Hilfedatei für 'Collapsing Schwarzschild interior'

Hilfsmetrik

#1……………………………………………………………………………………………

$$a_R = \sqrt{1-\frac{r^2}{\mathcal{R}_g^2}}, \quad v_R = -\frac{r}{\mathcal{R}_g}, \quad \mathcal{R}_g = \sqrt{\frac{r_g^3}{2M}}, \quad \alpha_R = \frac{1}{a_R}, \quad \partial_1 = \frac{\partial}{\alpha_R \partial r} = a_R \frac{\partial}{\partial r}$$

$$\frac{1}{a_R} a_{R|1} = \frac{1}{2a_R^2}\left(-v_R^2\right)_{|1} = -\alpha_R^2 v_R \left(-\frac{r}{\mathcal{R}_g}\right)_{|1} = \alpha_R v_R \frac{1}{\mathcal{R}_g} = \hat{U}_1$$

#2……………………………………………………………………………………………

$$B_1 = -\overset{2}{e}_2 \, \underset{2|1}{e^2} = \frac{1}{r} r_{|1} = \frac{a_R}{r}, \quad C_2 = -\overset{3}{e}_3 \, \underset{3|2}{e^3} = \frac{1}{r\sin\vartheta}\frac{\partial}{r\partial\vartheta}\left(r\sin\vartheta\right) = \frac{1}{r}\cot\vartheta$$

#3……………………………………………………………………………………………

$$\hat{A}_{41}{}^4 = -\overset{4}{e}_4 \, \underset{4|1}{e^4} = -a_R\left(\frac{1}{a_R}\right)_{|1} = \frac{1}{a_R} a_{R|1} = \hat{U}_1$$

#4……………………………………………………………………………………………

$$B_{1\|1} = \left(\frac{a_R}{r}\right)_{|1} = -\frac{a_R}{r^2} r_{|1} + B_1 \frac{1}{a_R} a_{R|1} = B_1 \hat{U}_1 \quad \text{mit } \#2,3$$

$$B_{1\|1} + B_1 B_1 = B_1 \alpha_R v_R \frac{1}{\mathcal{R}_g} = -\frac{1}{\mathcal{R}_g^2}$$

#5……………………………………………………………………………………………

$$C_{2|2} = \left(\frac{1}{r}\cot\vartheta\right)_{|2} = \frac{1}{r^2}\frac{\partial}{\partial\vartheta}\cot\vartheta = -\frac{1}{r^2}\left(1+\cot^2\vartheta\right), \quad C_{2|2} + C_2 C_2 = -\frac{1}{r^2}$$

$$C_{2\underset{3}{\|}2} + C_2 C_2 = C_{2|2} - B_{22}{}^1 C_1 + C_2 C_2 - \frac{1}{r^2} + \frac{a_R^2}{r^2} = -\frac{v_R^2}{r^2} = -\frac{1}{\mathcal{R}_g^2}$$

#6……………………………………………………………………………………………

$$\hat{U}^s{}_{|s} = \left(\alpha_R v_R \frac{1}{\mathcal{R}_g}\right)_{|1} = \alpha_R^3 v_{R|1} \frac{1}{\mathcal{R}_g} = -\alpha_R^2 \frac{1}{\mathcal{R}_g^2}, \quad \hat{U}^s{}_{|s} + \hat{U}^s \hat{U}_s = \left(\alpha_R^2 v_R^2 - \alpha_R^2\right)\frac{1}{\mathcal{R}_g^2} = -\frac{1}{\mathcal{R}_g^2}$$

#7…………………………………………………………………………………………………..

$$R_{mn} = A_{mn}{}^{s}{}_{|s} - A_{n|m} - A_{rm}{}^{s}A_{sn}{}^{r} + A_{mn}{}^{s}A_{s}, \quad A_{s} = A_{rs}{}^{r}$$

$$= -B_{mn}{}^{s}{}_{|s} - C_{mn}{}^{s}{}_{|s} - \hat{U}_{mn}{}^{s}{}_{|s}$$

$$- B_{n|m} - C_{n|m} - \hat{U}_{n|m}$$

$$- \left[B_{rm}{}^{s} + C_{rm}{}^{s} + \hat{U}_{rm}{}^{s}\right]\left[B_{sn}{}^{r} + C_{sn}{}^{r} + \hat{U}_{sn}{}^{r}\right]$$

$$+ \left[B_{mn}{}^{s} + C_{mn}{}^{s} + \hat{U}_{mn}{}^{s}\right]\left[B_{s} + C_{s} + \hat{U}_{s}\right]$$

$$I = -\left[b_m b_n B^{s}{}_{|s} + c_m c_n C^{s}{}_{|s} + u_m u_n \hat{U}^{s}{}_{|s}\right]$$

$$III = -\left[B_{rm}{}^{s}B_{sn}{}^{r} + C_{rm}{}^{s}B_{sn}{}^{r} + \hat{U}_{rm}{}^{s}B_{sn}{}^{r}\right]$$

$$-\left[B_{rm}{}^{s}C_{sn}{}^{r} + C_{rm}{}^{s}C_{sn}{}^{r} + \hat{U}_{rm}{}^{s}C_{sn}{}^{r}\right]$$

$$-\left[B_{rm}{}^{s}\hat{U}_{sn}{}^{r} + C_{rm}{}^{s}\hat{U}_{sn}{}^{r} + \hat{U}_{rm}{}^{s}\hat{U}_{sn}{}^{r}\right]$$

$$= -\left[B_m B_n + C_m C_n + \hat{U}_m \hat{U}_n\right]$$

$$IV = -b_m b_n B^{s} B_{s} - c_m c_n B_{s} C^{s} - \hat{U}_{mn}{}^{s} B_{s}$$

$$+ B_{mn}{}^{s} C_{s} - c_m c_n C_{s} C^{s} - \hat{U}_{mn}{}^{s} C_{s}$$

$$- b_m b_n \hat{U}_{s} B^{s} - c_m c_n \hat{U}_{s} C^{s} - u_m u_n \hat{U}_{s} \hat{U}^{s}$$

$$R_{mn} = -\left[\hat{U}_{n|m} + \hat{U}_n \hat{U}_m\right] - u_m u_n \left[\hat{U}^{s}{}_{|s} + \hat{U}^{s}\hat{U}_{s}\right]$$

$$-\left[B_{n|m} - \hat{U}_{mn}{}^{s}B_{s} + B_n B_m\right] - b_m b_n \left[B^{s}{}_{|s} + \hat{U}_{s}B^{s} + B^{s}B_{s}\right]$$

$$-\left[C_{n|m} - \hat{U}_{mn}{}^{s}C_{s} - B_{mn}{}^{s}C_{s} + C_n C_m\right] - c_m c_n \left[C^{s}{}_{|s} + \hat{U}_{s}C^{s} + B_{s}C^{s} + C^{s}C_{s}\right]$$

$$R_{mn} = -\left[\hat{U}^{s}{}_{\underset{1}{||}s} + \hat{U}^{s}\hat{U}_{s}\right] h_{mn}$$

$$-\left[B_{n\underset{2}{||}m} + B_n B_m\right] - b_m b_n \left[B^{s}{}_{\underset{2}{||}s} + B^{s}B_{s}\right]$$

$$-\left[C_{n\underset{3}{||}m} + C_n C_m\right] - c_m c_n \left[C^{s}{}_{\underset{3}{||}s} + C^{s}C_{s}\right]$$

$$h_{mn} = \begin{pmatrix} 1 & & & \\ & 0 & & \\ & & 0 & \\ & & & 1 \end{pmatrix}$$

Schwarzschild innere Metrik

#8……………………………………………………………………………………………………..

$$U_1 = \mathcal{p}\hat{U}_1, \quad \mathcal{p}_{|1} = (1-\mathcal{p})U_1$$

$$\mathcal{p}\left[\hat{U}_{1\|1} + \hat{U}_1\hat{U}_1\right] = U_{1\|1} - \hat{U}_1\mathcal{p}_{|1} + \hat{U}_1 U_1 = U_{1\|1} - \hat{U}_1(1-\mathcal{p})\mathcal{p}\hat{U}_1 + U_1\hat{U}_1 = U_{1\|1} + U_1U_1$$

$$U_{1\|1} + U_1U_1 = \mathcal{p}\left[\hat{U}_{1\|1} + \hat{U}_1\hat{U}_1\right]$$

#9……………………………………………………………………………………………………..

