

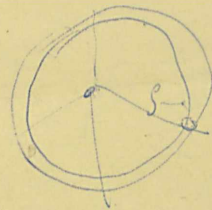
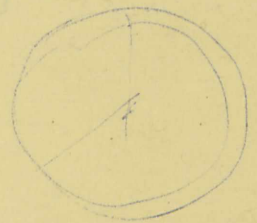
Sınırlı ^{kuin. uygun} ~~halen~~ ^{ve} ~~bu~~ ^{ve} ~~kötür~~, her sınıf uygun olacak şekilde
 mahiyette ^{yaeni} ~~menfaat~~ ^{uygunluklar} ~~menfaat~~ mahiyette ^{menfaat}
 bu faaliyetlerin ^{programları} faydalanabileceği kaymakla
 bu türlerin ^{ve} ~~başlamakla~~ ^{başlamakla} meşguldir.

in-service
 cross-country
 cam
 mood pieces

$$m_i = \int_0^R \frac{4n \rho^2 d\rho}{|\tau - \rho|}$$

$$4n \frac{\tau T}{2 \tau T} = \frac{2}{R^2}$$

$$\frac{\tau T}{6} = \frac{2}{R^2} = 6n$$



t-r-r

$$R^2 \equiv \frac{12}{\tau T} \cdot \frac{1}{(t+r)(t-r)} = \frac{1}{2t} \left(\frac{1}{t+r} + \frac{1}{t-r} \right)$$

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

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

$$\ln G \int_0^R \rho d\rho = 2n G R^2$$

method of outgoing and incoming waves.

$$\int \nabla^2 \phi d^3x$$

$$dr = \gamma_{\text{sur}} d\phi$$

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

$$\square \phi = -4nK' \nabla \phi = -\frac{4nK'}{R^2} \phi^3$$

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

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

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

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

$$2r dr = d\xi$$

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

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

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

$$e^{\frac{y}{R}} = e^{\frac{a}{2R} + \frac{y}{R}}$$

$$x' = x - a$$

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

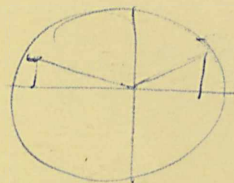
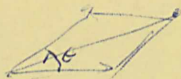
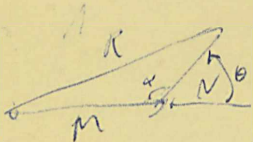
$$1+y = y - x y \quad x(1+y) = y - 1$$

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

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

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

$MN \cos \theta$



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

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

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

$$f(\vec{x} + \vec{a}) = f(\vec{x}) + a_m \vec{a}_m f'(\vec{x}) = (1 + \vec{a} \cdot \vec{\nabla}) f(\vec{x})$$

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

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

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

$$X'_1 + X = e^{\frac{\vec{a}}{2R}} (X_5 + \vec{x}) e^{\frac{\vec{a}}{2R}}$$

$$e^{\frac{\vec{a}}{R}} = e^{\frac{\vec{a}}{2R} + \frac{\vec{a}}{2R}}$$

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

$$1 + Y = Y - XY$$

$$X(1+Y) = Y-1$$

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

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

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

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

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

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

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

$$= \frac{A + aB + Bbz + (Ca^2 + 2Cabz + Cb^2z^2)}{(a+bz)^3}$$

$$C=0$$

$$b \neq 0. \quad A + aB = 0$$

$$Bb = 1$$

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

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

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

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

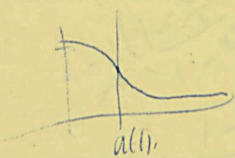
$\int_0^R \frac{4\pi T r^2 dr}{\pi} = 4\pi T \int_0^R r^2 dr = 4\pi T \frac{R^3}{3}$
 $= 2\pi T R^3 = \phi$
 $M = \frac{4\pi}{3} T R^3 = \phi$
 $\frac{M}{R} = \frac{4\pi}{3} T R^2 = \frac{2}{3\pi} (2\pi T R^2) = \frac{2}{3\pi} \phi$
 $\phi = \frac{3\pi M}{2R}$

$$g = \phi^8 \delta$$

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

$$\phi \partial_{\mu} \partial^{\mu} \phi = \partial_{\mu} (\phi \partial^{\mu} \phi) - (\partial_{\mu} \phi) (\partial^{\mu} \phi)$$

$$\int \phi \square \phi d^4 x = - \int (\partial_{\mu} \phi) (\partial^{\mu} \phi) + \phi$$



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

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

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

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

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

$$\frac{9}{7} r^2 = \frac{2}{7} R^2$$

$$r^2 = \frac{2}{9} R^2$$

$$\frac{3}{\pi R^2} \left[\frac{4r^2}{R^2} - \frac{1}{2} \frac{r^2}{R^2} - 1 + \frac{r^2}{R^2} \right]$$

$$\phi = \frac{1}{1 - \frac{r^2}{R^2}} + \frac{Hc / \pi m s}{\pi}$$

$$\frac{\sum m_i}{R} \phi^{-3} \phi^{-4} \frac{d\phi}{dr}$$

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

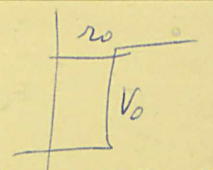
$$\frac{d\phi}{dr} = -\frac{3}{R^2} \frac{r}{\left(\right)^4}$$

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

4
 $L_0 = k \cot \delta_0$

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

$n = \frac{1}{k} \sqrt{2m(E+V_0)} = \sqrt{\frac{2mE}{\hbar^2} + \frac{2mV_0}{\hbar^2}} = \sqrt{k^2 + k_0^2}$



$k \cot \delta_0 = \frac{k n r_0 + n (\cot n r_0) \cos k r_0}{\cos k r_0 - n \cot k r_0 \frac{n r_0}{k}}$

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

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

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

$= k n r_0 + \frac{1}{k} \sqrt{\dots}$

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

$k \cot \delta_0 = \frac{K \cot K r_0}{1 - r_0 K \cot K r_0} = \frac{1}{\frac{1 - r_0}{K \cot K r_0}} = \frac{1}{r_0 \left(1 - \frac{1}{K \cot K r_0} \right)}$

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

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

$\cot x = \frac{1 - \frac{x^2}{6}}{x}$
 $n = K + \frac{1}{2} \frac{k^2}{K}$

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

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

$k^2 = K^2 + k^2$

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

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

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

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

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

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

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

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

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

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

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

$$1 - \frac{3}{2} r_0^2 k^2 + \frac{1}{18} r_0^4 k^2 k^2 \quad \left| \quad -\frac{1}{3} - 1 - \frac{1}{6} = -\frac{2}{6} - \frac{1}{6} - 1 = -\frac{1}{2} - 1 = -\frac{3}{2} \right.$$

2m

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

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

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

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

$$abc - cab = a\{bc\} + a\{cb\} - a\{cb\} - a\{bc\}$$

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

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

$$[\gamma_\mu\gamma_\nu, \gamma_\lambda] = \gamma_\mu\{\gamma_\nu\gamma_\lambda\} - \gamma_\nu\{\gamma_\mu\gamma_\lambda\}$$

$$\gamma_\mu\gamma_\nu = \gamma_\mu + \gamma_\nu a$$

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

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

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

$$\gamma_\mu\gamma_\nu = \gamma_\mu + \gamma_\nu a$$

$$\gamma_\mu = \gamma_\mu' + a\gamma_\nu\gamma_\mu'$$

$$\gamma_\nu\gamma_\mu = \gamma_\nu' + \gamma_\mu'a\gamma_\nu'$$

$$\frac{d}{dc} \phi \frac{dx^{\lambda}}{dc} = \gamma^{\lambda} \phi$$

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

$$\sigma^2 = \gamma^{\lambda} x_{\lambda}$$

$$\frac{d\sigma^2}{dc} = 2 \frac{dx^{\lambda}}{dc} x_{\lambda}$$

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

$$\frac{d}{dc} \phi(\sigma^2) \frac{dx^{\lambda}}{dc} = 2 x^{\lambda} \phi'(\sigma^2)$$

$$\frac{\partial}{\partial x^{\lambda}} \sigma^2 = \gamma^{\lambda} \sigma^2 = 2 x_{\lambda}$$

$$\phi(\sigma^2) \frac{d^2 x^{\lambda}}{dc^2} + \phi'(\sigma^2) 2 x^{\lambda} \frac{dx^{\lambda}}{dc} \frac{d\sigma^2}{dc} = 2 x^{\lambda} \phi'(\sigma^2)$$

$$\frac{d^2 x^{\lambda}}{dc^2} = \frac{2 \phi'(\sigma^2)}{\phi(\sigma^2)} \left[x^{\lambda} - x_{\lambda} \frac{dx^{\lambda}}{dc} \frac{d\sigma^2}{dc} \right]$$

$$\frac{d^2 x^{\lambda}}{dc^2} = \frac{2 \phi'(\sigma^2)}{\phi(\sigma^2)} \left[x^{\lambda} - x_{\lambda} \frac{dx^{\lambda}}{dc} \frac{d\sigma^2}{dc} \right]$$

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

$$dc^2 = dt^2 (1 - \frac{v^2}{c^2})$$

Maline

$$\frac{d^2 x^{\lambda}}{dt^2} = \left(x^{\lambda} - t \frac{dx^{\lambda}}{dt} \right) \frac{\gamma}{\sigma^2} \left(\frac{1}{\sigma^2} \left(\frac{d\sigma^2}{dt} \right)^2 \right)$$

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

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

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

$$\gamma = \left(\frac{d\sigma}{dc} \right)^2$$

$$x^{\lambda} \frac{dt}{dc} - x^m \frac{dx^m}{dc} = \frac{t}{\sqrt{1 - \frac{v^2}{c^2}}} - x^m \frac{dx^m}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$x^{\lambda} - \frac{1}{\gamma} \left(t \frac{dx^{\lambda}}{dt} - x^m \frac{dx^m}{dt} \frac{dt}{dc} \right) = \left(t - x^m \frac{dx^m}{dt} \right) \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \frac{dx^{\lambda}}{dt \sqrt{1 - \frac{v^2}{c^2}}}$$

