
Physics of the Interstellar and Intergalactic Medium

Errata in the first printing.

Updated 2018.04.09

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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 $0.3 - 10^4 \text{ cm}^{-3}$ to $0.2 - 10^4 \text{ cm}^{-3}$.
noted 2011.09.22 by B. Ménard.
- §1.2, p. 8, Table 1.4: change abundance of P from $N_{\text{P}}/N_{\text{H}} = 3.23 \times 10^{-7 \pm 0.03}$, $M_{\text{P}}/M_{\text{H}} = 1.00 \times 10^{-5}$ to $N_{\text{P}}/N_{\text{H}} = 2.82 \times 10^{-7 \pm 0.03}$, $M_{\text{P}}/M_{\text{H}} = 8.73 \times 10^{-6}$
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

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

noted 2015.06.01 by E. B. Jenkins

- §3.7, p. 28, Eq. (3.33), typo: sign error. Change $e^{-I_n/kT}$ → $e^{I_n/kT}$.
noted 2017.02.09
- §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-H₂O must have $K_{-1} + K_{+1}$ odd →
para-H₂O must have $K_{-1} + K_{+1}$ even
and
ortho-H₂O must have $K_{-1} + K_{+1}$ even →
ortho-H₂O 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 H₂O: change
The selection rules for electric dipole radiative transitions are $\Delta J = 0, \pm 1$; $\Delta K_{-1} = \pm 1, \pm 3$; and $\Delta K_{+1} = \pm 1, \pm 3$.
to
The selection rules for electric dipole radiative transitions in H₂O are $\Delta J = 0, \pm 1$; $\Delta K_{-1} = \pm 1, \pm 3$; and $\Delta K_{+1} = \pm 1, \pm 3$; 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 $7618 \text{ cm s}^{-1} \rightarrow 7616 \text{ cm s}^{-1}$
and in the following line change $7618 \text{ cm s}^{-1} \rightarrow 7616 \text{ cm s}^{-1}$.
noted 2011.08.18 by K.-G. Lee.
- §6.4, p. 58, typos: change
H Lyman α ($\lambda = 1215 \text{ \AA}$) has ... $f_{\ell u} = 0.4162$
→
H Lyman α ($\lambda = 1215.67 \text{ \AA}$) 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
$$2924 \left[\frac{7618 \text{ cm s}^{-1}}{\gamma_{ul} \lambda_{ul}} b_6 \right] \rightarrow 2925 \left[\frac{7616 \text{ cm s}^{-1}}{\gamma_{ul} \lambda_{ul}} b_6 \right]$$

and in Eq. (6.42) change $7618 \text{ cm s}^{-1} \rightarrow 7616 \text{ cm s}^{-1}$.
noted 2011.08.18 by K.-G. Lee.
- §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 $n(\text{HI})$. Should read:
$$\kappa_\nu = \frac{3}{32\pi} \frac{1}{\sqrt{2\pi}} \frac{A_{ul} \lambda_{ul}^2}{\sigma_V} \frac{hc}{kT_{\text{spin}}} n(\text{HI}) e^{-u^2/2\sigma_V^2} \quad (8.9)$$

noted 2011.03.07 by P. Pattarakijwanich.
- §8.1, p. 71, Eq. (8.10), typo: omit the comma.
noted 2010.02.09

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- §8.2, p. 72, Eq. (8.17), typo: change 54.89 → 55.17
noted 2011.07.06 by R. Allen.
- §8.2, p. 73, Eq. (8.21), typo: change $(1 + z) \rightarrow (1 + z)^{-1}$
noted 2012.06.01 by B. Catinella and N. Evans.
- §8.3, p. 74, Eq. (8.26), typo: $T_{\text{sky}}(v) \rightarrow T_{\text{sky}}$ (two occurrences).
noted 2011.02.10
- §8.3, p. 74, Eq. (8.26), typos: $T_A^{\text{on}}(v) \rightarrow T_A^{\text{off}}(v)$ (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.
- §9.10, Table 9.4, p. 88, typos: for C II and N III, change ${}^2D_J^o \rightarrow {}^2D_J$ for
 $J = 3/2$ and $J = 5/2$.
noted 2015.02.12 by Semyeong Oh.

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

$$\dots \nu_9^{-2.118} \text{ cm}^5 \left(\frac{n_i}{n_p} \right) \frac{EM}{10^{25} \text{ cm}^{-5}} \rightarrow \dots \nu_9^{-2.118} \left(\frac{n_i}{n_p} \right) \frac{EM}{10^{25} \text{ cm}^{-5}}$$

noted 2011.03.05 by B. Hensley and P. Pattarakijwanich.

