

In this file you find all sorts of misprints. There are quite many but it does not mean that the book is entirely bad. On the contrary, it gives you the opportunity to carry out a lot of calculations, and it is a good starting point. If the misprint is marked by an asterix (\*) it means that you can find a more thorough calculation in my file 'lots of calculations' on my homepage <http://physicssusan.mono.net/9035/General%20Relativity>. The list is not complete, it covers the chapters 1-13 and the final exam, but I will post more on my homepage as I get along. I have made this list entirely on my own, and should you find that I have made something wrong or missed something, which I am bound to, please do not hesitate to contact me: [logik.susan@gmail.com](mailto:logik.susan@gmail.com)

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## Contents

p.ix 1.7 ~~Eddington-Finkelstein Coordinates~~ The Radial Null Geodesic

## Chapter 1

p.2 1.20 operator to the right-hand side of (1.1), we obtain

p.6 1.6-7 clock 1 at time  $t'$ , and the reflected beam arrives at the location of clock 1 at time  $t_2$ .

p.12 l.12  $ct' =$   
 p.16 l.13  $\beta_3^2 = \frac{(\beta_1 + \beta_2)^2}{(1 + \beta_1\beta_2)^2}$   
 l.15  $\beta_3 = \frac{\beta_1 + \beta_2}{1 + \beta_1\beta_2}$

### Chapter 2

p.29 l.18  $Vf = (V^a e_a)f = V^a \partial_a$   
 p.33 l.7 as shown in Fig. 2-5  
 p.34 l.4  $ds^2 = dr^2 + r^2 d\theta^2 + r^2 \sin^2 \theta d\phi^2$  (2.9)  
 p.40 l.15  $g^{yx}x^2 + g^{yy} = 0$   
 l.16  $g^{yy} = -x^2 g^{yx}$   
 p.41 l.11  $W_x = x^2(0) + 1(1) = 1$   
 l.12  $W_y = 1(0) - 1(1) = -1$   
 l.13  $\Rightarrow W_a = (1, -1)$   
 p.42 l.2  $S^a_b =$   
 l.3  $= g^{ac} T_c^b =$   
 l.4  $= g_{ae} R^e_{bcd}$   
 p.44 l.12  $\partial_r = \frac{\partial x}{\partial r} \partial_x + \frac{\partial y}{\partial r} \partial_y + \frac{\partial z}{\partial r} \partial_z$

### Chapter 3

p.49 l.5  $U_1$ . A point  $p$  that belongs to the manifold  $M$  (say in  $U_1$ )  
 p.55 l.3  $Q^a_b = S^a_b - T^a_b$

### Chapter 4

p.67 l.2  $= \left( \frac{\partial A^b}{\partial x^a} + \Gamma^b_{ca} A^c \right) e_b$   
 l.5  $\nabla_b A^a = \frac{\partial A^a}{\partial x^b} + \Gamma^a_{bc} A^c$  (4.6)  
 p.73 l.3  $\frac{\partial g_{ab}}{\partial x^c} = \Gamma_{cab} + \Gamma_{cba}$   
 l.73  $\Gamma^a_{bc} = g^{ad} \Gamma_{bcd}$   
 l.17  $\Gamma^a_{bc} = \frac{1}{2} g^{ad} \left( \frac{\partial g_{bd}}{\partial x^c} + \frac{\partial g_{cd}}{\partial x^b} - \frac{\partial g_{bc}}{\partial x^d} \right)$  (4.16)  
 p.75 l.2 the last term  
 l.3  $\Gamma^{\phi}_{bc} = \frac{1}{2} g^{\phi\phi} \left( \frac{\partial g_{\phi b}}{\partial x^c} + \frac{\partial g_{\phi c}}{\partial x^b} \right)$   
 l.5  $\Gamma^{\phi}_{\phi\theta} = \frac{1}{2} g^{\phi\phi} \left( \frac{\partial g_{\phi\phi}}{\partial \theta} + \frac{\partial g_{\phi\theta}}{\partial \phi} \right) =$   
 p.80 l.6  $(a\alpha + b\beta) \wedge \gamma = a\alpha \wedge \gamma + b\beta \wedge \gamma$   
 p.81 l.17  $L_V W^a = V^b \nabla_b W^a - W^b \nabla_b V^a$  (4.27)  
 l.19  $L_V T_{ab} = V^c \nabla_c T_{ab} + T_{cb} \nabla_a V^c + T_{ac} \nabla_b V^c$  (4.28)  
 p.82 l.17  $\frac{d^2 x^a}{d\lambda^2} + \Gamma^a_{bc} \frac{dx^b}{d\lambda} \frac{dx^c}{d\lambda} = 0$