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

$$2m^2 = 20$$

$$X_p X_p + X_s^2 = R^2$$

$$X_p = \frac{x_p}{1 + \frac{x_p^2}{4R^2}}$$

then we find $X_s = R \frac{1 - \frac{x_p^2}{4R^2}}{1 + \frac{x_p^2}{4R^2}} = R \frac{1 - \frac{c^2}{4R^2}}{1 + \frac{c^2}{4R^2}}$

$$X_s = R \text{ constant } \text{if } c^2 = 0$$

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

$$\frac{c^2}{4R^2} = \frac{1 + \frac{X_s}{R}}{1 - \frac{X_s}{R}}$$

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

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

$$c^2 = 4R^2 \frac{1 + \frac{X_s}{R}}{1 - \frac{X_s}{R}}$$

$$ds^2 = d\gamma_p dX_p + dX_s^2 = \frac{1}{\left(1 + \frac{c^2}{4R^2}\right)^2} d\sigma^2$$

$$d\sigma^2 = \gamma_p d\lambda^2 + d\lambda^2$$

$$c^2 = f(c, a, \gamma_p)$$

$$c^2 = \text{constant}$$

$$\gamma_s ds + \gamma_p X_p = \gamma_p \frac{x_p}{1 + \frac{c^2}{4R^2}} + \gamma_s R \frac{1 - \frac{c^2}{4R^2}}{1 + \frac{c^2}{4R^2}}$$

$$\gamma_s ds + \gamma_p X_p = \frac{\gamma_p x_p + \gamma_s R \left(1 - \frac{c^2}{4R^2}\right)}{1 + \frac{c^2}{4R^2}}$$

$$X'_s + \gamma_p X'_p = \gamma_p (X_s + \gamma_p X_p)$$

$$\gamma_s X'_s + \gamma_p X'_p = e^{\int \gamma_p \gamma_s d\lambda} (\gamma_s X_s + \gamma_p X_p) e^{-\int \gamma_p \gamma_s d\lambda}$$

$$X'_s + \gamma_p X'_p = e^{\int \gamma_p \gamma_s d\lambda} (\gamma_s X_s + \gamma_p X_p) e^{-\int \gamma_p \gamma_s d\lambda}$$

$$X'_s = \gamma_p \gamma_s X_s - \gamma_p \gamma_s X_p$$



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

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

radius

$$dz = \frac{d\zeta}{1 + \frac{\zeta^2}{4R^2}}$$

2'4cm

$$x = R \frac{\zeta/R}{1 + \frac{\zeta^2}{4R^2}}$$

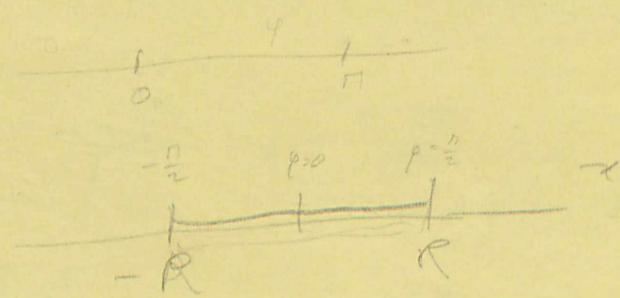
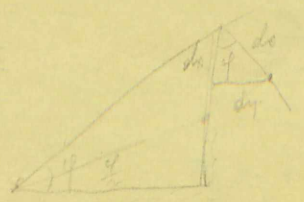
$$y = R \frac{1 - \frac{\zeta^2}{4R^2}}{1 + \frac{\zeta^2}{4R^2}}$$

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

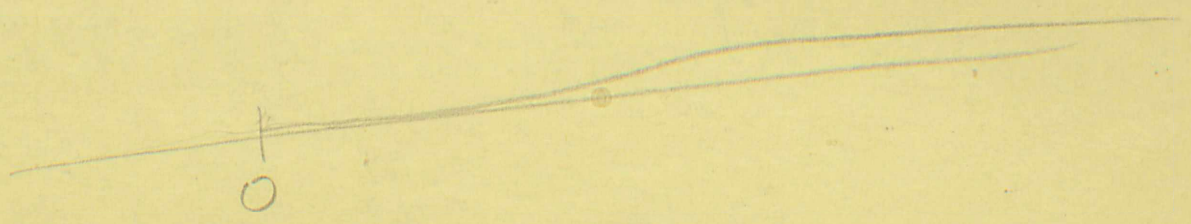
$$-\infty < \zeta < \infty$$

$$F(x) = x \frac{\partial}{\partial y} - y \frac{\partial}{\partial x}$$

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



$$\frac{R d\zeta}{1 + \frac{\zeta^2}{4R^2}} = dx$$



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

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

$$\frac{\partial}{\partial \varphi} = \frac{d\zeta}{d\varphi} \frac{\partial}{\partial \zeta}$$

$$\zeta = 2R \frac{\sin \frac{\varphi}{2}}{\cos \frac{\varphi}{2}}$$

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

$$d\zeta = 2R \frac{\cos \frac{\varphi}{2} \cos \frac{\varphi}{2} - \sin \frac{\varphi}{2} \sin \frac{\varphi}{2}}{\cos^2 \frac{\varphi}{2}} \times \frac{1}{2} d\varphi = \frac{R d\varphi}{\cos^2 \frac{\varphi}{2}}$$

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

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

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

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

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

$$x^2 + y^2 + z^2 = R^2, \quad x^2 + y^2 = r^2$$

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

$$|e_1 X + e_2 Y + e_3 Z| = \sqrt{\left(\frac{x}{\left(1 + \frac{r^2}{4R^2} \right)} \right)^2 + \left(\frac{y}{\left(1 + \frac{r^2}{4R^2} \right)} \right)^2 + \left(R \frac{1 - \frac{r^2}{4R^2}}{\left(1 + \frac{r^2}{4R^2} \right)} \right)^2} = R^2$$

$$|g| = 1, \quad \frac{e_1^2 + e_2^2 + e_3^2 R^2 \left(1 - \frac{r^2 + y^2}{4R^2} \right)}{1 + \dots}$$

$$Re + e^{-2}$$

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

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



$$\frac{\partial}{\partial x}$$

$$2x^2 dx + \dots$$

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

$dx^2 = 2x dx + dy^2$

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

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

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

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

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

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

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

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

$$X_0^2 + X_1^2 + X_2^2 + X_3^2 = R^2$$

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

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

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

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

$$R \frac{\vec{x}}{1 - \frac{\vec{x}}{R}}$$

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

$$R \frac{1 + \frac{\delta_1 \gamma_1 \gamma_2}{2R}}{1 - \frac{\delta_1 \gamma_1 \gamma_2}{2R}} = X_5 + \frac{\delta_1 \gamma_1 \gamma_2}{R} X_\mu$$

$$R \frac{2R\delta_1 + \delta_1 \gamma_1 \gamma_2}{2R\delta_1 + \delta_1 \gamma_1 \gamma_2} = X_5 + \frac{\delta_1 \gamma_1 \gamma_2}{R} X_\mu$$

$$\left(1 - \frac{\delta_1 \gamma_1 \gamma_2}{2R}\right) \left(1 + \frac{\delta_1 \gamma_1 \gamma_2}{2R}\right) = 1 - \frac{\delta_1 \gamma_1 \gamma_2 \delta_1 \gamma_1 \gamma_2}{4R^2}$$

$$\ln R \frac{1 + \frac{\delta_1 \gamma_1 \gamma_2}{2R}}{1 - \frac{\delta_1 \gamma_1 \gamma_2}{2R}} = \ln \left(e^{\frac{\delta_1 \gamma_1 \gamma_2}{2R}} \right) \left(e^{-\frac{\delta_1 \gamma_1 \gamma_2}{2R}} \right) = \ln \frac{1 + \frac{\delta_1 \gamma_1 \gamma_2}{2R}}{1 - \frac{\delta_1 \gamma_1 \gamma_2}{2R}}$$

h

X

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

$$X_r \rightarrow X_s \quad \vec{X} \rightarrow e^i$$

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

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

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

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

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

$$\frac{\vec{q}}{2R} = \frac{S \frac{X_{r+X}}{R} S^{-1} - 1}{S \frac{X_{r+X}}{R} S^{-1} + 1} = S^x$$

Transfer

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

$$\frac{1 + \frac{x}{2R}}{1 - \frac{x}{2R}} = e^{\frac{2x}{2R}} \frac{1 + \frac{x}{2R}}{1 - \frac{x}{2R}} e^{\frac{2x}{2R}} \quad \text{bambel}$$

$$\frac{1+x}{1-x} = \eta \quad 1+x = \eta - \eta^{-1} \quad x(\text{long}) = \eta^{-1} \quad x = \frac{\eta^{-1} - \eta}{\eta^{-1} + \eta}$$

$$\frac{x}{2R} = \frac{e^{\frac{2x}{2R}} \left(\frac{1 + \frac{x}{2R}}{1 - \frac{x}{2R}} e^{\frac{2x}{2R}} - 1 \right)}{e^{\frac{2x}{2R}} \frac{1 + \frac{x}{2R}}{1 - \frac{x}{2R}} e^{\frac{2x}{2R}} + 1}$$

inf. limit $a^2 \approx 0$ $\Omega = \frac{\Omega a^2}{2R} + \frac{a^2}{2R} \Omega$

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

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

$\sqrt{2} \frac{dx}{2R} = \frac{x \cdot dx}{R}$

$$X + iY = R \frac{1 + i\frac{x}{2R}}{1 - i\frac{x}{2R}} \quad \text{or } V + iY = R e^{i\frac{x}{R}}$$

$$X + iY = R e^{\frac{x}{R}} = R \left(\cos \frac{x}{R} + \frac{x}{R} \sin \frac{x}{R} \right)$$

$$d(X + iY) = R \left(-\frac{x}{R} \cdot dx \cdot \frac{1}{R} + \frac{dx}{R} \right) = \frac{dx}{R} \left(-x + 1 \right)$$

$$dV + i dY = i \frac{1}{R} e^{i\frac{x}{R}} dx$$

$$ds^2 = dS^2$$

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

$$X_5 + X^{\vec{}} = Q$$

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

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

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

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

|Q'| = |Q|

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

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

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

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

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

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

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

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

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

$$= S \left\{ \left[\right] \right\} \left\{ \left[\right] \right\}^{-1} S^{-1}$$

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

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

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

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

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

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

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

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

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

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

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

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

$$\begin{aligned} \vec{q}' &= \vec{q} + \vec{a} - \vec{q} \frac{\vec{a} \cdot \vec{q}}{R^2} = \vec{q} + \vec{a} + \frac{q^2}{R^2} \vec{a} \\ &= \vec{q} + \left(1 + \frac{q^2}{R^2}\right) \vec{a} \end{aligned}$$

$$f(\vec{x}) \quad \vec{x}' = \vec{x} + \left(1 + \frac{v^2}{R^2}\right) \vec{a}$$

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

$$\vec{\nabla}' = \left(1 + \frac{v^2}{R^2}\right) \vec{\nabla}$$

$$J_{p_v} = x_p \partial_v \pm x_v \partial_p$$

$$\Pi_m = \frac{1}{R} L_{sv} = \left(1 + \frac{v^2}{R^2}\right) \partial_v = \cancel{p_v} \left(1 + \frac{v^2}{R^2}\right) \cancel{p_v}$$

$$\frac{1}{R^2} L_{p_v} L_{p_v} + \frac{1}{R^2} L_{s_v} L_{s_v} = \Omega$$

$$\Omega = \left(1 + \frac{v^2}{R^2}\right) p_v \left(1 + \frac{v^2}{R^2}\right) p_v + \frac{1}{R^2} L(L+1)$$