- §10.5, p. 97, footnote 3, typo: $5 \times 10^6 \text{ cm}^{-3} \text{ pc} \rightarrow 5 \times 10^6 \text{ cm}^{-6} \text{ pc}$.
noted 2011.02.15 by C. Petrovich.
- §11.4, p. 110, Eq. (11.35) should read

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

noted 2013.02.03 by W. Vlemmings.

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

- §12, p. 121, Table 12.1, typos:

CMB, $T = 2.725 \text{ K}$:	4.19×10^{-13}	\rightarrow	4.17×10^{-13}
$T_2 = 4000 \text{ K}, W_2 = 1.65 \times 10^{-13}$:	3.19×10^{-13}	\rightarrow	3.20×10^{-13}
$T_3 = 7500 \text{ K}, W_3 = 1 \times 10^{-14}$:	2.29×10^{-13}	\rightarrow	2.39×10^{-13}
Starlight total	:	1.05×10^{-12}	\rightarrow	1.06×10^{-12}
ISRF total	:	2.19×10^{-12}	\rightarrow	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} . →
 ... 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 $\sigma_{pe} \rightarrow \sigma_{pi}$
 noted 2018.01.07 by L. Bouma.
- §13.1, p. 128, typo:
 $\sigma_{pe}(\text{H}_2) = 2.8\sigma_{p.i.}(\text{H}) \rightarrow \sigma_{pe}(\text{H}_2) = 2.8\sigma_{pe}(\text{H})$
 noted 2011.03.06
- §13.1, p. 129, clarification:
 ...photoionization cross sections for O... →
 ...photoionization cross sections σ_{pi} for O...
 noted 2011.03.06
- §13.1, p. 130, Eq. (13.5), clarification:
 $\zeta_{p.i.} \rightarrow \zeta_{pi}, \sigma_{pe} \rightarrow \sigma_{pi}$
 noted 2011.03.06
- §13.1, p. 130, second paragraph, typo:
 ...to $3 \times 10^{-10} \text{ s}^{-1}$ for Si → ...to $3 \times 10^{-9} \text{ s}^{-1}$ for Si
 noted 2017.03.05
- §13.1, p. 131, Table 13.1, typo: $\zeta_{p.i.} \rightarrow \zeta_{pi}, \sigma_{p.i.} \rightarrow \sigma_{pi}$
 noted 2011.03.06
- §13.4, p. 134, typos:
 $\sigma_{c.i.} \rightarrow \sigma_{ci}$ (4 places), $k_{c.i.} \rightarrow k_{ci}$ (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 $\alpha_{n\ell}$ ($\text{cm}^3 \text{ s}^{-1}$) for H^{α} . 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).

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

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

- §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

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

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

noted 2012.01.04 by E. Jenkins.

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

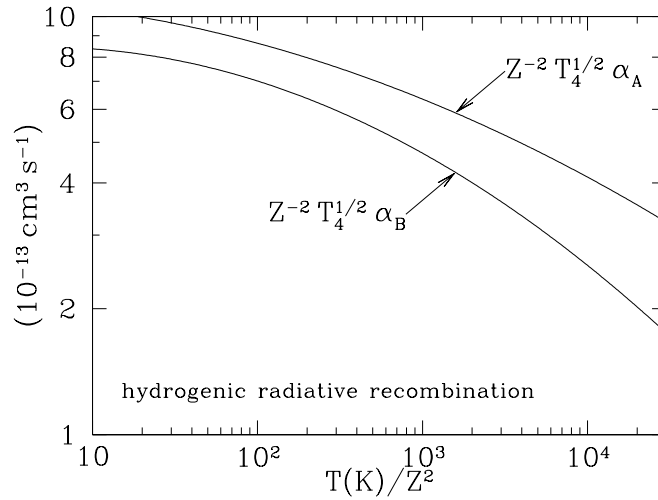


Figure 14.1 Case A and Case B rate coefficients α_A and α_B for radiative recombination of hydrogen, multiplied by $T_4^{1/2}$ (equations 14.5,14.6). Note that no single power-law fit can reproduce the T -dependence over a wide range in T .