- p.83 (\*) l.18  $\frac{d^2\phi}{ds^2} + \frac{2}{r} \frac{dr}{ds} \frac{d\phi}{ds} = 0$
- p.85 (\*) l.13  $\Rightarrow \Gamma^\tau_{\xi\tau} = \frac{1}{\xi} = \Gamma^\tau_{\tau\xi}$
- p.86 l.6  $R_{abcd} = g_{ae} R^e_{bcd}$
- p.87 l.3 All together, in  $n$  dimensions, there are  $n^2(n^2 - 1)/12$  independent ~~nonzero~~ components ...
- l.10  $R_{1212}; R_{1313}; R_{2323}; R_{1213}; R_{1232} = R_{2123}; R_{1323} = R_{3132}$
- p.88 l.1 ... of the Riemann tensor in two **dimensions** are ...
- p.92 (\*) Q7  $\Gamma^v_{xx} = -1 + u$

## Chapter 5

- p.105 l.17  $\alpha \wedge \beta = (-1)^{pq} \beta \wedge \alpha$  (5.13)
- p.120 (\*) l.4  $R^{\hat{\phi}}_{\hat{r}\hat{r}\hat{\phi}} = -\frac{\dot{a}^2 + k}{a^2}$
- (\*) Q3  $\Gamma^r_{\phi\phi} = (\Lambda^{-1})^r_{\hat{r}} \Gamma^{\hat{r}}_{\hat{\phi}\hat{\phi}} \Lambda^{\hat{\phi}}_{\phi} \Lambda^{\hat{\phi}}_{\phi} = 1 \left(-\frac{1}{r}\right) (r \sin \theta)^2 = -r \sin^2 \theta$
- (\*) Q4  $\Gamma^{\hat{u}}_{\hat{v}\hat{v}} = \Gamma^{\hat{v}}_{\hat{u}\hat{v}} = +\frac{1}{u}$
- p.121 Q5 Where are the "hats"?
- (\*) Q7  $G_{\hat{t}\hat{t}} = \frac{1}{R^2} [-Re^{2\Psi}(2R'\Psi' + 2R'' + R^{-1}R'^2) - 2\dot{R}\dot{\Psi}R + 1 + \dot{R}^2]$

## Chapter 6

- p.130 l.15 Cases 2 and 3 in our
- p.133 l.5  $L_u \eta^a = u^b \nabla_b \eta^a - \eta^b \nabla_b u^a = 0$
- l.19  $\nabla_a S^c_b = \partial_a S^c_b + \Gamma^c_{ad} S^d_b - \Gamma^d_{ba} S^c_d$
- l.24  $\nabla_b \nabla_a V^c = \partial_b (\partial_a V^c + \dots$
- p.134 l.4  $\partial_a (\partial_b V^c - \Gamma^c_{eb} V^e) - \partial_b (\partial_a V^c + \dots$  (6.2)
- p.135 l.2  $= R^c_{dab} V^d$  (6.3)
- p.136 l.1 However, since  $u^a$  is the tangent
- p.137 l.12  $\Gamma^a_{bc} = \frac{1}{2} g^{ad} \left( \frac{\partial g_{bd}}{\partial x^c} + \frac{\partial g_{cd}}{\partial x^b} - \frac{\partial g_{bc}}{\partial x^d} \right)$  (4.16)
- p.139 l.21  $ds^2 = -dt^2 + e^{2b(t,r)} dr^2 + R^2(t,r) d\phi^2$
- p.141 (\*) l.18  $= -\frac{1}{R} \frac{\partial R}{\partial t} \omega^{\hat{\phi}} \wedge \omega^{\hat{t}} - \frac{1}{R} \frac{\partial R}{\partial r} e^{-b(t,r)} \omega^{\hat{\phi}} \wedge \omega^{\hat{r}}$
- p.143 l.3  $\Rightarrow \Gamma^{\hat{r}}_{\hat{\phi}\hat{\phi}} =$
- l.7  $= \frac{1}{2} R^{\hat{a}}_{\hat{b}\hat{c}\hat{d}} \omega^{\hat{c}} \wedge \omega^{\hat{d}}$  (6.21)
- p.144 l.10  $\Omega^{\hat{r}}_{\hat{t}} =$
- p.146 l.4 we write out  $\Omega^{\hat{t}}_{\hat{\phi}} =$
- l.6  $\Omega^{\hat{t}}_{\hat{\phi}} =$
- l.11  $R^{\hat{t}}_{\hat{\phi}\hat{t}\hat{\phi}} =$
- l.12 All together, the **independent** nonzero components
- p.147 l.2 Using the results of Example 6-2

(\*) l.15  $R^{\hat{\phi}}_{\hat{t}\hat{r}} = -R^{\hat{t}}_{\hat{\phi}\hat{r}}$

l.18  $R_{\hat{r}\hat{r}} = R^{\hat{c}}_{\hat{r}\hat{c}\hat{r}} = R^{\hat{t}}_{\hat{r}\hat{t}\hat{r}} + R^{\hat{r}}_{\hat{r}\hat{r}\hat{r}} + R^{\hat{\phi}}_{\hat{r}\hat{\phi}\hat{r}}$  (6.29)

p.149 (\*) l.5  $G_{\hat{t}\hat{r}} = -\frac{e^{-b(t,r)}}{R} \frac{\partial^2 R}{\partial t \partial r} + \frac{e^{-b(t,r)}}{R} \frac{\partial b}{\partial t} \frac{\partial R}{\partial r}$

l.8  $ds^2 = -dt^2 + e^{2b(t,r)} dr^2 + R^2(t,r) d\phi^2$ , this is easy enough:

(\*) l.9  $\Lambda^{\hat{a}}_{\hat{b}} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & e^{b(t,r)} & 0 \\ 0 & 0 & R(t,r) \end{pmatrix}$  (6.33)

(\*) l.15  $G_{tt} = \Lambda^{\hat{t}}_{\hat{t}} \Lambda^{\hat{t}}_{\hat{t}} G_{\hat{t}\hat{t}} = (1)(1)G_{\hat{t}\hat{t}}$  (6.35)

(\*) l.18  $(1)(e^{b(t,r)}) \left( -\frac{e^{-b(t,r)}}{R} \frac{\partial^2 R}{\partial t \partial r} + \frac{e^{-b(t,r)}}{R} \frac{\partial b}{\partial t} \frac{\partial R}{\partial r} \right)$  (6.36)

p.153 l.10  $\Gamma^{\hat{t}}_{\hat{r}\hat{r}}$

l.15  $\Gamma^{\hat{r}}_{\hat{\phi}\hat{\phi}}$

## Chapter 7

p.155 l.9 tensor and energy-momentum **tensor** interchangeably.

p.159 l.4  $\gamma = \frac{1}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$

l.16  $= \gamma^2 \frac{\partial \rho}{\partial t} + \gamma^2 \frac{\partial(\rho u^x)}{\partial x} + \gamma^2 \frac{\partial(\rho u^y)}{\partial y} + \gamma^2 \frac{\partial(\rho u^z)}{\partial z}$

l.17  $= \gamma^2 \frac{\partial \rho}{\partial t} + \gamma^2 \nabla \cdot (\rho \vec{u})$

p.160 l.18  $T^{ab} = Au^a u^b + Bg^{ab}$  (7.8)

l.22  $T^{ij} = \delta^{ij} P$  (7.9)

p.161 l.3  $T^{ij} = B\eta^{ij}$

l.6  $= Au^0 u^0 + B\eta^{00} =$

l.9  $= (\rho + P)u^a u^b - P\eta^{ab}$  (7.10)

l.11  $= (\rho + P)u^a u^b - Pg^{ab}$  (7.11)

l.14  $= (\rho + P)u^a u^b + P\eta^{ab}$  (7.12)

l.15  $= (\rho + P)u^a u^b + Pg^{ab}$

p.162 l.5  $G_{\hat{a}\hat{b}} + \Lambda\eta_{\hat{a}\hat{b}} = 8\pi T_{\hat{a}\hat{b}}$  (7.14)

l.13 Putting this together with (7.14) and (7.13), we have

l.14  $G_{\hat{t}\hat{t}} + \Lambda\eta_{\hat{t}\hat{t}} = 8\pi T_{\hat{t}\hat{t}}$

l.15 (\*)  $\Rightarrow \frac{3}{a^2}(k + \dot{a}^2) - \Lambda = 8\pi\rho$  (7.17)

l.18  $G_{\hat{r}\hat{r}} + \Lambda\eta_{\hat{r}\hat{r}} = 8\pi T_{\hat{r}\hat{r}}$

l.19 (\*)  $\Rightarrow 2\frac{\ddot{a}}{a} + \frac{1}{a^2}(k + \dot{a}^2) - \Lambda = -8\pi P$  (7.18)

p.165 l.10 worldlines

## Chapter 8

p.171 l.6  $\nabla_{\theta} X_{\theta} = \partial_{\theta} X_{\theta} - \Gamma^c_{\theta\theta} X_c = \partial_{\theta} X_{\theta} - \Gamma^{\theta}_{\theta\theta} X_{\theta} - \Gamma^{\phi}_{\theta\theta} X_{\phi}$

p.172 l.17  $\partial_{\theta} X_{\phi} = \partial_{\theta} [-\sin\theta \cos\theta \int f(\phi') d\phi' + g(\theta)]$

