Errata and Clarifications
Astrophysical Processes (Bradt)
incorporated into 2010 Printing

Note for 2010 printing:

The only substantive corrections in the 2010 printing pertain to the Sunyaev-Zeldovich effect. These include

(i) a revised Figure 9.7c with thanks to E.L. Wright of UCLA, The modified spectrum in that figure in the original printing follows that of Sunyaev and Zeldovich's (S-Z) papers but is rather misleading in that it uses a first order formula to calculate a modified spectrum for the "large" value of $y = 0.15$. This introduces a strange (erroneous) notch in the rising edge of the spectrum whereas the correct calculation has no such notch. See our discussion of the S-Z effect elsewhere in these resources.

(ii) a revised Eq. 9.26 and the subsequent discussion in order to clarify the distinction between the "scattered spectrum" and the "modified" (observed) spectrum when only a portion of the photons are scattered, with thanks to Alan Levine of MIT,

(iii) an addition to Problem 9.52 to make it consistent with the revised text and figure on the S-Z effect.

(iv) a photograph of the solar surface (Figure 4.3) with more contrast to better show the granules, etc.

(v) other corrections to errors that are not fundamentally misleading in both the text and the problem solutions with thanks to John Fulton of Austin Community College

I look forward to further comments from interested readers.

Detailed corrections incorporated in 2010 printing

p. xxiii. Append "Note for 2010 printing" similar to that above.

p. 121: Replace Fig. 4.3 with lighter (more contrast) version.

p 137: Credits to Fig. 4.90.

Add initial and "&" to read: "H. Gautschy & H. Saio".

p. 162. line 4, Insert index codes after "Trojan asteroids" for two new index entries:

"asteroids, Trojan"

"Trojan asteroids"

p. 177, Problem 4.44, line 1. Delete solar symbol in "$R_\odot$" so it reads "$R = 10^4$ m".

p. 344: Replace Figure 9.7 with provided revised "new" figure that corrects Fig. 9.7c.

p. 344, Fig. 9.7 caption,

line 5–7, Delete all 3 sentences of item (c) "(c) The sketch . . . . . = 0.15." and replace with:

"(c) Sketch of a blackbody spectrum (dark line) with the S-Z modified spectrum for $y = kT_e\tau/mc^2 = 0.15$ (light line); $T_r = 2.73$ K. The latter curve is broadened and shifted to the right."

p. 344, Fig. 9.7 caption, last two lines (credits).

Modify credits to read as follows:

"[(b) after Sunyaev & Zel'dovich, in ARAA **18**, 537 (1980), with permission; (c) after E. L. Wright, pvt. comm.; see http://www.astro.ucla.edu/~wright/SZ-spectrum.html; (d) S&Z, ibid, p. 551.][1]"

p. 344, Note footnote number at end of Fig. 9.7 caption (as modified here)

Add the footnote "1" to bottom of page:

"The modified curve of (c) in Fig. 9c is obtained by Wright from the exact formula (Eq. A8 of S&Z (1980)) rather than the approximate formula, Eq. A7. He points out that the latter expression is not appropriate for this large value of $y = 0.15$, but that it is often used for such plots (see Prob. 52). The approximation Eq. A7 is, however, appropriate for the small values of y characteristic of clusters of galaxies. (Wright, see link in caption)"

p. 344: line –5: insert "photon" after "fractional" to read: " . . . so the fractional photon energy gain . . . . "

p. 345: Delete three paragraphs under heading "Shifted spectrum": "The net effect . . . . .the crossover." and replace with the following. [Later note: "Modified spectrum" would have been the better heading.]

BEGIN INSERT

The number spectrum of the scattered photons is obtained by applying $K(\nu/\nu_0)$, the *kernel*, to each frequency bin $d\nu_0$, of the original spectrum $N(\nu_0)$ and summing (integrating) over all frequencies ν_0. Since the fraction of photons that are scattered is the optical depth τ (for $\tau << 1$), the factor τ must also be included in the integrand. Finally, the normalization of $K(\nu/\nu_0)$ must be addressed. A function of ν/ν_0 alone such as that in Fig. 7b (with unit area under the curve), will broaden in absolute frequency space as ν_0 is increased. (A 30% upward scatter from 1 Hz is 0.3 Hz, but from 2 Hz, it is 0.6 Hz.) Hence, to preserve normalization at unity, a factor $1/\nu_0$ must also be included.

The integral that gives the number spectrum of scattered photons is thus

$$N_{\text{scatt}}(\nu) = \int_0^\infty \tau N(\nu_0) K\left(\frac{\nu}{\nu_0}\right)\frac{d\nu_0}{\nu_0} \qquad (\text{s}^{-1}\ \text{m}^{-2}\ \text{Hz}^{-1}\ \text{sr}^{-1})$$

which can be evaluated for $N_{\text{scatt}}(\nu)$, given a known unscattered spectrum $N(\nu_0) = I(\nu_0)/h\nu_0$ and a known kernel. The latter is not given here; its shape depends on the "y" parameter, $y \equiv kT_e\tau/mc^2$.

The spectrum one observes is the sum of the scattered and unscattered number spectra where the latter is $(1–\tau)N(\nu_0)$. For comparison to Fig. 7c, this combined spectrum must be converted to specific intensity $I'(\nu)$ (W m^{-2} Hz^{-1} sr^{-1}). In the figure, a 2.73-K (unscattered) blackbody spectrum is shown alongside the modified spectrum for $y = 0.15$ obtained from a proper calculation. This is an unrealistically large value of y; it is 1500 times greater than the expected values of $\lesssim 10^{-4}$.

The net effect is that the spectrum broadens slightly and shifts to the right by varying amounts; its shape is thus distorted. At a *fixed* frequency below the crossover point, the measured intensity is reduced, and above the crossover point, the intensity is increased (Fig.

7c). Further, in the low-frequency Rayleigh-Jeans regime, it can be shown that the modified curve approximates a power-law with the same logarithmic slope as the blackbody, i.e., 2.0. One can visualize the straight-line curve being shifted to the right parallel to itself, for small shifts.

Microwave observations . . . . . .

END INSERT

P. 346, line 5: Replace "shifted" with "modified" to read ."*. . .*the modified CMB . ."

p. 346, line 12: Insert "interval" after "given time" to read "given time interval over the . . ."

p. 346, line 4 below Eq. (9.27). Replace "change of a scattered photon is constant" with "interval between the two curves does not change"

p. 347, line –4 (not counting equation),

Spell "kernel" with two e's..

In-line equation in same line ". . . = $kT_e\tau$ . . ." Make subscript "e" roman.

p. 347, line –2, (not counting equation): change "decrease" to "change" to read

". . . . temperature change for S-Z . . ."

p. 353, Prob. 9.52 statement,

line 2 under first display equation: Delete hyphen in "fixed-radiation temperature", to read "fixed radiation temperature"

Delete the last sentence "Do you . . . .spectrum?" and replace with the following:

"Your result will differ from Fig. 7c. What is the likely source of this discrepancy? (d) Calculate the difference spectrum $I' - I$ for $y = 0.0005$ and $T = 2.73$ K, and plot $\Delta I = I' - I$ versus log ν. Label the axes of the plot quantitatively in SI units."

Second display equation: insert after last dash, another semicolon and dash, so it reads: . . . .(x–4); –; –]"

p. 404, line 5: change "sine" to "cosine".

p. 411, eqn. 11.31. Change the "9" to "9.0".

p. 411, eqn. 11.32. Change the "9" to "9.0".