 2\pi^2 = 20$$

$$\xi = \frac{1}{4\sigma^2}\left(\frac{d\sigma^2}{d\tau}\right)^2 = \frac{1}{4\sigma^2}4\sigma^2\left(\frac{d\sigma}{dt}\right)^2 = \left(\frac{d\sigma}{d\tau}\right)^2.$$

$$\xi = \left(\frac{d\sigma}{d\tau}\right)^2.$$

$$x^0\frac{dt}{d\tau} - x^m\frac{dx^m}{d\tau} = \frac{t}{\sqrt{1-v^2/c^2}} - \frac{x^m\,dx^m}{\sqrt{1-v^2/c^2}\,dt}$$

$$x^\mu - \frac{1}{\gamma}\left(t\frac{dx^\mu}{dt} - x^m\frac{dx^m}{dt}\frac{dx^\mu}{dt}\right). \qquad \left(t - x^m\frac{dx^m}{dt}\right)\frac{1}{\sqrt{1-v^2/c^2}}\,\frac{dx^\mu}{dt\sqrt{1-v^2/c^2}}$$

$$X_\mu X_\mu + X_5^2 = R^2$$

$$X_\mu = \frac{x_\mu}{1 + \frac{x_\lambda x_\lambda}{4R^2}}$$

then we find $\quad X_5 = R\,\frac{1 - \frac{x_\lambda x_\lambda}{4R^2}}{1 + \frac{x_\lambda x_\lambda}{4R^2}} = R\,\frac{1 - \frac{\tau^2}{4R^2}}{1 + \frac{\tau^2}{4R^2}}$

$X_5 = R$ corresponds to $\tau^2 = 0$.

$$\frac{1-x}{1+x} = y \qquad x = \frac{1+y}{1-y} \qquad \frac{\tau^2}{4R^2} = \frac{1 + \frac{X_5}{R}}{1 - \frac{X_5}{R}}$$

$x = -1 \quad y \to \infty$

$x \to \infty \quad y = -1$

$$\tau^2 = 4R^2\,\frac{1 + \frac{X_5}{R}}{1 + \frac{X_5}{R}}$$

$$ds^2 = dX_\mu dX_\mu + dX_5^2 = \frac{1}{\left(1 + \frac{\tau^2}{4R^2}\right)^2}\, d\sigma^2 \qquad d\sigma^2 = \eta_{\mu\nu}\, dx^\mu dx^\nu$$

$$\tau'^2 = f(\tau^2, a^2, \tau_\mu a_\mu)$$

$(x-a)$

$\tau'^2 = \tau^2 + a^2 - 2\tau_\mu a_\mu$

$$\gamma_5 X_5 + \gamma_\mu X_\mu = \gamma_\mu \frac{x_\mu}{1 + \frac{\tau^2}{4R^2}} + \gamma_5 R\,\frac{1 - \frac{\tau^2}{4R^2}}{1 + \frac{\tau^2}{4R^2}}$$

$$X'_5 + \gamma_\mu \gamma_5 X'_\mu = \mathrm{Tr}\,(X_5 + \gamma_\mu\gamma_5 X_\mu)\, e^{f(a, \gamma)}$$

$$\gamma_5 X_5 + \gamma_\mu X_\mu = \frac{\gamma_\mu x_\mu + \gamma_5 R\left(1 - \frac{\tau^2}{4R^2}\right)}{1 + \frac{\tau^2}{4R^2}}$$

$$\gamma_5 X'_5 + \gamma_\mu X'_\mu = e^{\frac{i}{2}\gamma_5\gamma_\mu a_\mu}(\gamma_5 X_5 + \gamma_\mu X_\mu)\, e^{-\frac{i}{2}\gamma_5\gamma_\mu a_\mu}$$

$$X'_5 + \gamma_\mu \gamma_5 X'_\mu = e^{i\gamma_5\gamma_\mu a_\mu}(X_5 + \gamma_\mu\gamma_5 X_\mu)\, e^{i\gamma_5\gamma_\mu a_\mu}$$

$$X'_5 = \mathrm{Tr}\, S\,C\,S = \mathrm{Tr}\,C\,S^2$$

$$\frac{\gamma_\mu x'_\mu + \gamma_5 R\left(1-\frac{\tau'^2}{4R^2}\right)}{1+\frac{\tau'^2}{4R^2}} = e^{-\frac{1}{2}\gamma_5\gamma_\mu a_\mu}\frac{\gamma_\mu x_\mu + \gamma_5 R\left(1-\frac{\tau^2}{4R^2}\right)}{1+\frac{\tau^2}{4R^2}}e^{\frac{1}{2}\gamma_5\gamma_\mu a_\mu}$$

$$\frac{R\left(1-\frac{\tau'^2}{4R^2}\right) + \gamma_5\gamma_\mu x'_\mu}{1+\frac{\tau'^2}{4R^2}} = e^{-\frac{1}{2}\gamma_5\gamma_\mu a_\mu}\frac{\left[R\left(1-\frac{\tau^2}{4R^2}\right)+\gamma_5\gamma_\mu x_\mu\right]e^{\frac{1}{2}\gamma_5\gamma_\mu a_\mu}}{1+\frac{\tau^2}{4R^2}}$$

$$X_\mu \frac{\partial}{\partial X_\nu} - X_\nu \frac{\partial}{\partial X_\mu}$$

$$X_5 \frac{\partial}{\partial X_\mu} - X_\mu \frac{\partial}{\partial X_5}$$

$$\frac{\partial}{\partial X_\mu} = \frac{\partial x_\lambda}{\partial X_\mu}\frac{\partial}{\partial x_\lambda}$$

$$\frac{\partial}{\partial X_5} = \frac{\partial x_\lambda}{\partial X_5}\frac{\partial}{\partial x_\lambda}$$

$X_5 = f(\tau^2)$

$\psi(X_1, \ldots)$

$x^2+y^2 = R^2$

$x = R\frac{\xi/R}{1+\frac{\xi^2}{4R^2}}$ $\quad y = R\frac{1-\xi^2/4R^2}{1+\xi^2/4R^2}$

$x\partial_y - y\partial_x$

$x = r$

$y = r$

$x = r\cos\varphi$

$y = r\sin\varphi$

$$\frac{\partial}{\partial x} = \frac{\partial r}{\partial x}\frac{\partial}{\partial r} + \frac{\partial\varphi}{\partial x}\frac{\partial}{\partial\varphi}$$

$$y\frac{\partial}{\partial x} = r\sin\varphi\frac{\partial r}{\partial x}\frac{\partial}{\partial r} + r\sin\varphi\frac{\partial\varphi}{\partial x}\frac{\partial}{\partial\varphi}$$

$\xi^2 + R^2\left(1+\frac{\xi^4}{4R^4}\ldots\right.$

$\frac{\xi^2}{R^2} + 1 + \frac{\xi^2}{2R^2} + \frac{\xi^4}{\ldots}$

$\left(1+\frac{\xi^2}{4R^2}\right)^2$

$\gamma_\mu\gamma_\nu\ldots$

$G^2 \ldots$

$1-x = y - yx$ $\quad x(1-y) = 1-y$ $\quad x = \frac{1-y}{1+y}$

$x^2 + y^2 = R^2$ $\qquad \frac{1-x}{1+x} = y$

$x = R\cos\varphi \quad y = R\sin\varphi$

$\frac{\xi^2}{4R^2} = \frac{1-\cos\varphi}{1+\cos\varphi} = \frac{\sin^2\frac{\varphi}{2}}{\cos^2\frac{\varphi}{2}}$

$\sin\varphi = \frac{\xi/R}{1+\frac{\xi^2}{4R^2}} \qquad \cos\varphi = \frac{1-\frac{\xi^2}{4R^2}}{1+\frac{\xi^2}{4R^2}} \qquad \varphi = \varphi(\xi^2)$

$$x\partial_y - y\partial_x = \frac{\partial}{\partial\varphi} = \frac{d\xi}{d\varphi}\frac{\partial}{\partial\xi}$$

$t = \frac{\xi}{2}$ $\qquad \frac{2t}{1+t^2}$

$\frac{\xi}{2R} = \operatorname{tg}\frac{\varphi}{2}$ $\qquad \frac{\xi^2}{4R^2} = \operatorname{tg}^2\frac{\varphi}{2}$

$\xi = 4R\operatorname{tg}\frac{\varphi}{2}$

$x = \frac{\xi}{\left(1+\frac{\xi^2}{4R^2}\right)} \qquad y = R\,\frac{1-\xi^2/4R^2}{1+\xi^2/4R^2}$

$dx^2 + dy^2 =$

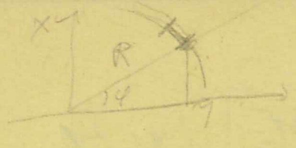
$$\frac{dx}{d\xi} = \frac{d\xi\;1}{\left(1+\frac{\xi^2}{4R^2}\right)} - \frac{\xi \times 2\xi/4R^2}{(\quad)^2} = \frac{1+\frac{\xi^2}{4R^2}-\frac{2\xi^2}{4R^2}}{(\quad)^2} = \frac{1-\frac{\xi^2}{4R^2}}{(\quad)^2}$$

$$\frac{dy}{d\xi} = R\,\frac{-\left(1+\frac{\xi^2}{4R^2}\right)\frac{2\xi}{4R^2} - \left(1-\frac{\xi^2}{4R^2}\right)\frac{2\xi}{4R^2}}{(\quad)^2} = \frac{-\frac{2\xi}{4R^2}-\frac{2\xi}{4R^2}-\frac{2\xi^3}{16R^4}+\frac{2\xi^3}{16R^3}}{(\quad)^2}$$

$$\frac{dy}{d\xi} = \frac{-\xi/R}{(\quad)^2}$$

$$dx^2+dy^2 = \left[\left(\frac{dx}{d\xi}\right)^2+\left(\frac{dy}{d\xi}\right)^2\right]d\xi^2 = \frac{1+\frac{\xi^4}{16R^4}-\frac{\xi^2}{2R^2}+\frac{2\xi^2}{2R^2}}{(\quad)^4} = \frac{\left(1+\frac{\xi^2}{4R^2}\right)^2}{\left(1+\frac{\xi^2}{4R^2}\right)^4}d\xi^2$$

$$dx^2+dy^2 = \frac{d\xi^2}{\left(1+\frac{\xi^2}{4R^2}\right)^2}$$



$\xi = 2R \tan\frac{\varphi}{2}$

$x = R \sin\varphi \qquad y = R \cos\varphi \qquad x^2+y^2=R^2 \qquad ds = \dfrac{d\xi}{1+\frac{\xi^2}{4R^2}}$