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: $1880 \text{ cm}^{-3} \rightarrow 1.55 \times 10^4 \text{ cm}^{-3}$
noted 2011.03.17
- §14.5, p. 151, typo: [OIII]4959,5007 \rightarrow [OIII]4960,5008
noted 2012.06.22 by F. van der Tak.
- §14.6, p. 153, typo:
...from the wave function of $AB\dots \rightarrow$...from the wave function of $AB^+\dots$
noted 2011.03.05 by P. Pattarakijwanich.
- §14.6, p. 154, Table 14.8 update: replace

$$\text{H}_3^+ + e^- \rightarrow \text{H}_2 + \text{H} \quad 1.1 \times 10^{-7} T_2^{-0.56} \quad \text{McCall et al. (2004)}$$
with

$$\text{H}_3^+ + e^- \rightarrow \text{H} + \text{H} + \text{H} \quad 8.9 \times 10^{-8} T_2^{-0.48} \quad \text{McCall et al. (2004)}$$

$$\text{H}_3^+ + e^- \rightarrow \text{H}_2 + \text{H} \quad 5.0 \times 10^{-8} T_2^{-0.48} \quad \text{McCall et al. (2004)}$$
noted 2013.04.03
- §14.7.1, p. 155, typo: $I_{\text{O}(^3\text{P}_0)} = 13.6181 \text{ eV}, \rightarrow I_{\text{O}(^3\text{P}_2)} = 13.6181 \text{ eV},$
noted 2011.02.22 by Xu Huang.
- §14.7.1, p. 156, Eq. (14.31), for notational consistency: $n(\text{H}) \rightarrow n(\text{H}^0)$
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:

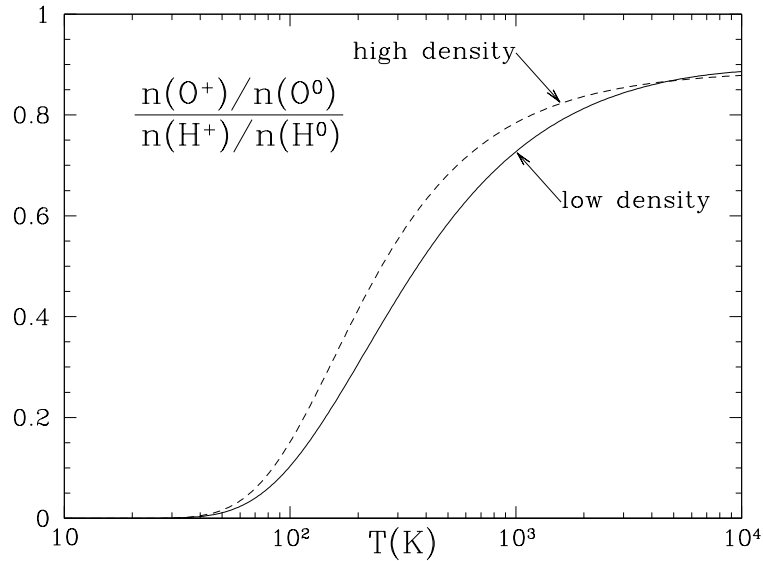


Figure 14.5 Dependence of oxygen ionization fraction on hydrogen ionization fraction due to charge exchange. The low-density limit applies for $n_{\text{H}} \lesssim 10^4 \text{ cm}^{-3}$. noted 2011.05.18 by E. B. Jenkins.

- §14.9, p. 159, typo: factor of 2 error. Eq. (14.41) should read

$$\sigma_{\text{rr}}(E) = \frac{g_{\ell}}{2g_u} \frac{(I+E)^2}{Em_e c^2} \sigma_{\text{pi}}(h\nu = I+E) . \quad (14.41)$$

noted 2015.06.01 by E. B. Jenkins.

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

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

noted 2015.06.01 by E. B. Jenkins.

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

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

If $C \approx 1$ and $f_{\text{pi}} \approx 1$, this has solution $I/kT \approx 10.6$

noted 2015.06.01 by E. B. Jenkins.

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

noted 2011.03.05

- §15.1.2, p. 163, change

the Case B radiative recombination rate for $\text{He}^+ + e^- \rightarrow \text{He}^0$ is ~ 1.9 times

larger than for hydrogen.

→

$\alpha_{\text{eff}}(\text{He})/\alpha_B(\text{H}) \approx 1.1 - 1.7$, depending on the fraction y of $h\nu > 24.6 \text{ eV}$ 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 → 28.0
noted 2013.01.31
- §15.1.2, p. 165, change
will be $\sim 18\%$ → will be $\sim 14\%$
noted 2011.03.17
- §15.1.2, p. 165, change
if $Q_1 < 0.18Q_0$, → if $Q_1 \lesssim 0.14Q_0$,
noted 2011.03.17
- §15.1.2, p. 165, change
 $Q_1/Q_0 \geq 0.18$, → $Q_1/Q_0 \gtrsim 0.14$,
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 $Q_1/Q_0 \gtrsim 0.18$.
→
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: $\sigma_d \rightarrow \sigma_{\text{dust}}$
noted 2011.02.24 by Xu Huang.
- §15.3, p. 166, Eqs. (15.10, 15.11), typo: $\sigma_{\text{p.i.}} \rightarrow \sigma_{\text{pi}}$
noted 2011.03.06
- §15.3, p. 167, Eq. (15.12), typo: $\sigma_{\text{p.i.}} \rightarrow \sigma_{\text{pi}}$
noted 2011.03.06
- §15.3, p. 167, Eq. (15.13), typo:
$$3360 (Q_{0,49})^{1/3} n_2^{1/3} \rightarrow 2880 (Q_{0,49})^{1/3} n_2^{1/3} T_4^{0.28}$$