$$B_{\underset{2}{n\|m}} + B_nB_m = B_{n|m} - U_{mn}{}^{s}B_s + B_nB_m$$

$$B_{\underset{2}{4\|4}} + B_4B_4 = -U_{44}{}^{1}B_1 = U_1B_1 = -\frac{\mathcal{p}}{\mathcal{R}_g^2}$$

$$B_{\underset{2}{n\|m}} + B_nB_m = -\begin{pmatrix} 1 & & & \\ & 0 & & \\ & & 0 & \\ & & & \mathcal{p} \end{pmatrix}\frac{1}{\mathcal{R}_g^2}$$

Kollabierendes Modell

#10……………………………………………………………………………………………………..

$$v_{l|1'} = -\left(\frac{r'}{\mathcal{R}_0}\right)_{|1'} = v_l\frac{1}{r'}r'_{|1'} = a_l v_l\frac{1}{r}, \quad v_{l|m'} = \{1,0,0,0\}a_l v_l\frac{1}{r}, \quad v_{l|m} = \{\alpha_C, 0, 0, i\alpha_C v_C\}a_l v_l\frac{1}{r}$$

#11……………………………………………………………………………………………………..

$$\frac{1}{\mathcal{R}_g}\mathcal{R}_{g|m} = \frac{1}{\mathcal{R}_g}\frac{1}{\sqrt{2M}}\left(r_g^{3/2}\right)_{|m} = \frac{3}{2}\frac{1}{r_g}r_{g|m}$$

$$\mathcal{F}_m = \frac{1}{\mathcal{R}_g}\mathcal{R}_{g|m} = \frac{3}{2}\frac{1}{r_g}r_{g|m}$$

#12……………………………………………………………………………………………………..

$$L^{1}_{1'} = \alpha_C, \quad L^{4}_{1'} = i\alpha_C v_C, \quad L^{1}_{4'} = -i\alpha_C v_C, \quad L^{4}_{4'} = \alpha_C$$

$$v_C = \frac{v_R - v_l}{1 - v_R v_l}, \quad v_R = \frac{v_C + v_l}{1 + v_C v_l}, \quad v_l = \frac{v_R - v_C}{1 - v_R v_C}$$

$$\alpha_C = \alpha_R\alpha_l(1 - v_R v_l), \quad \alpha_R = \alpha_C\alpha_l(1 + v_C v_l), \quad \alpha_l = \alpha_C\alpha_R(1 - v_C v_R)$$

$$\alpha_C v_C = \alpha_R\alpha_l(v_R - v_l), \quad \alpha_R v_R = \alpha_C\alpha_l(v_C + v_l), \quad \alpha_l v_l = \alpha_R\alpha_C(v_R - v_C)$$

#13………………………………………………………………………………………………

$$\hat{U}_{1'} = \hat{A}_{4'1'}{}^{4'} = L^{4\,1\,4'}_{4'1'4}\hat{A}_{41}{}^{4} + L^{4\,4\,4'}_{4'1'1}\hat{A}_{44}{}^{1} = \alpha_C^3\hat{U}_1 - \alpha_C\left(i\alpha_C v_C\right)\left(-i\alpha_C v_C\right)\hat{U}_1 = \alpha_C\hat{U}_1$$

$$\hat{U}_{4'} = \hat{A}_{1'4'}{}^{1'} = L^{4\,1\,1'}_{1'4'4}\hat{A}_{41}{}^{4} + L^{4\,4\,1'}_{1'4'1}\hat{A}_{44}{}^{1} = \left(i\alpha_C v_C\right)^2\left(-i\alpha_C v_C\right)\hat{U}_1 - \alpha_C^2\left(i\alpha_C v_C\right)\hat{U}_1 = -i\alpha_C v_C\hat{U}_1$$

#14………………………………………………………………………………………………

$$'\hat{L}_{1'} = {}'\hat{L}_{4'1'}{}^{4'} = L_s^{4'}L^{s}_{1'|4'} = L_1^{4'}L^{1}_{1'|4'} + L_4^{4'}L^{4}_{1'|4'} = -i\alpha_C v_C\alpha_{C|4'} + \alpha_C\left(i\alpha_C v_C\right)_{|4'} = i\alpha_C^2 v_{C|4'}$$

$$= i\left(\alpha_R^2 v_{R|4'} - \alpha_I^2 v_{I|4'}\right) = -i\alpha_C v_C i\alpha_R^2 v_{R|1} = \alpha_C v_C\alpha_R^2\left(-a_R\frac{1}{\mathcal{R}_g}\right) = -\alpha_C v_C\alpha_R\frac{1}{\mathcal{R}_g} = -G_{1'}$$

$$'\hat{L}_{4'} = {}'\hat{L}_{1'4'}{}^{1'} = L_s^{1'}L^{s}_{4'|1'} = L_1^{1'}L^{1}_{4'|1'} + L_4^{1'}L^{4}_{4'|1'} = \alpha_C\left(-i\alpha_C v_C\right)_{|1'} + i\alpha_C v_C\alpha_{C|1'} = -i\alpha_C^2 v_{C|1'}$$

$$= -i\left(\alpha_R^2 v_{R|1'} - \alpha_I^2 v_{I|1'}\right) = -i\left(-\alpha_C\alpha_R^2 a_R\frac{1}{\mathcal{R}_g} - \alpha_I^2 a_I v_I\frac{1}{r}\right) = i\alpha_C\alpha_R\frac{1}{\mathcal{R}_g} + i\alpha_I v_I\frac{1}{r} = -G_{4'} + I_{4'}$$

#15………………………………………………………………………………………………

$$g_{1'} = \hat{U}_{1'} - G_{1'} = \alpha_C\alpha_R v_R\frac{1}{\mathcal{R}_g} - \alpha_C v_C\alpha_R\frac{1}{\mathcal{R}_g} = \alpha_C\alpha_R\left(v_R - v_C\right)\frac{1}{\mathcal{R}_g} = \alpha_I v_I\frac{1}{\mathcal{R}_g}$$

$$'U_{1'} = \mathcal{P}\alpha_I v_I\frac{1}{\mathcal{R}_g}$$

$$'U_{4'} = \hat{U}_{4'} - G_{4'} + I_{4'} = -i\alpha_C v_C\alpha_R v_R\frac{1}{\mathcal{R}_g} + i\alpha_C\alpha_R\frac{1}{\mathcal{R}_g} + i\alpha_I v_I\frac{1}{r}$$

$$= i\alpha_C\alpha_R\left(1 - v_C v_R\right)\frac{1}{\mathcal{R}_g} + i\alpha_C\alpha_R\left(v_R - v_C\right)\frac{1}{r}$$

$$= i\alpha_I\frac{1}{\mathcal{R}_g} + i\alpha_I v_I\frac{1}{r} = i\alpha_I\left(v_I - v_R\right)\frac{1}{r} = -i\alpha_C v_C\frac{1}{\alpha_R}\frac{1}{r} = -i\alpha_C v_C a_R\frac{1}{r}$$

#16………………………………………………………………………………………………

$$T^{4'n'}{}_{||n'} = T^{4'n'}{}_{|n'} + {}'A_{n'r'}{}^{4'}T^{r'n'} + {}'A_{n'}T^{4'n'}$$

$$= T^{4'4'}{}_{|4'} + {}'A_{1'1'}{}^{4'}T^{1'1'} + {}'A_{2'2'}{}^{4'}T^{2'2'} + {}'A_{3'3'}{}^{4'}T^{3'3'} + {}'A_{4'}T^{4'4'}$$

$$= \mu_{0|4'} + p\left({}'U_{4'} + B_{4'} + C_{4'}\right) + \mu_0\left({}'U_{4'} + B_{4'} + C_{4'}\right) = 0$$

$$\mu_{0|4'} = -3\left(p + \mu_0\right){}'U_{4'}$$

$$\kappa\mu_{0|4'} = \left(\frac{3}{\mathcal{R}_g^2}\right)_{|4'} = -2\cdot 3\frac{1}{\mathcal{R}_g^3}\mathcal{R}_{4'} = -2\,\kappa\mu_0\mathcal{F}_{4'}, \quad \mu_{0|4'} = -2\mu_0\mathcal{F}_{4'}$$

$$2\mu_0\mathcal{F}_{4'} = 3\left(p + \mu_0\right){}'U_{4'} = 2\left(1 - \mathcal{P}\right)\mu_0\,{}'U_{4'}$$

$$\mathcal{F}_{4'} = \left(1 - \mathcal{P}\right){}'U_{4'} = -i\alpha_C v_C\left(1 - \mathcal{P}\right)\frac{a_R}{r}, \quad \mathcal{F}_{1'} = 0, \quad \mathcal{F}_m = \left\{-i\alpha_C v_C, 0, 0, \alpha_C\right\}\left(-i\alpha_C v_C\right)\left(1 - \mathcal{P}\right)\frac{a_R}{r}$$

