Physics of the Interstellar and Intergalactic Medium

Errata in the first printing.

Updated 2023.05.23

Bruce T. Draine

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Which printing of the book you have can be determined from the last line on the copyright page:

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Errata in the first printing.

- preface, p. xvii, typo: reaquaint → reacquaint
  noted 2011.02.13 by B. Hensley.

- Plate 5 caption, typo:
  ...seen in Plate 6. → ...seen in Plate 4.
  noted 2018.04.07 by L. Bouma.

- §1, p. 2, 1st paragraph, typo:
  nuclear transitions and π^0 decays. → nuclear transitions, π^0 decays, and $e^+ - e^-$ annihilations.
  noted 2012.06.26

- §1.1, p. 6, Table 1.3: change range of densities for H II gas from $0.3 - 10^4\,\mathrm{cm}^{-3}$ to $0.2 - 10^4\,\mathrm{cm}^{-3}$.
  noted 2011.09.22 by B. Ménard.

- §1.2, p. 8, Table 1.4: change abundance of P from $N_\mathrm{P}/N_\mathrm{H} = 3.23 \times 10^{-7\pm0.03}$, $M_\mathrm{P}/M_\mathrm{H} = 1.00\times10^{-5}$ to $N_\mathrm{P}/N_\mathrm{H} = 2.82\times10^{-7\pm0.03}$, $M_\mathrm{P}/M_\mathrm{H} = 8.73 \times 10^{-6}$
  noted 2013.10.21 by Bon-Chul Koo.

- §2, p. 11, 3rd paragraph, typo: three basic types → four basic types
  noted 2012.06.22 by F. van der Tak.

- §3.6, p. 28, Eq. 3.31, typo: factor of 2 error. Eq. (3.31) should read

$$\sigma_{\mathrm{rr},u\ell}(E) = \frac{1}{2}\frac{g(X_\ell)}{g(X_u^+)}\frac{(I_{X,\ell u}+E)^2}{E m_e c^2}\sigma_{\mathrm{pi},\ell u}(h\nu = I_{X,\ell u}+E) \quad , \quad (3.31)$$

  noted 2015.06.01 by E. B. Jenkins

- §3.7, p. 28, Eq. (3.33), typo: sign error. Change $e^{-I_n/kT} \to e^{I_n/kT}$.
  noted 2017.02.09

- §3.8, p. 31, Eq. (3.48), typo: change

$$I_{n\alpha} \propto A_{n\alpha} h\nu_{n\alpha} \int n[\mathrm{H}(n)]ds \propto n^{-6}b_n \int n_e n(\mathrm{H}^+)ds$$

$$\rightarrow I_{n\alpha} \propto A_{n\alpha} h\nu_{n\alpha} \int n[\mathrm{H}(n+1)]ds \propto n^{-6}b_{n+1} \int n_e n(\mathrm{H}^+)ds$$

noted 2019.02.06

- §5.2.2, p. 50, Fig. 5.5: add reference to caption: (Chandra et al. 1984)
  ref: Chandra, Kegel & Varshalovich 1984, *Astr. Astrophys. Suppl.*, **55**, 51.
  noted 2011.11.03.

- §5.2.2, p. 50, 3rd paragraph, typos: change
  para-H_2O must have $K_{-1}+K_{+1}$ odd $\rightarrow$
  para-H_2O must have $K_{-1}+K_{+1}$ even
  and
  ortho-H_2O must have $K_{-1}+K_{+1}$ even $\rightarrow$
  ortho-H_2O must have $K_{-1}+K_{+1}$ odd
  noted 2015.01.15 by Neal Evans.

- §5.2.2, p. 50: the text should have made clear that the selection rules given
  were specifically for H_2O: change
  The selection rules for electric dipole radiative transitions are $\Delta J = 0, \pm1$;
  $\Delta K_{-1} = \pm1, \pm3$; and $\Delta K_{+1} = \pm1, \pm3$.
  to
  The selection rules for electric dipole radiative transitions in H_2O are $\Delta J = 0, \pm1$; $\Delta K_{-1} = \pm1, \pm3$; and $\Delta K_{+1} = \pm1, \pm3$; for less symmetric molecules
  (e.g., HDO) additional transitions are allowed.
  noted 2011.11.03 by J. M. Shull.

- §6.4, p. 58, Eq. (6.29), typo: replace $7618\,\mathrm{cm\,s^{-1}} \rightarrow 7616\,\mathrm{cm\,s^{-1}}$
  and in the following line change $7618\,\mathrm{cm\,s^{-1}} \rightarrow 7616\,\mathrm{cm\,s^{-1}}$.
  noted 2011.08.18 by K.-G. Lee.

- §6.4, p. 58, typos: change
  H Lyman α ($\lambda = 1215\,\text{Å}$) has ... $f_{\ell u} = 0.4162$
  $\rightarrow$
  H Lyman α ($\lambda = 1215.67\,\text{Å}$) has ... $f_{\ell u} = 0.4164$,
  and in the following sentence, change $0.4162 \rightarrow 0.4164$.
  noted 2011.08.19

- §6.4, p. 60, Eq. (6.41), typo: replace
  $$2924\left[\frac{7618\,\mathrm{cm\,s^{-1}}}{\gamma_{u\ell}\lambda_{u\ell}}b_6\right] \rightarrow 2925\left[\frac{7616\,\mathrm{cm\,s^{-1}}}{\gamma_{u\ell}\lambda_{u\ell}}b_6\right]$$
  and in Eq. (6.42) change $7618\,\mathrm{cm\,s^{-1}} \rightarrow 7616\,\mathrm{cm\,s^{-1}}$.
  noted 2011.08.18 by K.-G. Lee.

- §7.5, p. 69, Eq. (7.29), typo: missing a factor n_ℓ. Should read
  $$\kappa_\nu = n_\ell \sigma_{\ell\rightarrow u}\left(1 - \frac{n_u/g_u}{n_\ell/g_\ell}\right) < 0$$

noted 2020.10.12 by Yan Liang.

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- §8.1, p. 71, 3 places: just before Eq. (8.4), just after Eq. (8.7), and between Eq. (8.8) and (8.9): change "absorption coefficient" → "attenuation coefficient".
  noted 2011.03.07

- §8.1, p. 71, Eq. (8.9), typo: missing a factor $n(\mathrm{H\,I})$. Should read:

$$\kappa_\nu = \frac{3}{32\pi}\frac{1}{\sqrt{2\pi}}\frac{A_{u\ell}\lambda_{u\ell}^2}{\sigma_V}\frac{hc}{kT_{\mathrm{spin}}}n(\mathrm{H\,I})\mathrm{e}^{-u^2/2\sigma_V^2} \qquad (8.9)$$

  noted 2011.03.07 by P. Pattarakijwanich.

- §8.1, p. 71, Eq. (8.10), typo: omit the comma.
  noted 2010.02.09

- §8.2, p. 72, Eq. (8.17), typo: change $54.89 \to 55.17$
  noted 2011.07.06 by R. Allen.

- §8.2, p. 73, Eq. (8.21), typo: change $(1+z) \to (1+z)^{-1}$
  noted 2012.06.01 by B. Catinella and N. Evans.

- §8.3, p. 74, Eq. (8.26), typo: $T_{\mathrm{sky}}(v) \to T_{\mathrm{sky}}$ (two occurrences).
  noted 2011.02.10

- §8.3, p. 74, Eq. (8.26), typos: $T_A^{\mathrm{on}}(v) \to T_A^{\mathrm{off}}(v)$ (two occurrences).
  noted 2013.02.14 by Munan Gong.

- §9.4, p. 79, Eq. (9.21), the second "=" should be changed to "≈".
  noted 2011.08.18 by K.-G. Lee.

- §9.8, p. 84, typo in line following Eq. (9.35): change
  $(v_{\mathrm{FWHM}}/2\,\mathrm{km\,s}^{-1})^2/3 \;\to\; (v_{\mathrm{FWHM}}/2\,\mathrm{km\,s}^{-1})^{2/3}$.
  noted 2020.09.09 by Roohi Dalal.

- §9.10, Table 9.4, p. 88, typos: for C II and N III, change ${}^2\mathrm{D}_J^o \to {}^2\mathrm{D}_J$ for $J = 3/2$ and $J = 5/2$.
  noted 2015.02.12 by Semyeong Oh.

- §10.2, sentence preceding Eq. (10.5): change
  ...the Gaunt factor from quantum-mechanical calculations is approximately
  →
  ...the Gaunt factor is approximately (Scheuer 1960)
  noted 2018.11.18 by S. Weinberg.

- §10.5, p. 96, Eq. (10.23), typo (extraneous factor of cm^5):

$$...\nu_9^{-2.118}\,\mathrm{cm}^5\left(\frac{n_i}{n_p}\right)\frac{EM}{10^{25}\,\mathrm{cm}^{-5}} \;\to\; ...\nu_9^{-2.118}\left(\frac{n_i}{n_p}\right)\frac{EM}{10^{25}\,\mathrm{cm}^{-5}}$$

  noted 2011.03.05 by B. Hensley and P. Pattarakijwanich.

- §10.5, p. 97, Eq. (10.25), typo (missing factor of 2): should read

$$j_{\mathrm{fb},\nu} = \frac{g_{\mathrm{b}}}{g_e g_i} \frac{2\,h^4\nu^3}{(2\pi m_e kT)^{3/2}c^2}\, \mathrm{e}^{(I_{\mathrm{b}}-h\nu)/kT}\, \sigma_{\mathrm{b,pi}}(\nu) n_e n_i$$

  noted 2021.02.14 by Shigenobu Hirose.

- §10.5, p. 97, foonote 3, typo: $5 \times 10^6\ \mathrm{cm}^{-3}\,\mathrm{pc} \to 5 \times 10^6\ \mathrm{cm}^{-6}\,\mathrm{pc}$.
  noted 2011.02.15 by C. Petrovich.