where we have taken $\sigma_{\text{pi}} = 2.95 \times 10^{-18} \text{ cm}^2$.
noted 2011.03.17
- §15.4, p. 169, Eq. (15.27) (twice) and following paragraph (twice): typo:
 $\sigma_d \rightarrow \sigma_{\text{dust}}$
noted 2011.03.05 by B. Hensley.
- §15.4, p. 170, Eq. (15.30), typo: $\sigma_d \rightarrow \sigma_{\text{dust}}$
noted 2011.03.05 by B. Hensley.

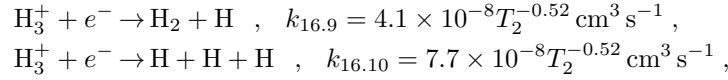
10

- §15.4, p. 170, following Eq. (15.30), add:
where $\sigma_{d,-21} \equiv \sigma_{\text{dust}}/10^{-21} \text{ cm}^2$.
noted 2011.03.05
- §15.5, p. 172, line 4, typo: ... about the He ... \rightarrow ... above the He ...
noted 2011.03.06 by S. Ferraro
- §15.7.1, p. 179, Eq. (15.53), typo: $\sigma_d \rightarrow \sigma_{\text{dust}}$
noted 2011.03.05
- §15.7, p. 180, typo: substantially reduced \rightarrow 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

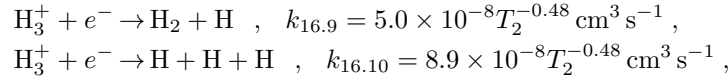
$$U \equiv \frac{1}{n_{\text{H}}} \int_{\nu_0}^{\infty} \frac{u_{\nu} d\nu}{h\nu}$$

noted 2011.03.06 by S. Ferraro.

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



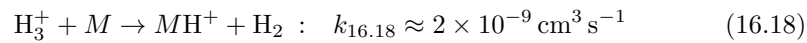
to



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. (16.18), added information:



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

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

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 $\zeta_{CR} = 1 \times 10^{-17} \text{ s}^{-1}$:

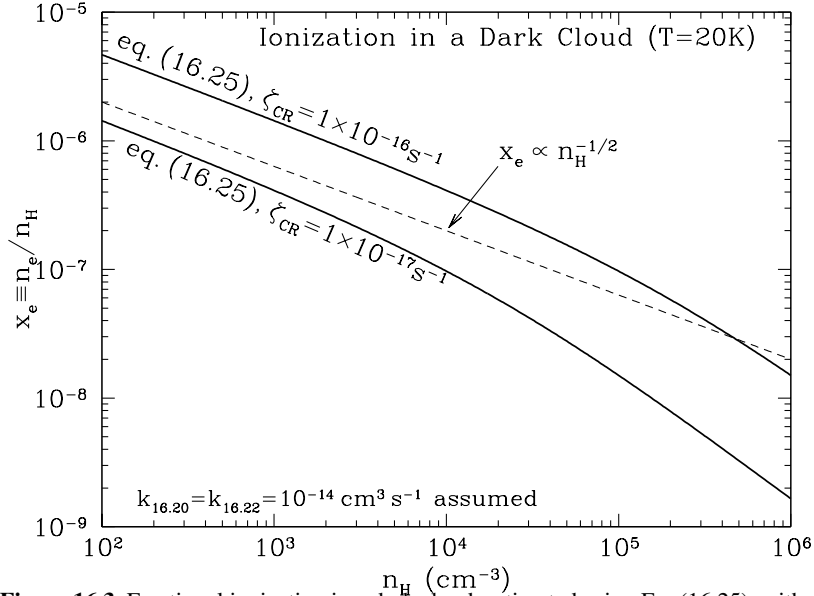


Figure 16.3 Fractional ionization in a dark cloud, estimated using Eq. (16.25), with the grain recombination rate coefficients set to $k_{16.20} = k_{16.22} = 10^{-14} \text{ cm}^3 \text{ s}^{-1}$ (see Fig. 14.6). The dashed line is a simple power-law approximation $x_e \approx 2 \times 10^{-5} (n_H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