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

$$p_v v^2 - v^2 p_v = 2x_v$$

$$\Omega = \left(1 + \frac{v^2}{R^2}\right)^2 p_v p_v + \frac{2}{R^2} \left(1 + \frac{v^2}{R^2}\right) p_v x_v + \frac{1}{R^2} L(L+1)$$

$$\Omega = \left(1 + \frac{v^2}{R^2}\right)^2 p^2 + \frac{2}{R^2} \left(1 + \frac{v^2}{R^2}\right) x \cdot p + \frac{1}{R^2} L(L+1)$$

$(x)^2$

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

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

$$J_{s_m} = R \left(1 + \frac{v^2}{R^2}\right) p_m$$

$$\Pi_m = \left(1 + \frac{v^2}{R^2}\right) p_m \quad \frac{2}{R^2} \left(1 + \frac{v^2}{R^2}\right) J_{p_m} R$$

$$J_{s_m} J_{s_m} = p^2$$

$$[\Pi_m, \Pi_m] = \left[\left(1 + \frac{v^2}{R^2}\right) p_m, \left(1 + \frac{v^2}{R^2}\right) p_m \right]$$

$$\left(1 + \frac{v^2}{R^2}\right) p_m, \left(1 + \frac{v^2}{R^2}\right) p_m$$

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

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

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

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

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

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

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

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

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

$$\bullet \times \frac{\partial}{\partial \eta} - \eta \frac{\partial}{\partial \xi}$$

$$\left\{ \begin{array}{l} \frac{\sqrt{\xi^2 + \eta^2}}{2R} = \tan \frac{\theta}{2} \\ \frac{\eta}{\xi} = \tan \varphi \end{array} \right.$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$-\frac{dL}{dt} = \sin \varphi \frac{d}{dt} + \cos \varphi \frac{d}{dt}$$

$$\sin \varphi \frac{d}{dt} = R(1 + \tan^2 \frac{\theta}{2}) \sin \varphi \cos \varphi \frac{d}{dt}$$

$$+ R(1 + \tan^2 \frac{\theta}{2}) \sin \varphi \cos \varphi \frac{d}{dt}$$

$$\sin \varphi = \frac{7}{8} \quad \cos \varphi = \frac{3}{8}$$

$$\tan \frac{\theta}{2} = \frac{\sqrt{3^2 + 7^2}}{2R} = \frac{8}{R} \quad \tan^2 \frac{\theta}{2} = \frac{8^2}{4R^2}$$

$$\sin \varphi \frac{d}{dt} = R(1 + \frac{8^2}{4R^2}) \left[\sin \varphi \frac{d}{dt} + \sin \varphi \cos \varphi \frac{d}{dt} \right]$$

$$= R(1 + \frac{8^2}{4R^2}) \left[\frac{7^2}{8^2} \frac{d}{dt} + \frac{7 \cdot 3}{8^2} \frac{d}{dt} \right]$$

$$\cos \theta = \frac{\cos \varphi}{\sin \theta} = \frac{\cos^2 \frac{\theta}{2} - \sin^2 \frac{\theta}{2}}{2 \sin \frac{\theta}{2} \cos \frac{\theta}{2}} = \frac{1 - \tan^2 \frac{\theta}{2}}{2 \tan \frac{\theta}{2}} = \frac{1 - \frac{8^2}{4R^2}}{8/2R}$$

$$\cos \theta \cos \varphi \frac{d}{dt} = 2R \frac{1 - \frac{8^2}{4R^2}}{8} \frac{3}{8} \left(3 \frac{d}{dt} - 7 \frac{d}{dt} \right)$$

$$= 2R \frac{1 - \frac{8^2}{4R^2}}{8^2} \left(3^2 \frac{d}{dt} - 3 \cdot 7 \frac{d}{dt} \right)$$

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

$$+ \frac{2R}{s^2} (1 - \frac{s^2}{4a^2}) (\xi \frac{\partial}{\partial \eta} - \eta \frac{\partial}{\partial \xi})$$

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

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

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

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

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

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

$$\sin \theta = 2 \sin \frac{\theta}{2} \cos \frac{\theta}{2} = 2 \tan \frac{\theta}{2} \cos^2 \frac{\theta}{2} = \frac{2 \tan \frac{\theta}{2} \cos^2 \frac{\theta}{2}}{\sin^2 \frac{\theta}{2} + \cos^2 \frac{\theta}{2}} = \frac{2 \tan \frac{\theta}{2}}{1 + \tan^2 \frac{\theta}{2}}$$

$$\cos \theta = \frac{1 - s^2/4a^2}{1 + s^2/4a^2}$$

$$x = R \frac{\frac{s}{R}}{1 + \frac{s^2}{4a^2}} \cos \varphi = \frac{s \cos \varphi}{1 + \frac{s^2}{4a^2}} = \frac{\xi}{1 + s^2/4a^2}$$

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

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

$$L_x = \frac{\eta}{s} \frac{\partial}{\partial \theta} + R \frac{\xi}{s^2} (1 - s^2/4a^2) \frac{\partial}{\partial \varphi}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\xi = \rho \cos \varphi$$

$$\eta = \rho \sin \varphi$$

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

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

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

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

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

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

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

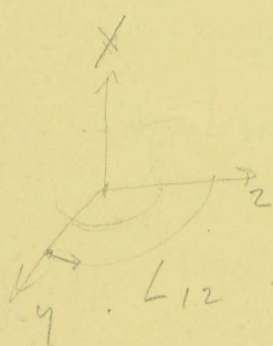
$$\cos \varphi \cot \varphi \frac{\partial}{\partial \varphi} = \frac{\xi}{s} \frac{R}{s} \left(1 - \frac{\rho^2}{4R^2} \right) \left(\xi \frac{\partial}{\partial \eta} - \eta \frac{\partial}{\partial \xi} \right)$$

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

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

$$= \frac{1}{s^2} \left[\eta \xi \frac{\partial}{\partial \xi} + \eta^2 \frac{\partial}{\partial \eta} + \xi^2 \frac{\partial}{\partial \eta} - \eta \xi \frac{\partial}{\partial \xi} \right]$$

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



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

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

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

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

$$X = \frac{\xi}{1 + \frac{\rho^2}{4R^2}}$$

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

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

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

$$Y' = Y$$

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

$$Y' = Y$$

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

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

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

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

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

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

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

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

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

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

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

$$\left\{ \begin{aligned} -\frac{c}{h} \frac{1}{R} L_{13} &= \frac{\partial}{\partial \xi} + \frac{1}{4R^2} \left[(\xi^2 - \eta^2) \frac{\partial}{\partial \xi} + 2\eta\xi \frac{\partial}{\partial \eta} \right] \\ &= \frac{c}{h} \frac{1}{R} L_{31} \end{aligned} \right.$$

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

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

$$L_{12} = J$$

$$\begin{aligned} -i\hbar \frac{\partial}{\partial \xi} &= p_1 & \xi &= \xi_1 \\ -i\hbar \frac{\partial}{\partial \eta} &= p_2 & \eta &= \xi_2 \end{aligned}$$

~~$$-\frac{c}{h} J_{12} = J$$~~

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

$$\left\{ \begin{aligned} \Pi_1 &= \frac{1}{R} L_{31} \\ \Pi_2 &= \frac{1}{R} L_{32} \end{aligned} \right. \quad \left\{ \begin{aligned} \Pi_1 &= p_1 + \frac{1}{4R^2} \left[(\xi_1^2 - \xi_2^2) p_1 + 2\xi_1 \xi_2 p_2 \right] \\ \Pi_2 &= p_2 + \frac{1}{4R^2} \left[-(\xi_1^2 - \xi_2^2) p_2 + 2\xi_1 \xi_2 p_1 \right] \end{aligned} \right.$$

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

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

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

$$\frac{\partial}{\partial \xi} \frac{\partial}{\partial \eta} \frac{\partial}{\partial \xi} \frac{\partial}{\partial \eta}$$

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

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

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

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

$$\rho \frac{\partial \varphi}{\partial \rho} = \left(\xi \frac{\partial \varphi}{\partial \xi} + \eta \frac{\partial \varphi}{\partial \eta} \right) \varphi \quad - \text{it } \frac{\partial \varphi}{\partial \rho} = \rho \varphi$$

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

$$\xi \cdot \vec{p} = \rho p_2$$

$$\text{Let } V_m = J_{mn} \xi_n$$

$$V_1 = J_{1n} \xi_n = J_{12} \xi_2$$

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

$$\Pi_m = p_m + \frac{1}{4R^2} \left[\sum_n J_{mn} \xi_n + \xi_m \rho p_2 \right]$$

$$\Pi_m = \left(1 - \frac{\rho^2}{4R^2} \right) p_m + \frac{1}{4R^2} \sum_n \left(\xi_n \cdot \vec{p} \right) = \left(1 - \frac{\rho^2}{4R^2} \right) p_m + \frac{1}{4R^2} \xi_m \rho p_2$$

$$\rho p_2 = \xi_m p_m$$

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

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

$$J_{mp} - \xi_m p_p = 2 \xi_m p_p - \xi_m p_p$$

$$\text{We need find } \left[\Pi_m, \Pi_n \right] = \frac{1}{R^2} J_{mn} \quad \xi_m \left[2 \xi_m p_m - \xi_m p_m \right]$$

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

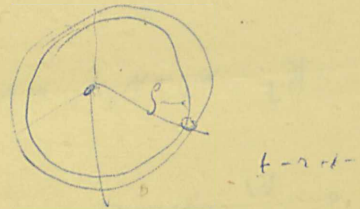
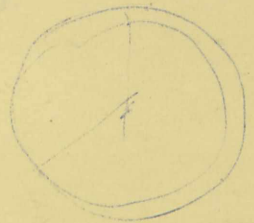
Sınırlı ^{kuşun} ^{uygun}
~~halin~~ ^{ve} ~~bu~~ ^{ve} ~~kötü~~, her ^{veya} ^{uygun} olacak şekilde
 mahiyette ^{veya} ^{uygun} ^{ufuklar} ^{aslında} ^{mahiyette} ^{uygun}
 bu faaliyetleri ^{program} faydalanabileceği kaynakları
 bu türlerin ^{ve} ^{hakkında} ^{meğuldir}.

in-service
 cross-country
 cam
 mood pieces

$$4\pi \frac{\kappa T}{24\pi} = \frac{2}{R^2}$$

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

$$m_i = \int_0^R \frac{4\pi r^2 dr}{|r-8|}$$



$$R^2 \equiv \frac{12}{\kappa T} \frac{1}{(t+r)(t-r)} = \frac{1}{2t} \left(\frac{1}{t+r} + \frac{1}{t-r} \right)$$