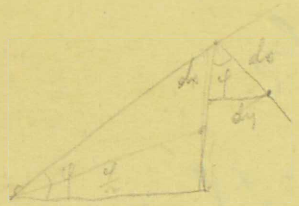
$0<\varphi<\pi$

$$x = R\,\frac{\xi/R}{1+\frac{\xi^2}{4R^2}} \qquad y = R\,\frac{1-\frac{\xi^2}{4R^2}}{1+\frac{\xi^2}{4R^2}} \qquad ds^2 = \frac{d\xi^2}{\left(1+\frac{\xi^2}{4R^2}\right)^2}$$

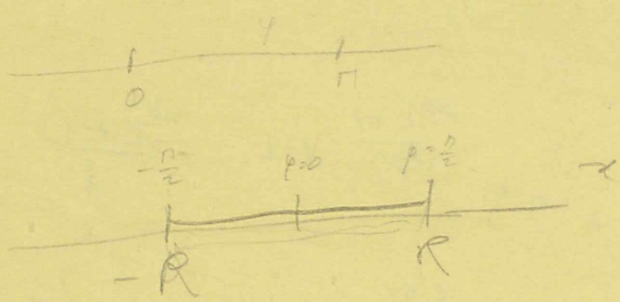
$-\infty<\xi<\infty$

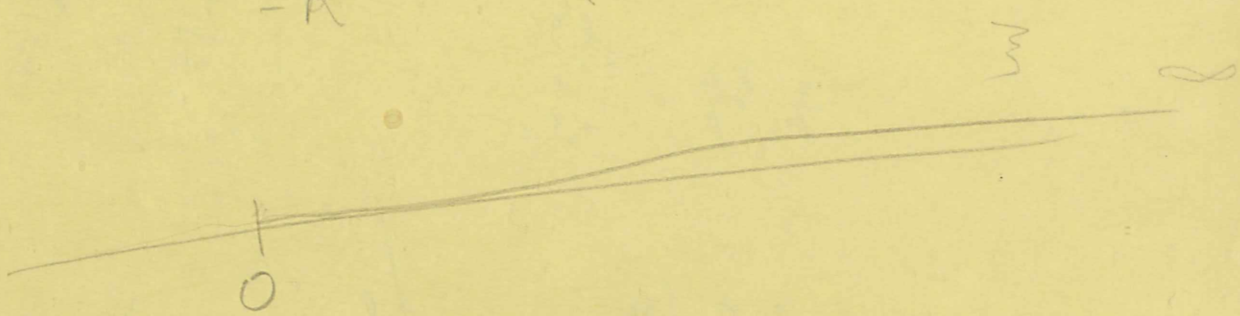
Find $\quad x\dfrac{\partial}{\partial y} - y\dfrac{\partial}{\partial x}$

$$1+\frac{\xi^2}{4R^2} = 1+\tan^2\frac{\varphi}{2} = \frac{1}{\cos^2\frac{\varphi}{2}}$$



$$\frac{\frac{1}{R}\,d\xi}{1+\frac{\xi^2}{4R^2}} = d\varphi$$





$$\tan\frac{\varphi}{2} = \frac{\xi}{2R} \qquad \varphi = 2\tan^{-1}\frac{\xi}{2R} = \varphi(\xi)$$

$$\frac{\partial}{\partial\varphi} = \frac{d\xi}{d\varphi}\frac{\partial}{\partial\xi} \qquad \xi = 2R\,\frac{\sin\frac{\varphi}{2}}{\cos\frac{\varphi}{2}}$$

$$d\xi = 2R\,\frac{\cos^2\frac{\varphi}{2}+\sin^2\frac{\varphi}{2}}{\cos^2\frac{\varphi}{2}} \times \frac{1}{2}d\varphi = \frac{R\,d\varphi}{\cos^2\frac{\varphi}{2}}$$

$$x\partial_y - y\partial_x = \frac{\partial}{\partial\varphi}$$

$$d\xi = R\left(1+\tan^2\frac{\varphi}{2}\right)d\varphi = R\left(1+\frac{\xi^2}{4R^2}\right)d\varphi$$

$$\frac{\partial}{\partial\varphi} = R\left(1+\frac{\xi^2}{4R^2}\right)\frac{\partial}{\partial\xi}$$

$$L_{54} = x\frac{\partial}{\partial y} - y\frac{\partial}{\partial x} = R\left(1+\frac{\zeta^2}{4R^2}\right)\frac{\partial}{\partial \zeta} - \sim R\frac{\partial}{\partial \zeta}$$

$$\frac{1}{R}L_{54} = \left(1+\frac{\zeta^2}{4R^2}\right)\frac{\partial}{\partial \zeta}$$

$$X^2+Y^2+Z^2 = R^2, \qquad x^2+y^2=r^2.$$

$$X = \frac{x}{\left(1+\frac{r^2}{4R^2}\right)} \qquad Y = \frac{y}{\left(1+\frac{r^2}{4R^2}\right)} \qquad Z = R\,\frac{1-\frac{r^2}{4R^2}}{\left(1+\frac{r^2}{4R^2}\right)}$$

$$X^2+Y^2+Z^2 = \frac{r^2+R^2\left(1-\frac{r^2}{4R^2}\right)^2}{(\quad)^2} = R^2\,\frac{\frac{2r^2}{2R^2}+1+\left(\frac{r^2}{4R^2}\right)^2-\frac{2r^2}{4R^2}}{(\quad)^2} = R^2$$

$$e_1X+e_2Y+e_3Z = \vec{q}$$

$$|q|=1 \qquad \frac{e_1x+e_2y+e_3R\left(1-\frac{x^2+y^2}{4R^2}\right)}{1+}$$

$$Re^{i\alpha}+e^{-i\alpha}$$

$$\left|\frac{1+i\alpha}{1-i\alpha}\right| =$$

$$X\frac{\partial}{\partial Y} - Y\frac{\partial}{\partial X}$$

$$\frac{\partial}{\partial X}$$

$$Z\frac{\partial}{\partial X} - X\frac{\partial}{\partial Y} = Z(r^2)$$

$$2x^2\,dx+$$

$$\frac{\partial}{\partial X} = \frac{\partial x}{\partial X}\frac{\partial}{\partial x} + \frac{\partial y}{\partial X}\frac{\partial}{\partial y}$$

$$dr^2 = 2x\,dx+2y\,dy$$

$$dX = \frac{\left(1+\frac{r^2}{4R^2}\right)dx - x\times\frac{2x\,dx+2y\,dy}{4R^2}}{(\quad)^2} =$$

$$X^2+Y^2 = \frac{r^2}{\left(1+\frac{r^2}{4R^2}\right)^2} \qquad x = \left(1+\frac{r^2}{4R^2}\right)X \qquad y = \left(1+\frac{r^2}{4R^2}\right)Y$$

$$\left(1+\frac{r^2}{4R^2}\right)^2(X^2+Y^2) = r^2$$

$$r^2\left(1-\frac{X^2+Y^2}{4R^2}\right) = X^2+Y^2 \qquad \frac{r^2}{4R^2} = \frac{(X^2+Y^2)/4R^2}{1-\frac{X^2+Y^2}{4R^2}}$$

$$\vec{q}' = e^{\frac{1}{2}\vec{\omega}}\, \vec{q}\, e^{-\frac{1}{2}\vec{\omega}}$$

$$\vec{q} = \frac{e_1 \rho \cos\varphi + e_2 \rho \sin\varphi + e_3 R \left(1 - \frac{\rho^2}{4R^2}\right)}{1 + \frac{\rho^2}{4R^2}}$$

$$\frac{e_1 \rho (\cos\varphi - e_3 \sin\varphi) + e_3 R (\quad)}{}$$

$$= \frac{e_1 \rho e^{-e_3 \varphi} + e_3 R \left(1 - \frac{\rho^2}{4R^2}\right)}{1 + \frac{\rho^2}{4R^2}}$$

e_1

$$\left| R\,\frac{1+\vec{q}}{1-\vec{q}} \right| = R$$

$$X_1^2 + X_2^2 + X_3^2 + X_4^2 = R^2$$

$$\frac{1+\vec{q}}{(1-\vec{q})}\frac{(1+\vec{q})}{(1+\vec{q})} = \frac{1 \pm q^2 + 2\vec{q}}{1+q^2} = X_0 + e_1 X_1 + e_2 X_2 + e_3 X_3$$

$$R\,\frac{1+\frac{\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}} = X_5 + e_1 X_1 + e_2 X_2 + e_3 X_3$$

$$R\,\frac{\vec{q}}{2} = \vec{x} \qquad \frac{\vec{q}}{2} = \frac{\vec{x}}{R}$$

$$X + iY = R\,\frac{1 + i\frac{\xi}{2R}}{1 - i\frac{\xi}{2R}} = R\,\frac{1 - \frac{\xi^2}{4R^2} + i\frac{\xi}{R}}{1 + \frac{\xi^2}{4R^2}}$$

$$R\,\frac{1 + \vec{x}}{1 - \frac{\vec{x}}{R}} =$$

$$R\,\frac{1 - \frac{q^2}{4R^2} + \frac{\vec{q}}{R}}{1 + \frac{q^2}{4R^2}} = \frac{R\left(1 - \frac{q^2}{4R^2}\right)}{1 + \frac{q^2}{4R^2}} + \frac{\vec{q}}{1 + \frac{q^2}{4R^2}} = X_5 + \vec{X}$$

$$\boxed{R\,\frac{1 + \frac{\gamma_5\gamma_\mu x_\mu}{2R}}{1 - \frac{\gamma_5\gamma_\mu x_\mu}{2R}} = X_5 + \gamma_5\gamma_\mu X_\mu} \qquad R\,\frac{2R\gamma_5 + \gamma_\mu x_\mu}{2R\gamma_5 \pm \gamma_\mu x_\mu} = X_5 + \gamma_5\gamma_\mu X_\mu$$

$$\left(1 - \frac{\gamma_5\gamma_\mu x_\mu}{2R}\right)\left(1 + \frac{\gamma_5\gamma_\mu x_\mu}{2R}\right) = 1 - \frac{\gamma_5\gamma_\mu\gamma_5\gamma_\nu x_\mu x_\nu}{4R^2}$$

but $$R\,\frac{1 + \gamma_5\gamma_\mu\frac{x_\mu}{2R}}{1 - \gamma_5\gamma_\mu\frac{x_\mu}{2R}} = e^{\frac{1}{2}\gamma_5\gamma_\mu\frac{a_\mu}{R}} \quad (\;)\,e^{-\frac{1}{2}\gamma_5\gamma_\mu\frac{a_\mu}{R}} \quad 1 + \frac{\gamma_\mu\gamma_\nu x_\mu x_\nu}{4R^2} \quad 1 + \frac{x_\mu^2}{4R^2}$$