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 HI Regions

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

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

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

noted 2010.11.27

- §17.7, p. 199, top line, typo: $n_{\text{H,crit}} \rightarrow n_{\text{crit}}(\text{H})$
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 $\lambda = 3645.1 \text{ \AA}$ \rightarrow “Balmer jump” at $\lambda = 3647.0 \text{ \AA}$
noted 2011.03.11
- §18.4.1, p. 212: Refine wavelength midway between H 20 and H 21 lines:
 $\lambda_{\text{BJ,red}} = 3682.6 \text{ \AA}$ \rightarrow $\lambda_{\text{BJ,red}} = 3682.1 \text{ \AA}$
noted 2011.03.11

- §18.5, p. 214, Eq. (18.11): Change
... Ω_{03} is approximately independent of T_e , we have
$$\frac{n(\text{O III})}{n(\text{H}^+)} = C \frac{I([\text{O III}]5008)}{I(\text{H}\beta)} T_4^{-0.37} e^{2.917/T_4}, \quad (18.11)$$

to

- ... $\Omega_{03} \propto T_4^{0.12}$ (see Appendix F), we have
$$\frac{n(\text{O III})}{n(\text{H}^+)} = C \frac{I([\text{O III}]5008)}{I(\text{H}\beta)} T_4^{-0.49} e^{2.917/T_4}, \quad (18.11)$$

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
- §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:
$$n_{\text{gr}} C_{\text{ext}}(\omega) = 2\text{Im}(k) = 2\omega c \text{Im}(\sqrt{\epsilon_{\text{ISM}}}) \approx \omega c \text{Im}(\epsilon_{\text{ISM}}) \quad (21.12)$$

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

noted 2011.03.28

- §22.4.2, p. 252, Eq. (22.27), typo: $4\pi \rightarrow 9\pi$.
noted 2012.06.26
- §23.1, p. 265, typo:
lower oscillator strength $f(\text{C II}]2325 \text{ \AA}) = 1.0 \times 10^{-7}$
 \rightarrow
larger oscillator strength $f(\text{C II}]2325 \text{ \AA}) = 1.0 \times 10^{-7}$
noted 2012.12.27
- §23.1, p. 266, typo: $\text{Mg}_{2x}\text{Fe}_{2-2x}\text{SiO}_4 \rightarrow \text{Mg}_{2x}\text{Fe}_{2-2x}\text{SiO}_4$
noted 2011.03.24 by C. Petrovich
- §23.3, 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 $\sim 23\text{K}$. \rightarrow ...does not extend
below $\sim 35\text{K}$.
noted 2011.03.24
- §24.2, p. 293, typo:
...corresponds the grain... \rightarrow ...corresponds to the grain...
noted 2011.03.25
- §26.2, p. 308, Eq. (26.23), numerical error: should read

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

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.

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- §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
- §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 2015.04.07
- §29.1, p. 332, 1st paragraph, typo: $b=0 \rightarrow b=90^\circ$, so that the 2nd sentence reads
...vary as $N(\text{HI}, b) = N(\text{HI}, b=90^\circ) / \sin |b| = N_0 \csc |b|$.
noted 2012.11.04 by R. Simons.
- §29.4, p. 335, typo:
...found $nT \approx 2800 \text{ cm}^{-3} \text{ K} \dots \rightarrow$...found $nT \approx 3800 \text{ cm}^{-3} \text{ K} \dots$
noted 2011.04.05
- §29.4, p. 335, typo: ...implies $n_{\text{H}} \approx 35 \text{ cm}^{-3}$. \rightarrow ...implies $n_{\text{H}} \approx 50 \text{ cm}^{-3}$.
noted 2011.04.05
- §30.2, p. 339, typo: ...near threshold are... \rightarrow near-threshold yields are...
noted 2011.04.05 by B. Hensley.
- §31.4, p. 349, Eq. (31.24), typo: on RHS, change

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

noted 2013.04.12 by Ai-Lei Sun.

- §31.4, p. 349, Eq. (31.25), typo: $\tau_{1000} \rightarrow \tau_{d,1000}$
noted 2012.07.10
 - §32.1, p. 357, 1st paragraph, typo: ...a their... \rightarrow ...their...
noted 2012.06.22 by F. van der Tak.
 - §32.1, p. 357, 2nd paragraph, typo: (see Plate 15). \rightarrow (see Plate 11).
noted 2011.06.07 by S. Lorenz Martins.
 - §32.9, p. 368, typo: magntic \rightarrow magnetic
noted 2011.04.11
 - §32.9, p. 368, just before eq. (32.11), typo: change
 $A_V/N_H = 1.87 \times 10^{21} \text{ cm}^2 \rightarrow A_V/N_H = 5.3 \times 10^{-22} \text{ mag cm}^2$.
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 \rightarrow photodissociation
noted 2011.04.11
 - §33.1, p. 375, typo: occuring \rightarrow occurring
noted 2011.04.25 by B. Hensley.
 - §33.2.2, p. 378, typo: reaction products should be $\text{OH}^+ + \text{H}_2$
noted 2011.04.12
 - §34.4, p. 387, typo: Eq. (34.17) is off by a factor 3, and should read