#17……………………………………………………………………………………………………

$$T^{1'n'}{}_{||n'} = T^{1'n'}{}_{|n'} + {}'A_{n'r'}{}^{1'}T^{r'n'} + {}'A_{n'}T^{1'n'}$$
$$= T^{1'1'}{}_{|1'} + {}'A_{2'2'}{}^{1'}T^{2'2'} + {}'A_{3'3'}{}^{1'}T^{3'3'} + {}'A_{4'4'}{}^{1'}T^{4'4'} + {}'A_{1'}T^{1'1'}$$
$$= -p_{|1'} + p\left(B_{1'} + C_{1'}\right) - \mu_0\,{}'U_{1'} - p\left(B_{1'} + C_{1'} + {}'U_{1'}\right)$$
$$= -p_{|1'} - \left(p + \mu_0\right){}'U_{1'} = 0$$

$$p_{|1'} = -\left(p + \mu_0\right){}'U_{1'}$$
$$\kappa p_{|1'} = \left[-\frac{1}{\mathcal{R}_g^2}\left(1 + 2\mathcal{p}\right)\right]_{|1'} = -\frac{2}{\mathcal{R}_g^2}\mathcal{p}_{|1'}$$
$$\kappa\left(p + \mu_0\right){}'U_{1'} = \frac{2}{\mathcal{R}_g^2}\mathcal{p}_{|1'}$$
$$\mathcal{p}_{|1'} = \left(1 - \mathcal{p}\right){}'U_{1'}$$

#18……………………………………………………………………………………………………

$$v_{R|1} = \left(-\frac{r}{\mathcal{R}_g}\right)_{|1} = -\frac{1}{\mathcal{R}_g}r_{|1} + \frac{r}{\mathcal{R}_g^2}\mathcal{R}_{g|1} = -\frac{a_R}{\mathcal{R}_g} - v_R\mathcal{F}_1, \quad v_{R|4} = \left(-\frac{r}{\mathcal{R}_g}\right)_{|4} = -\frac{1}{\mathcal{R}_g}r_{|4} + \frac{r}{\mathcal{R}_g^2}\mathcal{R}_{g|4} = -v_R\mathcal{F}_4$$
$$v_{R|m} = \left\{1,0,0,0\right\}\left(-\frac{a_R}{\mathcal{R}_g}\right) - v_R\mathcal{F}_m$$
$$\frac{1}{\alpha_R}\alpha_{R|1} = \alpha_R^2 v_R v_{R|1} = \alpha_R^2 v_R\left(-\frac{a_R}{\mathcal{R}_g} - v_R\mathcal{F}_1\right) = -\alpha_R v_R\frac{1}{\mathcal{R}_g} - \alpha_R^2 v_R^2\mathcal{F}_1$$
$$\frac{1}{\alpha_R}\alpha_{R|4} = \alpha_R^2 v_R v_{R|4} = \alpha_R^2 v_R\left(-v_R\mathcal{F}_4\right) = -\alpha_R^2 v_R^2\mathcal{F}_4$$
$$\frac{1}{\alpha_R}\alpha_{R|m} = -\hat{U}_m - \alpha_R^2 v_R^2\mathcal{F}_m, \quad \hat{U}_m = \left\{1,0,0,0\right\}\alpha_R v_R\frac{1}{\mathcal{R}_g}$$
$$\frac{1}{\alpha_R}\alpha_{R|m'} = -\hat{U}_{m'} - \alpha_R^2 v_R^2\mathcal{F}_{m'}, \quad \hat{U}_{m'} = \left\{\alpha_C, 0, 0, -i\alpha_C v_C\right\}\alpha_R v_R\frac{1}{\mathcal{R}_g}, \quad \mathcal{F}_{1'} = 0$$

$$\frac{1}{\alpha_R}\alpha_{R|1'} = -\hat{U}_{1'}$$
$$\frac{1}{\alpha_R}\alpha_{R|4'} = -\hat{U}_{4'} - \alpha_R^2 v_R^2\mathcal{F}_{4'} = i\alpha_C v_C\alpha_R v_R\frac{1}{\mathcal{R}_g} - \alpha_R^2 v_R^2\left(-i\alpha_C v_C\right)\left(1 - \mathcal{p}\right)\frac{\alpha_R}{r}$$
$$= i\alpha_C v_C\alpha_R v_R\frac{1}{\mathcal{R}_g} - i_C v_C\left(1 - \mathcal{p}\right)\alpha_R v_R\frac{1}{\mathcal{R}_g} = i\alpha_C v_C\mathcal{p}\alpha_R v_R\frac{1}{\mathcal{R}_g} = -\mathcal{p}\hat{U}_{4'}$$
$$\frac{1}{\alpha_R}\alpha_{R|m'} = \left\{-\hat{U}_{1'}, 0, 0, -\mathcal{p}\hat{U}_{4'}\right\}$$

$$\alpha_C^2 v_{C|1'} = \alpha_R^2 v_{R|1'} - \alpha_I^2 v_{I|1'} = \alpha_R^2 \left(-\alpha_C a_R \frac{1}{\mathcal{R}_g} \right) - \alpha_I^2 a_I v_I \frac{1}{r}$$

$$= -\alpha_C \alpha_R \frac{1}{\mathcal{R}_g} - \alpha_I v_I \frac{1}{r} = -\alpha_C \alpha_R \frac{1}{\mathcal{R}_g} - \alpha_C \alpha_R \left(v_R - v_C \right) \frac{1}{r} = \alpha_C v_C \alpha_R \frac{1}{r}$$

$$\alpha_C^2 v_{C|4'} = \alpha_R^2 v_{R|4'} - \alpha_I^2 v_{I|4'} = \alpha_R^2 \left(i\alpha_C v_C a_R \frac{1}{\mathcal{R}_g} - v_R \mathcal{F}_{4'} \right) = i\alpha_C v_C \alpha_R \frac{1}{\mathcal{R}_g} - \alpha_R^2 v_R \left[-i\alpha_C v_C \left(1 - \mathfrak{p} \right) \frac{a_R}{r} \right]$$

$$= i\alpha_C v_C \alpha_R \frac{1}{\mathcal{R}_g} - i\alpha_C v_C \left(1 - \mathfrak{p} \right) \alpha_R \frac{1}{\mathcal{R}_g} = i\alpha_C v_C \alpha_R \mathfrak{p} \frac{1}{\mathcal{R}_g}$$

$$\frac{1}{\alpha_C} \alpha_{C|1'} = \alpha_C^2 v_C v_{C|1'} = \alpha_C v_C^2 \alpha_R \frac{1}{r}, \quad \frac{1}{\alpha_C} \alpha_{C|4'} = \alpha_C^2 v_C v_{C|4'} = -i\alpha_C v_C^2 \mathfrak{p} \alpha_R \frac{1}{\mathcal{R}_g}$$

$$\alpha_C^2 v_{C|1} = \alpha_R^2 v_{R|1} - \alpha_I^2 v_{I|1} = \alpha_R^2 \left(-a_R \frac{1}{\mathcal{R}_g} - v_R \mathcal{F}_1 \right) - \alpha_I^2 \alpha_C a_I v_I \frac{1}{r}$$

$$= -\alpha_R \frac{1}{\mathcal{R}_g} - \alpha_R^2 v_R \left(-\alpha_C^2 v_C^2 \right) \left(1 - \mathfrak{p} \right) \frac{a_R}{r} - \alpha_C \alpha_I v_I \frac{1}{r}$$

$$= -\alpha_R \frac{1}{\mathcal{R}_g} - \alpha_C^2 v_C^2 \left(1 - \mathfrak{p} \right) \alpha_R \frac{1}{\mathcal{R}_g} - \alpha_C \alpha_I v_I \frac{1}{r}$$

$$= -\alpha_C^2 \alpha_R \frac{1}{\mathcal{R}_g} + \alpha_C^2 v_C^2 \mathfrak{p} \alpha_R \frac{1}{\mathcal{R}_g} - \alpha_C^2 \alpha_R \left(v_R - v_C \right) \frac{1}{r} = \alpha_C^2 v_C \alpha_R \frac{1}{r} + \alpha_C^2 v_C^2 \mathfrak{p} \alpha_R \frac{1}{\mathcal{R}_g}$$