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

$$-G \frac{4\pi r^2 dr}{g}$$

$$\ln G \int_0^R g dr = 2\pi G R^2$$

radius of outgoing and ingoing waves.

$$\int \nabla^2 \phi d^3x$$

$dr = \frac{1}{2} \frac{d\phi}{\phi}$

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

$$\square \phi = -4\pi k' \sqrt{b} = \frac{+2}{R^2} \phi^3$$
$$-(4\pi k' T) \phi^3 =$$

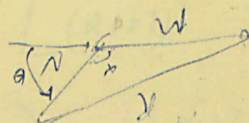
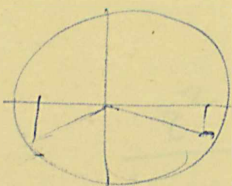
$$M(t) = \frac{1}{2} \frac{4\pi R^2}{R^2} \int_0^{\infty} \frac{2r^2 dr}{b \left(1 - \frac{cr^2}{2R^2} + \frac{r^2}{2R^2} \right)^3}$$

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

$$r^2 = \xi \quad r = \xi^{1/2}$$
$$2r dr = d\xi$$

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

$$R^2 = M^2 + N^2 + W^2 = 2R$$



$M^2 + N^2 + W^2 = 2R$

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

$$1-x = (1+x)x$$

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

$$1+x = y-x+y$$

$$x = x - 1 + 1$$

$$e^{\frac{1-x}{1+x}}$$

$$e^{\frac{1-x}{1+x}} = e^{\frac{1-x}{1+x}}$$

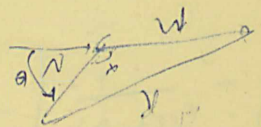
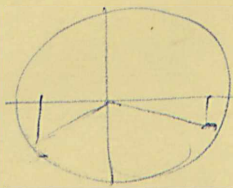
$$f = \frac{1 + \frac{x}{2R}}{1 - \frac{x}{2R}} = R e^{\frac{1 + \frac{x}{2R}}{1 - \frac{x}{2R}}}$$

$$f(x) = f(x) + \dots$$

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

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

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



MN cos alpha

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

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

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

$(a^2+2abz+lb^2z^2)$

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

$b \neq 0$. $C=0$.

$$A + aB = 0$$

$$Bb = 1$$

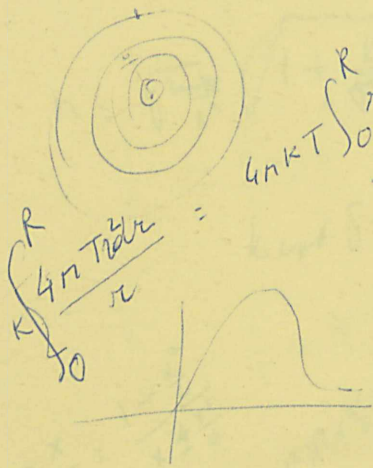
$$B = \frac{1}{b} \quad A = -\frac{a}{b}$$

$$= \frac{A + aB + \cancel{a^2C} + (Bb + 2abC)z + (Cb^2)z^2}{(a+bz)^3}$$

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

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

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



$$4\pi n k T \int_0^R r dr = 4\pi n k T \frac{R^2}{2}$$

$$= 2\pi n k T R^2 = \phi$$

$$M = \frac{4\pi}{3} \rho R^3 = \phi$$

$$\frac{M}{R} = \frac{4\pi}{3} \rho R^2 = \frac{2}{3\pi} (2\pi n k T R^2) = \frac{2}{3\pi} \phi$$

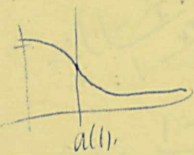
$$\phi = \frac{3\pi M}{2R}$$

$$g = \phi^8 \delta$$

$$\sqrt{g} = \phi^4 \sqrt{\delta}$$

$$\phi \partial_{\mu} \partial_{\mu} \phi = \partial_{\mu} (\phi \partial_{\mu} \phi) - (\partial_{\mu} \phi) (\partial_{\mu} \phi)$$

$$\int \phi \square \phi d^4 x = - \int (\partial_{\mu} \phi) (\partial_{\mu} \phi) + \phi$$



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

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

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

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

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

$$\frac{3}{\pi R^2} \left[\frac{4}{R^2} \frac{r^2}{R^2} - \frac{1}{2} \frac{r^2}{R^2} - 1 + \frac{r^2}{R^2} \right]$$

$$\phi = \frac{1}{\sqrt{1 - \frac{r^2}{R^2}}} + \frac{H c \lambda^2 m s}{\pi}$$

$$\frac{\sum m_i}{R} \phi^{-3} \phi^{-4} \frac{d\phi}{dr}$$

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

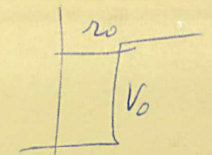
$$\frac{d\phi}{dr} = -\frac{3}{R^2} \frac{r}{\left(\right)^4}$$

$$\frac{d\phi}{dr} = \frac{3 \times 4}{R^2} \frac{\frac{r^2}{R^2}}{\left(\right)^5} - \frac{3}{R^2} \frac{1 - \frac{r^2}{R^2} + \frac{r^2}{R^2}}{\left(\right)^5}$$

4
 $L_0 = k \cot \delta_0$

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

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



$k \cot \delta_0 = \frac{k n \cot k r_0 + n (\cot n r_0) \cos k r_0}{\cos k r_0 - n \cot n r_0 \frac{n i k r_0}{k}}$

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

$k=0 \quad n=K$

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

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

$= k n i k r_0 + \frac{1}{\hbar} \sqrt{\dots}$

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

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

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

$A = \frac{r_0 k \cot K r_0 - 1}{K \cot K r_0} = r_0 - \frac{1}{K \cot K r_0} = r_0 \left(1 - \frac{1}{r_0 K \cot K r_0} \right)$

$\cot x = \frac{1 - \frac{x^2}{3}}{x}$
 $n = K + \frac{1}{2} \frac{k^2}{K}$

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

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

$K^2 = K^2 + k^2$

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

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

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

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

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

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

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

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

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

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

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

$$1 - \frac{3}{2} r_0^2 k^2 + \frac{1}{18} r_0^4 k^2 \left| -\frac{1}{3} - 1 - \frac{1}{6} = -\frac{2}{6} - \frac{1}{6} - 1 = -\frac{1}{2} - 1 = -\frac{3}{2} \right.$$

$2m$

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

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

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

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

$$abc - cab = a \underbrace{bc + acb - acb - cab}$$
$$= a\{bc\} - \{ac\}b$$

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

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

$$\{x, y\} = xy + yx$$

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

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

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

$$\gamma_\mu\gamma_\mu = m^2$$

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

$$\frac{d}{dc} \phi \frac{dx^h}{dc} = \gamma^h \phi$$

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

$$\sigma^2 = \gamma^h \gamma_h$$

$$\frac{d\sigma^2}{dc} = 2 \frac{dx^h}{dc} \gamma_h$$

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

$$\frac{d}{dc} \phi(\sigma^2) \frac{dx^h}{dc} = 2 \gamma^h \phi'(\sigma^2)$$

$$\frac{\partial}{\partial x^h} \sigma^2 = \gamma_h \sigma^2 = 2 \gamma^h$$

$$\phi(\sigma^2) \frac{d^2 x^h}{dc^2} + \phi'(\sigma^2) 2 \gamma^h \frac{dx^h}{dc} \frac{dx^h}{dc} = 2 \gamma^h \phi'(\sigma^2)$$

$$\frac{d^2 x^h}{dc^2} = \frac{2 \phi'(\sigma^2)}{\phi(\sigma^2)} \left[\gamma^h - \gamma^h \frac{dx^h}{dc} \frac{dx^h}{dc} \right]$$

$$\frac{d^2 x^h}{dc^2} = \frac{2 \phi'(\sigma^2)}{\phi(\sigma^2)} \left[\gamma^h - \underbrace{\gamma^h \frac{dx^h}{dc} \frac{dx^h}{dc}}_{\left(\frac{d\sigma^2}{dc}\right)^2} \right]$$

$$\gamma^m - \gamma^h \frac{dx^h}{dc}$$

$$dc^2 = dt^2 (1 - \frac{v^2}{c^2})$$

Module

$$\frac{d^2 x^h}{dt^2} = \left(\gamma^h - t \frac{d\gamma^h}{dt} \right) \frac{\gamma}{\sigma^2} \left(\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \frac{d\sigma^2}{dt} \right)^2$$

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

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

$$\gamma = \frac{1}{4\sigma^2} \left(\frac{d\sigma^2}{dc} \right)^2 = \frac{1}{4\sigma^2} \phi \sigma^2 \left(\frac{d\phi}{dc} \right)^2 = \left(\frac{d\phi}{dc} \right)^2$$

$$\gamma = \left(\frac{d\phi}{dc} \right)^2$$

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

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

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

$$2n^2 = 20$$

$$X_p X_p + X_s^2 = R^2$$

$$X_p = \frac{x_p}{1 + \frac{x_p^2}{4R^2}}$$

then we find $X_s = R \frac{1 - \frac{x_p^2}{4R^2}}{1 + \frac{x_p^2}{4R^2}} = R \frac{1 - \frac{z^2}{4R^2}}{1 + \frac{z^2}{4R^2}}$

$X_s = R$ corresponds to $z^2 = 0$.