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

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

$$= 5.1 \times 10^4 \text{ yr} \left(\frac{(n_H)_c}{30 \text{ cm}^{-3}} \right) \left(\frac{R_c}{\text{pc}} \right)^2 \left(\frac{T_h}{10^7 \text{ K}} \right)^{-2.5} \left(\frac{\ln \Lambda}{30} \right). \quad (34.18)$$
- noted 2013.01.05 by B. Hensley.
- §35.3, p. 392, typo: rate-of-change v of... \rightarrow rate-of-change of v...
noted 2011.04.14
 - §36.1, p. 397, typo: occuring \rightarrow occurring
noted 2011.04.26

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- §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

$$\frac{\partial}{\partial x} \left[\frac{1}{2} \rho v_x v^2 + U v_x + p v_x + \frac{(B_y^2 + B_z^2)}{4\pi} v_x - \frac{B_x B_y v_y}{4\pi} - \frac{B_x B_z v_z}{4\pi} - v_j \sigma_{jx} - \kappa \frac{dT}{dx} + \rho v_x \Phi_{\text{grav}} \right] = \Gamma - \Lambda. \quad (36.8)$$

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

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

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

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

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

noted 2011.04.19

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

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

noted 2011.04.19

- §36.2.5, p. 402, Eq. (36.27), typo:

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

noted 2011.05.17 by P. Pattarakijwanich.

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

- §37.1, p. 413, 2nd paragraph: Change
Cases of astrophysical interest will normally have..
→
Many cases of astrophysical interest will have...
noted 2018.04.09.
- §37.1, p. 413, typo just above Eq. (37.3):
 $Jh\nu/c = \rho_1 u_1 h\nu/\mu_i c \ll \rho_1(u_1^2 + c_1^2 + B_1^2/8\pi)$.
→
 $Jh\nu/c = \rho_1 u_1 h\nu/\mu_i c \ll \rho_1(u_1^2 + c_1^2) + B_1^2/8\pi$.
noted 2016.12.08 by Ryohei Nakatani.
- §37.1, Eq. (37.8): The correction term for x_R is not accurate for magnetized I-fronts: change

$$x_R \approx \frac{1}{2} + \frac{2c_1^2 + v_{A1}^2}{16c_2^2} \rightarrow x_R \approx \frac{1}{2}$$

[see Kim & Kim (2014, ApJ 797:135) for better approximations.]
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...
→
...are called **weak R-type**. Weak R-type solutions...
 - §37.1.1, p. 414, second paragraph:
...referred to as **weak R-type**,... → ...referred to as **strong R-type**,...
 - §37.1.1, p. 414, second paragraph:
Hence, only strong R-type I-fronts are physically relevant.
→
Hence, only weak R-type I-fronts are physically relevant.
 - §37.1.2, p. 414, first paragraph:
...is termed **weak D-type**. → ...is termed **strong D-type**.
 - §37.1.2, p. 414, second paragraph:
...is termed **strong D-type**. → ...is termed **weak D-type**.
 - Fig. 37.1 and caption should be:

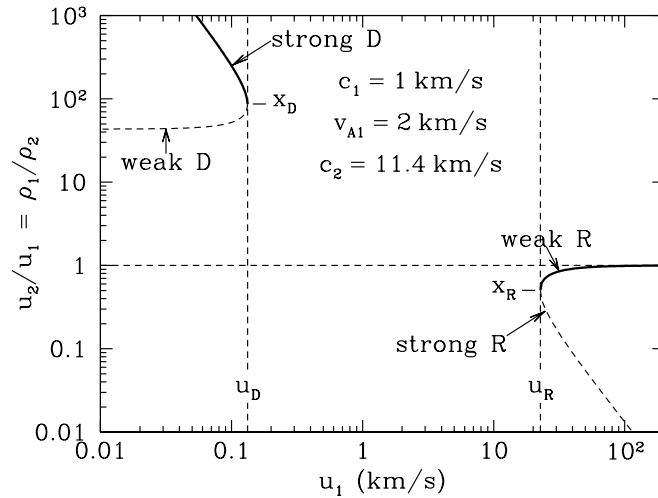


Figure 37.1 $u_2/u_1 = \rho_1/\rho_2$, as a function of the velocity u_1 of the I-front relative to the neutral gas just ahead of the I-front, for D-type and R-type ionization front solutions (see text) for an example with $c_1 = 1 \text{ km s}^{-1}$, $v_{A1} = 2 \text{ km s}^{-1}$, and $c_2 = 11.4 \text{ km s}^{-1}$. 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, ... → ...will be weak R-type, ...

