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Errata for:

## “Probing the Universe: A Geometrical View for Observers of Spacetime Physics”

Robin W. Tucker and Timothy J. Walton (Springer: 2026)

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A list of typographical errors and correction for the book will be kept here. Corrections are emphasised in **red** text.

Please email [TWalton@lancashire.ac.uk](mailto:TWalton@lancashire.ac.uk) if you find any typographical errors not already listed.

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page 177: The line immediately below the first displayed equation should read:

“In the  $\mathbf{g}_{\mathbb{R}^3}$ -orthonormal cobasis for . . .”

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page 285: The line directly above the only displayed equation on this page should read:

“Since  $\Pi_Q^\perp(W') = \mathbf{W}$ , both the spacelike. . .”

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page 290: The sentence directly preceding equation (15.45) should read:

“Recalling  $W \equiv \Pi_Q^\perp(W')$  where  $Q$  is geodesic with  $\mathbf{g}(Q, Q) = -L_0^2$  and  $W'$  is Lie-parallel with respect to  $Q$ , the vector fields  $Q, W$  **satisfy** the conditions. . .”

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page 376: The last displayed equation on this page should read:

$$\begin{aligned}\mathcal{G}_c &= \mathcal{R} \star e_c - 2(i_a P_c) \star e^a + \mathbf{2}(i_c i_a i_b \mathfrak{D}T^b) \star e^a \\ &= \mathcal{R} \star e_c - 2 \star P_c - 2i_a(i_c i_b \mathfrak{D}T^b) \star e^a\end{aligned}$$

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page 380: The line immediately below the first displayed equation should read:

“... is a type-preserving *derivation* on the algebra of exterior forms on  $\mathcal{M}$  (**see appendix H for further details**) that commutes with the exterior derivative. . .”

There is also a typographical error on this page. The eighth line below equation (20.8) should say:

“...equality modulo  $d$  will below be **denoted** by. . .”

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page 382: The line immediately below equation (20.13) should read:

“...of the interior operator  $i_c \equiv i_{\textcolor{red}{X}_c}, \dots$ ”

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page 383: The top displayed equation on this page should read:

$$\psi_2 = \dot{e}^{\textcolor{red}{a}} \wedge e^b \wedge \star R_{ab}.$$

The displayed equation between (20.17) and (20.18) should read:

$$\begin{aligned} \mathfrak{D} \star e^{ab} &= \frac{1}{2} \epsilon^{ab}_{cd} \mathfrak{D} e^{cd} = \frac{1}{2} \epsilon^{ab}_{cd} (T^c \wedge e^d - e^c \wedge T^d) \\ &= \epsilon^{ab}_{cd} T^c \wedge e^d = T_c \wedge \star e^{abc} \end{aligned}$$

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page 384: The line of text above equation (20.22) should read:

“In this case the 3-forms  $\{\mathcal{G}_c^{(\text{EH})} \equiv -\frac{1}{2} \mathcal{G}_c\}$  define...”

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page 385: Equation (20.24) should read:

$$\begin{aligned} \Lambda_{\text{TOTAL}}(e, \omega, A, \phi, \bar{\phi}) &\equiv \frac{\textcolor{red}{1}}{\textcolor{red}{2}\kappa} R_{ab}(\omega) \wedge \star e^{ab} + \kappa_A dA \wedge \star dA \\ &\quad + \kappa_1 \text{Re} \left( \overline{\mathfrak{D}_{\text{U}(1)} \phi} \wedge \star \mathfrak{D}_{\text{U}(1)} \phi \right) \\ &\quad + \kappa_2 \phi \bar{\phi} \star 1 + \kappa_3 R_{ab}(\omega) \wedge R^{ab}(\omega) \end{aligned} \tag{20.24}$$

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page 386: Equation (20.30) should read:

$$\mathcal{I}_{\text{EH}}[e, \omega] \equiv \frac{\textcolor{red}{1}}{\textcolor{red}{2}\kappa} \int_{\mathcal{M}} R_{ab}(\omega) \wedge \star (e^a \wedge e^b), \tag{20.30}$$

and the displayed equation below becomes:

$$\begin{aligned} \mathcal{G}_c^{(\text{EH})} &\equiv -\frac{\textcolor{red}{1}}{\textcolor{red}{2}} R_{ab} \wedge i_c \star (e^a \wedge e^{\textcolor{red}{b}}) = 0, \quad a, b, c = 0, 1, 2, 3, \quad e^a(X_c) = \delta_c^a \\ T^c &= 0. \end{aligned}$$