- §11.4, p. 110, Eq. (11.35) should read

$$\nu \ll \frac{e^2(\Delta n_e)_{L,\mathrm{rms}}}{2\pi m_e c}\,(2LD)^{1/2} = 1{\times}10^3\ \mathrm{GHz}\,\frac{(\Delta n_e)_{L,\mathrm{rms}}}{10^{-3}\,\mathrm{cm}^{-3}}\left(\frac{L}{10^{14}\,\mathrm{cm}}\frac{D}{\mathrm{kpc}}\right)^{1/2}.$$

  noted 2013.02.03 by W. Vlemmings.

- §11.4, p. 110, Eq. (11.34), typo (was off by factor 10^4): should read

$$= 6.53 \times 10^{-5}\ \mathrm{arcsec}\left(\frac{D/\,\mathrm{kpc}}{L/10^{14}\,\mathrm{cm}}\right)^{1/2}\frac{(\Delta n_e)_{L,\mathrm{rms}}}{10^{-3}\,\mathrm{cm}^{-3}}\nu_9^{-2}$$

  noted 2021.10.25 by I. Wasserman.

- §12.1, p. 120, Eq. (12.1), add: where $\nu_9 \equiv \nu/\,\mathrm{GHz}$
  noted 2012.06.22 by F. van der Tak.

- §12, p. 121, Table 12.1, typos:

CMB, $T = 2.725\,\mathrm{K}$	:	$4.19{\times}10^{-13}$	$\to$	4.17×10^{-13}
$T_2 = 4000\,\mathrm{K}$, $W_2 = 1.65{\times}10^{-13}$	:	$3.19{\times}10^{-13}$	$\to$	3.20×10^{-13}
$T_3 = 7500\,\mathrm{K}$, $W_3 = 1{\times}10^{-14}$	:	$2.29{\times}10^{-13}$	$\to$	2.39×10^{-13}
Starlight total	:	$1.05{\times}10^{-12}$	$\to$	1.06×10^{-12}
ISRF total	:	$2.19{\times}10^{-12}$	$\to$	1.98×10^{-12}.

  noted 2012.11.08

- §12.5, p. 123, below eq. (12.4): change
     ...W_1 by 40%, from $W_1 = 5 \times 10^{-13}$ to 7×10^{-13}. $\to$
     ...W_1 by 75%, from $W_1 = 4 \times 10^{-13}$ to 7×10^{-13}, and raised W_2 from
        1.0×10^{-13} to 1.65×10^{-13}.
  noted 2014.11.11 by S. Bianchi.

- §13.1, pp. 128, eq. (13.1), (13.3), (13.4): for notational consistency with the
  rest of the chapter, change $\sigma_{\mathrm{pe}} \to \sigma_{\mathrm{pi}}$
  noted 2018.01.07 by L. Bouma.

- §13.1, p. 128, typo:
     $\sigma_{\mathrm{pe}}(\mathrm{H}_2) = 2.8\sigma_{\mathrm{p.i.}}(\mathrm{H})$ $\to \sigma_{\mathrm{pe}}(\mathrm{H}_2) = 2.8\sigma_{\mathrm{pe}}(\mathrm{H})$
  noted 2011.03.06

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- §13.1, p. 129, clarification:
  ...photoionization cross sections for O... $\rightarrow$
  ...photoionization cross sections $\sigma_{\rm pi}$ for O...
  noted 2011.03.06

- §13.1, p. 130, Eq. (13.5), clarification:
  $\zeta_{\rm p.i.}$ $\rightarrow$ $\zeta_{\rm pi}$, $\sigma_{\rm pe}$ $\rightarrow$ $\sigma_{\rm pi}$
  noted 2011.03.06

- §13.1, p. 130, second paragraph, typo:
  ...to $3\times10^{-10}\,{\rm s}^{-1}$ for Si $\rightarrow$ ...to $3\times10^{-9}\,{\rm s}^{-1}$ for Si
  noted 2017.03.05

- §13.1, p. 131, Table 13.1, typo: $\zeta_{\rm p.i.}$ $\rightarrow$ $\zeta_{\rm pi}$, $\sigma_{\rm p.i.}$ $\rightarrow$ $\sigma_{\rm pi}$
  noted 2011.03.06

- §13.4, p. 134, typos:
  $\sigma_{\rm c.i.}$ $\rightarrow$ $\sigma_{\rm ci}$ (4 places), $k_{\rm c.i.}$ $\rightarrow$ $k_{\rm ci}$ (2 places).
  noted 2011.03.06

- §14.2, p. 138, Table 14.1. A reference to Burgess (1965; *Mem. Royal Astr. Soc.*, **69**, 1) [the source of the hydrogenic radiative recombination rates] has been added in the table footnote. Upon recomputing the rates from Burgess, a few of the table entries had the last digit change by 1. Some of the coefficients in the approximate fitting formulae have also changed slightly. Here is the revised version:

Table 14.1 Recombination Coefficients $\alpha_{n\ell}$ (cm^3 s^{-1}) for H.[a] The approximation formulae are valid for $0.3 \lesssim T_4 \lesssim 3$. For a broader range of T, see Eq. (14.5,14.6).

$\alpha_n(^2L)$	\multicolumn{3}{c}{Temperature T}	approximation
	5×10^3 K	1×10^4 K	2×10^4 K	
α_{1s}	2.28×10^{-13}	1.58×10^{-13}	1.08×10^{-13}	$1.58\times10^{-13}T_4^{-0.540-0.017\ln T_4}$
α_{2s}	3.37×10^{-14}	2.34×10^{-14}	1.60×10^{-14}	$2.34\times10^{-14}T_4^{-0.537-0.019\ln T_4}$
α_{2p}	8.33×10^{-14}	5.36×10^{-14}	3.24×10^{-14}	$5.36\times10^{-14}T_4^{-0.681-0.061\ln T_4}$
α_2	1.17×10^{-13}	7.70×10^{-14}	4.84×10^{-14}	$7.70\times10^{-14}T_4^{-0.636-0.046\ln T_4}$
α_{3s}	1.13×10^{-14}	7.82×10^{-15}	5.29×10^{-15}	$7.82\times10^{-15}T_4^{-0.547-0.024\ln T_4}$
α_{3p}	3.17×10^{-14}	2.04×10^{-14}	1.23×10^{-14}	$2.04\times10^{-15}T_4^{-0.683-0.062\ln T_4}$
α_{3d}	3.03×10^{-14}	1.73×10^{-14}	9.09×10^{-15}	$1.73\times10^{-14}T_4^{-0.868-0.093\ln T_4}$
α_3	7.33×10^{-14}	4.55×10^{-14}	2.67×10^{-14}	$4.55\times10^{-14}T_4^{-0.729-0.060\ln T_4}$
α_{4s}	5.23×10^{-15}	3.59×10^{-15}	2.40×10^{-15}	$3.59\times10^{-15}T_4^{-0.562-0.026\ln T_4}$
α_{4p}	1.51×10^{-14}	9.66×10^{-15}	5.80×10^{-15}	$9.66\times10^{-15}T_4^{-0.691-0.064\ln T_4}$
α_{4d}	1.90×10^{-14}	1.08×10^{-14}	5.67×10^{-15}	$1.08\times10^{-14}T_4^{-0.870-0.094\ln T_4}$
α_{4f}	1.09×10^{-14}	5.54×10^{-15}	2.57×10^{-15}	$5.54\times10^{-15}T_4^{-1.041-0.100\ln T_4}$
α_4	5.02×10^{-14}	2.96×10^{-14}	1.64×10^{-14}	$2.96\times10^{-14}T_4^{-0.805-0.065\ln T_4}$
α_A	6.81×10^{-13}	4.17×10^{-13}	2.51×10^{-13}	$4.17\times10^{-13}T_4^{-0.721-0.018\ln T_4}$
α_B	4.53×10^{-13}	2.59×10^{-13}	1.43×10^{-13}	$2.59\times10^{-13}T_4^{-0.833-0.035\ln T_4}$

[a] $\alpha_{n\ell}$ from Burgess (1965); α_B from Hummer & Storey (1987) (for $n_e = 10^3$ cm^{-3})

- §14.2, p. 139, typos: In Equations (14.3) and (14.4), the leading factor of Z should be to the first power, rather than Z^2: the equations should read

$$\alpha_A(T) \approx 4.13 \times 10^{-13} \, Z \, (T_4/Z^2)^{-0.7131-0.0115\ln(T_4/Z^2)} \, \mathrm{cm}^3 \, \mathrm{s}^{-1} \, , \qquad (14.3)$$

$$\alpha_B(T) \approx 2.54 \times 10^{-13} \, Z \, (T_4/Z^2)^{-0.8163-0.0208\ln(T_4/Z^2)} \, \mathrm{cm}^3 \, \mathrm{s}^{-1} \, . \qquad (14.4)$$

noted 2012.01.04 by E. Jenkins.

- Fig. 14.1, p. 140, typos: the quantities plotted should be labelled $Z^{-2}T_4^{1/2}\alpha_\mathrm{A}$ and $Z^{-2}T_4^{1/2}\alpha_\mathrm{B}$ (rather than $Z^{-3}T_4^{1/2}\alpha_\mathrm{A}$ and $Z^{-3}T_4^{1/2}\alpha_\mathrm{B}$):
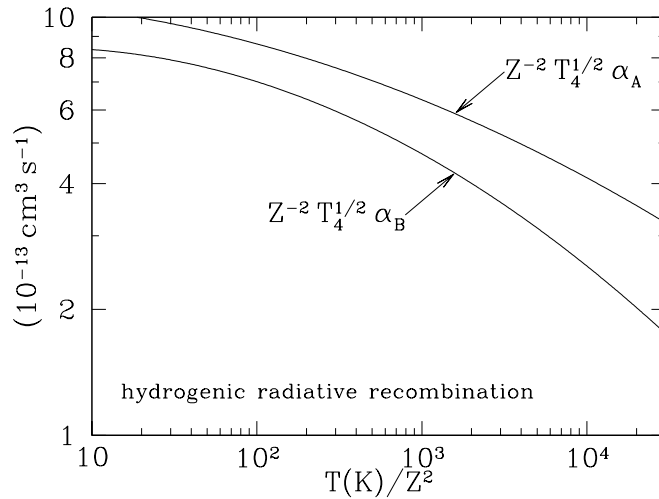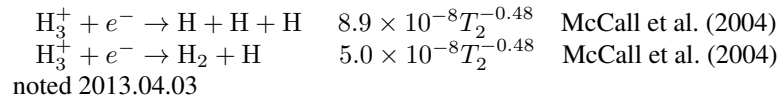

Figure 14.1 Case A and Case B rate coefficients α_A and α_B for radiative recombination of hydrogen, multiplied by $T_4^{1/2}$ (equations 14.5,14.6). Note that no single power-law fit can reproduce the T-dependence over a wide range in T.

noted 2012.01.04 by E. B. Jenkins.