$$v_{C|1} = v_C \alpha_R \frac{1}{r} + v_C^2 \mathfrak{p} \alpha_R \frac{1}{\mathcal{R}_g}$$

$$\alpha_C^2 v_{C|4} = \alpha_R^2 v_{R|4} - \alpha_I^2 v_{I|4} = -i\alpha_C^2 v_C \left(1 - \mathfrak{p} \right) \alpha_R \frac{1}{\mathcal{R}_g} - \alpha_I^2 \, i\alpha_C v_C a_I v_I \frac{1}{r}$$

$$= -i\alpha_C^2 v_C \alpha_R \frac{1}{\mathcal{R}_g} + i\,\alpha_C^2 v_C \mathfrak{p} \alpha_R \frac{1}{\mathcal{R}_g} - i\alpha_C v_C \alpha_I v_I \frac{1}{r}$$

$$= -i\alpha_C^2 v_C \alpha_R \frac{1}{\mathcal{R}_g} + i\alpha_C^2 v_C \mathfrak{p} \alpha_R \frac{1}{\mathcal{R}_g} - i\alpha_C v_C \alpha_C \alpha_R \left(v_R - v_C \right) \frac{1}{r} = i\alpha_C^2 v_C^2 \alpha_R \frac{1}{r} + i\alpha_C^2 v_C \mathfrak{p} \alpha_R \frac{1}{\mathcal{R}_g}$$

$$v_{C|4} = i v_C^2 \alpha_R \frac{1}{r} + i\, v_C \mathfrak{p} \alpha_R \frac{1}{\mathcal{R}_g}$$

#19……………………………………………………………………………………………………..

$$L_1 = -i\alpha_C^2 v_{C|4} = -i\left(\alpha_R^2 v_{R|4} - \alpha_I^2 v_{I|4}\right) = -i\alpha_R^2\left(-v_R \mathcal{F}_4\right) - \alpha_C v_C \alpha_I v_I \frac{1}{r}$$

$$= i\alpha_R^2 v_R\left(1-\mathfrak{p}\right)\left(-i\alpha_C^2 v_C\right)\frac{a_R}{r} - I_1 = \left(1-\mathfrak{p}\right)\alpha_C^2 v_C \alpha_R v_R \frac{1}{r} - I_1 = -\left(1-\mathfrak{p}\right)\alpha_C^2 v_C \alpha_R \frac{1}{\mathcal{R}_g} = -f_1 - I_1$$

$$L_4 = i\alpha_C^2 v_{C|1} = i\left(\alpha_R^2 v_{R|1} - \alpha_I^2 v_{I|1}\right) = i\left[\alpha_R^2\left(-\frac{a_R}{\mathcal{R}_g} - v_R \mathcal{F}_1\right) - \alpha_I^2 a_I v_I \frac{1}{r}\right]$$

$$= -i\alpha_R \frac{1}{\mathcal{R}_g} - i\alpha_R^2 v_R\left(1-\mathfrak{p}\right)\left(-i\alpha_C v_C\right)\left(-i\alpha_C v_C\right)\frac{a_R}{r} - \alpha_I v_I \frac{1}{r}$$

$$= G_4 - I_4 - \left(1-\mathfrak{p}\right)\alpha_C^2 v_C^2 \alpha_R \frac{1}{\mathcal{R}_g} = G_4 - I_4 - f_4$$

#20……………………………………………………………………………………………………….

$${}'R_{m'n'} = L^{m\,n}_{m'n'} R_{mn} + {}'L_{m'n'}$$

$${}'L_{m'n'} = {}'L_{m'n'}{}^{s'}{}_{|s'} - {}'L_{n'|m'} - {}'L_{r'm'}{}^{s'}\,{}'L_{s'n'}{}^{r'} + {}'L_{m'n'}{}^{s'}\,{}'L_{s'} + 2A_{[m'r']}{}^{s'}\,{}'L_{s'n'}{}^{r'}$$

$$I + II = \left[h_{m'}{}^{s'}\,{}'L_{n'} - h_{m'n'}\,{}'L^{s'}\right]_{|s'} - {}'L_{n'|m'} = {}'L_{n'|m'} - h_{m'n'}\,{}'L^{s'}{}_{|s'} - {}'L_{n'|m'} = -h_{m'n'}\,{}'L^{s'}{}_{|s'}$$

$$III = -\left[h_{r'}{}^{s'}\,{}'L_{m'} - h_{r'm'}\,{}'L^{s'}\right]\left[h_{s'}{}^{r'}\,{}'L_{n'} - h_{s'n'}\,{}'L^{r'}\right]$$

$$= -\left[2\,{}'L_{m'}{}'L_{n'} - {}'L_{m'}{}'L_{n'} - {}'L_{m'}{}'L_{n'} + {}'L_{m'}{}'L_{n'}\right] = -{}'L_{m'}{}'L_{n'}$$

$$IV = \left[h_{m'}{}^{s'}\,{}'L_{n'} - h_{m'n'}\,{}'L^{s'}\right]{}'L_{s'} = {}'L_{m'}{}'L_{n'} - h_{m'n'}\,{}'L^{s'}\,{}'L_{s'}$$

$$V = 2A_{[m'r']}{}^{s'}\,{}'L_{s'n'}{}^{r'} = \left(U_{m'r'}{}^{s'} - U_{r'm'}{}^{s'}\right)\left(h_{s'}{}^{r'}\,{}'L_{n'} - h_{s'n'}\,{}'L^{r'}\right)$$

$$= -U_{m'}\,{}'L_{n'} - U_{m'r'n'}\,{}'L^{r'} + U_{r'm'n'}\,{}'L^{r'}$$

$$= -U_{m'}\,{}'L_{n'} - h_{m'n'}U_{r'}\,{}'L^{r'} + h_{m'r'}U_{n'}\,{}'L^{r'} + h_{r'n'}U_{m'}\,{}'L^{r'} - h_{r'm'}U_{n'}\,{}'L^{r'}$$

$$= -U_{m'}\,{}'L_{n'} - h_{m'n'}U_{r'}\,{}'L^{r'} + U_{n'}\,{}'L_{m'} + U_{m'}\,{}'L_{n'} - U_{n'}\,{}'L_{m'} = -h_{m'n'}U_{r'}\,{}'L^{r'}$$

$${}'L_{m'n'} = -h_{m'n'}\left[{}'L^{s'}{}_{|s'} + U_s\,{}'L^{s'} + {}'L^{s'}\,{}'L_{s'}\right] = -h_{m'n'}\left[{}'L^{s'}{}_{|s'} + {}'U_s\,{}'L^{s'}\right] = 0$$

$$R_{m'n'} = L^{m\,n}_{m'n'} R_{mn}, \quad {}'L^{s'}{}_{|s'} + {}'U_s\,{}'L^{s'} = 0$$

#21……………………………………………………………………………………………………

$$G_{1'|1'}=\left(\alpha_C v_C \alpha_R \frac{1}{\mathcal{R}_g}\right)_{|1'}=\left(\alpha_C v_C\right)_{|1'}\alpha_R\frac{1}{\mathcal{R}_g}+\alpha_C v_C \alpha_{R|1'}\frac{1}{\mathcal{R}_g}=\alpha_C^3 v_{C|1'}\alpha_R\frac{1}{\mathcal{R}_g}+\frac{1}{\alpha_C}\alpha_{R|1'}G_{1'}$$

$$\frac{1}{\alpha_R}\alpha_{R|m'}=-\hat{U}_{m'}-\alpha_R^2 v_R^2 \mathcal{F}_{m'}\qquad \mathcal{F}_{1'}=0$$

$$G_{1'|1'}=i\alpha_C^2 v_{C|1'}\left(-i\alpha_C\alpha_R\frac{1}{\mathcal{R}_g}\right)-\hat{U}_{1'}G_{1'}=-G_{4'}\,{}'L_{4'}-\hat{U}_{1'}G_{1'}$$

$$G_{4'|4'}=\left(-i\alpha_C\alpha_R\frac{1}{\mathcal{R}_g}\right)_{|4'}=-i\left(\alpha_{C|4'}\alpha_R+\alpha_C\alpha_{R|4'}\right)\frac{1}{\mathcal{R}_g}+i\alpha_C\alpha_R\frac{1}{\mathcal{R}_g^2}\mathcal{R}_{g|4'}$$