p.174 l.8  $P(t) = \int p(t') dt'$

- l.10  $y(t) = e^{-P(t)} \int e^{P(t')} r(t') dt' + C e^{-P(t)}$
- l.14  $P(\theta) =$
- l.16  $e^{-P(\theta)} =$
- l.17 From this we deduce that  $e^{P(\theta)} =$
- p.176 l.20  $X^\theta = g^{\theta\theta} X_\theta = \frac{1}{a^2} X_\theta$
- l.22  $X^\phi = g^{\phi\phi} X_\phi = \frac{1}{a^2} \frac{1}{\sin^2 \theta} X_\phi$
- p.177 l.6  $= \frac{1}{a^2} (A \cos \phi + B \sin \phi) \partial_\theta + \frac{1}{a^2} [C - \cot \theta (A \sin \phi - B \cos \phi)] \partial_\phi$
- l.7  $= A' \cos \phi \partial_\theta - A' \cot \theta \sin \phi \partial_\phi + B' \sin \phi \partial_\theta + B' \cot \theta \cos \phi \partial_\phi + C' \partial_\phi$
- l.8  $= +A' L_x + B' L_y + C' L_z$
- l.10  $L_x = + \cos \phi \frac{\partial}{\partial \theta} - \cot \theta \sin \phi \frac{\partial}{\partial \phi}$
- l.17  $\nabla_b \nabla_c X^a - \nabla_c \nabla_b X^a = R^a{}_{bcd} X^d$  (8.6)
- l.19 (\*)  $\nabla_a \nabla_b X^b - \nabla_b \nabla_a X^b = R_{ac} X^c$  (8.7)
- l.21 (\*)  $X^a \nabla_a R = L_X R$  (8.8)
- p.178 l.5  $\nabla_b T^{ab} = 0$
- p.179 l.1 (b)  $\nabla_b \nabla_c X^a - \nabla_c \nabla_b X^a = R^a{}_{bcd} X^d$
- l.4 (a)  $X^a \nabla_a R = L_X R$

## Chapter 9

- p.188 l.2  $= -r^2 \sin^2 \theta$
- p.190 l.2  $m \cdot \bar{m} = m^a \cdot \bar{m}_a =$
- l.23  $\delta = \bar{m}^a \nabla_a$
- p.198 (\*) l.22  $\Gamma^v{}_{uu} = + \frac{1}{2} \frac{\partial H}{\partial u}$
- p.199 l.8 Now  $\nabla_b l_a =$  and so we can immediately...
- l.22 Having a look at the Christoffel symbols (9.29), we see ...

## Chapter 10

- p.204 l.20 This tells us that the **metric** line element will not
- p.205 l.21  $= Cr^2 d\theta^2 + Cr^2 \sin^2 \theta d\phi^2$
- l.26  $= \sqrt{C} \left( \frac{r}{2c} \frac{dC}{dr} + 1 \right) dr$
- p.207 (\*) l.19  $\Gamma_{\hat{t}}^{\hat{t}} = \Gamma_{\hat{\theta}}^{\hat{t}} = \Gamma_{\hat{\phi}}^{\hat{t}} = 0$  (10.16)
- p.208 (\*) l.5  $\Gamma_{\hat{t}}^{\hat{\theta}} = \Gamma_{\hat{\theta}}^{\hat{\theta}} = \Gamma_{\hat{\phi}}^{\hat{\theta}} = 0$  (10.17)
- (\*) l.9  $\Gamma_{\hat{t}}^{\hat{\phi}} = \Gamma_{\hat{\phi}}^{\hat{\phi}} = 0$  (10.18)
- p.210 l.12  $= -R^{\hat{t}}{}_{\hat{t}\hat{t}\hat{t}}$
- l.17 All together, the **independent** nonzero components of the
- l.19  $= -R^{\hat{t}}{}_{\hat{\phi}\hat{t}\hat{\phi}}$
- p.211 l.4  $R_{\hat{a}\hat{b}} = R^{\hat{c}}{}_{\hat{a}\hat{c}\hat{b}}$
- p.216 l.32 **la**grangian

