Science Supplementary Material
S383 The Relativistic Universe

S383

Errata 2010 - 2012

This document lists errors identified during the first few presentations of the module. As the books were subsequently reprinted, this errata document is applicable only if you have received the original editions of the books. Please check the page opposite the first contents page of each book to see whether you have received the original version or the reprinted version. The original versions will have 1.1 at the bottom of the page and the reprints will have 1.2. (Note that both versions have the same published/copyright year 2010.) PDF copies of the reprinted books are available to download from the S383 website. Errors identified after the books were reprinted can be found in the document S383 Errata 2013 onwards. *New errors identified during the current presentation of this module will be added directly to the Errata section of the website.*

Relativity, Gravitation and Cosmology

P.28: In paragraph 6, the equation for the proper wavelength should read $\lambda_{\text{em}} = c/f_{\text{em}}$.

P.28: In the last paragraph, the first sentence should read '...time separating the emission of successive equivalent nodes is ...'

P.30: In the answer to the in-text question, just above the equation for v'_x it should refer to the velocity of object 1 not object 2.

P.31–32: Bottom of p.31, top of p.32 the sentence has ct'-axis and x'-axis the wrong way around. It should say: 'This shows that in the spacetime diagram for frame S, the x'-axis of frame S′ is represented by the line $ct = (V/c)x$, ... Similarly ... showing that the ct'-axis of frame S′ is represented by the line $ct = (c/V)x$ ...' The diagram is correct.

P.54: In the Taylor theorem expansion of the Lorentz factor in Equation 2.20 and the equation above Equation 2.21, the coefficient of the v^4/c^4 term should be $\frac{3}{8}$ not $\frac{3}{4}$.

P.59: In the solution to the in-text question at the bottom of the page, the units for the substitutions m^2c^4 and c^2p^2 should be J^2 and not J. The rest of the solution is unchanged.

P.60–61: In Equations 2.46, 2.47 and 2.48, all the P symbols on the right hand sides should be $\overline{P}$ (with appropriate index, subscript and prime as necessary) to indicate the momenta of the emergent particles.

P.69: In the sentence following Equation 2.80, the units for μ_0 should be $\text{T}\,\text{m}\,\text{A}^{-1}$, as in Table A.3 on p.278, and not $\text{N}\,\text{m}\,\text{A}^{-1}$.

P.70: In the un-numbered equation for f_y, the first term inside the brackets should be $\mathcal{E}_y$ not $\mathcal{E}_x$.

P.72: The first component of the vector on the right of Equation 2.91 should be $\gamma(v)c$ not just c.

P.75 and 79: Equation 2.102 on page 75 (and again in the chapter summary, item 14 on page 79) should have $\mu_0 J^\nu$ on the right hand side and not J^ν/ε_0.

P.86: The second equation below Figure 3.7 should read

$$\mathrm{d}y = \sin\theta \sin\phi \,\mathrm{d}r + r\cos\theta\sin\phi\,\mathrm{d}\theta + r\sin\theta\cos\phi\,\mathrm{d}\phi$$

but Equation 3.9 is correct.

P.87: In the solution to Worked Example 3.3, the final sentence should read '... since each one points in the direction of increasing ϕ ... '.

P.96: In the box on 'Parallel transport and connection coefficients', the second line should read '...with coordinates $x^1, \ldots, x^n$ ... '.

P.116: Replace the last paragraph of subsection 4.1.1 (which starts 'The final form of general relativity was not clear to Einstein in 1907 ...') with the following:

'The equivalence principle calls into question the reality of gravitational forces. The centrifugal force experienced by an observer in a bus turning a corner is usually described as a *fictitious force* since it only arises from the use of a non-inertial frame. The equivalence principle indicates that, locally at least, gravitational forces are similarly 'fictitious' results of using a frame that is not freely falling and so not locally inertial. In a freely falling frame the (local) effects of gravitation would vanish and there would be no gravitational force. This does not mean that gravitation is not real but suggests that in its final formulation general relativity might be a 'geometric theory' in which spacetime curvature determines gravitational effects (including what is a locally inertial frame), and gravitational forces will not be needed. In such a theory gravitational mass would play no role and its equivalence to inertial mass would cease to be a mystery.'