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

$$\frac{z^2}{4R^2} = \frac{1 + \frac{X_s}{R}}{1 - \frac{X_s}{R}}$$

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

$$z^2 = 4R^2 \frac{1 + \frac{X_s}{R}}{1 - \frac{X_s}{R}}$$

$$ds^2 = \delta_p dx_p + dX_s^2 = \frac{1}{\left(1 + \frac{z^2}{4R^2}\right)^2} dz^2$$

$ds^2 = g_{\mu\nu} dx^\mu dx^\nu$

$$\delta_r X_s + \delta_p X_p = \delta_p \frac{x_p}{1 + \frac{z^2}{4R^2}} + \delta_s R \frac{1 - \frac{z^2}{4R^2}}{1 + \frac{z^2}{4R^2}}$$

$$z^2 = f(z^2, a^2, g_{\mu\nu})$$

$$\delta_r X_s + \delta_p X_p = \frac{\delta_p x_p + \delta_s R \left(1 - \frac{z^2}{4R^2}\right)}{1 + \frac{z^2}{4R^2}}$$

$$X'_s + \delta_p X'_p = \dots$$

$$\delta_r X'_s + \delta_p X'_p = e^{\delta_r \delta_p a_p} (\delta_r X_s + \delta_p X_p) e^{-\delta_r \delta_p a_p}$$

$$X'_s + \delta_p X'_p = e^{\delta_r \delta_p a_p} (X_s + \delta_p X_p) e^{-\delta_r \delta_p a_p} \quad X'_s = \dots$$

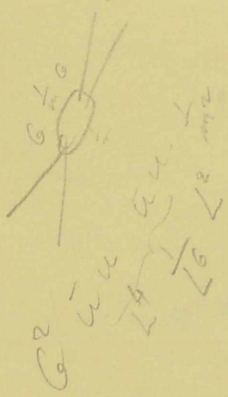
$$\frac{y_p x_p + r_s R \left(1 - \frac{r^2}{4R^2}\right)}{1 + \frac{r^2}{4R^2}} = e^{-\frac{1}{2} \frac{r}{R} \frac{y_p}{x_p}} \frac{y_p x_p + r_s R \left(1 - \frac{r^2}{4R^2}\right)}{1 + \frac{r^2}{4R^2}} e^{\frac{1}{2} \frac{r}{R} \frac{y_p}{x_p}}$$

$$\frac{R \left(1 - \frac{r^2}{4R^2}\right) + r_s y_p x_p}{1 + \frac{r^2}{4R^2}} = \frac{e^{-\frac{1}{2} \frac{r}{R} \frac{y_p}{x_p}} \left[R \left(1 - \frac{r^2}{4R^2}\right) + r_s y_p x_p \right] e^{\frac{1}{2} \frac{r}{R} \frac{y_p}{x_p}}}{1 + \frac{r^2}{4R^2}}$$

$$x_s \frac{\partial x}{\partial x_s} - x_p \frac{\partial x}{\partial x_p}$$

$$x_s \frac{\partial y}{\partial x_s} - x_p \frac{\partial y}{\partial x_p}$$

$\frac{1}{2} \frac{r}{R} \frac{y_p}{x_p}$



$$\frac{\partial}{\partial x_p} = \frac{\partial x_p}{\partial x} \frac{\partial}{\partial x}$$

$$\frac{\partial}{\partial x_s} = \frac{\partial x_s}{\partial x} \frac{\partial}{\partial x}$$

$$x_s = f(r^2)$$

$$\psi(x_s, x_p, y)$$

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

$$x = R \frac{3/R}{1 + \frac{3}{4R^2}}$$

$$y = R \frac{1 - \frac{3}{4R^2}}{1 + \frac{3}{4R^2}}$$

$$x \partial_y - y \partial_x$$

$$x = r \cos \theta$$

$$y = r \sin \theta$$

$$x = r \cos \theta$$

$$y = r \sin \theta$$

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

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

$$\frac{3}{R^2} + 1 + \frac{3}{4R^2} + \frac{3}{4R^2}$$

$$\left(1 + \frac{3}{4R^2}\right)^2$$

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

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

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

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

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

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

$$x \, dx - y \, dy = \frac{2}{\rho} = \frac{d\xi}{d\rho} \frac{2}{\xi}$$

$$\frac{2}{1+\rho}$$

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

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

$$z = 4R \tan \frac{\varphi}{2}$$

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

$$dx^2 + dy^2 =$$

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

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

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

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

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



$$z = 2R \tan \frac{\phi}{2}$$

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

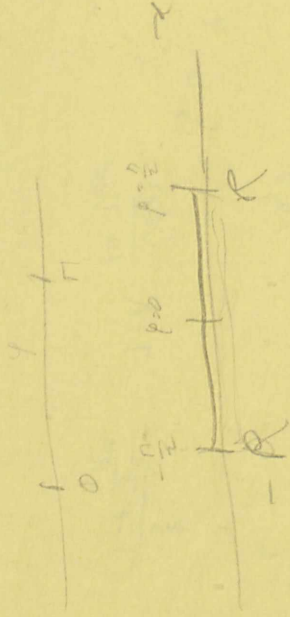
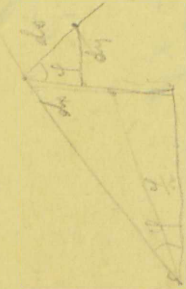
align

$$x = R \frac{\frac{3}{4}R}{1 + \frac{3^2}{4R^2}}$$

$$y = R \frac{1 - \frac{3^2}{4R^2}}{1 + \frac{3^2}{4R^2}}$$

$$- \infty < z < \infty$$

$$F(x) = \frac{\partial}{\partial y} - y \frac{\partial}{\partial x}$$



$$\frac{\partial}{\partial x} \frac{\partial}{\partial y} = \text{diag.}$$

3

0

$$\tan \frac{\phi}{2} = \frac{z}{2R} \quad \phi = 2 \tan^{-1} \frac{z}{2R} = \phi(z)$$

$$\frac{\partial}{\partial y} = \frac{\partial z}{\partial y} \frac{\partial}{\partial z}$$

$$dz = 2R \frac{\cos^2 \frac{\phi}{2} \cdot \frac{d\phi}{2}}{\cos^2 \frac{\phi}{2}} \times \frac{1}{2} d\phi = \frac{R d\phi}{\cos^2 \frac{\phi}{2}}$$

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

$$d\left\{ \frac{z}{2R} \right\} = -R \left(1 + \tan^2 \frac{\phi}{2} \right) d\phi = -R \left(1 + \frac{3^2}{4R^2} \right) d\phi$$

$$\frac{\partial}{\partial y} = R \left(1 + \frac{3^2}{4R^2} \right) \frac{\partial}{\partial z}$$

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

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

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

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

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

$$e_1 X + e_2 Y + e_3 Z = \vec{q}$$

$$|q| = 1 \quad e_1 x + e_2 y + e_3 R \left(1 - \frac{z^2 + y^2}{4R^2}\right)$$

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

$$\left(\frac{1+i\alpha}{1-i\alpha}\right)^2$$

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

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



$$\frac{\partial}{\partial x}$$

$$2x^2 dx + \dots$$

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

$$dX = \frac{\left(1 + \frac{z^2}{4R^2}\right) dx - x \frac{2z dz + 2y dy}{4R^2}}{\left(1 + \frac{z^2}{4R^2}\right)^2} =$$

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

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

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

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

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

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

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

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

$$e_3 (\cos \varphi - e_3 \sin \varphi) + e_3 R ()$$

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

e_1

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

$$X_0^2 + X_1^2 + X_2^2 = R$$

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

$$R \frac{1 + \frac{q}{2R}}{1 - \frac{q}{2R}} = X_0 + e_1 X_1 + e_2 X_2 + X_3$$

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

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

$$R \frac{x}{1 - \frac{q^2}{4R^2}}$$

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

$$R \frac{1 + \frac{q}{2R}}{1 - \frac{q}{2R}} = X_5 + X_6$$

$$R \frac{1 + \frac{q}{2R}}{1 - \frac{q}{2R}} = X_5 + X_6$$

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

$$\frac{R^2}{4R^2} \frac{q}{2R} - 1 = \frac{R^2}{4R^2} \frac{q}{2R} - 1$$

R

X

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

$$X_5 \rightarrow X_5 \quad \vec{X} \rightarrow e$$

$$\frac{X_5 + X}{R} = \frac{1 + \frac{g^2}{2R}}{1 - \frac{g}{2R}}$$

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

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

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

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

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

Trunk

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

$$\frac{\vec{X}}{1 - \frac{\vec{X}}{R}} = e^{\frac{\vec{X}}{R}} \cdot \frac{1 + \frac{\vec{X}}{R}}{1 - \frac{\vec{X}}{R}}$$

$$\frac{1+x}{1-x} = e^{2x}$$

$$x = \frac{2-1}{2+1}$$

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

Inf. limit

$$x^2 \approx 0$$

$$\Omega + \frac{\partial \Omega}{\partial R} + \frac{\partial^2 \Omega}{\partial R^2}$$

$$\frac{\vec{X}}{R} = \frac{\left(1 + \frac{\vec{X}}{R}\right) \Omega \left(1 + \frac{\partial \vec{X}}{R}\right) - 1}{\left(1 + \frac{\vec{X}}{R}\right) \Omega \left(1 + \frac{\partial \vec{X}}{R}\right) - 1} = \frac{\Omega + \left\{ \frac{\partial \Omega}{\partial R} \right\} - 1}{\Omega + \left\{ \frac{\partial \Omega}{\partial R} \right\} - 1}$$

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

$$i \frac{\vec{X}}{R}$$

$$X + iY = R \frac{1 + i \frac{X}{R}}{1 - i \frac{Y}{R}} = R \left(\cos \frac{X}{R} + i \sin \frac{Y}{R} \right)$$

$$\text{or } Y + iX = R e^{i \frac{X}{R}}$$

$$d(Y + iX) = i e^{i \frac{X}{R}} dX$$

$$\vec{X} + i\vec{Y} = R$$

$$d(\vec{X} + i\vec{Y}) = \left(\frac{\partial \vec{X}}{\partial R} dR + \frac{\partial \vec{Y}}{\partial R} dR \right) + \frac{dR}{R} (X + iY)$$

$$dR = dS^2$$

$\frac{\vec{X}}{R}$

baulet

$$\vec{\frac{q}{zR}} = \frac{X_{s+\vec{X}} - 1}{X_{s+\vec{X}} + 1} = \left(\frac{X_{s+\vec{X}} - 1}{X_{s+\vec{X}} + 1} \right)^{-1}$$

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

$$X_{s+\vec{X}} = Q$$

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

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

$$Q' = e^{\frac{\vec{q}}{zR}} Q e^{-\frac{\vec{q}'}{zR}} \cdot S Q S$$

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

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

$$1 + \frac{\vec{q}'}{zR} = S \frac{1 + \frac{\vec{q}}{zR}}{1 - \frac{\vec{q}}{zR}} S = Q'$$

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

$$\vec{\frac{q'}{zR}} (1+Q) = Q' - 1$$

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

$$\begin{aligned} \vec{q}' \frac{1}{2R} &= \frac{S \left[\frac{1 + \frac{\vec{q}}{2R}}{1 - \frac{\vec{q}}{2R}} \right] S - 1}{S \left[\frac{1 + \frac{\vec{q}}{2R}}{1 - \frac{\vec{q}}{2R}} \right] S + 1} \cdot S = e \end{aligned}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

$a^2 \sim 0$

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

$$q' = \frac{\vec{q} + \vec{a}}{1 + \frac{\vec{a}\vec{q}}{R^2}}$$

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

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

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

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

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

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

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

$$\Pi_W = \frac{1}{R} L_{\mu\nu} = \left(1 + \frac{z^2}{R^2}\right) \partial_{\nu} = p_{\nu} \left(1 + \frac{z^2}{R^2}\right) p_{\nu}$$