X

$$X_5 + \vec{X} = R\,\frac{1 + \frac{i\vec{q}}{2R}}{1 - \frac{i\vec{q}}{2R}} = R\,\frac{1 - \frac{q^2}{4R^2} + i\,\frac{\vec{q}}{R}}{1 + \frac{q^2}{4R^2}}$$

$$X_5 \to X_5 \qquad \vec{X} \to e^{i}$$

$$\frac{X_5 + \vec{X}}{R} = \frac{1 + \frac{\vec{q}}{2R}}{1 - \frac{\vec{q}}{2R}}$$

$$\frac{X_5 + \vec{X}}{R}\left(1 - \frac{\vec{q}}{2R}\right) = \frac{X_5 + \vec{X}}{R} - \left(\frac{X_5 + \vec{X}}{R}\right)\frac{\vec{q}}{2R} = 1 + \frac{\vec{q}}{2R}$$

$$\frac{X_5 + \vec{X}}{R} - 1 = \left(\frac{X_5 + \vec{X}}{R} + 1\right)\frac{\vec{q}}{2R}$$

$$\frac{\vec{q}}{2R} = \frac{\frac{X_5 + \vec{X}}{R} - 1}{\frac{X_5 + \vec{X}}{R} + 1} = S\left(\frac{X_5 + \vec{X}}{R} - 1\right)S^{-1}S\left(\frac{X_5 + \vec{X}}{R} + 1\right)^{-1}S^{-1}$$

$$q' = S q S^{-1}$$

$$\frac{\vec{q}'}{2R} = \frac{S\,\frac{X_5 + \vec{X}}{R}\,S^{-1} - 1}{S\,\frac{X_5 + \vec{X}}{R}\,S^{-1} + 1} = S^{X}$$

Transl.

$$\frac{\vec{q}'}{2R} = \cancel{S\left(\frac{X_5 + \vec{X}}{R} - 1\right)S}$$

$$\frac{1+\frac{\vec{x}'}{2R}}{1-\frac{\vec{x}'}{2R}} = e^{\frac{\vec{a}}{2R}} \frac{1+\frac{\vec{x}}{2R}}{1-\frac{\vec{x}}{2R}} e^{\frac{\vec{a}}{2R}}$$ translation

$\frac{1+x}{1-x} = y \qquad 1+x = y - yx \qquad x(1+y) = y-1 \qquad x = \frac{y-1}{y+1}$

$$\frac{\vec{x}'}{2R} = \frac{e^{\frac{\vec{a}}{2R}} \frac{1+\frac{\vec{x}}{2R}}{1-\frac{\vec{x}}{2R}} e^{\frac{\vec{a}}{2R}} - 1}{e^{\frac{\vec{a}}{2R}} \frac{1+\frac{\vec{x}}{2R}}{1-\frac{\vec{x}}{2R}} e^{\frac{\vec{a}}{2R}} + 1}$$

Inf. transl. $\quad a^2 \sim 0 \qquad \Omega + \frac{\Omega \vec{a}}{2R} + \frac{\vec{a}}{2R}\Omega$

$$\frac{\vec{x}'}{2R} = \frac{\left(1+\frac{\vec{a}}{2R}\right)\Omega\left(1+\frac{\vec{a}}{2R}\right)-1}{\left(1+\frac{\vec{a}}{2R}\right)\Omega\left(1+\frac{\vec{a}}{2R}\right)-1} = \frac{\Omega + \left\{\frac{\vec{a}}{2R}\Omega\right\} - 1}{\Omega + \left\{\frac{\vec{a}}{2R}\Omega\right\} - 1}$$

$$\frac{1+\frac{\vec{x}'}{2R}}{1-\frac{\vec{x}'}{2R}} = \frac{1+\frac{\vec{a}}{4R}}{1-\frac{\vec{a}}{4R}} \frac{1+\frac{\vec{x}}{2R}}{1-\frac{\vec{x}}{2R}} \frac{1+\frac{\vec{a}}{4R}}{1-\frac{\vec{a}}{4R}}$$

$dr = \frac{\vec{x}\cdot d\vec{x}}{r}$

$$X + iY = R\frac{1+\frac{i\xi}{2R}}{1-\frac{i\xi}{2R}} \quad \text{or} \quad X + iY = Re^{i\frac{\xi}{R}}$$

$$X_5 + \vec{X} = R e^{\frac{\vec{x}}{R}} = R\left(\cos\frac{r}{R} + \frac{\vec{x}}{r}\sin\frac{r}{R}\right) \qquad dX + i\,dY = \frac{i}{R}e^{i\frac{\xi}{R}}d\xi$$

$$d(X_5 + \vec{X}) = R\left(-\frac{\vec{x}}{r}\cdot d\vec{x}\,\frac{1}{R}\sin\frac{r}{R} + \frac{d\vec{x}}{r}\sin\frac{r}{R}\right) \qquad ds^2 = d\xi^2$$

$$\frac{\vec{q}}{2R} = \frac{\frac{X_5+\vec{X}}{R}-1}{\frac{X_5+\vec{X}}{R}+1} = \left(\frac{X_5+\vec{X}}{R}-1\right)\left(\frac{X_5+\vec{X}}{R}+1\right)^{-1}$$

$$X_5+\vec{X} = Q \qquad Q = R\,\frac{1+\frac{\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}}$$

$$\frac{\vec{q}}{2R} = \left(\frac{Q}{R}-1\right)\left(\frac{Q}{R}+1\right)^{-1}$$

$$\frac{\vec{q}'}{2R} = \left(\frac{Q'}{R}-1\right)\left(\frac{Q'}{R}+1\right)^{-1}$$

$$Q' = e^{\frac{\vec{a}}{2R}}\,Q\,e^{\frac{\vec{a}}{2R}} = SQS$$

$$|Q'| = |Q|$$

$$\frac{\vec{q}'}{2R} = \left(S\frac{Q}{R}S-1\right)\left(S\frac{Q}{R}S+1\right)^{-1}$$

$$\frac{1+\frac{\vec{q}'}{2R}}{1-\frac{\vec{q}'}{2R}} = S\,\frac{1+\frac{\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}}\,S = Q'$$

$$1+\frac{\vec{q}'}{2R} = Q' - \frac{\vec{q}'}{2R}Q'$$

$$\frac{\vec{q}'}{2R}(1+Q') = Q'-1 \qquad \frac{\vec{q}'}{2R} = \frac{Q'-1}{Q'+1}$$

$$\frac{\vec{q}'}{2R} = \frac{S\,\frac{1+\frac{\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}}\,S - 1}{S\,\frac{1+\frac{\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}}\,S + 1} \qquad S = e^{\frac{\vec{a}}{2R}}$$

$$\frac{\vec{q}'}{2R} = S\left[\frac{1+\frac{\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}} - S^{-2}\right] S\, S^{-1}\left[\frac{1+\frac{\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}} + S^{-2}\right]^{-1} S^{-1}$$

$$\frac{\vec{q}'}{2R} = S\left[\frac{1+\frac{\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}} - S^{-2}\right]\left[\frac{1+\frac{\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}} + S^{-2}\right]^{-1} S^{-1}$$

$$\frac{\vec{q}'}{2R} = S\left[\frac{1+\frac{\vec{q}}{2R}}{1-\frac{\vec{q}}{2R}} - S^{-2}\right]\left(1-\frac{\vec{q}}{2R}\right)\left(1-\frac{\vec{q}}{2R}\right)^{-1}\left[\quad\right]^{-1} S^{-1}$$

$$= S\left\{\left[\quad\right](\,)\right\}\left\{\left[\quad\right]'(\,)\right\}^{-1} S^{-1}$$

$$= S\left[1+\frac{\vec{q}}{2R} - S^{-2}\left(1-\frac{\vec{q}}{2R}\right)\right]\left[\left(1+\frac{\vec{q}}{2R}\right) + S^{-2}\left(1-\frac{\vec{q}}{2R}\right)\right]^{-1} S^{-1}$$

$$= \left[S\left(1+\frac{\vec{q}}{2R}\right) - S^{-1}\left(1-\frac{\vec{q}}{2R}\right)\right]\left[S\left(1+\frac{\vec{q}}{2R}\right) + S^{-1}\left(1-\frac{\vec{q}}{2R}\right)\right]^{-1}$$

$S = \cancel{1} + \frac{\vec{a}}{2R}$

$S^{-1} = 1 - \frac{\vec{a}}{2R}$

$S - S^{-1} = \frac{\vec{a}}{R}$

$S + S^{-1} = 2$

$$\cancel{S + \frac{S\vec{q}}{2R}}$$

$$\frac{\vec{q}'}{2R} = \frac{S - S^{-1} + \left(S + S^{-1}\right)\frac{\vec{q}}{2R}}{S + S^{-1} + \left(S - S^{-1}\right)\frac{\vec{q}}{2R}}$$

$$\frac{q'}{2R} = \frac{S - S^{-1} + (S + S^{-1})\frac{\vec{q}}{2R}}{(S + S^{-1}) + (S - S^{-1})\frac{\vec{q}}{2R}}$$

$$S - S^{-1} = \frac{\vec{a}}{R} \qquad S + S^{-1} = 2. \qquad a^2 \sim 0$$

$$\cancel{\frac{q'}{2R}} = \frac{\frac{\vec{a}}{\cancel{R}} + \frac{\vec{q}}{\cancel{R}}}{\cancel{2} + \frac{\vec{a}}{R}\frac{\vec{q}}{\cancel{2R}}}$$

$$\vec{q}\,' = \frac{\vec{q} + \vec{a}}{1 + \frac{\vec{a}\vec{q}}{R^2}} = (\vec{q} + \vec{a})\left(1 - \frac{\vec{a}\vec{q}}{R^2}\right)$$

$$\vec{q}\,' = \vec{q} + \vec{a} - \frac{\cancel{\vec{q}}^{\,2}\,\vec{a}\,\cancel{\vec{q}}}{R^2} = \vec{q} + \vec{a} + \frac{q^2}{R^2}\vec{a}$$

$$= \vec{q} + \left(1 + \frac{q^2}{R^2}\right)\vec{a}$$

$$\cancel{f(\circ} \qquad \vec{x}\,' = \vec{x} + \left(1 + \frac{r^2}{R^2}\right)\vec{a}$$