- Table 14.2, p. 143, typo: Pfundt $\rightarrow$ Pfund
  noted 2011.03.05 by B. Hensley.

- §14.2.4, p. 144, Eq. (14.11), typo: $1880\,\mathrm{cm}^{-3}$ $\rightarrow$ $1.55 \times 10^4\,\mathrm{cm}^{-3}$
  noted 2011.03.17

- §14.5, p. 151, typo: [OIII]4959,5007 → [OIII]4960,5008
  noted 2012.06.22 by F. van der Tak.

- §14.6, p. 153, typo:
  ...from the wave function of AB... $\rightarrow$ ...from the wave function of AB^+...
  noted 2011.03.05 by P. Pattarakijwanich.

- §14.6, p. 154, Table 14.8 update: replace
  $\mathrm{H}_3^+ + e^- \rightarrow \mathrm{H}_2 + \mathrm{H}$ $1.1 \times 10^{-7}T_2^{-0.56}$ McCall et al. (2004)
  with

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$$\mathrm{H_3^+} + e^- \rightarrow \mathrm{H} + \mathrm{H} + \mathrm{H} \quad 8.9 \times 10^{-8} T_2^{-0.48} \quad \text{McCall et al. (2004)}$$
$$\mathrm{H_3^+} + e^- \rightarrow \mathrm{H_2} + \mathrm{H} \qquad 5.0 \times 10^{-8} T_2^{-0.48} \quad \text{McCall et al. (2004)}$$

noted 2013.04.03

- §14.7.1, p. 155, typo:
$$I_{\mathrm{O(^3P_0)}} = 13.6181\,\mathrm{eV}, \quad \rightarrow \quad I_{\mathrm{O(^3P_2)}} = 13.6181\,\mathrm{eV}),$$
noted 2011.02.22 by Xu Huang.

- §14.7.1, p. 156, Eq. (14.21), typo:
$$\mathrm{H(^1S_{1/2})} \quad \rightarrow \quad \mathrm{H(^2S_{1/2})}$$
noted 2022.07.06 by S. R. Kulkarni.
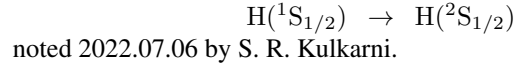
- §14.7.1, p. 156, Eq. (14.31), for notational consistency: $n(\mathrm{H}) \rightarrow n(\mathrm{H^0})$
noted 2011.05.15 by E. B. Jenkins.

- §14.7.1, p. 156, just before Eq. (14.35), typo:
In the low density limit... $\rightarrow$ In the high density limit...
noted 2011.05.15 by E. B. Jenkins.

- §14.7.1, p. 157, Figure 14.5: plotted curves were numerically incorrect.
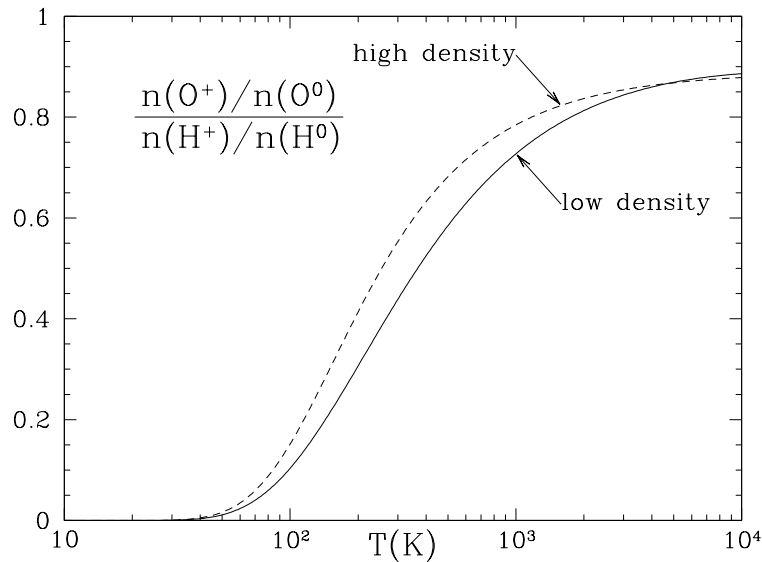Corrected Figure 14.5:

Figure 14.5 Dependence of oxygen ionization fraction on hydrogen ionization fraction due to charge exchange. The low-density limit applies for $n_{\mathrm{H}} \lesssim 10^4\,\mathrm{cm}^{-3}$.
noted 2011.05.18 by E. B. Jenkins.

- §14.9, p. 159, typo: factor of 2 error. Eq. (14.41) should read
$$\sigma_{\mathrm{rr}}(E) = \frac{g_\ell}{2g_u} \frac{(I+E)^2}{Em_ec^2} \sigma_{\mathrm{pi}}(h\nu = I+E) \ . \tag{14.41}$$

noted 2015.06.01 by E. B. Jenkins.

- §14.9, p. 160, typo: factor of 2 error. Eq. (14.43) should read

$$\frac{\langle \sigma v \rangle_{\rm rr}}{\langle \sigma v \rangle_{\rm ci}} \approx 2\pi\alpha^3 \frac{f_{\rm pi}}{C} \frac{I}{kT} e^{I/kT} \quad , \tag{14.43}$$

  noted 2015.06.01 by E. B. Jenkins.

- §14.9, p. 160, typo: factor of 2 error. Eq. (14.44) and following should read

$$\frac{I}{kT} e^{I/kT} = \frac{C}{2\pi f_{\rm pi}} \frac{1}{\alpha^3} \quad . \tag{14.44}$$

  If $C \approx 1$ and $f_{\rm pi} \approx 1$, this has solution $I/kT \approx 10.6$. ...
  noted 2015.06.01 by E. B. Jenkins.

- §15.1, p. 163, typo: $\sigma_{\rm p.i.} \rightarrow \sigma_{\rm pi}$ (two places)
  noted 2011.03.05

- §15.1.2, p. 163, change
  the Case B radiative recombination rate for $He^+ + e^- \rightarrow He^0$ is ~ 1.9 times
  larger than for hydrogen.
  $\rightarrow$
  $\alpha_{\rm eff}(He)/\alpha_B(H) \approx 1.1 - 1.7$, depending on the fraction y of $h\nu > 24.6\,{\rm eV}$
  photons that are absorbed by H.
  noted 2011.03.17

- Table 15.1, p. 164, typo: $M/M_\odot$ for O6.5V star: $38.0 \rightarrow 28.0$
  noted 2013.01.31

- §15.1.2, p. 165, change
  will be $\sim 18\%$ $\rightarrow$ will be $\sim 14\%$
  noted 2011.03.17

- §15.1.2, p. 165, change
  if $Q_1 < 0.18 Q_0$, $\rightarrow$ if $Q_1 \lesssim 0.14 Q_0$,
  noted 2011.03.17

- §15.1.2, p. 165, change
  $Q_1/Q_0 \geq 0.18$, $\rightarrow$ $Q_1/Q_0 \gtrsim 0.14$,
  noted 2011.03.17

- §15.1.2, p. 165, change
  O6.1 V and earlier, O5.3 III and earlier, and O4 I and earlier – have $Q_1/Q_0 \gtrsim$
  0.18.
  $\rightarrow$
  O6.9 V and earlier, O6.5 III and earlier, and O6 I and earlier – have $Q_1/Q_0 \gtrsim$
  0.14.
  noted 2011.03.17

- §15.4, p. 168, Eq. (15.19), typo: $\sigma_d \rightarrow \sigma_{\rm dust}$
  noted 2011.02.24 by Xu Huang.

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- §15.3, p. 166, Eqs. (15.10, 15.11), typo: $\sigma_{\rm p.i.} \to \sigma_{\rm pi}$
  noted 2011.03.06

- §15.3, p. 167, Eq. (15.12), typo: $\sigma_{\rm p.i.} \to \sigma_{\rm pi}$
  noted 2011.03.06

- §15.3, p. 167, Eq. (15.13), typo:
  $$3360 \, (Q_{0,49})^{1/3} \, n_2^{1/3} \quad \to \quad 2880 \, (Q_{0,49})^{1/3} \, n_2^{1/3} T_4^{0.28}$$
  where we have taken $\sigma_{\rm pi} = 2.95 \times 10^{-18} \, {\rm cm}^2$.
  noted 2011.03.17

- §15.4, p. 169, Eq. (15.27) (twice) and following paragraph (twice): typo:
  $\sigma_d \to \sigma_{\rm dust}$
  noted 2011.03.05 by B. Hensley.

- §15.4, p. 170, Eq. (15.30), typo: $\sigma_d \to \sigma_{\rm dust}$
  noted 2011.03.05 by B. Hensley.