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

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

$$= \frac{\partial}{\partial x} (x^2 + y^2) = (x^2 + y^2) \delta_{\nu} = 2 \times$$

$$p_{\nu} z^2 - z^2 p_{\nu} = 2 \times \nu$$

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

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

$$\left(1 + \frac{z^2}{R^2}\right)^2 \frac{2}{R^2} X_{\nu} p_{\nu}$$

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$$\left(1 + \frac{z^2}{R^2}\right)^2 \frac{2}{R^2} X_{\nu} p_{\nu}$$

$$\Pi_m = \left(1 + \frac{z^2}{R^2}\right) p_m$$

$$J_{5m} = \left(1 + \frac{z^2}{R^2}\right) p_m$$

$$\frac{2}{R^2} \left(1 + \frac{z^2}{R^2}\right) J_{5m} p_m$$

$$J_{5m} J_{5im} = P$$

$$[J_{5m}, J_{5im}] = \left[1 + \frac{z^2}{R^2}\right] p_m, \left(1 + \frac{z^2}{R^2}\right) p_m$$

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

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

$$= \frac{2}{R^2} p_m -$$

$$= \left(1 + \frac{z^2}{R^2}\right) p_m \left(1 + \frac{z^2}{R^2}\right) p_m$$

$$S = \frac{1}{\cos \theta}$$

$$x = R \cos \theta \cos \phi = \frac{\Sigma}{1 + \frac{\Sigma^2}{4R^2}}$$

$$y = R \sin \theta \cos \phi = \frac{\eta}{1 + \frac{\Sigma^2}{4R^2}}$$

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

$$\frac{S}{2R} = \tan \frac{\theta}{2}$$

$$\frac{\eta}{x} = \left\{ \begin{aligned} \frac{\eta}{\Sigma} &= \tan \phi \\ \frac{\rho}{2R} &= \tan \frac{\alpha}{2} \end{aligned} \right.$$

$$I_1 = \cos \phi \frac{d}{d\theta}$$

$$\left\{ \begin{aligned} \sqrt{\frac{\Sigma^2 + \eta^2}{2R}} &= \tan \frac{\theta}{2} \\ \frac{\eta}{\Sigma} &= \tan \phi \end{aligned} \right.$$

$$x \frac{d}{d\Sigma} - y \frac{d}{d\eta}$$

$$\frac{d}{d\Sigma} + \frac{\eta}{\Sigma} \frac{d}{d\eta} = \frac{d}{d\rho}$$

$$e^{i\theta} = e^{i\theta} \left(\frac{d}{d\rho} + i \frac{d}{d\phi} \right)$$

$$e^{i\theta} = e^{i\theta} \left(\frac{d}{d\rho} + i \frac{d}{d\phi} \right)$$

$$\frac{d}{d\rho} = \frac{d}{d\Sigma} + \frac{\eta}{\Sigma} \frac{d}{d\eta}$$

$$\frac{d}{d\rho} = \frac{d}{d\Sigma} + \frac{\eta}{\Sigma} \frac{d}{d\eta}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$-iL \frac{d}{dt} = \sin \varphi \frac{d}{d\theta} + \cos \varphi \frac{d}{d\varphi}$$

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

$$\sin \varphi = \frac{2}{5} \quad \cos \varphi = \frac{3}{5}$$

$$\tan \frac{\theta}{2} = \frac{\sqrt{3^2 + 4^2}}{2R} = \frac{5}{2R}$$

$$\tan^2 \frac{\theta}{2} = \frac{25}{4R^2}$$

$$\sin \varphi \frac{d}{d\theta} = R \left(1 + \frac{25}{4R^2} \right) \left[\sin^2 \varphi \frac{d}{d\varphi} + \sin \varphi \cos \varphi \frac{d}{d\theta} \right]$$

$$= R \left(1 + \frac{25}{4R^2} \right) \left[\frac{4^2}{9} \frac{d}{d\theta} + \frac{2 \cdot 3}{9} \frac{d}{d\theta} \right]$$

$$4 + 0 = \frac{\cos^2 \frac{\theta}{2} - \sin^2 \frac{\theta}{2}}{2 \sin \theta \cos \theta}$$

$$= \frac{1 - \tan^2 \frac{\theta}{2}}{2 \tan \frac{\theta}{2}} = \frac{1 - \frac{25}{4R^2}}{8/2R}$$

$$\cot \theta \cos \varphi \frac{d}{d\varphi} = 2R \frac{1 - \frac{25}{4R^2}}{8} \frac{1}{9} \left(3 \frac{d}{d\varphi} - 2 \frac{d}{d\theta} \right)$$

$$= 2R \frac{1 - \frac{25}{4R^2}}{9} \left(3^2 \frac{d}{d\varphi} - 3 \cdot 2 \frac{d}{d\theta} \right)$$

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

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

$$\left\{ \begin{array}{l} \xi = s \cos \varphi \\ \eta = s \sin \varphi \end{array} \right. \quad \frac{s}{2R} = \tan \frac{\theta}{2}$$

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

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

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

$$z = R \cos \theta = R \frac{z}{1 + \frac{s^2}{4R^2}}$$

$$\sin \theta = \frac{3/R}{1 + \frac{s^2}{4R^2}}$$

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

$$\sin \theta = 2 \sin \frac{\theta}{2} \cos \frac{\theta}{2} = 2 \tan \frac{\theta}{2} \cos^2 \frac{\theta}{2} = \frac{2 \tan \frac{\theta}{2} \cos^2 \frac{\theta}{2}}{\cos^2 \frac{\theta}{2} + \sin^2 \frac{\theta}{2}} = \frac{2 \tan \frac{\theta}{2}}{1 + \tan^2 \frac{\theta}{2}}$$

$$x = R \frac{\frac{3}{R}}{1 + \frac{s^2}{4R^2}} \cos \varphi = \frac{3 \cos \varphi}{1 + \frac{s^2}{4R^2}}$$

$$L_x = \eta \frac{\partial}{\partial \theta} + \frac{3}{s} \cot \theta \frac{\partial}{\partial \varphi} = \eta \frac{\partial}{\partial \theta} + \frac{3}{s} \frac{1 - s^2/4R^2}{1 + s^2/4R^2} \frac{\partial}{\partial \varphi}$$

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

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

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

$$\frac{\partial z}{\partial \theta} = \frac{\partial z}{\partial \theta} \frac{\partial \theta}{\partial \theta} + \frac{\partial z}{\partial \phi} \frac{\partial \phi}{\partial \theta}$$

$$z = r \cos \phi \quad \eta = r \sin \phi$$

$$\frac{r}{r_0} = \tan \frac{\theta}{2}$$

$$r = 2R \tan^2 \frac{\theta}{2}$$

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

$$\frac{\partial z}{\partial \theta} = \frac{ds}{d\theta} \cos \phi \quad \frac{\partial \eta}{\partial \theta} = \frac{ds}{d\theta} \sin \phi$$

$$\frac{\partial}{\partial \theta} = \frac{ds}{d\theta} \left(\cos \phi \frac{\partial}{\partial z} + \sin \phi \frac{\partial}{\partial \eta} \right)$$

$$= \frac{ds}{d\theta} \left(\frac{z}{s} \frac{\partial}{\partial z} + \frac{\eta}{s} \frac{\partial}{\partial \eta} \right)$$

$$\frac{\eta \frac{\partial}{\partial \eta}}{s} = \frac{ds \sin \phi}{s}$$

$$\frac{ds}{d\theta} = \frac{2R}{\cos^2 \frac{\theta}{2}} = R \left(1 + \tan^2 \frac{\theta}{2} \right) = R \left(1 + \frac{s^2}{4R^2} \right)$$

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

$$\sin \phi \frac{\partial}{\partial \theta} = \frac{R}{s} \left(1 + \frac{s^2}{4R^2} \right) \left(\frac{z}{s} \frac{\partial}{\partial z} + \frac{\eta}{s} \frac{\partial}{\partial \eta} \right)$$

$$\cos \phi \cot \theta \frac{\partial}{\partial \theta} = \frac{R}{s} \left(1 - \frac{s^2}{4R^2} \right) \left(\frac{z}{s} \frac{\partial}{\partial z} - \frac{\eta}{s} \frac{\partial}{\partial \eta} \right)$$

$$L_x = \frac{R}{s^2} \left[(1 + \frac{s^2}{4R^2}) (\eta \int \frac{d}{s} + \eta^2 \frac{d}{s^2}) + (1 - \frac{s^2}{4R^2}) (-\eta \int \frac{d}{s} + \int^2 \frac{d}{s^2}) \right]$$

$$= \frac{R}{s^2} \left[s^2 \frac{d}{s^2} + \frac{s^2}{4R^2} \eta \int \frac{d}{s^2} + (\eta^2 - s^2) \int^2 \frac{d}{4R^2} \frac{d}{s^2} \frac{d}{s^2} \right]$$

$$\frac{1}{R} L_x = \frac{d}{s^2} + \frac{1}{4R} \left(\eta \int \frac{d}{s^2} + (\eta^2 - s^2) \int \frac{d}{s^2} \right)$$

using

$$2\eta \int \frac{d}{s^2} - \frac{s^2}{R} \int \frac{d}{s^2} =$$

$$\eta \int \frac{d}{s^2} + \frac{s^2}{R} \int \frac{d}{s^2} + \eta \int \frac{d}{s^2} - \frac{s^2}{R} \int \frac{d}{s^2}$$

$$\eta \left(\int \frac{d}{s^2} + \frac{s^2}{R} \int \frac{d}{s^2} \right) + \underbrace{\left(\frac{s^2}{R} \int \frac{d}{s^2} - \int \frac{d}{s^2} \right)}_{\frac{d}{s^2}}$$

$$-y \frac{\partial}{\partial \theta} + \cos \gamma \cot \theta \frac{\partial}{\partial \gamma}$$

$$X = \frac{z}{1 + \frac{y^2}{4R^2}} = \frac{z \cos \gamma}{1 + \frac{y^2}{4R^2}} = R \sin \theta \cos \gamma$$

$$Y = \frac{y}{1 + \frac{y^2}{4R^2}} = \frac{z \sin \gamma}{1 + \frac{y^2}{4R^2}} = R \sin \theta \sin \gamma$$

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

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

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

$$\left\{ \frac{\partial}{\partial \eta} - \eta \frac{\partial}{\partial \xi} \right\} = \frac{\partial}{\partial \rho}$$

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

$$\tan \theta = \frac{-\sin^2 \theta - \cos^2 \theta}{\sin^2 \theta} d\theta = \left(-\frac{R}{y} - \frac{1}{4R} \right) dy = \frac{R}{y} \left(1 - \frac{y^2}{4R^2} \right) dy$$

$$\int (1 + \cot^2 \theta) d\theta = \left(\frac{R}{y} + \frac{1}{4R} \right) dy$$