$$=\left(\frac{1}{\alpha_C}\alpha_{C|4'}+\frac{1}{\alpha_R}\alpha_{R|4'}\right)G_{4'}-G_{4'}\mathcal{F}_{4'}=\left(\alpha_C^2 v_C v_{C|4'}-\hat{U}_{4'}-\alpha_R^2 v_R^2 \mathcal{F}_{4'}\right)G_{4'}-\mathcal{F}_{4'}G_{4'}$$

$$G_{4'|4'}=-{}'L_{1'}G_{1'}-\hat{U}_{4'}G_{4'}-\alpha_R^2\mathcal{F}_{4'}G_{4'}$$

$${}'L_{4'}=-G_{4'}+l_{4'}=i\alpha_C\alpha_R\frac{1}{\mathcal{R}_g}+i\alpha_l v_l\frac{1}{r}=-i\alpha_C\alpha_R v_R\frac{1}{r}+i\alpha_C\alpha_R\left(v_R-v_C\right)\frac{1}{r}=-i\alpha_C v_C\alpha_R\frac{1}{r}$$

$$\alpha_R^2\mathcal{F}_{4'}=-\left(1-\mathcal{P}\right)i\alpha_C v_C\alpha_R\frac{1}{r}=\left(1-\mathcal{P}\right){}'L_{4'}$$

$$G_{4'|4'}=-{}'L_{1'}G_{1'}-\hat{U}_{4'}G_{4'}-\left(1-\mathcal{P}\right){}'L_{4'}G_{4'}$$

$$G^{s'}{}_{|s'}+{}'L_{s'}G^{s'}=-\hat{U}^{s'}G_{s'}-\left(1-\mathcal{P}\right)G_{4'}\,{}'L_{4'},\quad \hat{U}^{s'}G_{s'}=\hat{U}^{s}G_{s}=0$$

$$G^{s'}{}_{|s'}+{}'L_{s'}G^{s'}=-\left(1-\mathcal{P}\right)G_{4'}\,{}'L_{4'}$$

$$l_{1'}=0,\quad l_{4'}=i\alpha_l v_l\frac{1}{r}$$

$$l_{4'|4'}=-i\alpha_l v_l\frac{1}{r^2}r_{|4'}=-l_{4'}\,{}'U_{4'}$$

$$l^{s'}{}_{|s'}=-l^{s'}\,{}'U_{s'}$$

$$f_{1'}=\left(1-\mathcal{P}\right)G_{1'},\quad f_{4'}=0,\quad \mathcal{P}_{|1'}=\left(1-\mathcal{P}\right){}'U_{1'}$$

$$f_{1'|1'}=\left(1-\mathcal{P}\right)G_{1'|1'}-G_{1'}\mathcal{P}_{|1'}=\left(1-\mathcal{P}\right)\left(-{}'L_{4'}G_{4'}-\hat{U}_{1'}G_{1'}\right)-G_{1'}\left(1-\mathcal{P}\right){}'U_{1'}$$

$$f^{s'}{}_{|s'}=-\left(1-\mathcal{P}\right)\left({}'L_{4'}G_{4'}+\hat{U}_{1'}G_{1'}+{}'U_{1'}G_{1'}\right)$$

$${}'L^{s'}{}_{|s'}=-G^{s'}{}_{|s'}+l^{s'}{}_{|s'}+f^{s'}{}_{|s'}$$

$$={}'L^{s'}G_{s'}+\left(1-\mathcal{P}\right){}'L_{4'}G_{4'}$$

$$-l^{s'}\,{}'U_{s'}$$

$$-\left(1-\mathcal{P}\right)\left[{}'L_{4'}G_{4'}+\hat{U}_{1'}G_{1'}+{}'U_{1'}G_{1'}\right]$$

$$'L^{s'}{}_{|s'} + 'U_{s'}\,'L^{s'} = \left[-G^{s'} + l^{s'} + f^{s'}\right]'U_{s'} + 'L^{s'}G_{s'} - l^{s'}\,'U_{s'} - (1-\wp)\left(\hat{U}_{1'} + 'U_{1'}\right)G_{1'}$$

$$= -G^{s'}\,'U_{s'} + 'L^{s'}G_{s'} + (1-\wp)G_{1'}\,'U_{1'} - (1-\wp)G_{1'}\,'U_{1'} - (1-\wp)\hat{U}_{1'}G_{1'}$$

$$= -G^{s'}\,'U_{s'} - \hat{U}_{1'}G_{1'} + \wp\hat{U}_{1'}G_{1'} = -G_{1'}\wp\hat{U}_{1'} - G_{4'}\,'U_{4'} - \hat{U}_{1'}G_{1'} + \wp\hat{U}_{1'}G_{1'} = -G^{s'}\hat{U}_{s'} = -G^{s}\hat{U}_{s} = 0$$

$$'L^{s'}{}_{|s'} + 'U_{s'}\,'L^{s'} = 0$$

#22……………………………………………………………………………………………………

$$'U_{1'} = \wp g_{1'} = \wp\hat{U}_{1'} - G_{1'}, \quad 'U_{4'} = g_{4'} + l_{4'}$$

$$g_{1'|1'} = \left(\alpha_l v_l \frac{1}{\mathcal{R}_g}\right)_{|1'} = \alpha_l^3 v_{l|1'} \frac{1}{\mathcal{R}_g} = \alpha_l^2 v_l \frac{1}{r}\frac{1}{\mathcal{R}_g} = -i\alpha_l v_l \frac{1}{r}\cdot i\alpha_l \frac{1}{\mathcal{R}_g}$$

$$g_{1'|1'} = -g_{4'}l_{4'}$$

$$g_{4'|4'} = \left(i\alpha_l \frac{1}{\mathcal{R}_g}\right)_{|4'} = -i\alpha_l \frac{1}{\mathcal{R}_g^2}\mathcal{R}_{g|4'} = -g_{4'}\mathcal{F}_{4'}, \quad \alpha_{l|4'} = 0$$

$$g_{4'|4'} = -g_{4'}\mathcal{F}_{4'}, \quad \mathcal{F}_{4'} = (1-\wp)\,'U_{4'}$$

$$l_{4'|4'} = -l_{4'}\,'U_{4'}$$

$$'U_{1'|1'} = \wp g_{1'|1'} + g_{1'}\wp_{|1'} = -\wp g_{4'}l_{4'} + g_{1'}(1-\wp)\,'U_{1'}$$

$$'U^{s'}{}_{|s'} = -\wp g_{4'}l_{4'} + g_{1'}\,'U_{1'} - 'U_{1'}\,'U_{1'} - g_{4'}\mathcal{F}_{4'} - l_{4'}\,'U_{4'}$$

$$'U^{s'}{}_{|s'} + 'U^{s'}\,'U_{s'} = 'U_{4'}\,'U_{4'} - l_{4'}\,'U_{4'} + g_{1'}\,'U_{1'} - \wp g_{4'}l_{4'} - g_{4'}(1-\wp)\,'U_{4'}$$

$$= g_{4'}\,'U_{4'} + l_{4'}\,'U_{4'} - l_{4'}\,'U_{4'} + g_{1'}\,'U_{1'} - \wp g_{4'}l_{4'} - g_{4'}\,'U_{4'} + \wp g_{4'}\,'U_{4'}$$

$$= \wp g_{1'}g_{1'} + \wp g_{4'}g_{4'} = \wp g^{s'}g_{s'} = \wp g^{s}g_{s} = -\wp\frac{1}{\mathcal{R}_g^2}$$

$$'U^{s'}{}_{|s'} + 'U^{s'}\,'U_{s'} = -\wp\frac{1}{\mathcal{R}_g^2}$$

#23……………………………………………………………………………………………

$$B_{1'|1'} = \left(\alpha_C a_R \frac{1}{r}\right)_{|1'} = -\alpha_C a_R \frac{1}{r^2} r_{|1'} + B_{1'}\left(\frac{1}{\alpha_C}\alpha_{C|1'} + \frac{1}{a_R} a_{R|1'}\right)$$

$$B_{1'|1'} + B_{1'}B_{1'} = B_{1'}\left(\frac{1}{\alpha_C}\alpha_{C|1'} - \frac{1}{\alpha_R}\alpha_{R|1'}\right) = B_{1'}\left(\alpha_C^2 v_C v_{C|1'} - \alpha_R^2 v_R v_{R|1'}\right) = B_{1'}\left(\alpha_C v_C^2 \alpha_R \frac{1}{r} + \alpha_C \alpha_R v_R \frac{1}{\mathcal{R}_g}\right)$$