$$f\left(\vec{x} + \vec{a} + \frac{r^2}{R^2}\vec{a}\right) = f(\vec{x}) + \left(1 + \frac{r^2}{R^2}\right)\vec{a}\cdot\vec{\nabla} f$$

$$i\,\vec{p} = \left(1 + \frac{r^2}{R^2}\right)\vec{\nabla}$$

$$L_{\mu\nu} = x_\mu \partial_\nu \pm x_\nu \partial_\mu$$

$$\Pi_\nu = \frac{1}{R} L_{5\nu} = \left(1 + \frac{\tau^2}{R^2}\right) \partial_\nu = \cancel{p_\nu} \left(1 + \frac{\tau^2}{R^2}\right) p_\nu$$

$$\frac{1}{R^2} L_{\mu\nu} L_{\mu\nu} + \frac{1}{R^2} L_{5\nu} L_{5\nu} = \Omega$$

$$\Omega = \left(1 + \frac{\tau^2}{R^2}\right) p_\nu \left(1 + \frac{\tau^2}{R^2}\right) p_\nu + \frac{1}{R^2} L(L+1)$$

$$=$$

$$\frac{\partial}{\partial x} (x^2 + y^2) - (x^2 + y^2) \partial_x = 2x$$

$$p_\nu \tau^2 - \tau^2 p_\nu = 2 x_\nu$$

$$\Omega = \left(1 + \frac{\tau^2}{R^2}\right)^2 p_\nu p_\nu + \frac{2}{R^2}\left(1 + \frac{\tau^2}{R^2}\right) p_\nu x_\nu + \frac{1}{R^2} L(L+1)$$

$$\Omega = \left(1 + \frac{\tau^2}{R^2}\right)^2 P^2 + \frac{2}{R^2}\left(1 + \frac{\tau^2}{R^2}\right) X \cdot P + \frac{1}{R^2} L(L+1)$$

$$\left(1 + \frac{r^2}{R^2}\right)^{\varepsilon} \frac{2}{R^2} x_m p_m$$

$$\left(1 + \frac{r^2}{R^2}\right)^{\varepsilon} \frac{2}{R^2} x_m p_m$$

$$1 + r^2$$

$$J_{5n} = R\left(1 + \frac{r^2}{R^2}\right) p_n \qquad \Pi_n = \left(1 + \frac{r^2}{R^2}\right) p_n \qquad \frac{2}{R^2}\left(1 + \frac{r^2}{R^2}\right) J_{mn}$$

$$J_{5n} J_{5m} = R \qquad \left[\Pi_n, \Pi_m\right] = \left[\left(1 + \frac{r^2}{R^2}\right) p_n, \left(1 + \frac{r^2}{R^2}\right) p_m\right]$$

$$\left(1 + \frac{r^2}{R^2}\right) p_n, \left(1 + \frac{r^2}{R^2}\right) p_m \qquad = \frac{r^2}{R^2} p_m - \left(1 + \frac{r^2}{R^2}\right) p_m \left(1 + \frac{r^2}{R^2}\right) p_m$$

$$- \left(1 + \frac{r^2}{R^2}\right) p_m \left(1 + \frac{r^2}{R^2}\right) p_m$$

$$x = \cancel{R}\sin\theta\cos\varphi = \frac{\xi}{1+\frac{\rho^2}{4R^2}} \qquad \rho^2 = \xi^2 + \eta^2$$

$$y = \cancel{R}\sin\theta\sin\varphi = \frac{\eta}{1+\frac{\rho^2}{4R^2}}$$

$$z = \cancel{R}\cos\theta = R\,\frac{1-\frac{\rho^2}{4R^2}}{1+\frac{\rho^2}{4R^2}}$$

$$\frac{\rho}{2R} = \tan\frac{\theta}{2} \qquad , \varphi$$

$$\frac{y}{x} = \begin{cases} \frac{\eta}{\xi} = \tan\varphi \\ \frac{\rho}{2R} = \tan\frac{\theta}{2} \end{cases}$$

$$I_1 = \cos\varphi\,\frac{\partial}{\partial\theta}$$

$$x\frac{\partial}{\partial y} - y\frac{\partial}{\partial x}$$

$$\begin{cases} \frac{\sqrt{\xi^2+\eta^2}}{2R} = \tan\frac{\theta}{2} \\ \frac{\eta}{\xi} = \tan\varphi \end{cases}$$

$$\frac{\partial}{\partial\varphi} = \frac{\partial\eta}{\partial\varphi}\frac{\partial}{\partial\eta} + \frac{\partial\xi}{\partial\varphi}\frac{\partial}{\partial\xi}$$

$$L_x - iL_y = \hbar e^{-i\varphi}\left(-\frac{\partial}{\partial\theta} + i\cot\theta\frac{\partial}{\partial\varphi}\right)$$

$$L_x + iL_y = \hbar e^{i\varphi}\left(\frac{\partial}{\partial\theta} + i\cot\theta\frac{\partial}{\partial\varphi}\right)$$

$$L_z = -i\hbar\frac{\partial}{\partial\varphi}$$

$$\frac{\partial}{\partial\theta} = \frac{\partial}{\partial\rho}$$

$$2L_x = \hbar\frac{\partial}{\partial\theta}\left(e^{i\varphi}+e^{-i\varphi}\right) + 2i\hbar\cot\theta\frac{\partial}{\partial\varphi}$$

$$L_x = \hbar\cos\varphi\frac{\partial}{\partial\theta} + i\hbar\cot\theta\frac{\partial}{\partial\varphi}$$

$$\frac{\xi^2+\eta^2}{4R^2} = \tan^2\frac{\theta}{2}.$$

$$\frac{\eta}{\xi} = \tan\varphi$$

$$\xi^2\left(1+\frac{\eta^2}{\xi^2}\right) = 4R^2\tan^2\frac{\theta}{2}$$

$$\xi^2\,(1+\tan^2\varphi) = 4R^2\tan^2\frac{\theta}{2}.$$

$$\xi^2\,\frac{1}{\cos^2\varphi} = 4R^2\tan^2\frac{\theta}{2}$$

$$\xi = \left(2R\tan\frac{\theta}{2}\right)\cos\varphi = \rho\cos\varphi$$

$$\eta = \left(2R\tan\frac{\theta}{2}\right)\sin\varphi = \rho\sin\varphi$$

$$\frac{d}{d\theta}\tan\frac{\theta}{2} = \frac{1}{2}\left(1+\tan^2\frac{\theta}{2}\right).$$

$$\frac{d}{d\theta}\left(2\tan\frac{\theta}{2}\right) = \left(1+\tan^2\frac{\theta}{2}\right.$$

$$\frac{\partial\xi}{\partial\varphi} = -\rho\sin\varphi = -\eta \quad , \quad \frac{\partial\eta}{\partial\varphi} = \xi.$$

$$\frac{\partial}{\partial\varphi} = \frac{\partial\eta}{\partial\varphi}\frac{\partial}{\partial\eta} + \frac{\partial\xi}{\partial\varphi}\frac{\partial}{\partial\xi} = \xi\frac{\partial}{\partial\eta} - \eta\frac{\partial}{\partial\xi}$$

$$\frac{\partial}{\partial\theta} = \frac{\partial\eta}{\partial\theta}\cdot\frac{\partial}{\partial\eta} + \frac{\partial\xi}{\partial\theta}\frac{\partial}{\partial\xi}$$

$$\frac{\partial\eta}{\partial\theta} = (\cancel{1+R}\; R\left(1+\tan^2\frac{\theta}{2}\right)\cos\varphi$$

$$\frac{\partial\eta}{\partial\theta} = R\left(1+\tan^2\frac{\theta}{2}\right).\sin\varphi \qquad \frac{\partial\xi}{\partial\theta} = R\left(1+\tan^2\frac{\theta}{2}\right)\cos\varphi$$

$$-\frac{i L_x}{\hbar} = \sin\varphi \frac{\partial}{\partial\theta} + \cot\theta \cos\varphi \frac{\partial}{\partial\varphi}$$

$$\sin\varphi \frac{\partial}{\partial\theta} = R\left(1+\tan^2\frac{\theta}{2}\right)\sin\varphi \cancel{\cos\varphi} \frac{\partial}{\partial\eta}$$

$$+ R\left(1+\tan^2\frac{\theta}{2}\right)\sin\varphi\cos\varphi \frac{\partial}{\partial\xi}$$

$$\sin\varphi = \frac{\eta}{\varrho} \qquad \cos\varphi = \frac{\xi}{\varrho}$$

$$\tan\frac{\theta}{2} = \frac{\sqrt{\xi^2+\eta^2}}{2R} = \frac{\varrho}{2R} \qquad \tan^2\frac{\theta}{2} = \frac{\xi^2+\eta^2}{4R^2}$$

$$\sin\varphi \frac{\partial}{\partial\theta} = R\left(1+\frac{\varrho^2}{4R^2}\right)\left[\sin^2\varphi \frac{\partial}{\partial\eta} + \sin\varphi\cos\varphi \frac{\partial}{\partial\xi}\right]$$

$$\cancel{+R} = R\left(1+\frac{\varrho^2}{4R^2}\right)\left[\frac{\eta^2}{\varrho^2}\frac{\partial}{\partial\eta} + \frac{\eta\xi}{\varrho^2}\frac{\partial}{\partial\xi}\right]$$

$$\cot\theta = \frac{\cos\theta}{\sin\theta} = \frac{\cos^2\frac{\theta}{2}-\sin^2\frac{\theta}{2}}{2\sin\frac{\theta}{2}\cos\frac{\theta}{2}} = \frac{1-\tan^2\frac{\theta}{2}}{2\tan\frac{\theta}{2}} = \frac{1-\frac{\varrho^2}{4R^2}}{\varrho/2R}$$

$$\cot\theta\cos\varphi\frac{\partial}{\partial\varphi} = 2R\,\frac{1-\frac{\varrho^2}{4R^2}}{\varrho}\,\frac{\xi}{\varrho}\left(\xi\frac{\partial}{\partial\eta} - \eta\frac{\partial}{\partial\xi}\right)$$

$$= 2R\,\frac{1-\frac{\varrho^2}{4R^2}}{\varrho^2}\left(\xi^2\frac{\partial}{\partial\eta} - \xi\eta\frac{\partial}{\partial\xi}\right)$$

$$\sin\varphi\left(\frac{\partial}{\partial\theta}+\cot\theta\cos\varphi\frac{\partial}{\partial\varphi}\right)=\frac{R}{\rho^2}\left(1+\frac{\rho^2}{4R^2}\right)\left(\eta^2\frac{\partial}{\partial\eta}+\eta\xi\frac{\partial}{\partial\xi}\right)$$