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

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

$$\left. \begin{aligned} \xi &= \rho \cos \gamma \\ \eta &= \rho \sin \gamma \end{aligned} \right\}$$

$$\frac{\partial \xi}{\partial \theta} = \frac{dy}{d\theta} \cos \gamma \quad \frac{\partial \eta}{\partial \theta} = \frac{dy}{d\theta} \sin \gamma$$

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

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

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

$$\frac{dy}{dy} = R \left(1 + \frac{p^2}{4R^2} \right) \left(\cos \psi \frac{\partial}{\partial \xi} + \sin \psi \frac{\partial}{\partial \eta} \right)$$

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

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

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

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

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

$$= \frac{1}{\xi^2} \left[\eta \xi \frac{\partial}{\partial \xi} + \eta^2 \frac{\partial}{\partial \eta} + \xi^2 \frac{\partial}{\partial \eta} - \eta \xi \frac{\partial}{\partial \xi} \right]$$

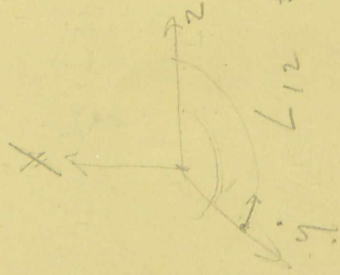
$$+ \frac{p^2}{4R^2} \left(\eta \xi \frac{\partial}{\partial \xi} + \eta^2 \frac{\partial}{\partial \eta} - \xi^2 \frac{\partial}{\partial \eta} + \eta \xi \frac{\partial}{\partial \xi} \right)$$

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

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

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

$$M_2 = p_2 + \frac{1}{4R^2} \left[\xi^2 p_2 + \xi p_1 \right] = \xi \left(\frac{p_2}{\xi} + \frac{p_1}{4R^2} \right)$$



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

$$Y = \frac{\eta}{1 + \frac{\xi^2}{4R^2}}$$

$$Z = R \frac{1 - \frac{\xi^2}{4R^2}}{1 + \frac{\xi^2}{4R^2}}$$

$$(X' + iZ') = e^{i\alpha} (X + iZ)$$

$$\frac{\xi' + iR(1 - \frac{\xi'^2}{4R^2})}{1 + \frac{\xi'^2}{4R^2}} = e^{i\alpha} \frac{\xi + iR(1 - \frac{\xi^2}{4R^2})}{1 + \frac{\xi^2}{4R^2}}$$

$$Y' = Y$$

$$Y' = Y$$

$$\frac{\eta'}{1 + \frac{\xi'^2}{4R^2}} = \frac{\eta}{1 + \frac{\xi^2}{4R^2}}$$

$$-\frac{i}{k} \Gamma_2 = -\frac{i}{k} R \left[\frac{\partial}{\partial z_2} + \frac{1}{4R^2} \left(\frac{\partial^2}{\partial z_2^2} + \frac{\partial}{\partial \eta} \right) - \frac{1}{3} \left(\frac{\partial}{\partial z_2} - \frac{\partial}{\partial \eta} \right) \right]$$

$$-\frac{i}{k} L_{31} = -\cos \varphi \frac{\partial}{\partial \theta} + \sin \varphi \cot \theta \frac{\partial}{\partial \varphi}$$

$$\cos \varphi = \frac{z}{R}$$

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

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

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

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

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

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

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

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

$$= \frac{i}{k} R L_{31}$$

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

$$= \frac{i}{k} R L_{32}$$

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

$$L_{12} = \xi$$

$$-i k \frac{\partial}{\partial \xi} = p_1 \quad \xi = \xi_1$$

$$-i k \frac{\partial}{\partial \eta} = p_2 \quad \eta = \xi_2$$

$$-\frac{i}{k} J_{12} = \xi$$

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

$$P_1 = \frac{i}{k} L_{31}$$

$$P_2 = \frac{i}{k} L_{32}$$

$$P_1 = p_1 + \frac{1}{4R^2} [(\xi_1^2 - \xi_2^2) p_1 + 2\xi_1 \xi_2 p_2]$$

$$P_2 = p_2 + \frac{1}{4R^2} [-(\xi_1^2 - \xi_2^2) p_2 + 2\xi_1 \xi_2 p_1]$$

$$-\xi_1^2 p_2 + \xi_2^2 p_1 + \xi_1 \xi_2 p_1 + \xi_1 \xi_2 p_2$$

$$+ \xi_1 (\xi_1 p_1 - \xi_2 p_2)$$

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

$$P_1 = p_1 + \frac{1}{4R^2} [\xi_2 J_{12} + \xi_1 (\xi_1 p_1 + \xi_2 p_2)]$$

$$P_2 = p_2 + \frac{1}{4R^2} [-\xi_1 J_{12} + \xi_2 (\xi_1 p_1 + \xi_2 p_2)]$$

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

Conrad

$$\frac{\partial \psi}{\partial \rho} = \frac{21}{88} \frac{\partial \psi}{\partial \xi} + \frac{27}{18} \frac{\partial \psi}{\partial \eta}$$

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

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

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

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

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

$$-i \frac{\partial \psi}{\partial \rho} = \beta \psi$$

$$\begin{cases} \Pi_1 = P_1 + \frac{1}{4R^2} [J_{12} \xi_2 + \xi_1 \rho \beta] \\ \Pi_2 = P_2 + \frac{1}{4R^2} [-J_{12} \xi_1 + \xi_2 \rho \beta] \end{cases}$$

$$\xi \cdot \vec{\rho} = \rho^2 \beta$$

Let $V_m = J_{12} \xi_m$

$$V_1 = J_{12} \xi_1 = J_{12} \xi_2$$

$$V_2 = J_{21} \xi_m = J_{21} \xi_1 = -J_{12} \xi_2$$

$$\Pi_m = P_m + \frac{1}{4R^2} [\sum_n J_{mn} + \sum_m \rho \beta]$$

$$\Pi_m = \left(1 - \frac{\rho^2}{4R^2} \right) P_m + \frac{1}{4R^2} \sum_n (\xi_n \cdot \vec{\rho}) = \left(1 - \frac{\rho^2}{4R^2} \right) P_m + \frac{1}{4R^2} \sum_m \rho \beta$$

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

$$\Pi_m = P_m + \frac{1}{4R^2} \sum_n [J_{mn} + \sum_m \rho \beta]$$

$$[\Pi_m, \Pi_n] = \frac{1}{R^2} J_{mn}$$

We need find

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

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

$$\sum_n [2 J_{mn} p_n - 2 \xi_n p_n]$$

$$\sum_m \rho \beta - \sum_n p_n = \sum_m \rho \beta - \sum_n p_n$$

$$\rho \beta = \sum_m \rho \beta$$

$$\Pi_1 \Pi_2 - \Pi_2 \Pi_1$$

$$\Pi_1 \Pi_2 = \left(p_1 + \frac{1}{4R^2} \left[\xi_2 (\xi_1^2 - \xi_2^2) p_1 + 2 \xi_1 \xi_2 p_2 \right] \right) \left(p_2 + \frac{1}{4R^2} \left[-(\xi_1^2 - \xi_2^2) p_2 + 2 \xi_1 \xi_2 p_1 \right] \right)$$

$$= p_1 p_2 +$$

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

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

$$\xi_m \left[2 \xi_1 p_m - \xi_m p_m \right]$$

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

$$= 2 \xi_1^2 p_1 + 2 \xi_1 \xi_2 p_2 - \xi_1^2 p_1 - \xi_2^2 p_1$$

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

$$\xi_m (2 \xi_2 p_m - \xi_m p_m)$$

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

$$= 2 \xi_2^2 p_1 + 2 \xi_1 \xi_2 p_2 - \xi_1^2 p_2 - \xi_2^2 p_2$$

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

$$\square \text{Dirac} = \delta(x-z)$$

$$\text{Dirac} = \theta(x_0 - z_0) \delta^3(x - z)$$

$$\partial_\mu \delta^3(x) = \frac{1}{(2\pi)^4} \int d^4k \frac{e^{ik(x-z)}}{k^2 - 2i\epsilon k^0}$$

$$\partial_\mu \partial_\nu \text{Dirac} = \frac{1}{(2\pi)^4} \int d^4k \frac{k_\mu k_\nu e^{ik(x-z)}}{k^2 - 2i\epsilon k^0}$$

$$\partial_\mu \partial_\nu \partial_\alpha \partial_\beta \text{Dirac} = \int d^4k \frac{k_\mu k_\nu e^{ik(x-z)} e^{ik'(x-z)}}{(k^2 - 2i\epsilon k^0) (k'^2 - 2i\epsilon k'^0)}$$

$$= \int d^4k \frac{k_\mu k_\nu e^{i(k+k')(x-z)}}{(k^2 - 2i\epsilon k^0) (k'^2 - 2i\epsilon k'^0)}$$

$$T_{12} = K_{12} \frac{1}{z} - iK_{03} = iz \partial_z - iz^x \partial_{z^x} - \frac{im}{z} + iz \partial_z + iz^x \partial_{z^x} + \frac{1}{2}(p+2i)$$

$$T_{12} = 2iz \partial_z + \frac{p}{2} + i(1 - \frac{m}{2})$$

$$b_3 \sigma_1 \zeta_1 + b_3 \sigma_2 \zeta_2$$

$$R \frac{b_3 + b_1 \zeta_1 + b_2 \zeta_2}{b_3 - b_1 \zeta_1 - b_2 \zeta_2} = b_3 z + b_1 x + b_2 y$$

$$R \frac{1 + b_3 \sigma_1 \zeta_1 + b_3 \sigma_2 \zeta_2}{1 - b_3 \sigma_1 \zeta_1 - b_3 \sigma_2 \zeta_2} = z + b_3 \sigma_1 x + b_3 \sigma_2 y$$

$$R \frac{1 + i\sigma_2 \zeta_1 - i\sigma_1 \zeta_2}{1 - i\sigma_2 \zeta_1 + i\sigma_1 \zeta_2} = z + i\sigma_2 x - i\sigma_1 y$$

$$b_3 z + b_1 x + b_2 y = e^{\frac{a}{2R} \ln \frac{z}{z_0}} e^{-\frac{a}{2R} \ln \frac{z}{z_0}}$$

$$z' + b_1 x' + b_2 y' = e^{-\frac{a}{2R}}$$

$$(1 - i\sigma_2 \zeta_1 + i\sigma_1 \zeta_2)(1 + i\sigma_2 \zeta_1 - i\sigma_1 \zeta_2)$$

$$1 + i\sigma_2 \zeta_1 - i\sigma_1 \zeta_2$$

$$\zeta = b_1 \zeta_1 - b_2 \zeta_2 \quad a = \frac{a}{2R} \ln \frac{z}{z_0}$$

$$q = b_1 x - b_2 y \quad a = b_1 x - b_2 y$$

$$R \frac{1 + \zeta/R}{1 - \zeta/R} = z + q$$

$$e^{\frac{a}{2R}} (z + q) e^{\frac{a}{2R}}$$

$$\frac{1 + \zeta/R}{1 - \zeta/R} = \frac{z + q}{R}$$

$$\frac{1 + \zeta/R}{1 - \zeta/R} = e^{\frac{a}{2R}} \frac{1 + \zeta/R}{1 - \zeta/R} e^{\frac{a}{2R}}$$