- §15.4, p. 170, following Eq. (15.30), add:
  where $\sigma_{d,-21} \equiv \sigma_{\rm dust}/10^{-21} \, {\rm cm}^2$.
  noted 2011.03.05

- §15.5, p. 172, line 4, typo: ... about the He ... $\to$ ... above the He ...
  noted 2011.03.06 by S. Ferraro

- §15.5, p. 174, sentence preceding Eq. (15.36), typo:
  $N({\rm He}^+)/N({\rm H}^+) < n_{\rm H}/n_{\rm He} \to N({\rm He}^+)/N({\rm H}^+) < n_{\rm He}/n_{\rm H}$
  noted 2020.09.29 by H. Jia

- §15.7.1, p. 179, Eq. (15.53), typo: $\sigma_d \to \sigma_{\rm dust}$
  noted 2011.03.05

- §15.7, p. 180, typo: substantially reduced $\to$ substantially increased
  noted 2011.02.24

- §15.8, p. 180, Eq. (15.59), typo: there is a spurious factor of c in the denominator. It should read
  $$U \equiv \frac{1}{n_{\rm H}} \int_{\nu_0}^{\infty} \frac{u_\nu d\nu}{h\nu}$$
  noted 2011.03.06 by S. Ferraro.

- §16.4, p. 186, Eq. (16.9, 16.10), update: change

  $$H_3^+ + e^- \to H_2 + H \quad , \quad k_{16.9} = 4.1 \times 10^{-8} T_2^{-0.52} \, {\rm cm}^3 \, {\rm s}^{-1} \, ,$$
  $$H_3^+ + e^- \to H + H + H \quad , \quad k_{16.10} = 7.7 \times 10^{-8} T_2^{-0.52} \, {\rm cm}^3 \, {\rm s}^{-1} \, ,$$

  to

  $$H_3^+ + e^- \to H_2 + H \quad , \quad k_{16.9} = 5.0 \times 10^{-8} T_2^{-0.48} \, {\rm cm}^3 \, {\rm s}^{-1} \, ,$$
  $$H_3^+ + e^- \to H + H + H \quad , \quad k_{16.10} = 8.9 \times 10^{-8} T_2^{-0.48} \, {\rm cm}^3 \, {\rm s}^{-1} \, ,$$

and cite McCall et al. (2004) for $k_{16.9}$ and $k_{16.10}$.
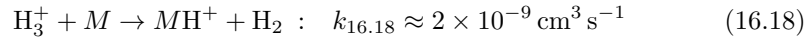noted 2013.04.03

- §16.4, p. 187, typo: in paragraph below Eq. (16.15), change
  $x_e \approx x_M \approx 1.9 \times 10^{-4}$ $\rightarrow$ $x_e \approx x_M \approx 1.1 \times 10^{-4}$ (see Eq. 16.3)
  noted 2013.04.04

- §16.5, p. 188, Eq. (16.16), typo: should read

$$H_2 + CR \rightarrow H_2^+ + e^- + CR$$
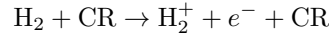
  noted 2020.09.29 by R. Córdova

- §16.5, p. 188, Eq. (16.18), added information:

$$H_3^+ + M \rightarrow MH^+ + H_2 : \quad k_{16.18} \approx 2 \times 10^{-9}\,\mathrm{cm^3\,s^{-1}} \tag{16.18}$$

  noted 2011.04.03

- §16.5, p. 189, Eq. (16.25), typo: in numerator of RHS, replace $k_{16.19} \rightarrow A$,
  so that it reads

$$\frac{n_e}{n_H} = \frac{\left[B^2 + 4A\zeta_{CR}(1+\phi_s)/n_H\right]^{1/2} - B}{2k_{16.19}} \quad , \tag{16.25}$$

  noted 2011.03.30 by C. Hill.

- §16.5, p. 189, Fig. 16.3. The original figure was evaluated with a too-large
  rate for $k_{16.19}$. The figure has been redone, now also showing the result if
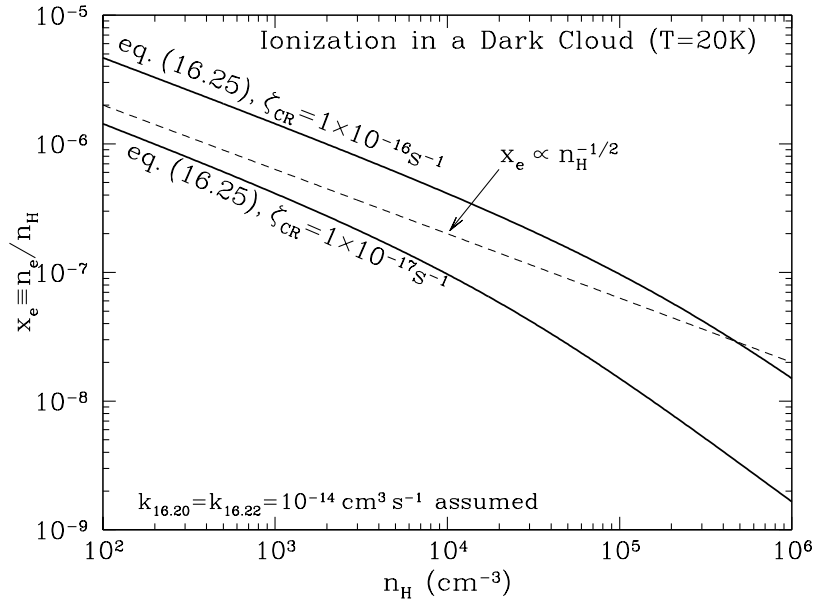 $\zeta_{CR} = 1 \times 10^{-17}\,\mathrm{s^{-1}}$:

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Figure 16.3 Fractional ionization in a dark cloud, estimated using Eq. (16.25), with the grain recombination rate coefficients set to $k_{16.20} = k_{16.22} = 10^{-14}\,\mathrm{cm^3\,s^{-1}}$ (see Fig. 14.6). The dashed line is a simple power-law approximation $x_e \approx 2 \times 10^{-5}(n_{\mathrm{H}}/\,\mathrm{cm^{-3}})^{-1/2}$.

noted 2013.03.05.

- §17.2, p. 192, Table 17.1. This has been revised to include critical densities for both H and e^-:

Table 17.1 Critical Densities for Fine-Structure Excitation in H I Regions

| | | | | | $\lambda_{u\ell}$ | $n_{\mathrm{crit},u}(\mathrm{H})$ | | $n_{\mathrm{crit},u}(e^-)$ | |
| | | | E_ℓ/k | E_u/k | | $T\!=\!100\,\mathrm{K}$ | $T\!=\!5000\,\mathrm{K}$ | $T\!=\!100\,\mathrm{K}$ | $T\!=\!5000\,\mathrm{K}$ |
Ion	ℓ	u	(K)	(K)	(μm)	($\mathrm{cm^{-3}}$)	($\mathrm{cm^{-3}}$)	($\mathrm{cm^{-3}}$)	($\mathrm{cm^{-3}}$)
C II	$^2\mathrm{P}^{\mathrm{o}}_{1/2}$	$^2\mathrm{P}^{\mathrm{o}}_{3/2}$	0	91.21	157.74	2.7×10^3	1.5×10^3	6.8	40.
C I	$^3\mathrm{P}_0$	$^3\mathrm{P}_1$	0	23.60	609.7	620	170	76.	6.4
	$^3\mathrm{P}_1$	$^3\mathrm{P}_2$	23.60	62.44	370.37	720	150	75.	6.3
O I	$^3\mathrm{P}_2$	$^3\mathrm{P}_1$	0	227.71	63.185	2.5×10^5	4.9×10^4	1.8×10^5	4.8×10^4
	$^3\mathrm{P}_1$	$^3\mathrm{P}_0$	227.71	326.57	145.53	2.4×10^4	8.6×10^3	2.3×10^4	5.8×10^3
Si II	$^2\mathrm{P}^{\mathrm{o}}_{1/2}$	$^2\mathrm{P}^{\mathrm{o}}_{3/2}$	0	413.28	34.814	2.5×10^5	1.2×10^5	140.	1.5×10^3
Si I	$^3\mathrm{P}_0$	$^3\mathrm{P}_1$	0	110.95	129.68	4.8×10^4	2.8×10^4	2.9×10^4	830.
	$^3\mathrm{P}_1$	$^3\mathrm{P}_2$	110.95	321.07	68.473	9.9×10^4	3.6×10^4	4.4×10^4	1.9×10^3

noted 2011.03.06

- §17.3, p. 195, footnote 3, typos:
  ...frequency $\sim 8\times10^{10}$ Hz... $\rightarrow$ ...frequency $\sim 1.1\times10^{10}$ Hz...
  ...$\sim 10^2$ precession periods. $\rightarrow$ ...~ 18 precession periods.
  noted 2020.10.02

- §17.5, p. 197, Eq. (17.27) should read

$$R_{12} = (g_2/g_1)\left[C_{21}e^{-E_{21}/kT} + n_{\gamma,21}A_{21}\right]. \tag{17.27}$$

noted 2010.11.27

- §17.7, p. 199, top line, typo: $n_{\mathrm{H,crit}}$ $\rightarrow$ $n_{\mathrm{crit}}(\mathrm{H})$
  noted 2011.03.10

- §18.1.2, Fig. 18.3, p. 208, two typos: The ground states of S II and Ar IV should both have degeneracy $g_0 = 4$
  noted 2012.11.12 by A. Natta

- §18.4.1, p. 212: Replace wavelength in air with wavelength *in vacuo*:
  "Balmer jump" at $\lambda = 3645.1\,\text{Å}$ $\rightarrow$ "Balmer jump" at $\lambda = 3647.0\,\text{Å}$
  noted 2011.03.11

- §18.4.1, p. 212: Refine wavelength midway between H 20 and H 21 lines:
  $\lambda_{\mathrm{BJ,red}} = 3682.6\,\text{Å}$ $\rightarrow$ $\lambda_{\mathrm{BJ,red}} = 3682.1\,\text{Å}$
  noted 2011.03.11