P.137: The definition of the norm on the 4th line down should read:

$$\Sigma_{\alpha,\beta} g_{\alpha,\beta} t^\alpha t^\beta$$

i.e. the metric $g_{\alpha,\beta}$ was inadvertently omitted from the text.

P.149: In the fourth equation from the top (for R_{33}), the exponential term should be e^{-2B} not e^{2B}.

P.159: The left hand side of Equation 5.19 should be $(\mathrm{d}\sigma)^2$.

P.162: The beginning of line 3 should read $x^0 = ct(\lambda)$.

P.190: In Equation 6.28 there should *not* be an r^2 term in front of the coefficient of $(\mathrm{d}r)^2$.

P.193: Second bullet point from the end of the page should say 'As $r \to \infty$ it can be seen that $p^2 \to r^2$ and $\Delta \to r^2$ '.

P.202: In bullet point 13, the statement in brackets is confusing two issues. In an extreme Kerr black hole (i.e. one where $a = R_\mathrm{S}/2$) the two event horizons are coincident spheres. Alternatively, in a black hole where $a = 0$, then the outer event horizon and the surface of infinite redshift are coincident spheres – and the object is a Schwarzschild black hole. So the best thing is to delete the statement in brackets.

P.208: The first word on this page should be 'emitter' and not 'receiver'.

P.245: The equation in the text four lines up from the bottom of the page should read $\mathrm{d}\sigma = R(t)\mathrm{d}r/(1 - kr^2)^{1/2}$.

P.250: Under 'Case 4', the third line below the equation, should say '... would sum to less than π radians.'

P.261: The expression in the fourth line from the top should say that ρ_r (and not ρ_m) is proportional to $1/R^4$.

P.262 and 305: In Exercise 8.7, on p.262, the unit of the current cosmic matter density should be $\mathrm{kg\,m^{-3}}$. In the answer to the Exercise, on p.305, it should say setting $\rho_{\mathrm{r},0} = 0$ not $\rho_{\mathrm{m},0} = 0$.

P.262: In Figure 8.14, the labels $k > 0$ and $k < 0$ are the wrong way round.

P.267: In Equation 8.62, the third term on the right-hand side should be $-\frac{1}{2}q_0 H_0^2 (t_0 - t)^2$. Also, the line beneath Equation 8.63 should refer to Equation 8.61 and not Equation 8.53.

P.273: On Figure 8.18, the line labelled 'Hubble distance' should have $v = c$ not $v = 2c$ (see Figure 8.17 where it's correct). Also on the line for 'proper distance at emission / Gly', the labels for 0.5 and 0.1 should be swapped.

P.275: Summary item 11 should read: '... dominated respectively by dark energy, radiation and matter , ...'.

P.284: In the solution to Exercise 2.14 replace each of the four occurrences of Λ with Λ^{-1}.

P.287: In the solution to Exercise 3.9, in Equation 3.69, $(d\theta/d\lambda)^2$ should be $(d\phi/d\lambda)^2$.

P.288: Towards the end of the solution to Exercise 3.9c it should say $\sin\theta = \cos\theta = 1/\sqrt{2}$ (i.e. not $\sqrt{2}$). So the following line should read: 'Equation 3.69 becomes $0 - (1/\sqrt{2}) \times (1/\sqrt{2}) \times 1 = -1/2 \neq 0$.' The rest of the answer is unaffected.

P.295: The first line of the answer to Exercise 5.3 should read $\dfrac{\mathrm{d}\tau}{\mathrm{d}t} \geq 1 - 10^{-8}$.

P.304: In the last paragraph of the solution to Exercise 8.5, the relation should be $p_\Lambda = -\rho_\Lambda c^2$ so the two intermediate lines of the solution should have $-\rho_\Lambda c^2$ as the last term inside the brackets. The final line of the solution is already correct.

P.306: Add the following sentence to the end of the solution to Exercise 8.9 (iii): 'The Einstein model also requires $k > 0$, so this corresponds to any location along the green line, to the right of the red dashed line.'