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page 388: Equation (20.31) should read:

$$\text{Ein} \equiv (\star^{-1} \mathcal{G}_c^{(\text{EH})}) \otimes e^c = \kappa (\star^{-1} \tau_c^{(\text{SOURCE})}) \otimes e^c. \tag{20.31}$$

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page 392: The first equation of section 20.4 should read:

$$\mathcal{I}_{\text{EH}}[e, \omega] \equiv \frac{1}{2\kappa} \int_{\mathcal{M}} R_{ab}(\omega) \wedge \star(e^a \wedge e^b), \quad (20.30)$$

and the second equation becomes:

$$\begin{aligned} \mathcal{I}_{\text{SOURCE}}[e, A, \phi, \bar{\phi}] \equiv & \kappa_A \int_{\mathcal{M}} \Lambda_2(e, A) + \kappa_1 \int_{\mathcal{M}} \Lambda_1(e, A, \phi, \bar{\phi}) \\ & + \mu^2 \int_{\mathcal{M}} \Lambda_3(e, \phi, \bar{\phi}) \quad (\kappa_1, \mu \in \mathbb{R}) \end{aligned}$$

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page 395: The displayed equation immediately above equation (20.37) should read:

$$\widehat{\delta} \left( \mathcal{I}_{\text{EH}}[e, \omega] + \mathcal{I}_{\text{SOURCE}}[e, A, \phi, \bar{\phi}] \right) \simeq 0,$$

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page 396: Equation (20.39) should read:

$$\frac{\mathcal{G}_c^{(\text{EH})}}{\kappa} = \tau_c \quad (20.39)$$

and the text immediately after this displayed equation becomes:

“where  $\mathcal{G}_c^{(\text{EH})} \equiv -\frac{1}{2} R_{ab} \wedge i_c \star e^{ab} \dots$ ”.

The text in the first paragraph immediately below the last displayed equation of this page should be:

“Note  $[\tau_c] = \mathbf{M}[c_0^2]$ . Since the  $\dot{\omega}_{ab}$  partial variations in  $\mathcal{I}_{\text{EH}}[e, \omega]$  and  $\mathcal{I}_{\text{SOURCE}}[e, A, \phi, \bar{\phi}]$  yield a set of zero-torsion connection 1-forms (see section above), if these are assumed to be metric-compatible with respect to the metric tensor  $g = \eta_{ab} e^a \otimes e^b$  then (20.37), (20.38), (20.20) constitute the necessary conditions for the functional  $\mathcal{I}_{\text{EH}}[e, \omega] + \mathcal{I}_{\text{SOURCE}}[e, A, \phi, \bar{\phi}]$  to be extremal and (20.39) yields a *Levi-Civita Einstein tensor field equation with sources*. ”

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page 402: The penultimate displayed equation on this page should read:

$$\mathbf{T}^{(\text{MAX})}(X_0, X_0) = (\star \tau_c^{(\text{MAX})})(X_0) \delta_0^c = i_0(\star \tau_0^{(\text{MAX})})$$

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page 405: The second displayed equation in section 21.1 should read:

$$(\nabla \cdot \Xi)(\mathbf{Y}) \equiv (\nabla_{X_a} \Xi)(X^a, Y) \quad \text{for all } Y \in \Gamma T\mathcal{U}_{\mathcal{M}}.$$

page 414: Equation (22.8) should read:

$$\mathcal{G}_a^{(\text{EH})} = \kappa \tau_a^{(\text{SOURCE})}, \quad a = 0, 1, 2, 3. \quad (22.8)$$

The text immediately following this line should then read:

“Recall that it follows from  $\left[ \mathcal{G}_a^{(\text{EH})} \right]$  and ...”.