- §18.5, p. 214, Eq. (18.11): Change
  ... Ω_{03} is approximately independent of T_e, we have

$$\frac{n(\text{O III})}{n(\text{H}^+)} = C \frac{I([\text{O III}]5008)}{I(\text{H}\beta)} T_4^{-0.37} e^{2.917/T_4} \ , \qquad (18.11)$$

  to
  ... $\Omega_{03} \propto T_4^{0.12}$ (see Appendix F), we have

$$\frac{n(\text{O III})}{n(\text{H}^+)} = C \frac{I([\text{O III}]5008)}{I(\text{H}\beta)} T_4^{-0.49} e^{2.917/T_4} \ , \qquad (18.11)$$

  noted 2015.02.27

- §19.3, p. 222: revise value for A_{10}: replace
  $A_{10} = 6.78 \times 10^{-8}\,\text{s}^{-1} \rightarrow A_{10} = 7.16 \times 10^{-8}\,\text{s}^{-1}$ (see Eq. 5.7).
  noted 2013.04.17

- §19.3, p. 223: revised numbers according to revised value for A_{10}:
  Eq. (19.15): $281 \rightarrow 297$, Eq. (19.17): $281 \rightarrow 297$, Eq. (19.19): $46 \rightarrow 50$
  noted 2013.04.17

- §19.4, p. 224, typo: functon $\rightarrow$ function
  noted 2011.03.11 by C. Petrovich

- §20.1, p. 229, typo just below Eq. (20.2): replace
  ...unit time that level x will... $\rightarrow$ ...unit time the level u will...
  noted 2020.10.12 by Yan Liang

- §21.3, p. 242, typo: ...into the UV. whereas... $\rightarrow$ ...into the UV, whereas...
  noted 2011.03.21

- §21.6.1, p. 244, typo: $k^2 = \epsilon_{\text{ISM}}\omega^2 c^2 \rightarrow k^2 = \epsilon_{\text{ISM}}\omega^2/c^2$
  noted 2011.03.28

- §21.6.1, p. 244, Eq. (21.12), typo:

$$n_{\text{gr}} C_{\text{ext}}(\omega) = 2\text{Im}(k) = 2\omega c \,\text{Im}(\sqrt{\epsilon_{\text{ISM}}}) \approx \omega c \,\text{Im}(\epsilon_{\text{ISM}}) \qquad (21.12)$$

  $\rightarrow$

$$n_{\text{gr}} C_{\text{ext}}(\omega) = 2\text{Im}(k) = 2(\omega/c)\text{Im}(\sqrt{\epsilon_{\text{ISM}}}) \approx (\omega/c) \,\text{Im}(\epsilon_{\text{ISM}}) \qquad (21.12)$$

  noted 2011.03.28

- §22.4.2, p. 252, Eq. (22.27), typo: $4\pi \rightarrow 9\pi$.
  noted 2012.06.26

- §22.6, p. 256, footnote 6: the DDSCAT website has moved. Change
  http://code.google.com/p/ddscat $\rightarrow$ http://www.ddscat.org
  noted 2019.03.25

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- §23.1, p. 265, typo:
  lower oscillator strength $f(\text{C II}]2325\,\text{Å}) = 1.0 \times 10^{-7}$
  $\rightarrow$
  larger oscillator strength $f(\text{C II}]2325\,\text{Å}) = 1.0 \times 10^{-7}$
  noted 2012.12.27

- §23.1, p. 266, typo: $\text{Mg}_2 x\text{Fe}_{2-2x}\text{SiO}_4$ $\rightarrow$ $\text{Mg}_{2x}\text{Fe}_{2-2x}\text{SiO}_4$
  noted 2011.03.24 by C. Petrovich

- §23.3.2, p. 268, typo: Si-O-Si bending mode $\rightarrow$ O-Si-O bending mode
  noted 2020.10.12

- §23.3, p. 269, typo: ...that the *at most*... $\rightarrow$ ...that *at most*...
  noted 2011.03.23

- §23.4, p. 272, Fig. 23.5 caption, typo: Lowe panels:... $\rightarrow$ Lower panels:...
  noted 2011.03.23

- §23.10, p. 280, typo: varyies $\rightarrow$ varies
  noted 2011.03.23

- §23.10, p. 283, typo: totaly $\rightarrow$ total
  noted 2011.03.23

- §24.2, p. 293, typo: ...does not extend below $\sim$23K. $\rightarrow$ ...does not extend below $\sim$35K.
  noted 2011.03.24

- §24.2, p. 293, typo:
  ...corresponds the grain... $\rightarrow$ ...corresponds to the grain...
  noted 2011.03.25

- §25.3, p. 299, typo following Eq. (25.11): change
  ...charge $Z_{\text{gr}} = Ua$ can... $\rightarrow$ ...charge $Z_{\text{gr}} = Ua/e$ can...
  noted 2021.06.25 by Yu Fung Wong.

- §26.2, p. 308, Eq. (26.23), numerical error: should read

$$\frac{\omega}{2\pi} = 4.6\,\text{GHz} \left(\frac{T_{\text{rot}}}{100\,\text{K}} \right)^{1/2} \left(\frac{0.001\,\mu\text{m}}{a} \right)^{5/2} \tag{26.23}$$

  noted 2014.06.27 by B. Jiang.

- §26.2.2, p. 309, Fig. 26.2: the rightmost abscissa label should read "100", not "10".
  noted 2011.03.29 by B. Hensley.

- §26.3.1, p. 311, Eq. (26.24), typo:

$$\mu = \frac{Qa^2\omega}{3} \;\; \rightarrow \mu = \frac{Qa^2\omega}{3c}$$

  noted 2011.05.01 by P. Pattarakijwanich.

- §26.3.1, p. 311, Eq. (26.25), typos: The equation should read

$$\Omega_L = \frac{5UB}{8\pi\rho a^2 c} = 3.7{\times}10^{-10}\left(\frac{3\,\text{g cm}^{-3}}{\rho}\right)\left(\frac{U}{\text{Volt}}\right)\left(\frac{B}{5\,\mu\text{G}}\right)\left(\frac{0.1\,\mu\text{m}}{a}\right)^2\text{s}^{-1}. \quad (26.25)$$

  noted 2011.05.01 by P. Pattarakijwanich.

- §26.3.1, p. 311, after Eq. (26.25), typo: $2\pi/\Omega_L \approx 10\,\text{yr} \;\rightarrow\; 2\pi/\Omega_L \approx 500\,\text{yr}$
  noted 2011.05.01 by P. Pattarakijwanich.

- §27.1, p. 315, 2nd paragraph, typo:
  ...resulting photoelectron will... $\rightarrow$ ...resulting photoelectrons will...
  noted 2011.03.31

- §27.1, p. 317, typo: ...injection of photoelectron energy rate... $\rightarrow$ ...injection of photoelectron energy...
  noted 2012.06.22 by F. van der Tak.

- §27.1, p. 317, typo: ...nebulae dust are dusty,... $\rightarrow$ ...nebulae are dusty,...
  noted 2011.03.31

- §27.3.1, p 320, typos in coefficient of $\ln(T_4/Z^2)$ term: Eq. (27.19) and (27.20) should read

$$\gamma_A = -1.2130 - 0.0115\ln(T_4/Z^2) \qquad\qquad (27.19)$$
$$\gamma_B = -1.3163 - 0.0208\ln(T_4/Z^2) \qquad\qquad (27.20)$$

  and (27.22) and (27.23) should read

$$\langle E_{\text{rr}}\rangle_A = \left[0.787 - 0.0115\ln(T_4/Z^2)\right]kT \qquad (27.21)$$
$$\langle E_{\text{rr}}\rangle_B = \left[0.684 - 0.0208\ln(T_4/Z^2)\right]kT \qquad (27.22)$$

  noted 2023.01.29 by S. R. Kulkarni.

- §28.1, p. 326, 2nd paragraph, typo: ...form the the... $\rightarrow$ ...form the...
  noted 2011.03.31

- §28.2, p. 327, 2nd paragraph, typo:
  $EM \approx 5{\times}10^6\,\text{cm}^{-3}\,\text{pc}$ $\rightarrow$ $EM \approx 5{\times}10^6\,\text{cm}^{-6}\,\text{pc}$
  noted 2011.03.31 by C. Petrovich.

- §28.3, p. 328, 4th paragraph, typo: change distance from $\Theta_1\text{Ori C}$ to the Orion Bar ionization front: $\sim 7.8{\times}10^{18}\,\text{cm}$ $\rightarrow$ $\sim 7.8{\times}10^{17}\,\text{cm}$
  noted 2020.10.26

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- §29.1, p. 332, 1st paragraph, typo: $b = 0 \to b = 90°$, so that the 2nd sentence reads
  ...vary as $N(\mathrm{H\,I}, b) = N(\mathrm{H\,I}, b = 90°)/\sin|b| = N_0 \csc|b|$.
  noted 2012.11.04 by R. Simons.

- §29.4, p. 335, typo:
  ...found $nT \approx 2800 \,\mathrm{cm}^{-3}\,\mathrm{K}$... $\to$ ...found $nT \approx 3800 \,\mathrm{cm}^{-3}\,\mathrm{K}$...
  noted 2011.04.05

- §29.4, p. 335, typo: ...implies $n_\mathrm{H} \approx 35\,\mathrm{cm}^{-3}$. $\to$ ...implies $n_\mathrm{H} \approx 50\,\mathrm{cm}^{-3}$.
  noted 2011.04.05

- §30.2, p. 339, typo: ...near threshold are... $\to$ near-threshold yields are...
  noted 2011.04.05 by B. Hensley.

- §31.4, p. 349, Eq. (31.24), typo: on RHS, change

$$\frac{\pi e^2}{m_e c^2 h} \sum_u f_{\ell u} \lambda_{\ell u}^3 u_\lambda f_{\mathrm{shield},\ell u} \to \frac{\pi e^2}{m_e c^2 h} \sum_u f_{\ell u} \lambda_{\ell u}^3 u_\lambda f_{\mathrm{shield},\ell u}\, p_{\mathrm{diss},u}$$

  noted 2013.04.12 by Ai-Lei Sun.

- §31.4, p. 349, Eq. (31.25), typo: $\tau_{1000} \to \tau_{d,1000}$
  noted 2012.07.10

- §32.1, p. 357, 1st paragraph, typo: ...a their... $\to$ ...their...
  noted 2012.06.22 by F. van der Tak.