Observational Cosmology

P.12: Line 6 should read 'Consider a shell around the *Sun* ...' (and not the Earth).

P.40: At the end of the 3rd paragraph of Section 2.1 add '(More precisely, it's at $z = 1090$.)'.

P.43: The equation below Equation 2.2 should read

$$I(\nu', T)\mathrm{d}\nu'(1+z) \propto \frac{(\nu')^3(1+z)^3}{\mathrm{e}^{h\nu'(1+z)/kT} - 1}\mathrm{d}\nu'(1+z)$$

but since the factors on each side immediately cancel out, the rest of the derivation is unaffected.

P.44: At the end of Exercise 2.3 add 'Evaluate z_{eq}'.

P.53: Replace the final paragraph with the following:

'The horizon problem is that 0.46 Mpc on the CMB is very small: by numerically integrating Equation 1.44, we find that the comoving distance to $z = 1090$ (the redshift of CMB) is $14\,189$ Mpc, so the angular diameter distance $d_{\mathrm{A}} = d_{\mathrm{comoving}}/(1+z) = 14\,189/1091 \simeq 13$ Mpc. Using Eqn 1.47, the angular size of the particle horizon at the time of recombination is $\theta = D/d_{\mathrm{A}} = 0.46/13$ radians $\simeq 2$ degrees (slightly less if we take into account the early radiation-dominated phase). We've just shown that objects further apart than this distance could not have been in causal contact, so how is it that parts of the CMB sky more distant than two degrees ever managed to look so similar?'

P.56: On the third line down, $R(r)$ should be $R(t)$.

P.58: Equation 2.18 should read: $\ddot{\phi} + 3H\dot{\phi} - \nabla^2\phi + \mathrm{d}V/\mathrm{d}\phi = 0$ (i.e. the first '=' sign as printed should be a '+').

P.69: On the horizontal axis at the top of Figure 2.9, the label for $l = 500$ should be moved one tick to the right.

P.72: The fourth sentence of the fourth paragraph in Section 2.12 should read 'Overtones correspond to situations where the sound horizon size is an integer multiple of half wavelengths ($n = 2, 3, 4$ etc); these are the subsequent peaks in Figure 2.9.'

P.73: The second and third sentences at the top of the page should read 'The ratio of the two is therefore *almost* H_0-independent. The apparent angular size of the first acoustic peak is therefore determined almost entirely by the geometry of the Universe, ...'.

P.73: In Exercise 2.9, the value of redshift z_{recomb} should be given as '$z_{\mathrm{recomb}} \simeq 1090$'. The redshift value in the third line should read '$z \simeq 23\,800\,\Omega_{\mathrm{m},0}h^2 \simeq 3160$'. This does not affect the answer.

P.76: Just above Figure 2.12, the sentence about optical depth should say: '...the probability of a photon undergoing Thomson scattering is defined as $1 - e^{-\tau}$'.

P.76: The x-axes of the two panels in Figure 2.12 should read 'redshift of reionization'.

P.88: In lines 4 and 5, the text should say '...120 orders of magnitude *greater* than the observed Λ'.

P.161: The end of line 8/beginning of line 9 should read '... at some observed frequency ν_0 ...' (and not wavelength).

P.168: In the third line from the bottom, the expression for ν_{rest} should be $\nu_{\mathrm{rest}} = \nu(1+z)$.

P.186–187: Towards the bottom of p.186 and in Equation 6.7 at the top of p.187, replace $\frac{\mathrm{d}M_{\mathrm{BH}}}{\mathrm{d}t}$ with $\frac{\mathrm{d}M_{\mathrm{acc}}}{\mathrm{d}t}$, i.e. the rate of mass accretion, not the rate of growth of black hole mass. Note therefore that the fraction of the accretion rate which goes into increasing the mass of the black hole is $(1-\eta)$, and so the rate of growth of the mass of the black hole is therefore $\frac{\mathrm{d}M_{\mathrm{BH}}}{\mathrm{d}t} = (1-\eta)\frac{\mathrm{d}M_{\mathrm{acc}}}{\mathrm{d}t}$. In the paragraph below Equation 6.8, delete everything after the first sentence and replace it with the following:

‘If we set $L_{\rm E} = \eta \frac{{\rm d}M_{\rm acc}}{{\rm d}t} c^2$, we can re-write this as $L_{\rm E} = \frac{\eta}{(1-\eta)} \frac{{\rm d}M_{\rm BH}}{{\rm d}t} c^2$. Then, given the definition of the Eddington timescale in Equation 6.8, we can combine these two equations to give $\frac{{\rm d}M_{\rm BH}}{{\rm d}t} = \frac{(1-\eta)}{\eta} \frac{M_{\rm BH}}{t_{\rm E}}$. This differential equation has a solution $M_{\rm BH} \propto \exp\left[\left(\frac{1-\eta}{\eta}\right) \frac{t}{t_{\rm E}}\right]$. So the e-folding timescale for growth of the black hole, i.e. the time to increase by a factor of $e = 2.71828...$, is $\eta t_{\rm E}/(1-\eta)$.’

P.192: The left-hand side of Equation 6.19 should read $\dfrac{r^2}{c}\dfrac{{\rm d}\phi}{{\rm d}\tau}$.

P.193: In Equation 6.25 the integral is not separable and should therefore read:

$$E_{\rm total} = \frac{4\pi}{c} \int_{z=0}^{\infty} \int_{S=0}^{\infty} (1+z) S n(S,z) {\rm d}z {\rm d}S.$$

P.195: Equation 6.29 should read:

$$r_h = \frac{GM_{\rm BH}}{\sigma^2} \simeq 10 \left(\frac{M_{\rm BH}}{10^8\ {\rm M}_\odot}\right) \left(\frac{\sigma}{200\ {\rm km\ s^{-1}}}\right)^{-2}\ {\rm pc}.$$

Then the paragraph following Equation 6.30 should say ‘... so the radius r_h is about 10^6 times bigger than the Schwarzschild radius .... if we can reach angular resolutions of $\sim 10^6 R_{\rm S}$ we may be able to...’.

P.201 and 307: In Exercise 6.6, add a phrase to the end of the question as follows ‘... you still cannot create a supermassive black hole by $z = 2$ through Eddington-limited black hole growth, if it is accreting with maximal efficiency, $\eta = 0.42$.’

Change the solution to Exercise 6.6 as follows: ‘The e-folding timescale for Eddington-limited black hole growth is $t_{\rm e-fold} = 4 \times 10^8 \times \eta/(1-\eta)$ years. There have been $3 \times 10^9/t_{\rm e-fold}$ e-foldings since the start of the Universe, or $7.5 \times (1-\eta)/\eta$ e-foldings. To reach $10^6 {\rm M}_\odot$, one needs $\log_{\rm e}(10^6/10^1) = 11.5$ e-foldings. If $\eta = 0.42$, there is only time for 10.4 e-foldings. In order to grow a black hole large enough, it must be spinning more slowly, and therefore have a lower accretion efficiency.’

P.207: About mid-way down the page, the ‘broad constraint on the accretion efficiency’ should be $\eta = 0.04 - 0.16$.

P.226: In Equation 7.20, the force vector ***F*** should be given by $(-kx, -ky)$.

P.231: The equation at the top of the page should read:

$$n = \sqrt{\frac{1 - 2\Phi/c^2}{1 + 2\Phi/c^2}} \simeq 1 - \frac{2\Phi}{c^2}.$$

P.233: The sentence immediately below the figures should say ‘Notice in figure 7.16 how ...’.

P.234: The right-hand side of Equation 7.46 should read $a + d$ (not ad).

P.235: In Figure 7.17, the pair of schematics at the top of the middle column is not quite correct. To get the effect shown it should have the centre of the little circle (i.e. the position of the background object) just outside the apex of the star-shaped inner caustic.

P.236: On the 7th line below Equation 7.51, ‘isothermal ellipse’ should say ‘isothermal ellipsoid’.

P.242: Equation 7.57 should read:

$$1 - \kappa = \frac{1}{2}({\rm tr}\,A) = 1 - \frac{1}{2}(\psi_{11} + \psi_{22})$$

P.242: Just above the equation for ε, the sentence should read ‘Sometimes the ellipticity is expressed as ...’.