$$+\frac{2R}{\rho^2}\left(1-\frac{\rho^2}{4R^2}\right)\left(\xi^2\frac{\partial}{\partial\eta}-\eta\xi\frac{\partial}{\partial\xi}\right)$$

$$\begin{cases}\xi=\rho\cos\varphi\\ \eta=\rho\sin\varphi\end{cases}\qquad \frac{\rho}{2R}=\tan\frac{\theta}{2}$$

$$L_x=\sin\varphi\frac{\partial}{\partial\theta}+\cot\theta\cos\varphi\frac{\partial}{\partial\varphi}$$

$$x=R\sin\theta\cos\varphi=\frac{\xi}{1+\rho^2/4R^2}$$

$$y=R\sin\theta\sin\varphi=\frac{\eta}{1+\rho^2/4R^2}$$

$$z=R\cos\theta=R\,\frac{1-\frac{\rho^2}{4R^2}}{1+\frac{\rho^2}{4R^2}}$$

$$\sin\theta=\frac{\rho/R}{1+\frac{\rho^2}{4R^2}}\qquad \sin\theta=2\sin\frac{\theta}{2}\cos\frac{\theta}{2}=2\tan\frac{\theta}{2}\cos^2\frac{\theta}{2}=\frac{2\tan\frac{\theta}{2}\cos^2\frac{\theta}{2}}{\sin^2\frac{\theta}{2}+\cos^2\frac{\theta}{2}}=\frac{2\tan\frac{\theta}{2}}{1+\tan^2\frac{\theta}{2}}$$

$$\cos\theta=\frac{1-\rho^2/4R^2}{1+\rho^2/4R^2}\qquad x=R\,\frac{\frac{\rho}{R}}{1+\frac{\rho^2}{4R^2}}\cos\varphi=\frac{\rho\cos\varphi}{1+\frac{\rho^2}{4R^2}}=\frac{\xi}{1+\rho^2/4R^2}$$

$$\cot\theta=\frac{\cos\theta}{\sin\theta}=\frac{1-\rho^2/4R^2}{\rho/R}$$

$$L_x=\frac{\eta}{\rho}\frac{\partial}{\partial\theta}+\frac{\xi}{\rho}\cot\theta\frac{\partial}{\partial\varphi}=\frac{\eta}{\rho}\frac{\partial}{\partial\theta}+\frac{\xi}{\rho}\,\frac{1-\rho^2/4R^2}{\rho/R}\,\frac{\partial}{\partial\varphi}$$

$$L_x=\frac{\eta}{\rho}\frac{\partial}{\partial\theta}+R\frac{\xi}{\rho^2}\left(1-\rho^2/4R^2\right)\frac{\partial}{\partial\varphi}\qquad \frac{\partial}{\partial\varphi}=\xi\frac{\partial}{\partial\eta}-\eta\frac{\partial}{\partial\xi}$$

$$L_x=\frac{\eta}{\rho}\frac{\partial}{\partial\theta}+R\frac{\xi}{\rho^2}\left(1-\frac{\rho^2}{4R^2}\right)\left(\xi\frac{\partial}{\partial\eta}-\eta\frac{\partial}{\partial\xi}\right)$$

$$\frac{\partial}{\partial\theta} = \frac{\partial\xi}{\partial\theta}\frac{\partial}{\partial\xi} + \frac{\partial\eta}{\partial\theta}\frac{\partial}{\partial\eta}$$

$$\xi = \rho\cos\varphi \qquad \eta = \rho\sin\varphi$$

$$\frac{\rho}{2R} = \tan\frac{\theta}{2} \qquad \rho = 2R\tan\frac{\theta}{2}$$

$$\xi \cancel{= 2R\tan\frac{\theta}{2}}$$

$$\frac{\partial\xi}{\partial\theta} = \frac{d\rho}{d\theta}\cos\varphi \qquad \frac{\partial\eta}{\partial\theta} = \frac{d\rho}{d\theta}\sin\varphi$$

$$\frac{\partial}{\partial\theta} = \frac{d\rho}{d\theta}\left(\cos\varphi\frac{\partial}{\partial\xi} + \sin\varphi\frac{\partial}{\partial\eta}\right)$$

$$= \frac{d\rho}{d\theta}\left(\frac{\xi}{\rho}\frac{\partial}{\partial\xi} + \frac{\eta}{\rho}\frac{\partial}{\partial\eta}\right)$$

$$\frac{\sin\theta}{\cos\theta} \qquad \frac{\cos\theta}{\cos\theta}$$

$$\frac{d\rho}{d\theta} = \frac{1}{2}2R\,\frac{\sin^2\frac{\theta}{2}+\cos^2\frac{\theta}{2}}{\cos^2\frac{\theta}{2}} = R\left(1+\tan^2\frac{\theta}{2}\right)$$

$$= R\left(1+\frac{\rho^2}{4R^2}\right)$$

$$\frac{\partial}{\partial\theta} = \frac{R}{\rho}\left(1+\frac{\rho^2}{4R^2}\right)\left(\xi\frac{\partial}{\partial\xi} + \eta\frac{\partial}{\partial\eta}\right)$$

$$\sin\varphi\frac{\partial}{\partial\theta} = \eta\frac{R}{\rho^2}\left(1+\frac{\rho^2}{4R^2}\right)\left(\xi\frac{\partial}{\partial\xi} + \eta\frac{\partial}{\partial\eta}\right)$$

$$\cos\varphi\cot\theta\frac{\partial}{\partial\varphi} = \xi\frac{R}{\rho^2}\left(1-\frac{\rho^2}{4R^2}\right)\left(\xi\frac{\partial}{\partial\eta} - \eta\frac{\partial}{\partial\xi}\right)$$

$$L_x = \frac{R}{\rho^2}\Big[\left(1+\frac{\rho^2}{4R^2}\right)\left(\eta\xi\frac{\partial}{\partial\xi} + \eta^2\frac{\partial}{\partial\eta}\right)$$

$$+\left(1-\frac{\rho^2}{4R^2}\right)\left(-\eta\xi\frac{\partial}{\partial\xi} + \xi^2\frac{\partial}{\partial\eta}\right)\Big]$$

$$= \frac{R}{\rho^2}\left[\rho^2\frac{\partial}{\partial\eta} + \frac{\rho^2}{4R^2}2\eta\xi\frac{\partial}{\partial\xi} + (\eta^2-\xi^2)\frac{\rho^2}{4R^2}\frac{\partial}{\partial\eta}\right]$$

$$\frac{1}{R}L_x = \frac{\partial}{\partial\eta} + \frac{1}{4R^2}\left(2\eta\xi\frac{\partial}{\partial\xi} + (\eta^2-\xi^2)\frac{\partial}{\partial\eta}\right)$$

wrong.

$$2\eta\xi\frac{\partial}{\partial\xi} - \xi^2\frac{\partial}{\partial\eta} =$$

$$\eta\xi\frac{\partial}{\partial\xi} + \eta\xi\frac{\partial}{\partial\xi} + \eta^2\frac{\partial}{\partial\eta} - \xi^2\frac{\partial}{\partial\eta}$$

$$\eta\left(\xi\frac{\partial}{\partial\xi} + \eta\frac{\partial}{\partial\eta}\right) + \xi\underbrace{\left(\eta\frac{\partial}{\partial\xi} - \xi\frac{\partial}{\partial\eta}\right)}_{\frac{\partial}{\partial\varphi}}$$

$$\sin\varphi \frac{\partial}{\partial\theta} + \cos\varphi \cot\theta \frac{\partial}{\partial\varphi}$$

$$\begin{cases} X = \dfrac{\xi}{1+\frac{\rho^2}{4R^2}} = \dfrac{\rho\cos\varphi}{1+\frac{\rho^2}{4R^2}} = R\sin\theta\cos\varphi \\ Y = \dfrac{\eta}{1+\frac{\rho^2}{4R^2}} = \dfrac{\rho\sin\varphi}{1+\frac{\rho^2}{4R^2}} = R\sin\theta\sin\varphi \\ Z = R\dfrac{1-\frac{\rho^2}{4R^2}}{1+\frac{\rho^2}{4R^2}} = R\cos\theta \end{cases}$$

$$\frac{\rho/R}{1+\frac{\rho^2}{4R^2}} = \sin\theta$$

$$\xi\frac{\partial}{\partial\eta} - \eta\frac{\partial}{\partial\xi} = \frac{\partial}{\partial\varphi} \qquad \frac{1-\frac{\rho^2}{4R^2}}{1+\frac{\rho^2}{4R^2}} = \cos\theta$$

$$\cot\theta = \frac{1-\frac{\rho^2}{4R^2}}{\rho/R} = \frac{\cos\theta}{\sin\theta} = \frac{R}{\rho}\left(1-\frac{\rho^2}{4R^2}\right) = \frac{R}{\rho} - \frac{\rho}{4R}$$
$$= \frac{R}{\rho}\left(1-\frac{\rho^2}{4R^2}\right)$$

kon' $$\frac{-\sin^2\theta-\cos^2\theta}{\sin^2\theta}\,d\theta = \left(-\frac{R}{\rho^2}-\frac{1}{4R}\right)d\rho$$

$$(1+\cot^2\theta)\,d\theta = \left(\frac{R}{\rho^2}+\frac{1}{4R}\right)d\rho \qquad 1+\cot^2\theta = \frac{1}{\sin^2\theta} = \frac{R^2}{\rho^2}\left(1+\frac{\rho^2}{4R^2}\right)^2$$

$$\frac{\partial}{\partial\theta} = \frac{\partial\xi}{\partial\theta}\frac{\partial}{\partial\xi} + \frac{\partial\eta}{\partial\theta}\frac{\partial}{\partial\eta} \qquad \begin{matrix}\xi = \rho\cos\varphi \\ \eta = \rho\sin\varphi\end{matrix}$$

$$\frac{\partial\xi}{\partial\theta} = \frac{d\rho}{d\theta}\cos\varphi \qquad \frac{\partial\eta}{\partial\theta} = \frac{d\rho}{d\theta}\sin\varphi$$

$$\frac{R^2}{\rho^2}\left(1+\frac{\rho^2}{4R^2}\right)^2 d\theta = \frac{R}{\rho^2}\left(1+\frac{\rho^2}{4R^2}\right)d\rho \qquad R\left(1+\frac{\rho^2}{4R^2}\right)d\theta = d\rho$$

$$\frac{d\varrho}{d\theta} = R\left(1+\frac{\varrho^2}{4R^2}\right)$$

$$\frac{\partial}{\partial\theta} = R\left(1+\frac{\varrho^2}{4R^2}\right)\left(\cos\varphi\frac{\partial}{\partial\xi}+\sin\varphi\frac{\partial}{\partial\eta}\right)$$