- §32.1, p. 357, 2nd paragraph, typo: (see Plate 15). $\to$ (see Plate 11).
  noted 2011.06.07 by S. Lorenz Martins.

- §32.9, p. 368, typo: magntic $\to$ magnetic
  noted 2011.04.11

- §32.9, p. 368, just before eq. (32.11), typo: change
  $A_V/N_\mathrm{H} = 1.87 \times 10^{21}\,\mathrm{cm}^2$ $\to$ $A_V/N_\mathrm{H} = 5.3 \times 10^{-22}\mathrm{mag\,cm}^2$.
  noted 2016.03.04 by Ilsang Yoon.

- §32.11, p. 372, prepenultimate paragraph: terminological correction. Change "core" to "clump" (three occurrences).
  noted 2015.04.16

- §33.1, p. 375, typo: photodisociation $\to$ photodissociation
  noted 2011.04.11

- §33.1, p. 375, typo: occuring $\to$ occurring
  noted 2011.04.25 by B. Hensley.

- §33.2.2, p. 378, typo: reaction products should be $\mathrm{OH}^+ + \mathrm{H}_2$
  noted 2011.04.12

- §34.4, p. 386, Eq. (34.10): sign mistake on RHS; change

$$-4\pi r^2 \kappa \frac{dT}{dr} \quad \rightarrow \quad 4\pi r^2 \kappa \frac{dT}{dr}$$

  noted 2019.04.18 by G. Halevi.

- §34.4, p. 387, typo: Eq. (34.17) is off by a factor 3, and should read

$$t_{\rm evap} = \frac{3M}{2\dot{M}} = \frac{25 \times 2.3 (n_{\rm H})_c R_c^2 m_e^{1/2} e^4 \ln \Lambda}{8 \times 0.87 (kT_h)^{2.5}} \tag{34.17}$$

  Eq. (34.18) is numerically correct, but should have shown the dependence on $\ln \Lambda$:

$$= 5.1 \times 10^4 \, {\rm yr} \left(\frac{(n_{\rm H})_c}{30 \, {\rm cm}^{-3}} \right) \left(\frac{R_c}{\rm pc} \right)^2 \left(\frac{T_h}{10^7 \, {\rm K}} \right)^{-2.5} \left(\frac{\ln \Lambda}{30} \right) . \tag{34.18}$$

  noted 2013.01.05 by B. Hensley.

- §35.3, p. 392, typo: rate-of-change $\mathbf{v}$ of... $\rightarrow$ rate-of-change of $\mathbf{v}$...
  noted 2011.04.14

- §36.1, p. 397, typo: occuring $\rightarrow$ occurring
  noted 2011.04.26

- §36.2.2, p. 399, Eq. (36.8), two corrections: $8\pi \rightarrow 4\pi$ and
  $B_x B_z v_x \rightarrow B_x B_z v_z$. The equation should read

$$\frac{\partial}{\partial x} \left[\frac{1}{2} \rho v_x v^2 + U v_x + p v_x + \frac{(B_y^2 + B_z^2)}{4\pi} v_x - \frac{B_x B_y v_y}{4\pi} - \frac{B_x B_z v_z}{4\pi} \right.$$

$$\left. - v_j \sigma_{jx} - \kappa \frac{dT}{dx} + \rho v_x \Phi_{\rm grav} \right] = \Gamma - \Lambda . \tag{36.8}$$

  noted 2011.04.19

- §36.2.3, p. 400, Eq. (36.10): $8\pi \rightarrow 4\pi$ (twice)
  noted 2011.04.19
  v_x multiplying $B_y B_x$ should be v_y, and v_x multiplying $B_z B_x$ should be v_z.
  noted 2015.12.17 by J. Miralda-Escudé.
  The equation should read

$$\left\{ \left[\frac{\rho v^2}{2} + \frac{\gamma p}{(\gamma - 1)} \right] v_x + \frac{(B_y^2 + B_z^2)}{4\pi} v_x - \frac{(B_x B_y v_y + B_x B_z v_z)}{4\pi} - \kappa \frac{dT}{dx} \right\}_1 =$$

$$\left\{ \left[\frac{\rho v^2}{2} + \frac{\gamma p}{(\gamma - 1)} \right] v_x + \frac{(B_y^2 + B_z^2)}{4\pi} v_x - \frac{(B_x B_y v_y + B_x B_z v_z)}{4\pi} - \kappa \frac{dT}{dx} \right\}_2 . \tag{36.10}$$

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- §36.2.5, p. 401, Eq. (36.16): $8\pi \to 4\pi$ (twice). The equation should read

$$\frac{\rho_1 u_1^3}{2} + \frac{\gamma}{\gamma - 1} u_1 p_1 + \frac{u_1 B_1^2}{4\pi} = \frac{\rho_2 u_2^3}{2} + \frac{\gamma}{\gamma - 1} u_2 p_2 + \frac{u_2 B_2^2}{4\pi} \quad , \quad (36.16)$$

  noted 2011.04.19

- §36.2.5, p. 401, Eq. (36.19): $8\pi \to 4\pi$ (twice). The equation should read

$$\frac{1}{2}\rho_1 v_s^3 + \frac{\gamma}{\gamma - 1} p_1 v_s + \frac{B_1^2}{4\pi} v_s = \frac{1}{2}\frac{\rho_1 v_s^3}{x^2} + \frac{\gamma}{\gamma - 1}\frac{p_2 v_s}{x} + \frac{B_1^2}{4\pi} v_s x \quad . \quad (1)$$

  noted 2011.04.19

- §36.2.5, p. 402, Eq. (36.27), typo:

$$\frac{3}{16}\mu v_s^2 \quad \to \quad \frac{3}{16}\frac{\mu v_s^2}{k}$$

  noted 2011.05.17 by P. Pattarakijwanich.

- §36.6, p. 409, typo: occuring $\to$ occurring
  noted 2011.04.25 by B. Hensley.

- §37.1, p. 413, 2nd paragraph: Change
  Cases of astrophysical interest will normally have..
  $\to$
  Many cases of astrophysical interest will have...
  noted 2018.04.09.

- §37.1, p. 413, typo just above Eq. (37.3):
  $Jh\nu/c = \rho_1 u_1 h\nu/\mu_i c \ll \rho_1(u_1^2 + c_1^2 + B_1^2/8\pi)$.
  $\to$
  $Jh\nu/c = \rho_1 u_1 h\nu/\mu_i c \ll \rho_1(u_1^2 + c_1^2) + B_1^2/8\pi$.
  noted 2016.12.08 by Ryohei Nakatani.

- §37.1, Eq. (37.8): The correction terms for u_R, x_R, u_D, and x_D can be improved by analyzing the full cubic equation (37.3): change

$$u_\mathrm{R} \approx 2c_2 \quad \to \quad u_\mathrm{R} \approx 2c_2 \left[1 - \frac{2c_1^2 - 3v_{A1}^2}{8c_2^2}\right]$$

$$x_\mathrm{R} \approx \frac{1}{2} + \frac{2c_1^2 + v_{A1}^2}{16c_2^2} \quad \to \quad x_\mathrm{R} \approx \frac{1}{2}$$

$$u_\mathrm{D} \approx \frac{2c_1^2 + v_{A1}^2}{4c_2} \quad \to \quad \frac{2c_1^2 + v_{A1}^2}{4c_2} \left[1 + \frac{2c_1^2 + v_{A1}^2}{8c_2^2}\right]$$

$$x_\mathrm{D} \approx \frac{4c_2^2}{2c_1^2 + v_{A1}^2} \quad \to \quad x_\mathrm{D} \approx \frac{4c_2^2}{2c_1^2 + v_{A1}^2} \left[1 - \frac{v_{A1}^2}{8c_2^2}\right]$$

  noted 2018.02.19 by Woong-Tae Kim.

- §37.1 and §37.2, pp. 414-416: the mathematics is correct, but the "weak-type", and "strong-type" terminology was unfortunately inverted: all occurrences of "weak-type" should be changed to "strong-type", and vice-versa:
  - §37.1.1, p. 414, first paragraph:
    ...are called **strong R-type**. Strong R-type solutions...
    $\rightarrow$
    ...are called **weak R-type**. Weak R-type solutions...
  - §37.1.1, p. 414, second paragraph:
    ...referred to as **weak R-type**,... $\rightarrow$ ...referred to as **strong R-type**,...
  - §37.1.1, p. 414, second paragraph:
    Hence, only strong R-type I-fronts are physically relevant.
    $\rightarrow$
    Hence, only weak R-type I-fronts are physically relevant.
  - §37.1.2, p. 414, first paragraph:
    ...is termed **weak D-type**. $\rightarrow$ ...is termed **strong D-type**.
  - §37.1.2, p. 414, second paragraph:
    ...is termed **strong D-type**. $\rightarrow$ ...is termed **weak D-type**.
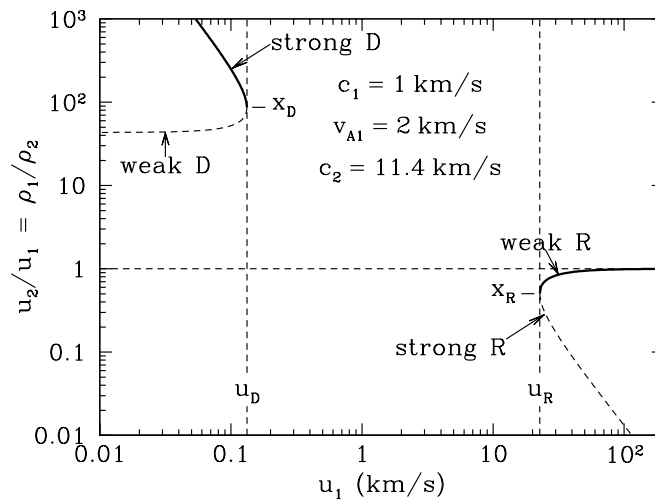 - Fig. 37.1 and caption should be:

Figure 37.1 $u_2/u_1 = \rho_1/\rho_2$, as a function of the velocity u_1 of the I-front relative to the neutral gas just ahead of the I-front, for D-type and R-type ionization front solutions (see text) for an example with $c_1 = 1\,\mathrm{km\,s^{-1}}$, $v_{A1} = 2\,\mathrm{km\,s^{-1}}$, and $c_2 = 11.4\,\mathrm{km\,s^{-1}}$. The astrophysically relevant solutions are the strong D-type and weak R-type cases, shown as heavy curves. There are no solutions with u_1 between u_D and u_R.