- p.217 (\*) l.18  $= -\frac{2}{1 - \frac{2m}{r}} \dot{r} + \frac{4m}{(r - 2m)^2} (\dot{r})^2$
- p.218 (\*) l.2  $= \frac{2m}{r^2} (\dot{t})^2 + \left(1 - \frac{2m}{r}\right)^{-2} \left(\frac{2m}{r^2}\right) (\dot{r})^2 - 2r(\dot{\theta})^2 - 2r \sin^2 \theta (\dot{\phi})^2$
- p.220 l.19  $= -r^2 \sin^2 \theta \frac{d\phi}{d\tau} = -r^2 \frac{d\phi}{d\tau}$  (10.48)
- p.226 l.2 respect to  $\phi$   $r$  a second time  
 l.19 ... and using  $r_0 = r \sin \phi$   
 l.20 ...  $\frac{1}{A} = r \sin \phi = r_0$   
 l.21 the constant  $1/A$  represents the
- p.227 l.5  $u_1^p = D \sin^2 \phi + E \cos^2 \phi$   
 l.7  $u_1^p =$   
 l.8  $u_1^p =$   
 l.10 This line should be omitted:  $u_p^u + u_p = -D \sin^2 \phi + 4D \sin^2 \phi = 3D \sin^2 \phi$   
 l.11  $u_1^{p''} + u_1^p =$   
 l.14  $u_1^{p''} + u_1^p = A^2 \sin^2 \phi$   
 l.17  $u_1^{p''} + u_1^p = A^2 \sin^2 \phi$
- p.228 l.17 and setting this  $u$  equal to zero
- p.230 l.2 so we put  $ct$  in place of  $t$  and  $\frac{Gm}{c^2 r}$  in place of  $\frac{m}{r}$   
 l.3  $ct = \frac{dr}{\sqrt{1 - \frac{r_0^2}{r^2}}} \left(1 + \frac{2m}{r} \frac{G}{c^2} - \frac{mr_0^2}{r^3} \frac{G}{c^2}\right)$   
 l.7  $ct = \sqrt{r_p^2 - r_0^2} - \sqrt{r_e^2 - r_0^2} + 2m \frac{G}{c^2} \ln \frac{(r_p + \sqrt{r_p^2 - r_0^2})(r_e + \sqrt{r_e^2 - r_0^2})}{r_0^2}$   
 $- m \frac{G}{c^2} \left[ \frac{\sqrt{r_p^2 - r_0^2}}{r_p} - \frac{\sqrt{r_e^2 - r_0^2}}{r_e} \right]$   
 l.20 Using the variational method described in Example 4-10, the nonzero Christoffel symbols for the general Schwarzschild metric are
- p.231 (\*) Q2 (b)  $R_{rt} = \frac{2}{r} \left(\frac{d\lambda}{dt}\right)$   
 (\*) Q3 (b)  $\Gamma^r_{\hat{t}\hat{t}} = \frac{3m - \Lambda r^3}{r^{3/2} \sqrt{9r - 18m - 3\Lambda r^3}}$
- p.236 l.27 ~~Eddington Finkelstein Coordinates~~ The Radial Null Geodesic
- p.238 (\*) l.10  $t - t_0 = -\frac{2}{3\sqrt{2m}} \left(r^{3/2} - r_0^{3/2} + 6m\sqrt{r} - 6m\sqrt{r_0}\right) + 2m \dots$
- p.239 (\*) l.2  $r - 2m = (r_0 - 2m)e^{-(t-t_0)/2m}$

## Chapter 11

- p.245 l.26  $ds^2 = \left(1 - \frac{2m}{\Sigma}\right) dt^2 + \frac{4amr \sin^2 \theta}{\Sigma} dt d\theta - \dots$  (11.9)
- p.246 (\*) l.12  $g^{\phi\phi} = -\frac{(\Delta - a^2 \sin^2 \theta)}{\Sigma \Delta \sin^2 \theta}$  (11.13)
- p.247 l.4 In this case,  $\theta = \frac{\pi}{2}$ , which  
 l.5 means that  $\sin \theta = 1$  and
- p.251 l.3  $R^2 = r^2 + a^2 + \frac{2m^3}{r}$  (11.19)

## Chapter 12

- p.258 l.11 Suppose that  $S$  represents the spacelike...
- p.261 l.4 
$$e^{2f} = \frac{1}{C' - kr^2} \tag{12.4}$$
- l.5 To find the constant  $C' = -2C$ , we can use the ...
- l.13  $= 1 - C' + Kr^2 - Kr^2 = 1 - C' + 2Kr^2$
- l.15  $1 - C' + 2Kr^2 = 2Kr^2$  or  $1 - C' = 0 \Rightarrow C' = 1$
- p.268 l.13 The detail were worked out in Example 7-3
- P.273 l.20 
$$ds^2 = dt^2 - e^{2\sqrt{\frac{\Lambda}{3}}t} [dr^2 + r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2]$$
- p.274 Fig. 12-5 The vertical coordinate is  $a$  not  $R$
- l.1 The de Sitter solution represents a universe without matter and without radiation.
- p.275 Fig. 12-6 The vertical coordinate is  $a$  not  $R$
- l.10 
$$\frac{da}{dt} = 2C \sin \tau \cos \tau \frac{d\tau}{dt}$$
- p.276 Fig. 12-7 The vertical coordinate is  $a$  not  $R$
- l.3 Integrating the left side becomes
- p.277 (\*) Q1  $R = -4\Lambda$
- (\*) Q2  $re^{2v(r)} = A + Br - \frac{1}{3}k^2\Lambda r^3$
- (\*) Q3  $B = k^2$
- (\*) Q4 
$$dl^2 = \frac{dr^2}{1 - \frac{2m}{r} - \frac{1}{3}\Lambda r^2} + r^2 d\theta^2 + r^2 \sin^2 \theta d\phi^2$$