- §37.1, p. 417, fourth line:

...will now be weak D-type, ... → ...will now be strong D-type, ...

noted 2016.12.06 by Ryohei Nakatani.

- §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:

$$v_s \approx V_i \quad . \quad (37.21)$$

→

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

$$V_s \approx V_i \quad . \quad (37.21)$$

noted 2016.12.08 by Ryohei Nakatani.

- §38.3, p. 428, last paragraph, typo:

$$\dot{M}_w \approx 2 \times 10^{-5} \text{ km s}^{-1} \rightarrow \dot{M}_w \approx 2 \times 10^{-5} M_\odot \text{ yr}^{-1}$$

noted 2015.12.17 by J. Miralda-Escudé.

- §39.1.1, p. 430, typo: case of Type II supernova → case of Type II supernovae

noted 2011.04.21

- §39.1.1, p. 430, typo: relative dense → relatively dense
noted 2011.04.21
- §39.1.1, p. 430, typo: Plate 11 → 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

$$v_s(t_{\text{rad}}) = 188 \text{ km s}^{-1} (E_{51}n_0^2)^{0.07}, \quad (39.22)$$

$$T_s(t_{\text{rad}}) = 4.86 \times 10^5 \text{ K} (E_{51}n_0^2)^{0.13}, \quad (39.23)$$

$$kT_s(t_{\text{rad}}) = 41 \text{ eV} (E_{51}n_0^2)^{0.13}. \quad (39.24)$$

noted 2012.10.02 by G.B. Field.

- §39.2, p. 435, footnote 1, typo (twice): occuring → occurring
noted 2011.04.12 by B. Hensley.
- §39.4, p. 438, Eqs. (39.35) and (39.36), typos: they should read

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

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

noted 2014.06.27 by B. Jiang.

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

$$\frac{p}{k} = S_{-13}^{0.77} E_{51}^{0.97} n_0^{-0.13} \times 5700 \text{ cm}^{-3} \text{ K} \quad (39.37)$$

noted 2014.06.27 by B. Jiang.

- §39.4, p. 439, typo: neighborhood → neighborhood
noted 2011.04.14
- §40.2, p. 442, typo: with a increased energy → with an increased energy
noted 2011.04.26
- §40.5, p. 447, typo: protons with $E \lesssim 10^5 \text{ GeV}$ have $R_{\text{gyro}} < 10^{-4} \text{ pc}$ →
protons with $E \lesssim 10^3 \text{ GeV}$ have $R_{\text{gyro}} < 10^{-4} \text{ pc}$
noted 2011.04.26
- §40.9, p. 450, typo: $e^+ \text{H} \rightarrow \text{H}^+ + 2\gamma \rightarrow e^+ + \text{H} \rightarrow \text{H}^+ + 2\gamma$
noted 2011.04.27

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

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

noted 2015.04.30 by J. Greco.

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

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

noted 2011.04.28

- §41.4, p. 460, Eq. (41.55), typo: $\langle \sigma v \rangle \rightarrow \langle \sigma v \rangle_{\text{mt}}$
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: $\langle \sigma v \rangle \rightarrow \langle \sigma v \rangle_{\text{mt}}$
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.
- §42.2, p. 467, last paragraph, typo: ...face-on it, may... \rightarrow ...face-on, it may...
noted 2012.06.22 by F. van der Tak.
- §42.4, p. 470, 3rd paragraph should read
... to be $Q_{0,\text{MW}} = (3.2 \pm 0.5) \times 10^{53} \text{ s}^{-1}$, after...
noted 2011.01.04
- §42.5, p. 471, Eq. (42.9) typo: dsik \rightarrow 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 $\equiv \hbar^2/m_e e^2 = \dots$
noted 2013.03.05 by Wenhua Ju.