  - §37.1, p. 416, first paragraph:
    ...will be strong R-type, ... $\rightarrow$ ...will be weak R-type, ...
  - §37.1, p. 417, fourth line:
    ...will now be weak D-type, ... $\rightarrow$ ...will now be strong D-type, ...
    noted 2016.12.06 by Ryohei Nakatani.

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- §37.2, p. 418, typos:
  ...moving at a speed v_s that will be close to (just slightly larger than) the speed of the I-front:

  $$v_s \approx V_i \quad . \tag{37.21}$$

  $\rightarrow$

  ...moving at a speed V_s that will be close to (just slightly larger than) the speed of the I-front:

  $$V_s \approx V_i \quad . \tag{37.21}$$

  noted 2016.12.08 by Ryohei Nakatani.

- §38.3, p. 428, last paragraph, typo:
  $\dot{M}_w \approx 2 \times 10^{-5}\,\mathrm{km\,s^{-1}} \rightarrow \dot{M}_w \approx 2 \times 10^{-5}\,M_\odot\,\mathrm{yr^{-1}}$
  noted 2015.12.17 by J. Miralda-Escudé.

- §39.1.1, p. 430, typo: case of Type II supernova $\rightarrow$ case of Type II supernovae
  noted 2011.04.21

- §39.1.1, p. 430, typo: relative dense $\rightarrow$ relatively dense
  noted 2011.04.21

- §39.1.1, p. 430, typo: Plate 11 $\rightarrow$ Plate 12
  noted 2011.04.21 by C. Petrovich.

- §39.1.2, p. 433, Eqs. (39.22, 39.23, 39.24), typos: the factor (E_{51}/n_0^2) should be $(E_{51}n_0^2)$, so that the equations should read

  $$v_s(t_{\mathrm{rad}}) = 188\,\mathrm{km\,s^{-1}}(E_{51}n_0^2)^{0.07} \quad , \tag{39.22}$$
  $$T_s(t_{\mathrm{rad}}) = 4.86 \times 10^5\,\mathrm{K}(E_{51}n_0^2)^{0.13} \quad , \tag{39.23}$$
  $$kT_s(t_{\mathrm{rad}}) = 41\,\mathrm{eV}(E_{51}n_0^2)^{0.13} \quad . \tag{39.24}$$

  noted 2012.10.02 by G.B. Field.

- §39.2, p. 435, footnote 1, typo (twice): occuring $\rightarrow$ occurring
  noted 2011.04.12 by B. Hensley.

- §39.4, p. 438, Eqs. (39.35) and (39.36), typos: they should read

  $$N_{\mathrm{SN}} = 0.24 S_{-13} E_{51}^{1.26} n_0^{-1.47} c_{s,6}^{-13/5} \tag{39.35}$$

  $$= 0.48 S_{-13} E_{51}^{1.26} n_0^{-0.17} p_4^{-1.30} \quad , \quad p_4 \equiv \frac{p/k}{10^4\,\mathrm{cm^{-3}\,K}} \tag{39.36}$$

  noted 2014.06.27 by B. Jiang.

- §39.4, p. 438, Eq. (39.37), typos: Eq. (39.37) should read

$$\frac{p}{k} = S_{-13}^{0.77} E_{51}^{0.97} n_0^{-0.13} \times 5700 \, \mathrm{cm}^{-3} \, \mathrm{K} \tag{39.37}$$

  noted 2014.06.27 by B. Jiang.

- §39.4, p. 439, typo: neighboorhood $\rightarrow$ neighborhood
  noted 2011.04.14

- §40.2, p. 442, typo: with a increased energy $\rightarrow$ with an increased energy
  noted 2011.04.26

- §40.5, p. 447, typo: protons with $E \lesssim 10^5 \, \mathrm{GeV}$ have $R_{\mathrm{gyro}} < 10^{-4} \, \mathrm{pc}$ $\rightarrow$
  protons with $E \lesssim 10^3 \, \mathrm{GeV}$ have $R_{\mathrm{gyro}} < 10^{-4} \, \mathrm{pc}$
  noted 2011.04.26

- §40.9, p. 450, typo: $e^+ \mathrm{H} \rightarrow \mathrm{H}^+ + 2\gamma$ $\rightarrow$ $e^+ + \mathrm{H} \rightarrow \mathrm{H}^+ + 2\gamma$
  noted 2011.04.27

- §41.3, p. 456, typo: missing factor of G. Eq. (41.36) should read

$$E_{\mathrm{grav}} = -\frac{G}{2} \int dV_1 \int dV_2 \frac{\rho(\mathbf{r}_1)\rho(\mathbf{r}_2)}{|\mathbf{r}_1 - \mathbf{r}_2|} \tag{41.36}$$

  noted 2015.04.30 by J. Greco.

- §41.3.2, p. 457, Eq. (41.46), typo: replace

$$E_{\mathrm{mag}} = \frac{B_{\mathrm{rms}}^2 - B_0^2}{8\pi} V \quad \rightarrow \quad E_{\mathrm{mag}} = \frac{B_{\mathrm{rms}}^2}{8\pi} V$$

  noted 2011.04.28

- §41.4, p. 460, Eq. (41.55), typo: $\langle \sigma v \rangle \rightarrow \langle \sigma v \rangle_{\mathrm{mt}}$
  noted 2012.04.16

- §41.4, p. 460, Eq. (41.55), typo: $m_m \rightarrow m_n$
  noted 2013.04.30 by K. Silsbee

- §41.4, p. 461, Eq. (41.56), typo: $\langle \sigma v \rangle \rightarrow \langle \sigma v \rangle_{\mathrm{mt}}$
  noted 2012.04.16

- §41.6, p. 463, typo: ... the allows the $\rightarrow$ ... this allows the
  noted 2011.04.28 by B. Hensley

- §41.6, p. 463, typo: magenetic $\rightarrow$ magnetic
  noted 2011.01.10

- §42, p. 465, typo: Stahler & Palla (2005) $\rightarrow$ Stahler & Palla (2004)
  (also corrected in Bibliography)
  noted 2012.06.22 by F. van der Tak.

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- §42.2, p. 467, last paragraph, typo: ...face-on it, may... → ...face-on, it may...
  noted 2012.06.22 by F. van der Tak.

- §42.4, p. 470, 3rd paragraph should read
  ... to be $Q_{0,\mathrm{MW}} = (3.2 \pm 0.5) \times 10^{53}\,\mathrm{s}^{-1}$, after...
  noted 2011.01.04

- §42.5, p. 471, Eq. (42.9) typo: dsik → disk
  noted 2011.01.04

- Plate 5 caption: 2nd sentence should read
  ... synchrotron emission seen in Plate 4.
  noted 2011.01.12

- Appendix A, p. 473, typo: entry for a_0 should read
  ...Bohr radius $\equiv \hbar^2/m_e e^2 =$...
  noted 2013.03.05 by Wenhua Ju.

- Appendix A, p. 475: entry for RM should read
  RM ... see Eq. (11.23)
  noted 2011.01.05

- Appendix B, p. 476: typo: incorrect units for Stefan-Boltzmann constant σ:
  $5.67040 \times 10^{-5}\,\mathrm{erg\,s^{-1}\,cm^{-3}\,K^{-4}}$ → $5.67040 \times 10^{-5}\,\mathrm{erg\,s^{-1}\,cm^{-2}\,K^{-4}}$
  noted 2019.05.14 by Aaron Tran.

- Appendix D, p. 481: corrected typos:
  F VI → VII: $I = 147.163 \to 157.163$
  Ne VI → VII: $I = 154.214 \to 157.934$
  Ti III → IV: $I = 24.492 \to 27.492$
  Ti V → VI: $I = 123.7 \to 99.299$
  Zn VI → VII: $I = 133.903 \to 108.0$
  noted 2015.07.10 by Guangtun Ben Zhu.

- Appendix E, p. 483, typo: Pfundt   →   Pfund
  noted 2011.04.28 by B. Hensley.

- Appendix E, p. 484: diagram for C IV: the wavelength labels 1548.2 and
  1550.8 should be interchanged.
  noted 2011.03.11

- Appendix E, p. 485: diagrams for N IV and O V: the levels shown as $^2\mathrm{P}^o_1$
  and $^2\mathrm{P}^o_2$ should be $^3\mathrm{P}^o_1$ and $^3\mathrm{P}^o_2$, respectively.
  noted 2023.05.23

- Appendix E, p. 486: labelling of the fine-structure excited state for C II, N III,
  and O IV should have $J = 3/2$ (not $J = 1/2$).
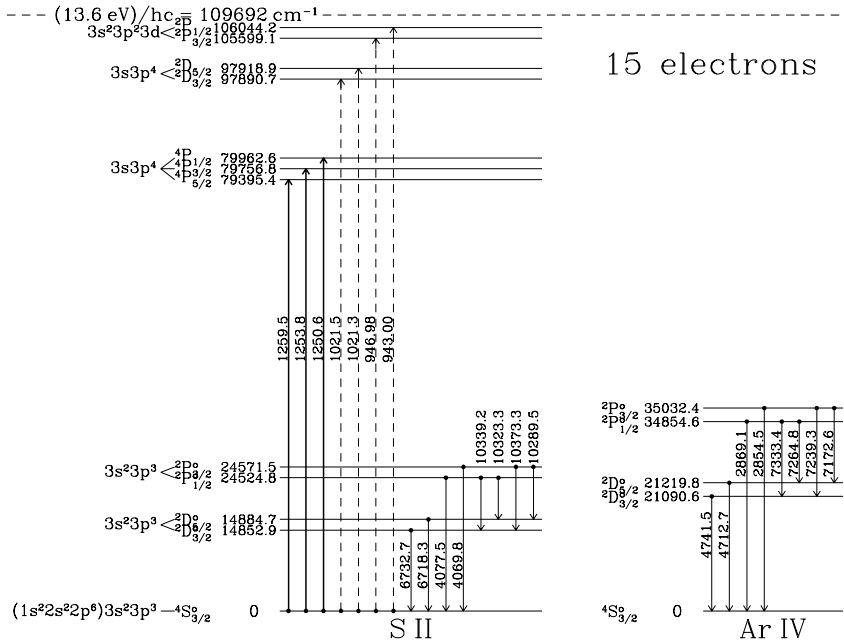 noted 2012.01.29 by E.B. Jenkins.