P.261: In the line directly below Figure 8.9 it should refer to the ‘red’ line (not dotted).

P.273: The second sentence of the last paragraph of Section 8.9 should read: ‘Figure 8.19 shows the constraints on the neutral fraction $(1-x)$ ... ’.

P.288–290: In Section B.7, the second equation should say $\mathbf{U} \cdot \mathbf{U} = c^2$. In Section B.10, the second equation should read $\boldsymbol{F} = \left(\dfrac{\mathrm{d}P^0}{\mathrm{d}\tau}, \gamma f^i\right)$. In Section B.11, the first four lines of equations should read:

$$
\begin{aligned}
0 &= \sum_{\alpha,\beta} \eta_{\alpha\beta} U^\alpha m a^\beta = \sum_{\alpha,\beta} \eta_{\alpha\beta} U^\alpha F^\beta \\
0 &= U^0 \frac{\mathrm{d}P^0}{\mathrm{d}\tau} - U^i \gamma f^i = c\frac{\mathrm{d}t}{\mathrm{d}\tau}\frac{\mathrm{d}(\gamma mc)}{\mathrm{d}\tau} - \frac{\mathrm{d}x^i}{\mathrm{d}\tau}\gamma f^i \\
0 &= c\frac{\mathrm{d}t}{\mathrm{d}\tau}\frac{\mathrm{d}t}{\mathrm{d}\tau}\frac{\mathrm{d}(\gamma mc)}{\mathrm{d}\tau} - \frac{\mathrm{d}t}{\mathrm{d}\tau}\frac{\mathrm{d}x^i}{\mathrm{d}t}\gamma f^i \\
0 &= c\gamma^2\frac{\mathrm{d}(\gamma mc)}{\mathrm{d}\tau} - \gamma\frac{\mathrm{d}x^i}{\mathrm{d}t}\gamma f^i
\end{aligned}
$$

Finally, the expression just above Equation B.7 should read $\boldsymbol{P} = (E/c, m\gamma u^i)$, whilst Equation B.7 and the following text should read '$E^2 = p^2c^2 + m^2c^4$, where p is the magnitude of the relativistic three-momentum.'

P.293: Add the following to the end of Exercise 2.3 'Using $\Omega_{\mathrm{m},0} = 0.268$, $h = 0.704$ and $T_{\mathrm{CMB},0} = 2.725\,\mathrm{K}$ gives $z_{\mathrm{eq}} \simeq 3160$.'

P.297: In the solution to Exercise 3.3, on the ninth line, the expression for mass should be $M = \frac{4}{3}\pi\rho R^3$ (i.e. the density ρ was missing).

P.303: In the solution to Exercise 4.13, the expression for n_{wide} should include the constant of proportionality k (as in the expression for n_{pencil}) so that it then cancels out when the two expressions are compared.

P.306–307: The first sentence of the solution to Exercise 6.5 should read 'The angular radius ... ' (not angular size).

In the solution to Exercise 6.5, inserting numbers into Equation 6.29 should give $r_h = 10 \times (10^8/10^8) \times (220/200)^{-2}\,\mathrm{pc} = 8.3\,\mathrm{pc}$. This then gives an angular radius of $\theta \simeq 8.3 \times 10^{-7}$ radians or $\theta \simeq 0.17''$. It is still the case that this is smaller than the seeing limit of ground based telescopes.

Immediately after the solution of $0.17''$, add the phrase '(or double that for the diameter)'.

Extreme Environment Astrophysics

P.39: Chapter 1 summary, point 11 should say 'a few tens of light days' not 'a few tens of pc'.

P.43: The final equation in Worked Example 2.1 should not have a minus sign in front of the GM/a term that has been factored out.

P.49: In the sentence in brackets following Equation 2.21, remove the minus sign in front of $(1/3)$.