$$= \alpha_C^2 v_C^2 \frac{1}{r^2} + \alpha_C^2 v_R \frac{1}{r}\frac{1}{\mathcal{R}_g} = \alpha_C^2 v_C^2 \frac{1}{r^2} - \alpha_C^2 \frac{1}{\mathcal{R}_g^2}$$

$$-{}'U_{1'1'}{}^{4'} B_{4'} = {}'U_{4'} B_{4'} = \left(-i\alpha_C v_C a_R \frac{1}{r}\right)^2 = -\alpha_C^2 v_C^2 a_R^2 \frac{1}{r^2}$$

$$B_{1'\underset{2}{||}1'} + B_{1'}B_{1'} = B_{1'|1'} - {}'U_{1'1'}{}^{4'} B_{4'} + B_{1'}B_{1'}$$

$$= \alpha_C^2 v_C^2 \left(1 - a_R^2\right)\frac{1}{r^2} - \alpha_C^2 \frac{1}{\mathcal{R}_g^2} = \alpha_C^2 v_C^2 v_R^2 \frac{1}{r^2} - \alpha_C^2 \frac{1}{\mathcal{R}_g^2} = \left(\alpha_C^2 v_C^2 - \alpha_C^2\right)\frac{1}{\mathcal{R}_g^2} = -\frac{1}{\mathcal{R}_g^2}$$

$$B_{4'|1'} = \left(i\alpha_C v_C a_R \frac{1}{r}\right)_{|1'} = -i\alpha_C a_R \frac{1}{r^2} r_{|1'} - i a_R \frac{1}{r}\left(\alpha_C v_C\right)_{|1'} + B_{4'} \frac{1}{a_R} a_{R|1'}$$

$$B_{4'|1'} + B_{4'}B_{1'} = -i a_R \frac{1}{r}\alpha_C^3 v_{C|1'} + B_{4'}\hat{U}_{1'} = -i a_R \frac{1}{r}\alpha_C^2 v_C \alpha_R \frac{1}{r} + B_{4'}\hat{U}_{1'}$$

$$= -i\alpha_C v_C a_R \frac{1}{r}\cdot \alpha_C \alpha_R \frac{1}{r} + B_{4'}\hat{U}_{1'} = B_{4'}\left(\alpha_C \alpha_R \frac{1}{r} + \alpha_C \alpha_R v_R \frac{1}{\mathcal{R}_g}\right)$$

$$= B_{4'}\alpha_C \alpha_R \left(1 - v_R^2\right)\frac{1}{r} = B_{4'}\alpha_C a_R \frac{1}{r} = \hat{U}_{4'}B_{1'} = \hat{U}_{14'}{}^{1'} B_{1'}$$

$$B_{4'\underset{2}{||}1'} + B_{4'}B_{1'} = 0$$

$$B_{1'|4'} = \left(\alpha_C a_R \frac{1}{r}\right)_{|4'} = -\alpha_C a_R \frac{1}{r^2} r_{|4'} + B_{1'}\left(\frac{1}{\alpha_C}\alpha_{C|4'} + \frac{1}{a_R} a_{R|4'}\right)$$

$$B_{1'|4'} + B_{1'}B_{4'} = B_{1'}\left(\frac{1}{\alpha_C}\alpha_{C|4'} - \frac{1}{\alpha_R}\alpha_{R|4'}\right) = B_{1'}\left(i\alpha_C v_C^2 \wp \alpha_R \frac{1}{\mathcal{R}_g} - i\alpha_C v_C \wp \alpha_R v_R \frac{1}{\mathcal{R}_g}\right)$$

$$= i\alpha_C B_1 \alpha_C \alpha_R \left(v_C - v_R\right)\wp \frac{1}{\mathcal{R}_g} = -i\alpha_C v_C B_1 \wp \alpha_I v_I \frac{1}{\mathcal{R}_g} = B_{4'}\,{}'U_{1'} = {}'U_{4'1'}{}^{4'} B_{4'}$$

$$B_{1'\underset{2}{||}4'} + B_{1'}B_{4'} = 0$$

$$B_{4'|4'} = \left(-i\alpha_C v_C a_R \frac{1}{r}\right)_{|4'} = -B_{4'}B_{4'} - i a_R \frac{1}{r}\left(\alpha_C v_C\right)_{|4'} + B_{4'}\frac{1}{a_R}a_{R|4'}$$

$$B_{4'|4'} + B_{4'}B_{4'} = -i a_R \frac{1}{r}\alpha_C^3 v_{C|4'} + B_{4'}\mathfrak{p}\hat{U}_{4'} = -B_1 i\alpha_C\left(i\alpha_C v_C \mathfrak{p}\alpha_R \frac{1}{\mathcal{R}_g}\right) + \mathfrak{p}B_{4'}\hat{U}_{4'}$$

$$= B_{1'}\alpha_C v_C \mathfrak{p}\alpha_R \frac{1}{\mathcal{R}_g} + \mathfrak{p}B_{4'}\hat{U}_{4'}$$

$$B_{4'|4'} - {}'U_{4'4'}{}^{1'}B_{1'} + B_{4'}B_{4'} = B_{1'}\left({}'U_{1'} + \alpha_C v_C \alpha_R \mathfrak{p}\frac{1}{\mathcal{R}_g}\right) + \mathfrak{p}B_{4'}\hat{U}_{4'}$$

$$= B_{1'}\left(\alpha_I v_I + \alpha_C v_C \alpha_R\right)\mathfrak{p}\frac{1}{\mathcal{R}_g} + \mathfrak{p}B_{4'}\hat{U}_{4'}$$

$$= B_{1'}\alpha_C\alpha_R\left(v_R - v_C + v_C\right)\mathfrak{p}\frac{1}{\mathcal{R}_g} + \mathfrak{p}B_{4'}\hat{U}_{4'} = B_{1'}\alpha_C\alpha_R v_R \mathfrak{p}\frac{1}{\mathcal{R}_g} + \mathfrak{p}B_{4'}\hat{U}_{4'}$$

$$= \mathfrak{p}B_{1'}\hat{U}_{1'} + \mathfrak{p}B_{4'}\hat{U}_{4'} = \mathfrak{p}B_1\hat{U}_1 = \mathfrak{p}a_R\frac{1}{r}\alpha_R v_R \frac{1}{\mathcal{R}_g} = -\mathfrak{p}\frac{1}{\mathcal{R}_g^2}$$

$$B_{m'\underset{2}{\|}n'} + B_{m'}B_{n'} = -\begin{pmatrix}1&&&\\&0&&\\&&0&\\&&&\mathfrak{p}\end{pmatrix}\frac{1}{\mathcal{R}_g^2}, \quad B_{m'\underset{2}{\|}n'} = B_{m'|n'} - {}'U_{n'm'}{}^{s'}B_{s'}, \quad B^{s'}{}_{\underset{2}{\|}s'} + B^{s'}B_{s'} = -(1+\mathfrak{p})\frac{1}{\mathcal{R}_g^2}$$

#24……………………………………………………………………………………………………

$$C_{2'\underset{3}{\|}2'} + C_{2'}C_{2'} = -\frac{1}{\mathcal{R}_g^2}, \quad \text{siehe \#5}$$

$$C_{m'\underset{3}{\|}n'} = C_{m'|n'} - {}'U_{n'm'}{}^{s'}C_{s'} - B_{n'm'}{}^{s'}C_{s'}$$

$$C^{s'}{}_{\underset{3}{\|}s'} + C^{S'}C_{s'} = -\left(2+\mathfrak{p}\right)\frac{1}{\mathcal{R}_g^2}$$

$$C_{m'\underset{3}{\|}n'} + C_{m'}C_{n'} = -\begin{pmatrix}1&&&\\&1&&\\&&0&\\&&&\mathfrak{p}\end{pmatrix}\frac{1}{\mathcal{R}_g^2}$$

#25……………………………………………………………………………………………………

$$-\frac{1}{2}R = \left[{}'U^{s'}{}_{\underset{1}{\|}s'} + {}'U^{s'}\,{}'U_{s'}\right] + \left[B^{s'}{}_{\underset{2}{\|}s'} + B^{s'}B_{s'}\right] + \left[C^{s'}{}_{\underset{3}{\|}s'} + C^{S'}C_{s'}\right]$$

$$= -\frac{\mathfrak{p}}{\mathcal{R}_g^2} - (1+\mathfrak{p})\frac{1}{\mathcal{R}_g^2} - \left(2+\mathfrak{p}\right)\frac{1}{\mathcal{R}_g^2} = -(1+\mathfrak{p})\frac{3}{\mathcal{R}_g^2}, \qquad R = (1+\mathfrak{p})\frac{6}{\mathcal{R}_g^2}$$