## Chapter 13

- p.280 l.25 
$$\Gamma^a_{bc} = \frac{1}{2}g^{ad} \left( \frac{\partial g_{bd}}{\partial x^c} + \frac{\partial g_{cd}}{\partial x^b} - \frac{\partial g_{bc}}{\partial x^d} \right)$$
- p.282 l.6 
$$\Gamma^a_{bc} = \frac{1}{2}g^{ad} \left( \frac{\partial g_{bd}}{\partial x^c} + \frac{\partial g_{cd}}{\partial x^b} - \frac{\partial g_{bc}}{\partial x^d} \right)$$
- l.7 
$$= \frac{\varepsilon}{2}g^{ad} \left( \frac{\partial h_{bd}}{\partial x^c} + \frac{\partial h_{cd}}{\partial x^b} - \frac{\partial h_{bc}}{\partial x^d} \right)$$
- l.8 
$$= \frac{\varepsilon}{2}(\eta^{ad} - \varepsilon h^{ad}) \left( \frac{\partial h_{bd}}{\partial x^c} + \frac{\partial h_{cd}}{\partial x^b} - \frac{\partial h_{bc}}{\partial x^d} \right)$$
- l.9 
$$= \frac{1}{2}(\varepsilon\eta^{ad} - \varepsilon^2 h^{ad}) \left( \frac{\partial h_{bd}}{\partial x^c} + \frac{\partial h_{cd}}{\partial x^b} - \frac{\partial h_{bc}}{\partial x^d} \right)$$
- l.12 
$$= \frac{1}{2}\varepsilon\eta^{ad} \left( \frac{\partial h_{bd}}{\partial x^c} + \frac{\partial h_{cd}}{\partial x^b} - \frac{\partial h_{bc}}{\partial x^d} \right) \tag{13.3}$$
- p.283 l.3 
$$= \partial_c \left[ \frac{1}{2}\varepsilon\eta^{ae} \left( \frac{\partial h_{be}}{\partial x^d} + \frac{\partial h_{de}}{\partial x^b} - \frac{\partial h_{bd}}{\partial x^e} \right) \right]$$
- l.4 
$$- \partial_d \left[ \frac{1}{2}\varepsilon\eta^{af} \left( \frac{\partial h_{bf}}{\partial x^c} + \frac{\partial h_{cf}}{\partial x^b} - \frac{\partial h_{bc}}{\partial x^f} \right) \right]$$
- l.5 
$$= \frac{1}{2}\varepsilon \left( \eta^{ae} \frac{\partial^2 h_{be}}{\partial x^c \partial x^d} + \eta^{ae} \frac{\partial^2 h_{de}}{\partial x^c \partial x^b} - \eta^{ae} \frac{\partial^2 h_{bd}}{\partial x^c \partial x^e} \right)$$
- l.6 
$$- \frac{1}{2}\varepsilon \left( \eta^{af} \frac{\partial^2 h_{bf}}{\partial x^d \partial x^c} + \eta^{af} \frac{\partial^2 h_{cf}}{\partial x^d \partial x^b} - \eta^{af} \frac{\partial^2 h_{bc}}{\partial x^d \partial x^f} \right)$$
- l.7 Let's relabel it as  $f$
- l.12 The first term will cancel

- p.287 l.13 
$$= \frac{1}{2} \varepsilon \eta^{ae} \left( -\frac{\partial^2 h_{bd}}{\partial x^c \partial x^f} + \frac{\partial^2 h_{df}}{\partial x^c \partial x^b} + \frac{\partial^2 h_{bc}}{\partial x^d \partial x^f} - \frac{\partial^2 h_{cf}}{\partial x^d \partial x^b} \right) \quad (13.4)$$
- p.287 l.15  $R_{ab} = \partial_c \Gamma^c_{ab} - \partial_b \Gamma^c_{ac}$
- p.287 l.2  $\psi'^a_{b,a} = \psi^a_{b,a} - \square \phi_b$
- p.287 l.4  $W \phi_a = \psi^b_{a,b}$   
 $\psi'^a_{b,a}$
- p.287 l.6  $\frac{1}{2} \varepsilon W \psi'_{ab} =$
- p.287 l.8  $W \psi'_{ab} = 0$
- p.287 l.14  $W \psi'_{ab} = W \left( h'_{ab} - \frac{1}{2} \eta_{ab} h' \right) = W h'_{ab} - \frac{1}{2} W \eta_{ab} h' = 0$
- p.287 l.16  $0 = W \psi'_{ab} = \eta^{ab} W \psi'_{ab} = W (\eta^{ab} \psi'_{ab}) = W (\psi'^b_b) = W \psi' = -W h'$
- p.287 l.19  $W h'_{ab} = 0$
- p.288 l.13 tensor can be shown to be a function of  $h_{xx}, h_{xy}, h_{yx}$  and  $h_{yy}$  alone, in the Einstein gauge.
- p.289 l.1 derivatives with respect to  $y$  and  $z$  vanish
- p.293 (\*) l.11  $ds^2 = d^2t - d^2x - d^2y - d^2z + 2\varepsilon h_{xy} dx dy \quad (13.19)$
- p.294 (\*) l.2  $ds^2 = dt^2 - (1 - \varepsilon h_{xy}) dx'^2 - (1 + \varepsilon h_{xy}) dy'^2 - dz^2 \quad (13.20)$
- p.299 l.5 ~~(see Quiz)~~
- p.300 l.11  $-2 \frac{a'}{a} X dudX$
- p.300 l.12  $= b^2 \left( -\frac{b'}{b} Y du + \frac{1}{b} dY \right)^2 = \dots - 2 \frac{b'}{b} Y dudY \dots$
- p.303 l.4 The ~~curvature tensor~~ Weyl scalar
- p.304 l.11  $ds^2 = \delta(u)(X^2 - Y^2) du^2 + 2dudr - dX^2 - dY^2 \quad (13.42)$
- p.304 l.13 ~~(see Problem 7)~~
- p.305 l.15 (13.45)
- p.306 l.13  $= -\frac{1}{2} \partial_\nu g_{xx}$
- p.306 l.14  $= -\frac{1}{2} \frac{\partial}{\partial \nu} (-[1 - \nu \theta(\nu)]^2)$
- p.306 l.15  $= (1 - \nu \theta(\nu)) \frac{\partial}{\partial \nu} (-\nu \theta(\nu))$
- p.306 l.16  $= (1 - \nu \theta(\nu)) \left( -\theta(\nu) - \nu \frac{d\theta}{d\nu} \right)$
- p.306 l.17  $= -(1 - \nu \theta(\nu)) (\theta(\nu) - \nu \delta(\nu))$
- p.306 l.19  $\int_{-\infty}^{\infty} f(\nu) \delta(\nu) d\nu = f(0)$
- p.307 l.7 since  $n_u$  is ~~not~~ 1
- p.307 l.8  $n_a = (1, 0, 0, 0)$
- p.308 l.3  $m^a = \frac{1}{\sqrt{2}} \left( 0, 0, -\frac{1}{(1 - \nu \theta(\nu))}, -i \frac{1}{(1 + \nu \theta(\nu))} \right)$
- p.308 l.4  $\bar{m}^a = \frac{1}{\sqrt{2}} \left( 0, 0, -\frac{1}{(1 - \nu \theta(\nu))}, i \frac{1}{(1 + \nu \theta(\nu))} \right)$
- p.309 l.2  $\bar{m}^x \bar{m}^x = \left( -\frac{1}{\sqrt{2}(1 - \nu \theta(\nu))} \right) \left( -\frac{1}{\sqrt{2}(1 - \nu \theta(\nu))} \right)$
- p.311 fig 13-11  $u^2 + v^2 = 1$