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

$$\xi' = \left[\xi - a \left(1 - \frac{\xi}{2R} \right) \right] \left[1 - \frac{a}{2R} \left(1 - \frac{\xi}{2R} \right) \right]$$

$$\xi' = \xi - a \left(1 - \frac{\xi}{2R} \right) - \xi \frac{a}{2R} \left(1 - \frac{\xi}{2R} \right)$$

$$= \xi - a + a \frac{\xi}{2R} - \frac{\xi a}{2R} + \frac{\xi a \xi}{4R^2}$$

$$\xi' = \xi - a + \frac{\xi a}{2R} \left((a\xi - \xi a) + \frac{\xi a \xi}{4R^2} \right)$$

$$a = e_2 a_1 - e_1 a_2 \quad \xi = e_2 \xi_1 - e_1 \xi_2$$

$$a \xi = (e_2 a_1 - e_1 a_2) (e_2 \xi_1 - e_1 \xi_2) = -(a_1 \xi_1 + a_2 \xi_2) - e_3 a_2 \xi_1 + e_3 a_1 \xi_2$$

$$a \xi = -(a_1 \xi_1 + a_2 \xi_2) + e_3 (a_1 \xi_2 - a_2 \xi_1)$$

$$\xi a = +(a_1 \xi_1 + a_2 \xi_2) - e_3 (a_1 \xi_2 - a_2 \xi_1)$$

$$\frac{a \xi - \xi a}{2} = -e_3 (a_1 \xi_2 - a_2 \xi_1)$$

$$\xi a \xi = (e_2 \xi_1 - e_1 \xi_2) \left[-a_1 \xi + e_3 (a_1 \xi_2 - a_2 \xi_1) \right]$$

$$= -\begin{pmatrix} a_1 & a_2 \\ e_2 & -e_1 \end{pmatrix} \begin{pmatrix} \xi_1 \\ \xi_2 \end{pmatrix} + -(e_2 \xi_1 - e_1 \xi_2) (a_1 \xi_2 - a_2 \xi_1)$$

$$= -a_1 \xi_1 / R + (a_1 \xi_2 - a_2 \xi_1) \xi_2$$

$$+ (e_2 \xi_1 - e_1 \xi_2) \xi_2 - \xi_1 (e_2 \xi_1 - e_1 \xi_2)$$

$$\frac{1}{1-A} = 1+A$$

$$(1-A)^{-1}$$

$$\frac{1+A}{1-A} = B$$

$$(1+A)(1-A)^{-1} = B$$

$$1+A = B - AB$$

$$A+AB = B-1$$

$$A = (B-1)(B+1)^{-1}$$

$$A(1+B) = B-1$$

$$A = \frac{B-1}{B+1}$$

$$\frac{(1+A)(1+A)}{(1+A)^2} = \frac{1+A^2+2A}{1+2A+A^2}$$

$$\frac{e^{\frac{a}{2R}} \left(\frac{1 + \frac{3}{2R}}{1 - \frac{3}{2R}} e^{\frac{a}{2R}} - 1 \right)}{e^{\frac{a}{2R}} \left(\frac{1 + \frac{3}{2R}}{1 - \frac{3}{2R}} e^{\frac{a}{2R}} + 1 \right)} = \frac{\frac{1 + \frac{3}{2R}}{1 - \frac{3}{2R}} - e^{\frac{a}{2R}}}{\frac{1 + \frac{3}{2R}}{1 - \frac{3}{2R}} + e^{\frac{a}{2R}}}$$

$$\frac{3'}{2R} = \frac{\frac{1 + \frac{3}{2R}}{1 - \frac{3}{2R}} - 1 - \frac{a}{R}}{\frac{1 + \frac{3}{2R}}{1 - \frac{3}{2R}} + 1 + \frac{a}{R}} = \left(\frac{1 + \frac{3}{2R}}{1 - \frac{3}{2R}} - 1 - \frac{a}{R} \right) \left(\frac{1 + \frac{3}{2R}}{1 - \frac{3}{2R}} + 1 + \frac{a}{R} \right)^{-1}$$

$$\frac{1 + \frac{3}{2R}}{1 - \frac{3}{2R}} + 1 = \frac{1 + \frac{3}{2R} + 1 - \frac{3}{2R}}{1 - \frac{3}{2R}} = \frac{2}{1 - \frac{3}{2R}}$$

$$\frac{1 - \frac{3}{2R}}{1 - \frac{3}{2R}} - 1 = \frac{1 + \frac{3}{2R} - 1 + \frac{3}{2R}}{1 - \frac{3}{2R}} = \frac{3/R}{1 - \frac{3}{2R}}$$

$$\frac{3'}{2R} = \left(\frac{1}{R} \frac{3}{1 - \frac{3}{2R}} - \frac{a}{R} \right) \left(\frac{2}{1 - \frac{3}{2R}} + \frac{a}{R} \right)^{-1}$$

$$\frac{3'}{2} = \left(\frac{3}{1 - \frac{3}{2R}} - a \right) \left(\frac{2}{1 - \frac{3}{2R}} + \frac{a}{R} \right)^{-1}$$

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

$$\frac{z'}{2R} = \frac{1 + \frac{z}{2R} - 1 - \frac{a}{R}}{1 - \frac{z}{2R}} = \frac{1 + \frac{z}{2R} + 1 + \frac{a}{R}}{1 - \frac{z}{2R}}$$

$$1 + \frac{z}{2R} - 1 - \frac{a}{R}$$

$$= \frac{\frac{z}{2R} - \frac{a}{R}}{1 - \frac{z}{2R}} = \frac{\frac{z}{1 - \frac{z}{2R}} + \frac{a}{R}}{1 - \frac{z}{2R}}$$

$$\frac{z'}{2} = \frac{\frac{z}{1 - \frac{z}{2R}} - a}{1 - \frac{z}{2R}} = \frac{\frac{z}{1 - \frac{z}{2R}} + \frac{a}{R}}{1 - \frac{z}{2R}}$$

$$\frac{A-1}{A+1} = B$$

$$A = \frac{B+1}{B-1}$$

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

$$= \frac{1 + \frac{1}{2R} \sqrt{1 - \frac{z}{2R}} + \sqrt{1 - \frac{z}{2R}}}{1 - \frac{z}{2R}}$$

$$z' = \frac{\frac{z}{1 - \frac{z}{2R}} - a}{1 - \frac{z}{2R}}$$

$$\left(1 - \sqrt{\frac{z}{2R}} \sqrt{1 - \frac{z}{2R}} + \sqrt{1 - \frac{z}{2R}}\right) \frac{1}{1 - \frac{z}{2R}}$$

$$\left(\frac{z}{1 - \frac{z}{2R}} - a\right) \left(1 - \frac{z}{2R}\right)$$

$$z' = \frac{\frac{z}{1 - \frac{z}{2R}} - a}{1 - \frac{z}{2R}} = \frac{\frac{z}{1 - \frac{z}{2R}} - a}{\frac{1}{1 - \frac{z}{2R}} + \frac{a}{2R}}$$

$$= \frac{\frac{z}{1 - \frac{z}{2R}} - a}{\frac{1 + \frac{a}{2R} \left(1 - \frac{z}{2R}\right)}{1 - \frac{z}{2R}}}$$

$$z' = \left[\frac{z}{1 - \frac{z}{2R}} - a\right] \left[1 - \frac{z}{2R}\right] \frac{1}{1 + \frac{a}{2R} \left(1 - \frac{z}{2R}\right)}$$

$$= \frac{z}{1 - \frac{z}{2R}} - a - \frac{z}{2R} \left(1 - \frac{z}{2R}\right)$$

$$= \frac{z}{1 - \frac{z}{2R}} - a + \frac{z^2}{4R^2} - \frac{za}{2R} + \frac{za^2}{4R^2}$$

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

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

$$= \frac{z}{1 - \frac{z}{2R}} - a + \frac{z^2}{2R} + \frac{(z-a)(z+a)}{2R}$$

$$= \frac{z}{1 - \frac{z}{2R}} - a + \frac{1}{2R} \left[z^2 + z^2 - a^2 + 3za - az^3 \right]$$

$$= \frac{z}{1 - \frac{z}{2R}} - a + \frac{1}{2R} [2z^2 + 3za - a^2]$$

$$\frac{1 + \frac{z}{2R}}{1 - \frac{z}{2R}} = e^{\frac{a}{2R}} \frac{1 + \frac{z}{2R}}{1 - \frac{z}{2R}} e^{\frac{a}{2R}}$$

$$1 + \frac{z'}{R} = \left(1 + \frac{a}{2R}\right) \left(1 + \frac{z}{R}\right) \left(1 + \frac{a}{2R}\right)$$

$$= \left(1 + \frac{a}{2R}\right) \left(1 + \frac{z}{R} + \frac{a}{2R}\right)$$

$$\frac{z'}{R} = 1 + \frac{a}{2R} + \frac{z}{R} + \frac{a}{2R} = 1 + \frac{a+z}{2R} = 1 + \frac{z'}{R}$$

$$z' = z + \frac{a}{2} + \frac{z}{2} = z + \frac{a+z}{2} = z + z' \implies z' = a + z$$

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

$$= \left(1 + \frac{a}{2R}\right) \left(\frac{1 + \frac{z}{R}}{1 - \frac{z}{R}} + \frac{1 + \frac{z}{R}}{1 - \frac{z}{R}} \frac{a}{2R} \right)$$

$$= \frac{1 + \frac{z}{R}}{1 - \frac{z}{R}} + \frac{a}{2R} \frac{1 + \frac{z}{R}}{1 - \frac{z}{R}} + \frac{1 + \frac{z}{R}}{1 - \frac{z}{R}} \frac{a}{2R}$$

$$\sigma_3 z' + \sigma_1 x' + \sigma_2 y' = e^{\frac{a_1 z + a_2 x}{2R}} (b_3 z + b_1 x + b_2 y) e^{-\frac{a}{2R}}$$

$$z' + b_1 x' + b_2 y' = e^{-\frac{a}{2R}} (z + b_1 x + b_2 y)$$

$$\frac{1 + e_1 z + e_2 x}{1 - e_1 z - e_2 x} = \frac{(1 + e_1 z + e_2 x)^2}{(1 - e_1 z - e_2 x)(1 + e_1 z + e_2 x)}$$

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