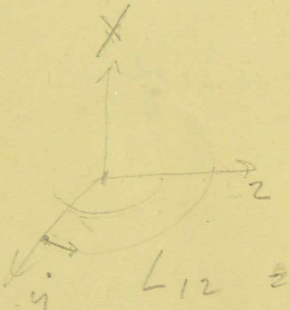
$$= \frac{R}{\varrho}\left(1+\frac{\varrho^2}{4R^2}\right)\left(\xi\frac{\partial}{\partial\xi}+\eta\frac{\partial}{\partial\eta}\right)$$

$$\sin\varphi\frac{\partial}{\partial\theta} = \frac{R}{\varrho^2}\left(1+\frac{\varrho^2}{4R^2}\right)\left(\eta\xi\frac{\partial}{\partial\xi}+\eta^2\frac{\partial}{\partial\eta}\right)$$

$$\cos\varphi\cot\theta\frac{\partial}{\partial\varphi} = \frac{\xi}{\varrho}\frac{R}{\varrho}\left(1-\frac{\varrho^2}{4R^2}\right)\left(\xi\frac{\partial}{\partial\eta}-\eta\frac{\partial}{\partial\xi}\right)$$

$$= \frac{R}{\varrho^2}\left(1-\frac{\varrho^2}{4R^2}\right)\left(\xi^2\frac{\partial}{\partial\eta}-\eta\xi\frac{\partial}{\partial\xi}\right)$$

$$L_{23}\quad \frac{L_x}{R} = \frac{1}{\varrho^2}\left[\left(1+\frac{\varrho^2}{4R^2}\right)\left(\eta\xi\frac{\partial}{\partial\xi}+\eta^2\frac{\partial}{\partial\eta}\right)+\left(1-\frac{\varrho^2}{4R^2}\right)\left(\xi^2\frac{\partial}{\partial\eta}-\eta\xi\frac{\partial}{\partial\xi}\right)\right]$$



$$= \frac{1}{\varrho^2}\left[\cancel{\eta\xi\frac{\partial}{\partial\xi}}+\eta^2\frac{\partial}{\partial\eta}+\xi^2\frac{\partial}{\partial\eta}-\cancel{\eta\xi\frac{\partial}{\partial\xi}}\right.$$
$$\left.+\frac{\varrho^2}{4R^2}\left(\eta\xi\frac{\partial}{\partial\xi}+\eta^2\frac{\partial}{\partial\eta}-\xi^2\frac{\partial}{\partial\eta}+\eta\xi\frac{\partial}{\partial\xi}\right)\right]$$

$$L_{12} = \xi\frac{\partial}{\partial\eta}-\eta\frac{\partial}{\partial\xi}$$

$$\frac{1}{R}L_{23} = \frac{\partial}{\partial\eta}+\frac{1}{4R^2}\left[\eta\left(\eta\frac{\partial}{\partial\eta}+\xi\frac{\partial}{\partial\xi}\right)-\xi\left(\xi\frac{\partial}{\partial\eta}-\eta\frac{\partial}{\partial\xi}\right)\right]$$

$$\frac{1}{R}L_{31} =$$

$$\Pi_2 = p_2+\frac{1}{4R^2}\left[\xi_2\left(\xi_2 p_2+\xi_1 p_1\right)-\xi_1\frac{\partial}{\partial\varphi}\right]$$

$$X = \frac{\xi}{1+\frac{\rho^2}{4R^2}} \qquad Y = \frac{\eta}{1+\frac{\rho^2}{4R^2}} \qquad Z = R\frac{1-\frac{\rho^2}{4R^2}}{1+\frac{\rho^2}{4R^2}}$$

$$(X' + iZ') = e^{i\frac{a}{R}}(X + iZ)$$

$$Y' = Y$$

$$\frac{\xi' + iR\left(1-\frac{\rho'^2}{4R^2}\right)}{1+\frac{\rho'^2}{4R^2}} = e^{i\frac{a}{R}}\,\frac{\xi + iR\left(1-\frac{\rho^2}{4R^2}\right)}{1+\frac{\rho^2}{4R^2}}$$

$$Y' = Y \qquad \frac{\eta'}{1+\frac{\rho'^2}{4R^2}} = \frac{\eta}{1+\frac{\rho^2}{4R^2}}$$

$$-\frac{i}{\hbar}\Pi_2 = -\frac{i}{\hbar}\frac{1}{R}L_{23} = \frac{\partial}{\partial\xi_2} + \frac{1}{4R^2}\left[\xi_2\left(\xi_2\frac{\partial}{\partial\xi_2}+\xi_1\frac{\partial}{\partial\xi_1}\right) - \xi_1\left(\xi_1\frac{\partial}{\partial\xi_2}-\xi_2\frac{\partial}{\partial\xi_1}\right)\right]$$

$$-\frac{i}{\hbar}\frac{1}{R}L_{31} = -\cos\varphi\frac{\partial}{\partial\theta} + \sin\varphi\cot\theta\frac{\partial}{\partial\varphi}$$

$$\cos\varphi = \frac{\xi}{\rho} \qquad \frac{\partial}{\partial\theta} = \frac{R}{\rho}\left(1+\frac{\rho^2}{4R^2}\right)\left(\xi\frac{\partial}{\partial\xi}+\eta\frac{\partial}{\partial\eta}\right)$$

$$\sin\varphi = \frac{\eta}{\rho}$$

$$\cot\theta = \frac{R}{\rho}\left(1-\frac{\rho^2}{4R^2}\right)$$

$$\frac{\partial}{\partial\varphi} = \xi\frac{\partial}{\partial\eta} - \eta\frac{\partial}{\partial\xi}$$

$$-\frac{i}{\hbar}L_{31} = -\frac{\xi}{\rho}\frac{R}{\rho}\left(1+\frac{\rho^2}{4R^2}\right)\left(\xi\frac{\partial}{\partial\xi}+\eta\frac{\partial}{\partial\eta}\right)$$
$$+\frac{\eta}{\rho}\frac{R}{\rho}\left(1-\frac{\rho^2}{4R^2}\right)\left(\xi\frac{\partial}{\partial\eta}-\eta\frac{\partial}{\partial\xi}\right)$$

$$-\frac{i}{\hbar}\frac{1}{R}L_{31} = -\frac{1}{\rho^2}\left(1+\frac{\rho^2}{4R^2}\right)\left(\xi^2\frac{\partial}{\partial\xi}+\xi\eta\frac{\partial}{\partial\eta}\right)$$
$$+\frac{1}{\rho^2}\left(1-\frac{\rho^2}{4R^2}\right)\left(\eta\xi\frac{\partial}{\partial\eta}-\eta^2\frac{\partial}{\partial\xi}\right)$$

$$= +\frac{1}{\rho^2}\left(\eta\xi\frac{\partial}{\partial\eta}-\eta^2\frac{\partial}{\partial\xi}-\xi^2\frac{\partial}{\partial\xi}-\xi\eta\frac{\partial}{\partial\eta}\right)$$
$$+\frac{\rho^2}{4R^2}\left(-\eta\xi\frac{\partial}{\partial\eta}+\eta^2\frac{\partial}{\partial\xi}-\xi^2\frac{\partial}{\partial\xi}-\eta\xi\frac{\partial}{\partial\eta}\right)$$

$$-\frac{i}{h}\frac{1}{R}L_{31} = -\frac{\partial}{\partial\xi} \cancel{x} - \frac{1}{4R^2}\left[(\xi^2-\eta^2)\frac{\partial}{\partial\xi} + 2\eta\xi\frac{\partial}{\partial\eta}\right]$$

Correct

$$\left\{\begin{aligned}
-\frac{i}{h}\frac{1}{R}L_{13} &= \frac{\partial}{\partial\xi} + \frac{1}{4R^2}\left[(\xi^2-\eta^2)\frac{\partial}{\partial\xi} + 2\eta\xi\frac{\partial}{\partial\eta}\right] \\
&= \frac{i}{h}\frac{1}{R}L_{31} \\
-\frac{i}{k}\frac{1}{R}L_{23} &= \frac{\partial}{\partial\eta} + \frac{1}{4R^2}\left[-(\xi^2-\eta^2)\frac{\partial}{\partial\eta} + 2\eta\xi\frac{\partial}{\partial\xi}\right] \\
&= \frac{i}{k}\frac{1}{R}L_{32} \\
+\frac{i}{h}L_{12} &= \xi\frac{\partial}{\partial\eta} - \eta\frac{\partial}{\partial\xi}
\end{aligned}\right.$$

$L_{12} = \xi$

$-i\hbar\frac{\partial}{\partial\xi} = p_1 \qquad \xi = \xi_1$

$-i\hbar\frac{\partial}{\partial\eta} = p_2 \qquad \eta = \xi_2$

$\cancel{-\frac{i}{h}J_{12} = \xi}$

$J_{12} = \xi_1 p_2 - \xi_2 p_1 = J$

$$\left\{\begin{aligned}
\Pi_1 &= \frac{1}{R}L_{31} \\
\Pi_2 &= \frac{1}{R}L_{32}
\end{aligned}\right.$$

$$\Pi_1 = p_1 + \frac{1}{4R^2}\left[(\xi_1^2-\xi_2^2)p_1 + 2\xi_1\xi_2 p_2\right]$$

$$\Pi_2 = p_2 + \frac{1}{4R^2}\left[-(\xi_1^2-\xi_2^2)p_2 + 2\xi_1\xi_2 p_1\right]$$

$\underbrace{-\xi_1^2 p_2 + \xi_2^2 p_2 + \xi_1\xi_2 p_1 + \xi_1\xi_2 p_1} \qquad + \xi_1(\xi_2 p_1 - \xi_1 p_2)$

$\xi_1 p_1^2 - \xi_2^2 p_1 + \xi_1\xi_2 p_2 + \xi_1\xi_2 p_2 = \xi_2(\overbrace{\xi_1 p_2 - \xi_2 p_1}^{J_{12}}) + \xi_1(\xi_1 p_1 + \xi_2 p_2)$

$$\Pi_1 = p_1 + \frac{1}{4R^2}\left[\xi_2 J_{12} + \xi_1(\xi_1 p_1 + \xi_2 p_2)\right]$$

$$\Pi_2 = p_2 + \frac{1}{4R^2}\left[-\xi_1 J_{12} + \xi_2(\xi_1 p_1 + \xi_2 p_2)\right]$$