- p.315 (\*) l.6  $m_a = \frac{1}{\sqrt{2}}(0, 0, \cos av, +i \cosh av)$  (13.56)
- p.317 l.1  $\sigma = \frac{a}{2}(\tan av + \tanh av)$
- l.6  $\Psi_0 = +D\sigma - 2\sigma\rho$  (13.57)
- l.11  $= \frac{\partial}{\partial v} \left[ \frac{a}{2}(\tan av + \tanh av) \right]$
- (\*) l.12  $= \frac{a^2}{2}(1 + \tan^2 av + 1 - \tanh^2 av)$
- l.14  $\Psi_0 = +D\sigma - 2\sigma\rho$
- (\*) l.15-18  $= \frac{a^2}{2}(1 + \tan^2 av + 1 - \tanh^2 av) - \dots = a^2$
- p.318 l.7 *Nariai*
- l.8  $R_{ab} = -\Lambda g_{ab}$
- (\*) l.11 if  $R_{ab} = -g_{ab}\Lambda$  should rightfully be  $\Omega = 1 + \frac{\Lambda}{4}(x^2 + y^2)$
- l.16  $g^{vv} = +\Lambda v^2$
- (\*) l.18  $\Gamma^u_{uu} = -\Gamma^v_{uv} = -\Gamma^v_{vu} = \Lambda v$   
 $\Gamma^v_{uu} = \Lambda^2 v^3$
- $\Gamma^x_{xx} = \Gamma^y_{yx} = \Gamma^y_{xy} = -\Gamma^x_{yy} = -\frac{\Lambda x}{\Omega}$   
 $\Gamma^y_{yy} = \Gamma^x_{xy} = \Gamma^x_{yx} = -\Gamma^y_{xx} = -\frac{\Lambda y}{\Omega}$
- l.23  $m_a = \frac{1}{\sqrt{2}}\left(0, 0, -\frac{1}{\Omega}, -i\frac{1}{\Omega}\right); \bar{m}_a = \frac{1}{\sqrt{2}}\left(0, 0, -\frac{1}{\Omega}, \frac{i}{\Omega}\right)$
- l.24-25 These lines should be omitted
- p.319 l.3  $n^a = \left(1, +\frac{1}{2}\Lambda v^2, 0, 0\right)$
- l.4  $m^a = \frac{1}{\sqrt{2}}(0, 0, \Omega, i\Omega); \bar{m}^a = \frac{1}{\sqrt{2}}(0, 0, \Omega, -i\Omega)$
- l.11  $-\Lambda v$
- l.12  $l_{a;b}n^a n^b = l_{u;u}n^u n^u = -\Lambda v$
- l.19  $m_x = -\frac{i}{\sqrt{2}\Omega}$
- l.22  $\gamma = \frac{1}{2}l_{u;u}n^u n^u = -\frac{1}{2}\Lambda v$
- p.320 (\*) l.1 An exercise shows that ~~all~~ remaining nonzero spin coefficients ~~vanish~~ are  $\alpha =$   
 $-\frac{\Lambda}{\sqrt{2}}(x - iy); \beta = \frac{\Lambda}{\sqrt{2}}(x + iy)$
- l.5  $= \rho\mu - \sigma\lambda + \alpha\bar{\alpha} + \beta\bar{\beta} - 2\alpha\beta + \gamma(\rho - \bar{\rho}) + \epsilon(\mu - \bar{\mu}) - \Psi_2 + \Lambda_{NP} + \Phi_{11}$  (13.59)
- l.8  $= \partial_v \left(-\frac{1}{2}\Lambda v\right) = -\frac{1}{2}\Lambda$
- l.10  $= -\frac{1}{2}\Lambda$  (13.61)
- l.18  $-\frac{1}{2}\Lambda =$
- l.19  $= -\frac{1}{12}\Lambda$  (13.64)
- p.321 l.2  $\Psi_2 = -\frac{1}{6}\Lambda$  and  $\Phi_{11} = -\frac{1}{4}\Lambda$  (13.65)
- p.322 Q1 l.2 used in Example 13-2