#26………………………………………………………………………………………………………

$$G_{1'1'}=\frac{\mathcal{p}}{\mathcal{R}_g^2}+\frac{1}{\mathcal{R}_g^2}+\frac{1}{\mathcal{R}_g^2}-(1+\mathcal{p})\frac{3}{\mathcal{R}_g^2}=-\frac{1}{\mathcal{R}_g^2}(1+2\mathcal{p})=\kappa p,\qquad T_{1'1'}=-p$$

$$G_{2'2'}=\frac{1}{\mathcal{R}_g^2}+(1+\mathcal{p})\frac{1}{\mathcal{R}_g^2}-(1+\mathcal{p})\frac{3}{\mathcal{R}_g^2}=-\frac{1}{\mathcal{R}_g^2}(1+2\mathcal{p})=\kappa p,\qquad T_{2'2'}=-p$$

$$G_{3'3'}=(2+\mathcal{p})\frac{1}{\mathcal{R}_g^2}-(1+\mathcal{p})\frac{3}{\mathcal{R}_g^2}=-\frac{1}{\mathcal{R}_g^2}(1+2\mathcal{p})=\kappa p,\qquad T_{3'3'}=-p$$

$$G_{4'4'}=\frac{\mathcal{p}}{\mathcal{R}_g^2}+\frac{\mathcal{p}}{\mathcal{R}_g^2}+\frac{\mathcal{p}}{\mathcal{R}_g^2}-(1+\mathcal{p})\frac{3}{\mathcal{R}_g^2}=-\frac{3}{\mathcal{R}_g^2}=-\kappa\mu_0,\qquad T_{4'4'}=\mu_0$$

$$G_{1'4'}=0$$

#27………………………………………………………………………………………………………

$$U_m=L_m^{m'}{}'U_{m'}+L_m,\quad B_m=L_m^{m'}B_{m'},\quad C_m=L_m^{m'}C_{m'}$$

$$\begin{aligned}
U_1&=L_1^{1'}{}'U_{1'}+L_1^{4'}{}'U_{4'}+L_1=\alpha_C\mathcal{p}g_{1'}-i\alpha_C v_C(-i\alpha_C v_C)a_R\frac{1}{r}+G_1-f_1-l_1\\
&=\alpha_C\mathcal{p}\left(\hat{U}_{1'}-G_{1'}\right)-\alpha_C^2v_C^2a_R\frac{1}{r}-\alpha_C v_C\alpha_I v_I\frac{1}{r}-\alpha_C(1-\mathcal{p})G_{1'}\\
&=\alpha_C\mathcal{p}\hat{U}_{1'}-\alpha_C G_{1'}-\alpha_C^2v_C^2a_R\frac{1}{r}-\alpha_C v_C\cdot\alpha_C\alpha_R(v_R-v_C)\frac{1}{r}\\
&=\alpha_C^2\mathcal{p}\hat{U}_1-\alpha_C^2v_C\alpha_R\frac{1}{\mathcal{R}_g}-\alpha_C^2v_C^2a_R\frac{1}{r}+\alpha_C^2v_C\alpha_R\frac{1}{\mathcal{R}_g}+\alpha_C^2v_C^2\alpha_R\frac{1}{r}\\
&=\left(1+\alpha_C^2v_C^2\right)\mathcal{p}\hat{U}_1+\alpha_C^2v_C^2\alpha_R\left(1-a_R^2\right)\frac{1}{r}\\
&=\mathcal{p}\hat{U}_1+\alpha_C^2v_C^2\left(-\mathcal{p}\alpha_R v_R^2\frac{1}{r}+\alpha_R v_R^2\frac{1}{r}\right)\\
&=\mathcal{p}\hat{U}_1+\alpha_R^2v_R^2(1-\mathcal{p})\alpha_C^2v_C^2a_R\frac{1}{r}\\
&=\mathcal{p}\hat{U}_1-\alpha_R^2v_R^2\mathcal{F}_1
\end{aligned}$$

$$U_4 = L_4^{1'}\,{}'U_{1'} + L_4^{4'}\,{}'U_{4'} + L_4 = i\alpha_C v_C \mathfrak{p}\left(\hat{U}_{1'} - G_{1'}\right) + \alpha_C\left(-i\alpha_C v_C\right) a_R \frac{1}{r} + G_4 - f_4 - l_4$$

$$= i\alpha_C v_C \mathfrak{p}\left(\hat{U}_{1'} - G_{1'}\right) - i\alpha_C^2 v_C a_R \frac{1}{r} - i\alpha_R \frac{1}{\mathfrak{R}_g} - i\alpha_C \alpha_I v_I \frac{1}{r} - i\alpha_C^2 v_C^2 (1-\mathfrak{p})\alpha_R \frac{1}{\mathfrak{R}_g}$$

$$= i\alpha_C v_C \mathfrak{p}\left(\alpha_C \alpha_R v_R \frac{1}{\mathfrak{R}_g} - \alpha_C v_C \alpha_R \frac{1}{\mathfrak{R}_g}\right) - i\alpha_C^2 v_C a_R \frac{1}{r}$$

$$- i\alpha_R \frac{1}{\mathfrak{R}_g} - \alpha_C^2 \alpha_R \left(v_R - v_C\right)\frac{1}{r} - i\alpha_C^2 v_C^2 \alpha_R \frac{1}{\mathfrak{R}_g} + \mathfrak{p} i\alpha_C^2 v_C^2 \alpha_R \frac{1}{\mathfrak{R}_g}$$

$$= i\alpha_C^2 v_C \mathfrak{p} \alpha_R v_R \frac{1}{\mathfrak{R}_g} - i\alpha_C^2 v_C a_R \frac{1}{r} - \left(1 + \alpha_C^2 v_C^2\right)\alpha_R \frac{1}{\mathfrak{R}_g} + i\alpha_C^2 \alpha_R \frac{1}{\mathfrak{R}_g} + i\alpha_C^2 v_C \alpha_R \frac{1}{r}$$

$$= i\alpha_C^2 v_C \mathfrak{p} \alpha_R v_R \frac{1}{\mathfrak{R}_g} - i\alpha_C^2 v_C \alpha_R \left(1 - v_R^2\right)\frac{1}{r} + i\alpha_C^2 v_C \alpha_R \frac{1}{r}$$

$$= i\alpha_C^2 v_C \mathfrak{p} \alpha_R v_R \frac{1}{\mathfrak{R}_g} - i\alpha_C^2 v_C \alpha_R v_R \frac{1}{\mathfrak{R}_g}$$

$$= -\alpha_R^2 v_R^2 \left(-i\alpha_C^2 v_C\right)(1-\mathfrak{p}) a_R \frac{1}{r}$$

$$= -\alpha_R^2 v_R^2 \mathcal{F}_4$$

$$U_m = \mathfrak{p}\hat{U}_m - \alpha_R^2 v_R^2 \mathcal{F}_m = -E_m - \alpha_R^2 v_R^2 \mathcal{F}_m$$

#28………………………………………………………………………………………………

$${}'U^{s'}{}_{|s'} + {}'U^{s'}\,{}'U_{s'} = -\frac{\mathfrak{p}}{\mathfrak{R}_g^2}, \quad {}'U^{s'} = U^{s'} + {}'L^{s'}$$

$$U^{s'}{}_{|s'} + {}'L^{s'}{}_{|s'} + \left(U^{s'} + {}'L^{s'}\right){}'U_{s'} = -\frac{\mathfrak{p}}{\mathfrak{R}_g^2}$$

$$U^{s'}{}_{|s'} + U^{s'}\,{}'U_{s'} + {}'L^{s'}{}_{|s'} + {}'U_{s'}\,{}'L^{s'} = -\frac{\mathfrak{p}}{\mathfrak{R}_g^2}$$

$$U^{s'}{}_{|s'} + {}'U_{s'} U^{s'} = -\frac{\mathfrak{p}}{\mathfrak{R}_g^2}$$

#29………………………………………………………………………………………………

$${}'U^{s'}{}_{|s'} = \left(L_s^{s'}\,{}'U^s\right)_{|s'} = {}'U^s{}_{|s} + {}'U^s L^{s'}_{s|s'} = U^s{}_{|s} - L^s{}_{|s} + {}'U^s L_s$$

$${}'U^{s'}{}_{|s'} + {}'U^{s'}\,{}'U_{s'} = U^s{}_{|s} - L^s{}_{|s} + {}'U^s\left(U_s - L_s\right) + {}'U^s L_s$$

$$= U^s{}_{|s} + U^s U_s - \left(L^s{}_{|s} + U_s L^s\right) = U^s{}_{|s} + U^s U_s$$

$$U^s{}_{|s} + U^s U_s = {}'U^{s'}{}_{|s'} + {}'U^{s'}\,{}'U_{s'} = -\frac{\mathfrak{p}}{\mathfrak{R}_g^2}$$