P.49: In Equation 2.22, the J should not be in the subscript. The equation should read:

$$\frac{\dot{M}_2}{M_2} = \frac{2\dot{J}_{\mathrm{sys}}/J - (\dot{R}_2/R_2)_{\mathrm{nuc}}}{\zeta - \zeta_{\mathrm{L}}}.$$

P.60: At the end of Worked Example 2.3, the equation on the penultimate line should have 1.42 on the top line not 2.82. The answer is correct though.

P.65: Summary item 5 should read '... is the radius of a sphere with the same volume as the Roche lobe.'

P.82: The label on the y-axis of figure 3.10 should read $\nu_{\mathrm{vis}}\Sigma/(\dot{M}/3\pi)$.

P.88: A couple of the indices are wrong in Equation 3.37. It should read:

$$\Sigma(r) = 52\alpha^{-4/5}\left(\frac{\dot{M}}{10^{13}\,\mathrm{kg\,s^{-1}}}\right)^{7/10}\left(\frac{M}{\mathrm{M}_\odot}\right)^{1/4}\left(\frac{r}{10^8\,\mathrm{m}}\right)^{-3/4} \times \left[1 - \left(\frac{R_1}{r}\right)^{1/2}\right]^{7/10}\ \mathrm{kg\,m^{-2}}\,.$$

P.95: The right hand side of Equation 4.2 should read $-r\dfrac{\partial\Sigma}{\partial t}$.

P.96: Mid-way down the second paragraph, the unit of j_u should be $\mathrm{J\,m^{-2}\,s^{-1}}$.

P.127: In Exercise 5.6, in order to match the answer provided, part (a) of the question should ask for the Keplerian speeds at the outer and inner edges of the accretion disc, whilst part (b) should ask for the corresponding maximum Doppler shifts of the hydrogen $H\alpha$ line.

P.131: Equation 5.2 should read $X^2 = \sum_{i=0}^{N} \dfrac{(x_i - \mu_i)^2}{\sigma_i^2}$.

P.139: In the second paragraph, the wavelength of the Lyman limit is 91.2 nm (or 912 Angstrom) not 912 nm.

P.139: In Figure 5.14, the text below the panels should say $\lambda_1 = hc/\Delta E_1$ and $\lambda_2 = hc/\Delta E_2$.

P.151: In the line immediately below Figure 6.5 it should say: '... as the change in momentum per unit time per unit area.'

P.162: In the caption to Figure 6.12(c), the first term added to the curve should be $0.77\sin(2\pi(10f)t)$ not $0.77\sin(2\pi(f/10)t)$.

P.179: Exercise 6.10(b) should say 'Use the expression for $\dot{M}_{\rm Edd}$ and Equation S1.1 (in the solution to Exercise 1.10 in subsection 1.4.1)...'.

P.181: To avoid ambiguity, the expression at the bottom of the page would be better written as:

$$-\log_{10}\left(\frac{f_{12}}{\rm Hz}\right) \simeq (2.2 \pm 0.3) \times \log_{10}\left(\frac{M_{\rm SMBH}}{\rm M_\odot}\right) - (0.9^{+0.3}_{-0.2}) \times \log_{10}\left(\frac{L}{\rm L_\odot}\right) - (2.4^{+0.2}_{-0.3}).$$

P.198: In the un-numbered question below Equation 7.30, the third sentence of the answer should read 'Equation 7.30 thus becomes $\nu_{\rm rec} = \nu'_{\rm em}/(1 - v_{\parallel}/c)$'.

P.201: The equation in the line immediately above Equation 7.35 should read $t = v_2\Delta t/(v_2 - v_1)$.

P.203: In the sentences immediately preceding Exercise 7.9, the expressions for the Lorentz factor of the decelerated flow should be $\gamma_{\rm b} \leq \gamma_2/\sqrt{2}$ and for the thermal energy generated should be $E_{\rm th} \geq \gamma_2 m_2 c^2(1 - 1/\sqrt{2})$.

P.208: In Equation 7.52 there should not be a factor of c on the bottom line in order for the equation to be dimensionally correct in SI units. (As written it is correct if magnetic field is defined differently, and you may see this form in some textbooks.) The same erratum occurs when the equation is repeated in the chapter summary. Please delete the factor of c in both places.