$$\begin{aligned}
 \text{Q2 l.13} &= -2\sqrt{2}\mu \left( \frac{x}{x^2 + y^2} + i \frac{y}{x^2 + y^2} \right) \\
 \text{Q3 l.15} &\text{ used in Example } \mathbf{13-1} \\
 \text{l.18} &\Phi_{22} = \delta v - \Delta\mu - \mu^2 - \lambda\bar{\lambda} - \mu(\gamma + \bar{\gamma}) + \bar{v}\pi - v(\tau - 3\beta - \bar{\alpha}) \quad (9.24)
 \end{aligned}$$

## Final Exam

p.323 E1 (\*) l.2  $\Delta s^2 \dots E_1 = (-1, 3, 2, 4)$   
 (\*) l.3  $E_2 = (4, 0, -1, 1)$

p.324 E7 (\*) The nonzero Christoffel symbols are:  $\Gamma^u_{uu} = -\Gamma^u_{vv} = \Gamma^v_{uv} = \frac{u}{(u^2+v^2)}$ ;  $\Gamma^v_{vv} = -\Gamma^v_{uu} = \Gamma^u_{vu} = \frac{v}{(u^2+v^2)}$ ;  $\Gamma^u_{\theta\theta} = -\frac{uv^2}{(u^2+v^2)}$ ;  $\Gamma^v_{\theta\theta} = -\frac{u^2v}{(u^2+v^2)}$ ;  $\Gamma^{\theta}_{u\theta} = \frac{1}{u}$ ;  $\Gamma^{\theta}_{v\theta} = \frac{1}{v}$

p.325 E9 (\*) l.11  $\Gamma^{\psi}_{\theta\theta} = -\cosh\psi \sinh\psi$ ,  $\Gamma^{\psi}_{\phi\phi} = -\cosh\psi \sinh\psi \sin^2\theta$   
 E10 (\*) The non-zero Ricci rotation coefficients are:  $\Gamma^{\hat{\psi}}_{\hat{\theta}\hat{\theta}} = -\Gamma^{\hat{\theta}}_{\hat{\psi}\hat{\theta}} = -\coth\psi$ ,  $\Gamma^{\hat{\psi}}_{\hat{\phi}\hat{\phi}} = -\Gamma^{\hat{\phi}}_{\hat{\psi}\hat{\phi}} = -\frac{\cot\theta}{\sinh^2\psi}$ ,  $\Gamma^{\hat{\theta}}_{\hat{\phi}\hat{\phi}} = -\Gamma^{\hat{\phi}}_{\hat{\theta}\hat{\phi}} = -\frac{\cot\theta}{\sinh^2\psi}$

p.326 E12 (\*) l.2  $\Psi_2 = \frac{r^2 - 4rm + 3e^2}{2r^4}$   
 E14 (\*) l.16  $ds^2 = \frac{1}{2\omega^2} \left( (dt + e^x dz)^2 - dx^2 - dy^2 - \frac{1}{2} e^{2x} dz^2 \right)$   
 (\*) l.18  $T_{ab} = \frac{\rho}{2\omega^2} \begin{pmatrix} 1 & 0 & 0 & e^x \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ e^x & 0 & 0 & e^{2x} \end{pmatrix}$

## Quiz and Exam Solutions

- p.330 l.3 (\*) 7.b  
 p.331 l.7 (\*) 5.c  
 l.9 (\*) 13.a

## Bibliografi

McMahon, D. (2006). *Relativity Demystified*. McGraw-Hill Companies, Inc.

<sup>1</sup> [http://en.wikipedia.org/wiki/G%C3%B6del\\_metric](http://en.wikipedia.org/wiki/G%C3%B6del_metric)