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

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

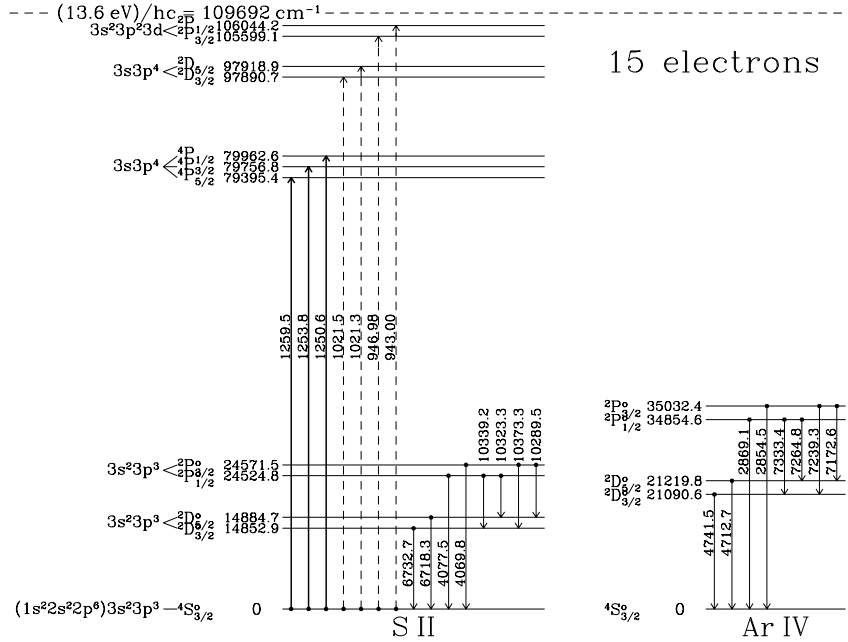
- Appendix E, p. 483, typo: Pfundt \rightarrow Pfund
noted 2011.04.28 by B. Hensley.

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

- 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. 495: ${}^2D_{3/2,5/2}^o$ 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]):



- 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	$^3P_2 - ^3P_1$	$0.0105 T_4^{0.4861+0.0054 \ln T_4}$	<i>a</i>
"	$^3P_2 - ^3P_0$	$0.00459 T_4^{0.4507-0.0066 \ln T_4}$	<i>a</i>
"	$^3P_1 - ^3P_0$	$0.00015 T_4^{0.4709-0.1396 \ln T_4}$	<i>a</i>
"	$^3P_J - ^1D_2$	$0.0312(2J+1) T_4^{0.945-0.001 \ln T_4}$	<i>b</i>
"	$^3P_J - ^1S_0$	$0.00353(2J+1) T_4^{1.000-0.135 \ln T_4}$	<i>b</i>
"	$^1D_2 - ^1S_0$	$0.0893 T_4^{0.662-0.089 \ln T_4}$	<i>b</i>

...

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

- Appendix F, Table F.6, p. 501: The table title should be "Rate Coefficients for ... Deexcitation..." rather than "... Excitation...". noted 2015.07.03
- Appendix F, Table F.6, p. 501: incorrect powers of 10 in lines 5 and 6: $k_{u\ell}$ for $\ell - u = ^3P_0 - ^3P_1$ should read $1.26 \times 10^{-10} T_2^{0.115+0.057 \ln T_2}$

$k_{u\ell}$ for $\ell-u = {}^3P_0-{}^3P_2$ should read $2.64 \times 10^{-10} T_2^{0.231+0.046 \ln T_2}$

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	CI	${}^3P_0 - {}^3P_1$	$1.26 \times 10^{-10} T_2^{0.115+0.057 \ln T_2}$	<i>b</i>
H	CI	${}^3P_0 - {}^3P_2$	$8.90 \times 10^{-11} T_2^{0.228+0.046 \ln T_2}$	<i>b</i>
H	CI	${}^3P_1 - {}^3P_2$	$2.64 \times 10^{-10} T_2^{0.231+0.046 \ln T_2}$	<i>b</i>

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)	OI	${}^3P_2 - {}^3P_1$	$1.49 \times 10^{-10} T_2^{0.369-0.026 \ln T_2}$	<i>h</i>
H ₂ (ortho)	OI	${}^3P_2 - {}^3P_1$	$1.37 \times 10^{-10} T_2^{0.395-0.005 \ln T_2}$	<i>h</i>
H ₂ (para)	OI	${}^3P_2 - {}^3P_0$	$2.37 \times 10^{-10} T_2^{0.255+0.016 \ln T_2}$	<i>h</i>
H ₂ (ortho)	OI	${}^3P_2 - {}^3P_0$	$2.23 \times 10^{-10} T_2^{0.284+0.035 \ln T_2}$	<i>h</i>
H ₂ (para)	OI	${}^3P_1 - {}^3P_0$	$2.10 \times 10^{-12} T_2^{1.117+0.070 \ln T_2}$	<i>h</i>
H ₂ (ortho)	OI	${}^3P_1 - {}^3P_0$	$3.00 \times 10^{-12} T_2^{0.792+0.188 \ln T_2}$	<i>h</i>

noted 2015.08.24 by E.B. Jenkins.

- 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

$$b_{\text{crit}}(v) = W a_0 \left[1 + \frac{Z e^2 / W a_0}{m_e v^2 / 2} \right]^{1/2}. \quad (\text{I.4})$$

noted 2011.02.08 by B. Hensley.

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

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

noted 2011.02.14 by Xu Huang.

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

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

noted 2017.03.08.