P.227: In the solution to Worked Example 8.1, towards the end of the first paragraph, the reference should be to Equation 7.31, not Equation 7.32.

P.239: In Figure 8.13(a), the value on the vertical axis given as -0.2 should be 0.02.

P.244: In Equation 8.13 replace $10^{-6}\,{\rm m^{-3}}$ with $10^{6}\,{\rm m^{-3}}$, as given on page 233.

P.253: The penultimate equation on p.253 in the solution to Exercise 1.6 should read:

$$\Phi_{\rm R}(x_{\rm c}) = -\frac{GM_1M}{M_2a} - \frac{GM_2M}{M_1a} - 0 = -\frac{GM}{a}\left(\frac{M_2^2 + M_1^2}{M_1M_2}\right).$$

The rest of the answer is correct.

P.255: In the solution to Exercise 1.12, the last sentence of the penultimate paragraph should say: 'The first is in the ultraviolet range, the second is in the classical X-ray range.'

P.261: In the solution to Exercise 3.5, the equation labelled as (3.22) (which should be (S3.2) - see below) should not have a minus sign on the right hand side.

P.262–263: In the solution to Exercise 3.7, delete the part of the answer labelled (d), relabel the first sentence of the current part (e) as (d), and label the second sentence of it as (e).

P.267: In the solution to Exercise 5.3, the white dwarf radius should be stated as 10^7 m.

P.270: In the solution to Exercise 6.3, the units of cross-section (σ) should be ${\rm cm^2}$ throughout, not ${\rm cm^{-2}}$.

P.272: In the solution to Exercise 6.5, in the penultimate equation (to calculate T), the exponent of the Boltzmann constant on the bottom line should be -23 (not 23).

P.274: In the solution to Exercise 6.11(a), the calculation for the luminosity should read $= (3.5 \times 10^{-15}\,{\rm W\,m^{-2}}) \times 4\pi \times (3.26 \times 10^6\,{\rm pc} \times 3.086 \times 10^{16}\,{\rm m\,pc^{-1}})^2$. The final answer is still the same to two significant figures.

P.276: In the solution to Exercise 7.9, the given values of the parameters should include $\gamma_\mathrm{b} \simeq \gamma_2/\sqrt{2}$ and $E_\mathrm{th} \simeq \gamma_2 m_2 c^2(1-1/\sqrt{2})$. The results of putting these into Equation 7.39 should then read:

$$\varepsilon = \frac{\gamma_2 m_2 c^2(1-1/\sqrt{2})}{(m_1+\gamma_2 m_2)c^2} = \frac{\gamma_2(1-1/\sqrt{2})}{1/\gamma_2+\gamma_2} = \left(1-\frac{1}{\sqrt{2}}\right)\left(\frac{\gamma_2}{1/\gamma_2+\gamma_2}\right).$$

As $\gamma_2 \gg 1$, we therefore have the efficiency $\varepsilon \approx 1-\frac{1}{\sqrt{2}} = 29\%$.

P.278: In the solution to Exercise 8.6, the speed of light on the bottom line should be squared. The final answer is correct.

Equation numbers in Solutions to Exercises:

The follow equation numbers in the Solutions to Exercises are all re-used mistakenly, having referred to different equations in the body of the chapter:

In solution to Exercise 1.10, the equation labelled as 1.17 should be labelled as equation S1.1.

In solution to Exercise 2.5, the equations labelled as 2.18 and 2.19 should be labelled as equations S2.1 and S2.2.

In solution to Exercise 2.8, the equation labelled as 2.20 should be labelled as equation S2.3 (but label not needed).

In solution to Exercise 3.5, the equations labelled as 3.21 and 3.22 should be labelled as equations S3.1 and S3.2.

In solution to Exercise 3.9, the equation labelled as 3.23 should be labelled as equation S3.3 (but label not needed).

In solution to Exercise 6.10, the equations labelled as 6.24 and 6.25 should be labelled as equations S6.1 and S6.2 (but labels not needed).

In solution to Exercise 7.10, the equations labelled as 7.26 and 7.27 should be labelled as equations S7.1 and S7.2 (but labels not needed).