#30……………………………………………………………………………………………

$$B_{1|1} = \left(\frac{a_R}{r}\right)_{|1} = -B_1B_1 + B_1\frac{1}{a_R}a_{R|1}$$

$$B_{1|1} + B_1B_1 = -B_1\frac{1}{\alpha_R}\alpha_{R|1} = -B_1\left(-\hat{U}_1 - \alpha_R^2 v_R^2 \mathcal{F}_1\right) = \frac{a_R}{r}\alpha_R v_R\frac{1}{\mathcal{R}_g} - \alpha_R v_R\frac{1}{\mathcal{R}_g}\mathcal{F}_1 = -\frac{1}{\mathcal{R}_g^2} - \hat{U}_1\mathcal{F}_1$$

$$B_{1|4} = -B_1\frac{1}{\alpha_R}\alpha_{R|4} = -B_1\left(-\alpha_R^2 v_R^2 \mathcal{F}_4\right) = -\hat{U}_1\mathcal{F}_4$$

$$B_{4|1} = 0, \quad B_{4|4} = 0$$

$$B_{4|1} - U_{14}{}^1 B_1 + B_4B_1 = -U_4B_1 = B_1\alpha_R^2 v_R^2 \mathcal{F}_4 = -\alpha_R v_R\frac{1}{\mathcal{R}_g}\mathcal{F}_4 = -\mathcal{F}_4\hat{U}_1$$

$$B_{4|4} - U_{44}{}^1 B_1 + B_4B_4 = U_1B_1 = B_1\wp\hat{U}_1 - B_1\alpha_R^2 v_R^2 \mathcal{F}_1 = -\frac{\wp}{\mathcal{R}_g^2} + \hat{U}_1\mathcal{F}_1$$

$$B_{m\underset{2}{||}n} + B_mB_n = -\begin{pmatrix} 1 & & & \\ & 0 & & \\ & & 0 & \\ & & & \wp \end{pmatrix}\frac{1}{\mathcal{R}_g^2} + \begin{pmatrix} -\hat{U}_1\mathcal{F}_1 & & & -\hat{U}_1\mathcal{F}_4 \\ & 0 & & \\ & & 0 & \\ -\mathcal{F}_4\hat{U}_1 & & & \hat{U}_1\mathcal{F}_1 \end{pmatrix}, \quad B^s{}_{\underset{2}{||}s} + B^sB_s = -\left(1+\wp\right)\frac{1}{\mathcal{R}_g^2}$$

#31……………………………………………………………………………………………

$$2\hat{U}_1\mathcal{F}_1 = 2\alpha_R v_R\frac{1}{\mathcal{R}_g}\cdot\left(-\alpha_C^2 v_C^2\right)\left(1-\wp\right)\frac{a_R}{r} = \alpha_C^2 v_C^2\left(1-\wp\right)\frac{2}{\mathcal{R}_g} = \alpha_C^2 v_C^2\kappa\left(p+\mu_0\right)$$

$$2\hat{U}_1\mathcal{F}_4 = 2\alpha_R v_R\frac{1}{\mathcal{R}_g}\cdot\left(-i\alpha_C^2 v_C\right)\left(1-\wp\right)\frac{a_R}{r} = i\alpha_C^2 v_C\left(1-\wp\right)\frac{2}{\mathcal{R}_g} = i\alpha_C^2 v_C\kappa\left(p+\mu_0\right)$$

$$2\hat{U}_1\mathcal{F}_1 = \alpha_C^2 v_C^2\kappa\left(p+\mu_0\right), \quad 2\hat{U}_1\mathcal{F}_4 = i\alpha_C^2 v_C\kappa\left(p+\mu_0\right)$$

#32……………………………………………………………………………………………

$$R_{11} = -\left[U^s{}_{\underset{1}{||}s} + U^sU_s\right] - \left[B_{1\underset{2}{||}1} + B_1B_1\right] - \left[C_{1\underset{3}{||}1} + C_1C_1\right]$$

$$= \frac{\wp}{\mathcal{R}_g^2} + \left[\frac{1}{\mathcal{R}_g^2} + \hat{U}_1\mathcal{F}_1\right] + \left[\frac{1}{\mathcal{R}_g^2} + \hat{U}_1\mathcal{F}_1\right] = \left(2+\wp\right)\frac{1}{\mathcal{R}_g^2} + 2\hat{U}_1\mathcal{F}_1$$

$$G_{11} = \left(2+\wp\right)\frac{1}{\mathcal{R}_g^2} - \left(1+\wp\right)\frac{3}{\mathcal{R}_g^2} + 2\hat{U}_1\mathcal{F}_1 \qquad \text{mit } \#25$$

$$= -\frac{1}{\mathcal{R}_g^2}\left(1+2\wp\right) + 2\hat{U}_1\mathcal{F}_1$$

$$= \kappa p + \alpha_C^2 v_C^2\kappa\left(p+\mu_0\right)$$

$$T_{11} = -p - \alpha_C^2 v_C^2\left(p+\mu_0\right)$$

$$R = (1+\mathcal{p})\frac{6}{\mathcal{R}^2} \qquad \#25$$

$$R_{22} = -\left[B^s{}_{\underset{2}{\|}s} + B^s B_s\right] - \left[C_{2\underset{3}{\|}2} + C_2 C_2\right]$$

$$= (1+\mathcal{p})\frac{1}{\mathcal{R}_g^2} + \frac{1}{\mathcal{R}_g^2} = (2+\mathcal{p})\frac{1}{\mathcal{R}_g^2}$$

$$G_{22} = (2+\mathcal{p})\frac{1}{\mathcal{R}_g^2} - (1+\mathcal{p})\frac{3}{\mathcal{R}_g^2} = -\frac{1}{\mathcal{R}_g^2}(1+2\mathcal{p}) = \kappa p$$

$$T_{22} = -p$$

$$R_{33} = -\left[C^s{}_{\underset{3}{\|}s} + C^s C_s\right] = (2+\mathcal{p})\frac{1}{\mathcal{R}_g^2}$$

$$T_{33} = -p$$

$$R_{44} = -\left[U^s{}_{\underset{1}{\|}s} + U^s U_s\right] - \left[B_{4\underset{2}{\|}4} + B_4 B_4\right] - \left[C_{4\underset{3}{\|}4} + C_4 C_4\right]$$

$$= \frac{\mathcal{p}}{\mathcal{R}_g^2} + 2\left[\frac{\mathcal{p}}{\mathcal{R}_g^2} - \hat{U}_1 \mathcal{F}_1\right] = 3\mathcal{p}\frac{1}{\mathcal{R}_g^2} - 2\hat{U}_1 \mathcal{F}_1$$

$$G_{44} = 3\mathcal{p}\frac{1}{\mathcal{R}_g^2} - (1+\mathcal{p})\frac{3}{\mathcal{R}_g^2} - 2\hat{U}_1\mathcal{F}_1 = -\frac{3}{\mathcal{R}_g^2} - 2\hat{U}_1\mathcal{F}_1$$

$$= -\kappa\mu_0 - \alpha_C^2 v_C^2 \kappa (p+\mu_0)$$

$$T_{44} = \mu_0 + \alpha_C^2 v_C^2 (p+\mu_0)$$

$$G_{41} = -\left[B_{1\underset{2}{\|}4} + B_1 B_4\right] - \left[C_{1\underset{3}{\|}4} + C_1 C_4\right] = 2\hat{U}_1\mathcal{F}_4 = i\alpha_C^2 v_C \kappa (p+\mu_0)$$

$$T_{41} = -i\alpha_C^2 v_C (p+\mu_0)$$

$$T_{mn} = -p\, g_{mn} + (p+\mu_0)\,'u_m\,'u_n, \quad 'u_m = \{-i\alpha_C v_C, 0, 0, \alpha_C\}$$