$\xi\frac{\partial}{\partial\xi} = \xi\frac{\partial J}{\partial\xi}\frac{\partial}{\partial J}$

$$\frac{\partial}{\partial\rho}\psi = \frac{\partial\xi}{\partial\rho}\frac{\partial}{\partial\xi}\psi + \frac{\partial\eta}{\partial\rho}\frac{\partial}{\partial\eta}\psi$$

$$\xi = \rho\cos\varphi \qquad \eta = \rho\sin\varphi$$

$$\frac{\partial\xi}{\partial\rho} = \cos\varphi = \frac{\xi}{\rho}$$

$$\frac{\partial}{\partial\rho}\psi = \frac{\xi}{\rho}\frac{\partial}{\partial\xi}\psi + \frac{\eta}{\rho}\frac{\partial}{\partial\eta}\psi$$

$J_{12}\xi_1 + J_{12}\xi_2$

$$\rho\frac{\partial}{\partial\rho}\psi = \left(\xi\frac{\partial}{\partial\xi} + \eta\frac{\partial}{\partial\eta}\right)\psi \qquad -i\hbar\frac{\partial}{\partial\rho} = p_\rho$$

forget
$$\Pi_1 = p_1 + \frac{1}{4R^2}\left[J_{12}\xi_2 + \xi_1\rho p_\rho\right]$$
$$\Pi_2 = p_2 + \frac{1}{4R^2}\left[-J_{12}\xi_1 + \xi_2\rho p_\rho\right]$$

$$\vec{\xi}\cdot\vec{p} = \rho p_\rho$$

Let $V_m = J_{mn}\xi_n$

$$V_1 = J_{1n}\xi_n = J_{12}\xi_2$$
$$V_2 = J_{2n}\xi_n = J_{21}\xi_1 = -J_{12}\xi_1$$

$$\Pi_m = p_m + \frac{1}{4R^2}\left[\xi_n J_{mn} + \xi_m\rho p_\rho\right] \qquad \rho p_\rho = \xi_n p_n$$

$$\Pi_m = \left(1 - \frac{\rho^2}{4R^2}\right)p_m + \frac{1}{2R^2}\xi_m(\vec{\xi}\cdot\vec{p}) = \left(1 - \frac{\rho^2}{4R^2}\right)p_m + \frac{1}{4R^2}\xi_m\rho p_\rho$$

$$J_{mn} = \xi_m p_n - \xi_n p_m$$

$+ \xi_m p_m$

$$\Pi_m = p_m + \frac{1}{4R^2}\xi_n\left[J_{mn} + \xi_m p_n\right]$$

$\xi_m p_n - \xi_n p_m \qquad = 2\xi_m p_n - \xi_n p_m$

$\xi_n\left[2\xi_m p_n - \xi_n p_m\right]$

We need find $\left[\Pi_m, \Pi_n\right] = \frac{1}{R^2}J_{mn}$

$\xi_m \qquad 2\xi_m\xi_n$

$1 + \vec{a}\cdot\vec{\rho} + \frac{1}{4R^2} +$

$$\Pi_m = \left(1 - \frac{\xi_n\xi_n}{4R^2}\right)p_m + \frac{1}{2R^2}\xi_m(\xi_n p_n)$$

$\Pi_1\Pi_2 - \Pi_2\Pi_1$

$\Pi_1\Pi_2 = \left(p_1 + \frac{1}{4R^2}\left[(\xi_1^2-\xi_2^2)p_1 + 2\xi_1\xi_2 p_2\right]\right)\left(p_2 + \frac{1}{4R^2}\left(-(\xi_1^2-\xi_2^2)p_2 + 2\xi_1\xi_2 p_1\right)\right)$

$= p_1 p_2 +$

$-(\xi_1^2-\xi_2^2)p_1 \, (\xi_1^2-\xi_2^2)p_2$

$\xi_n\left[2\xi_m p_n - \xi_n p_m\right]$

$\xi_n\left[2\xi_1 p_n - \xi_n p_1\right]$

$2\xi_1(\xi_1 p_1 + \xi_2 p_2) - (\xi_1^2 p_1 + \xi_2^2 p_1)$

$= 2\xi_1^2 p_1 + 2\xi_1\xi_2 p_2 - \xi_1^2 p_1 - \xi_2^2 p_1$

$= (\xi_1^2 - \xi_2^2)p_1 + 2\xi_1\xi_2 p_2$

$\xi_n(2\xi_2 p_n - \xi_n p_2)$

$2\xi_2(\xi_1 p_1 + \xi_2 p_2) - (\xi_1^2+\xi_2^2)p_2$

$2\xi_1\xi_2 p_1 + 2\xi_2^2 p_2 - \xi_1^2 p_2 - \xi_2^2 p_2$

$2\xi_1\xi_2 p_1 + (\xi_1^2-\xi_2^2)p_2$

$\Box D_{ret}(x-y) = \delta(x-y)$

$D_{ret} = \theta(x_0-y_0)\,\delta[(x-y)^2]$

$D_{ret}(x-y) = \frac{1}{(2\pi)^4}\int \frac{e^{ik(x-y)}}{k^2 - 2i\epsilon k^0}\,d^4k.$

$\partial_\mu \partial_\nu D_{ret} = \frac{+1}{(2\pi)^4}\int \frac{k_\mu k_\nu\, e^{ik(x-y)}}{k^2 - 2i\epsilon k^0}\,d^4k$

$\partial_\mu D_{ret}\,\partial_\nu D_{ret} = \iint \frac{k_\mu k'_\nu\, e^{ik(x-y)} e^{ik'(x-y)}}{(k^2 - 2i\epsilon k^0)(k'^2 - 2i\epsilon k'^0)}\,d^4k\,d^4k'$

$= \iint \frac{k_\mu k'_\nu\, e^{i(k+k')(x-y)}}{(k^2 \ldots k'^2 \ldots)}\,d^4k\,d^4k'$

$$J_{12} = K_{12} \pm iK_{03} = iz\partial_z - iz^*\partial_{z^*} - \frac{im}{2}$$

$$+ iz\partial_z + iz^*\partial_{z^*} + \frac{1}{2}(\rho + 2i)$$

$$J_{12} = 2iz\partial_z + \frac{\rho}{2} + i\left(1 - \frac{m}{2}\right)$$

$\sigma_3\sigma_1\xi_1 + \sigma_3\sigma_2\xi_2$

$$R\,\frac{e_3 + e_1\xi_1 + e_2\xi_2}{e_3 - e_1\xi_1 - e_2\xi_2} = e_3 z + e_1 x + e_2 y$$

$$R\,\frac{1 + \frac{\sigma_3\sigma_1\xi_1 + \sigma_3\sigma_2\xi_2}{2R}}{1 - \frac{\sigma_3\sigma_1\xi_1 \pm \sigma_3\sigma_1\xi_2}{2R}} = z + \sigma_3\sigma_1 x + \sigma_3\sigma_2 y$$

$$R\,\frac{1 + \frac{i\sigma_2\xi_1 - i\sigma_1\xi_2}{2R}}{1 - \frac{i\sigma_2\xi_1 + i\sigma_1\xi_2}{2R}} = z + i\sigma_2 x - i\sigma_1 y$$

$\sigma_3 z' + \sigma_1 x' + \sigma_2 y' = e^{e_1\frac{a_1 + e_2 a_2}{2R}}(\sigma_2 \ldots)e^{-e_1 a_1 \ldots}$

$$(1 - i\sigma_2\xi_1 + i\sigma_1\xi_2)(1 + i\sigma_2\xi_1 - i\sigma_1\xi_2)$$

$z' + \sigma_{3}\sigma_1 x' \ldots = \ldots e^{-\frac{a}{2R}}$

$\xi = e_2\xi_1 - e_1\xi_2$

$1 + e_2\xi_1 - e_1\xi_2$

$q = e_2 x - e_1 y$

~~$a = \ldots$~~

$a = e_2 a_1 - e_1 a_2$

$$R\,\frac{1 + \xi/2R}{1 - \xi/2R} = z + q \qquad e^{\frac{a}{2R}}(z+q)e^{\frac{a}{2R}}$$

$$\frac{1 + \xi/2R}{1 - \xi/2R} = \frac{z+q}{R}$$

$$\frac{1 + \xi/2R}{1 - \xi/2R} = e^{\frac{a}{2R}}\,\frac{1 + \xi/2R}{1 - \xi/2R}\,e^{\frac{a}{2R}}$$

$$\frac{\xi'}{2} = \left(\frac{\xi}{2} - a\,\frac{1-\frac{\xi}{2R}}{2}\right)\left(1+\frac{a}{R}\,\frac{1-\frac{\xi}{2R}}{2}\right)^{-1}$$

$$\xi' = \left[\xi - a\left(1-\frac{\xi}{2R}\right)\right]\left[1-\frac{a}{2R}\left(1-\frac{\xi}{2R}\right)\right]$$

$$\xi' = \xi - a\left(1-\frac{\xi}{2R}\right) - \xi\frac{a}{2R}\left(1-\frac{\xi}{2R}\right)$$

$$= \xi - a + a\frac{\xi}{2R} - \frac{\xi a}{2R} + \frac{\xi a \xi}{4R^2}$$

$$\xi' = \xi - a + \frac{1}{2R}(a\xi - \xi a) + \frac{\xi a \xi}{4R^2}$$

$$a = e_2 a_1 - e_1 a_2 \qquad \xi = e_2\xi_1 - e_1\xi_2$$

$$a\xi = (e_2 a_1 - e_1 a_2)(e_2\xi_1 - e_1\xi_2) = -(a_1\xi_1 + a_2\xi_2) - e_3 a_2\xi_1 + e_3 a_1\xi_2$$

$$a\xi = -(a_1\xi_1 + a_2\xi_2) + e_3(a_1\xi_2 - a_2\xi_1)$$

$$\xi a = -(a_1\xi_1 + a_2\xi_2) - e_3(a_1\xi_2 - a_2\xi_1)$$

$$\frac{a\xi - \xi a}{2} = e_3(a_1\xi_2 - a_2\xi_1)$$

$$\xi a \xi = (e_2\xi_1 - e_1\xi_2)\left[-\vec{a}\cdot\vec{\xi} + e_3(a_1\xi_2 - a_2\xi_1)\right]$$

$$= -(\vec{a}\cdot\vec{\xi})\underset{(e_2\xi_1 - e_1\xi_2)}{\xi_{,e}} + -(e_1\xi_1 + e_2\xi_2)(a_1\xi_2 - a_2\xi_1)$$