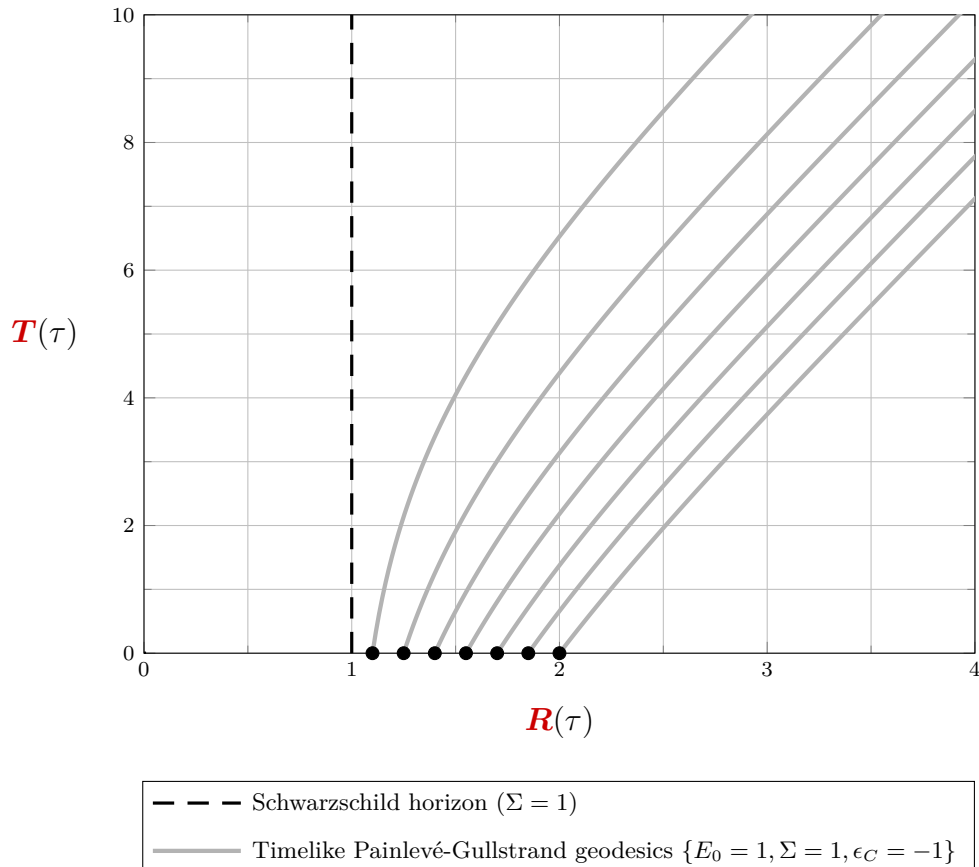
Equation (22.9) should read:

$$\mathcal{G}_a^{(\text{EH})} = \kappa \sum_N \tau_a^N \equiv \kappa \tau_a^{(\text{SOURCE})}. \quad (22.9)$$

page 488: The first displayed equation on this page should read:

$$\begin{aligned} \frac{1}{L_0} \mathbf{g}_{\text{PG}}(\dot{C}, X_0) \Big|_{C(\tau)} &= -\dot{T}(\tau) \\ \frac{1}{L_0^2} \mathbf{g}_{\text{PG}}(\dot{C}, \dot{C}) \Big|_{C(\tau)} &= - \left( 1 - \frac{\Sigma}{R(\tau)} \right) \dot{T}(\tau)^2 + 2 \sqrt{\frac{\Sigma}{R(\tau)}} \dot{T}(\tau) \dot{R}(\tau) + \dot{R}(\tau)^2 \\ &\quad + R(\tau)^2 \left( \dot{\Theta}(\tau)^2 + \sin^2(\Theta(\tau)) \dot{\Phi}(\tau)^2 \right). \end{aligned}$$

page 491: The axis labels  $(T(\tau), R(\tau))$  in Fig. 30.1 are the wrong way round and need to be swapped. The figure should be as follows:



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page 659: Equation (34.14) for the Bopp-Podolsky field equations should read:

$$d \star \mathcal{F} + \lambda_0^2 d\delta d \star \mathcal{F} = 0 \quad (34.14)$$

The change in sign here ensures the static, spherically symmetric solution is finite as  $r \rightarrow 0$ . This correction contributes to a number of changes over the next few pages.

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page 659: Equation (34.16) for the Bopp-Podolsky field equations should read:

$$\begin{aligned} d \star \mathcal{F} + \lambda_0^2 d\delta d \star \mathcal{F} &= d\delta d\alpha \wedge \Pi + \lambda_0^2 d\delta d\delta d\alpha \wedge \Pi \\ &= d \left( \delta d\alpha + \lambda_0^2 \delta d\delta d\alpha \right) \wedge \Pi = 0. \end{aligned} \quad (34.16)$$

The following equation also needs correcting:

$$\square \alpha + \lambda_0^2 \square^2 \alpha = 0, \quad \square \alpha \neq 0, \quad (34.17)$$

as does the final displayed equation of the page which should read:

$$\square \alpha + \frac{1}{\lambda_0^2} \alpha = 0, \quad \lambda_0 \neq 0.$$

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