- Appendix E, p. 488: inadvertent omisssionof $^2P^o_{1/2}{\rightarrow}^2D^o_{5/2}$ emission lines for N I, O II, and Ne IV. Corrected figure:
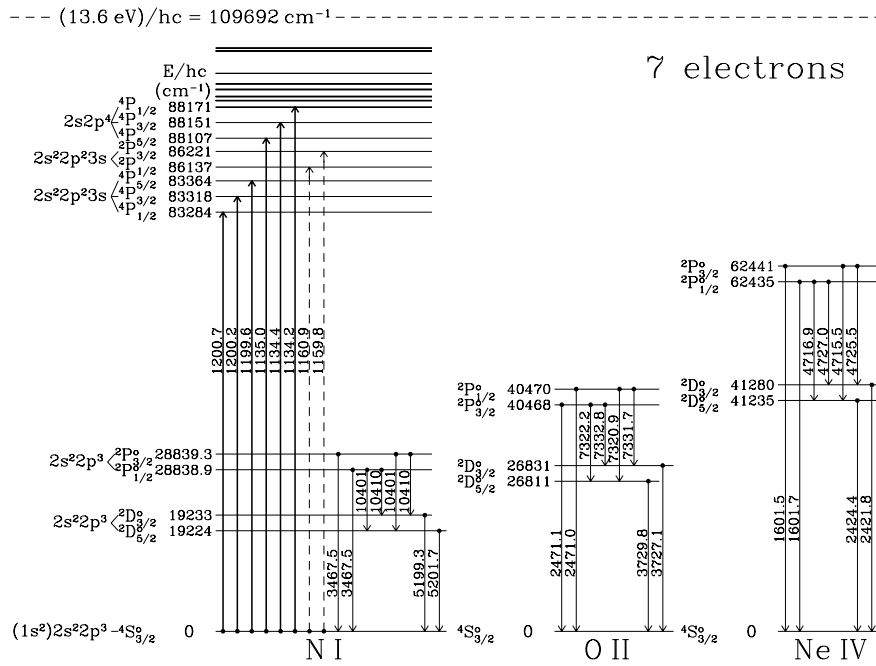
noted 2023.04.16 by S.R. Kulkarni

- Appendix E, p. 494: inadvertent omission of $^1S_0{\rightarrow}^1D_2$ emission lines for

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Si I and S III. Corrected figure:

noted 2023.04.16 by S.R. Kulkarni

- Appendix E, p. 495: $^2D^o_{3/2,5/2}$ energy levels were misplotted for S II and Ar IV.
  noted 2013.10.21 by Bon-Chul Koo.
  Corrected figure [Opportunity taken to update energy Ar IV energy levels

using latest values from NIST Atomic Spectra Database (ver. 5.1 [Online])]:

15 electrons

S II

Ar IV

- Appendix F, Table F.2, p. 497, typo: the first transition listed for S III: change
  $^3P_0-^1P_0 \rightarrow ^3P_0-^3P_1$
  noted 2016.10.03 by C.D. Kreisch.

- Appendix F, Table F.3, p. 498: updated electron collision strengths for O I:

Ion	$\ell - u$	$\Omega_{u\ell}$	Note
O I	$^3P_2-^3P_1$	$0.0105\, T_4^{0.4861+0.0054\ln T_4}$	a
"	$^3P_2-^3P_0$	$0.00459\, T_4^{0.4507-0.0066\ln T_4}$	a
"	$^3P_1-^3P_0$	$0.00015\, T_4^{0.4709-0.1396\ln T_4}$	a
"	$^3P_J-^1D_2$	$0.0312(2J{+}1)\, T_4^{0.945-0.001\ln T_4}$	b
"	$^3P_J-^1S_0$	$0.00353(2J{+}1)\, T_4^{1.000-0.135\ln T_4}$	b
"	$^1D_2-^1S_0$	$0.0893\, T_4^{0.662-0.089\ln T_4}$	b
		...	

  a fit to Bell et al. (1998)
  b fit to Zatsarriny & Tayal (2003)
  noted 2015.02.27

- Appendix F, Table F.5, p. 500: Level u in the fourth line in the table should
  be $^2P^o_{3/2}$ rather than $^2P^o_{5/2}$.
  noted 2022.09.03 by S. R. Kulkarni

- Appendix F, Table F.6, p. 501: The table title should be
  "Rate Coefficients for ... Deexcitation..." rather than "... Excitation...".

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noted 2015.07.03

- Appendix F, Table F.6, p. 501: incorrect powers of 10 in lines 5 and 6:
  $k_{u\ell}$ for ℓ–u = $^3P_0$–$^3P_1$ should read $1.26 \times 10^{-\mathbf{10}} T_2^{0.115+0.057 \ln T_2}$
  $k_{u\ell}$ for ℓ–u = $^3P_0$–$^3P_2$ should read $2.64 \times 10^{-\mathbf{10}} T_2^{0.231+0.046 \ln T_2}$
  NB!: See also erratum below on inadvertent interchange of $^3P_0$–$^3P_2$ and $^3P_1$–$^3P_2$ deexcitation rates.
  noted 2012.05.02 by M.J. Wolfire

- Appendix F, Table F.6, p. 501: the rates for entries 5 and 6 should be interchanged, so that entries 4-6 read

H	C I	$^3P_0 - ^3P_1$	$1.26 \times 10^{-10} T_2^{0.115+0.057 \ln T_2}$	b
H	C I	$^3P_0 - ^3P_2$	$8.90 \times 10^{-11} T_2^{0.228+0.046 \ln T_2}$	b
H	C I	$^3P_1 - ^3P_2$	$2.64 \times 10^{-10} T_2^{0.231+0.046 \ln T_2}$	b

  noted 2015.07.03 by Munan Gong.

- Appendix F, Table F.6, p. 501: the rates for entries 23-28 should be changed to

H_2(para)	O I	$^3P_2 - ^3P_1$	$1.49 \times 10^{-10} T_2^{0.369-0.026 \ln T_2}$	h
H_2(ortho)	O I	$^3P_2 - ^3P_1$	$1.37 \times 10^{-10} T_2^{0.395-0.005 \ln T_2}$	h
H_2(para)	O I	$^3P_2 - ^3P_0$	$2.37 \times 10^{-10} T_2^{0.255+0.016 \ln T_2}$	h
H_2(ortho)	O I	$^3P_2 - ^3P_0$	$2.23 \times 10^{-10} T_2^{0.284+0.035 \ln T_2}$	h
H_2(para)	O I	$^3P_1 - ^3P_0$	$2.10 \times 10^{-12} T_2^{1.117+0.070 \ln T_2}$	h
H_2(ortho)	O I	$^3P_1 - ^3P_0$	$3.00 \times 10^{-12} T_2^{0.792+0.188 \ln T_2}$	h

  noted 2015.08.24 by E.B. Jenkins.

- Appendix G, p. 503, typo just before Eq. (G.7): change
  ...solution $x_0 = e^{-i\omega t}$ $\rightarrow$ ...solution $x = x_0 e^{-i\omega t}$.
  noted 2019.02.11

- Appendix I, p. 506, typo: ...a time $\sim E_{u\ell}/h \rightarrow$ ...a time $\sim h/E_{u\ell}$
  noted 2013.02.07 by Munan Gong.

- Appendix I, p. 507, typo (missing $^{1/2}$): Eq. (I.4) should read

$$b_{\mathrm{crit}}(v) = W a_0 \left[1 + \frac{Ze^2/Wa_0}{m_e v^2/2} \right]^{1/2} . \qquad (\mathrm{I.4})$$

  noted 2011.02.08 by B. Hensley.

- Appendix I, p. 507, typo (15.78→31.56): Eq. (I.7) should read

$$\frac{Ze^2}{a_0 kT} = \frac{31.56Z}{T_4}$$

  noted 2019.01.14.

- Appendix J, p. 508, Eq. (J.3), typo in line 3:

$$... + \int dV \frac{\partial}{\partial j} (v_j \rho v_i x_i) \rightarrow ... + \int dV \frac{\partial}{\partial x_j} (v_j \rho v_i x_i)$$

  noted 2011.02.14 by Xu Huang.

- Appendix J, p. 510, Eq. (J.8): missing sign:

$$Y_3 = E_{\mathrm{grav}} = \frac{1}{2} \int dV_1 \int dV_2 \, G \, \frac{\rho(\mathbf{r}_1)\rho(\mathbf{r}_2)}{|\mathbf{r}_1 - \mathbf{r}_2|}$$

$\rightarrow$

$$Y_3 = E_{\mathrm{grav}} = -\frac{1}{2} \int dV_1 \int dV_2 \, G \, \frac{\rho(\mathbf{r}_1)\rho(\mathbf{r}_2)}{|\mathbf{r}_1 - \mathbf{r}_2|}$$

noted 2020.11.13

- Appendix J, p. 510, Eq. (J.13), typo:

$$\Pi_0 \equiv \oint d\mathbf{S} \cdot \mathbf{r} p \quad \rightarrow \quad \Pi_0 \equiv \frac{1}{3} \oint d\mathbf{S} \cdot \mathbf{r} p$$

noted 2017.03.08.