$$= \vec{a}\cdot\vec{\xi}\,\xi_1 + (a_1\xi_2 - a_2\xi_1)\,\xi_2$$

$$= (\xi_1 p_1 - \xi_1 p_2)\,\xi_2 - \xi_1(\vec{\xi}\cdot\vec{p})$$

$$\frac{1}{1-A} = 1+A$$

$$(1-A)^{-1}$$

$$\frac{1+A}{1-A} = B$$

$$(1+A)(1-A)^{-1} = B$$

$$1+A = B - AB$$

$$A + AB = B - 1 \qquad A(1+B) = B-1$$

$$A = \frac{B-1}{B+1}$$

$$A = (B-1)(B+1)^{-1}$$

$$\frac{(1+A)(1+A)}{(1+A)^2} = \frac{1+A^2+2A}{1+A^2}$$

$$\frac{\xi'}{2R} = \frac{e^{\frac{a}{2R}}\,\frac{1+\frac{\xi}{2R}}{1-\frac{\xi}{2R}}\,e^{\frac{a}{2R}} - 1}{e^{\frac{a}{2R}}\,\frac{1+\frac{\xi}{2R}}{1-\frac{\xi}{2R}}\,e^{\frac{a}{2R}} + 1} = \frac{\frac{1+\frac{\xi}{2R}}{1-\frac{\xi}{2R}} - e^{\frac{a}{R}}}{\frac{1+\frac{\xi}{2R}}{1-\frac{\xi}{2R}} + e^{\frac{a}{R}}}$$

$$\frac{\xi'}{2R} = \frac{\frac{1+\frac{\xi}{2R}}{1-\xi/2R} - 1 - \frac{a}{R}}{\frac{1+\frac{\xi}{2R}}{1-\frac{\xi}{2R}} + 1 + \frac{a}{R}} = \left(\frac{1+\frac{\xi}{2R}}{1-\frac{\xi}{2R}} - 1 - \frac{a}{R}\right)\left(\frac{1+\frac{\xi}{2R}}{1-\frac{\xi}{2R}} + 1 + \frac{a}{R}\right)^{-1}$$

$$\frac{1+\frac{\xi}{2R}}{1-\frac{\xi}{2R}} + 1 = \frac{1+\frac{\xi}{2R}+1-\frac{\xi}{2R}}{1-\frac{\xi}{2R}} = \frac{2}{1-\frac{\xi}{2R}}$$

$$\frac{1+\frac{\xi}{2R}}{1-\frac{\xi}{2R}} - 1 = \frac{1+\frac{\xi}{2R}-1+\frac{\xi}{2R}}{1-\xi/2R} = \frac{\xi/R}{1-\frac{\xi}{2R}}$$

$$\frac{\xi'}{2R} = \left(\frac{1}{R}\,\frac{\xi}{1-\frac{\xi}{2R}} - \frac{a}{R}\right)\left(\frac{2}{1-\frac{\xi}{2R}} + \frac{a}{R}\right)^{-1}$$

$$\frac{\xi'}{2} = \left(\frac{\xi}{1-\frac{\xi}{2R}} - a\right)\left(\frac{2}{1-\frac{\xi}{2R}} + \frac{a}{R}\right)^{-1}$$

$$= (\quad)\left[\left(1 + \frac{a}{R}\,\frac{1-\frac{\xi}{2R}}{2}\right)\left(\frac{2}{1-\frac{\xi}{2R}}\right)\right]^{-1}$$

$$= \left(\frac{\xi}{1-\frac{\xi}{2R}} - a\right)\frac{1-\frac{\xi}{2R}}{2}\left(1 + \frac{a}{R}\,\frac{1-\frac{\xi}{2R}}{2}\right)^{-1}$$

$$1+\frac{\xi}{2R} - 1 + \frac{\xi}{2R}$$
$$1+\frac{\xi}{2R} + 1 - \frac{\xi}{2R}$$

$$\frac{\xi'}{2R} = \frac{\dfrac{1+\frac{\xi}{2R}}{1-\xi/2R} - 1 - \frac{a}{R}}{\dfrac{1+\frac{\xi}{2R}}{1-\frac{\xi}{2R}} + 1 + \frac{a}{R}} = \frac{\dfrac{\xi/2R}{1-\xi/2R} - \frac{a}{R}}{\dfrac{2}{1-\frac{\xi}{2R}} + \frac{a}{R}}$$

$$\frac{A-1}{A+1} = B$$

$$A = \frac{B+1}{B-1}$$

$$\frac{\xi'}{2} = \frac{\dfrac{\xi}{1-\frac{\xi}{2R}} - a}{\dfrac{2}{1-\frac{\xi}{2R}} + \frac{a}{R}}$$

$$\xi' = \frac{\left(\frac{\xi}{1-\frac{\xi}{2R}} - a\right)\left(\frac{1}{1+\frac{\xi}{2R}} - \frac{a}{2R}\right)}{\left(\frac{1}{1-\frac{\xi}{2R}} + \frac{a}{2R}\right)\left(\frac{1}{1+\frac{\xi}{2R}} - \frac{a}{2R}\right)}$$

$$\frac{\xi - \sqrt{1-\frac{\xi}{2R}}\; a\sqrt{1-\frac{\xi}{2R}}}{1 + \frac{1}{2R}\sqrt{1-\frac{\xi}{2R}}\; a\sqrt{1-\frac{\xi}{2R}}}$$

$$\cancel{\xi' = \frac{\frac{\xi/2}{1-\xi/2R} - a}{\;}}$$

$$\frac{1}{1-}$$

$$\xi\left(1 - \sqrt{\xi}\sqrt{1-\tfrac{\xi}{2R}}\; a\sqrt{1-\tfrac{\xi}{2R}}\sqrt{\xi}\right)$$

$$\left(\xi - \sqrt{\;}\,a\sqrt{\;}\right)\left(1 - \tfrac{1}{2R}\sqrt{\;}\,a\sqrt{\;}\right)$$

$$= \xi - \sqrt{\;}\,a\sqrt{\;} -$$

$$\xi' = \frac{\dfrac{\xi}{1-\frac{\xi}{2R}} - a}{\dfrac{1}{1-\frac{\xi}{2R}} + \dfrac{a}{2R}} = \frac{\left(\frac{\xi}{1-\frac{\xi}{2R}} - a\right)}{\cancel{\frac{1}{1-\frac{\xi}{2R}}}\left[1+\frac{a}{2R}\left(1-\frac{\xi}{2R}\right)\right]\frac{1}{1-\frac{\xi}{2R}}}$$

$$\xi' = \left[\xi - a\left(1-\tfrac{\xi}{2R}\right)\right]\left[1 - \tfrac{a}{2R}\left(1-\tfrac{\xi}{2R}\right)\right]$$

$$\xi' = \left(\frac{\xi}{1-\frac{\xi}{2R}} - a\right)\left(1-\frac{\xi}{2R}\right)\left[1+\frac{a}{2R}\left(1-\frac{\xi}{2R}\right)\right]^{-1}$$

$$= \xi - a\left(1-\tfrac{\xi}{2R}\right) - \tfrac{\xi a}{2R}\left(1-\tfrac{\xi}{2R}\right)$$

$$= \xi - a + \frac{a\xi}{2R} - \frac{\xi a}{2R} + \frac{\xi a \xi}{4R^2}$$

$$\xi' = \frac{\xi\left(1+\frac{\xi}{2R}\right) - a}{1+\frac{\xi}{2R} + \frac{a}{2R}} = \left(\xi\left(1+\tfrac{\xi}{2R}\right) - a\right)\left(1 - \tfrac{\xi+a}{2R}\right)$$

$$\xi' = \left(\xi - a + \frac{\xi^2}{2R}\right)\left(1 - \frac{\xi+a}{2R}\right)$$

$$= \xi - a + \frac{\xi^2}{2R} + \frac{(\xi-a)(\xi+a)}{2R}$$

$$= \xi - a + \frac{1}{2R}\left[\xi^2 + \xi^2 - a^2 + \xi a - a\xi\right]$$

$$\xi - a + \frac{1}{2R}\left[2\xi^2 + \xi a - a\xi\right]$$

$$\frac{1+\frac{\xi'}{2R}}{1-\frac{\xi'}{2R}} = e^{\frac{a}{2R}}\,\frac{1+\frac{\xi}{2R}}{1-\frac{\xi}{2R}}\,e^{\frac{a}{2R}}$$

$$1+\frac{\xi'}{R} = \left(1+\frac{a}{2R}\right)\left(1+\frac{\xi}{R}\right)\left(1+\frac{a}{2R}\right)$$

$$= \left(1+\frac{a}{2R}\right)\left(1+\frac{\xi}{R}+\frac{a}{2R}\right)$$

$$= 1+\frac{a}{2R}+\frac{\xi}{R}+\frac{a}{2R} = 1+\frac{a+\xi}{2R} = 1+\frac{\xi'}{R}$$

$$\xi' = a+\xi$$

$$\frac{1+\frac{\xi'}{2R}}{1-\frac{\xi'}{2R}} = \left(1+\frac{a}{2R}\right)\frac{1+\frac{\xi}{2R}}{1-\frac{\xi}{2R}}\left(1+\frac{a}{2R}\right)$$

$$= \left(1+\frac{a}{2R}\right)\left(\frac{1+\xi/2R}{1-\xi/2R}+\frac{1+\frac{\xi}{2R}}{1-\frac{\xi}{2R}}\,\frac{a}{2R}\right)$$

$$= \frac{1+\xi/2R}{1-\xi/2R}+\frac{a}{2R}\,\frac{1+\xi/2R}{1-\xi/2R}+\frac{1+\xi/2R}{1-\frac{\xi}{2R}}\,\frac{a}{2R}$$

$$\sigma_3 z'+\sigma_1 x'+\sigma_2 y' = e^{\frac{\sigma_3\sigma_2 a_{31}+\sigma_3\sigma_1 a_2}{2R}}(\sigma_3 z+\sigma_1 x+\sigma_2 y)\,e^{-(\;)}$$

$$z'+\sigma_3\sigma_1 x'+\sigma_3\sigma_2 y' = e^{-\frac{a}{2R}}(z+\sigma_3\sigma_1 x+\sigma_3\sigma_2 y)$$

$$\frac{1+e_1\xi_1+e_2\xi_2}{1-e_1\xi_1-e_2\xi_2} = \frac{(1+e_1\xi_1+e_2\xi_2)^2}{(1-e_1\xi_1-e_2\xi_2)(1+e_1\xi_1+e_2\xi_2)}$$

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