Chapter 15

Errata

September 4, 2006

15.1 Chapter 1

1. p14: Table 1.2: Energy balance for diffuse clouds

15.2 Chapter 2

1. p46: Ignoring for the moment radiation trapping ($\beta = 1$ and $P = 0$ in Eq. (2.20)),

2. p51: The factor A_{ul} on the right-hand-side of eqn. (2.53) is in error; eg., the equation should read:

$$n^2 \Lambda = \gamma_{lu} \mathcal{A}_j n^2 h\nu_{ul} \quad . \tag{15.1}$$

3. p59 last line: The interstellar $^{13}C/^{12}C$ ratio is 1/65; eg., the sentence should read: Despite the low isotope ratio of $^{13}C/^{12}C$ (=1/65 in the ISM)

15.3 Chapter 3

1. p69: The units of the heating in Figure 3.3 are 10^{-27} erg s^{-1} (H-atom)$^{-1}$ (C-atom/PAH)$^{-1}$.

15.4 Chapter 4

1. p96: First line underneath Eq. (4.20): $j = 5$ should be $n = 5$.

15.5 Chapter 5

1. p119: Eqn. (5.9): This equation should read:

$$\frac{1}{C_{\rm sca}}\frac{d\sigma}{d\Omega} = \frac{3}{16\pi}\left(1 + \cos^2\theta\right) \tag{15.2}$$

2. p124: Equation (5.30) should read:

$$C^j_{ext} = \frac{2\pi}{\lambda} V \frac{9}{\epsilon_2} \quad . \tag{15.3}$$

3. p134: The unit of T_{cr} in equation (5.68 is K:

$$T_{cr} \simeq 1.4\times 10^5 \frac{a}{100\ \text{Å}} \qquad \text{K} \tag{15.4}$$

4. p135: Eq. (5.70): The denominator in the right-hand-side of this equation should read: $\tilde{J}\left(\tau, \nu = -Z_d - 1\right)$.

5. p136: Eq. (5.76): This expression should read:

$$\sigma_Z \simeq 0.9 \left(\frac{akT}{e^2}\right)^{1/2} \simeq 1.2 \left(\frac{a}{1000\ \text{Å}}\right)^{1/2} \left(\frac{T}{100\ \text{K}}\right)^{1/2} \tag{15.5}$$

15.6 Chapter 6

1. p182: First line: with s the number of degrees of freedom ($s = 3N_c - 6$, .

2. p185: First line: where the right-hand expression is derived using Eq. (6.18).

3. p185: Eq. (6.23) should read:

$$I\left(E, i\right) = \frac{N\left(E\right) h\nu_i A_{1,i}}{4\pi} \sum_{v=1}^{\infty} \frac{v \exp\left[-vh\nu_i/kT\right]}{\left(1 - \exp\left[-h\nu_i/kT\right]\right)} \tag{15.6}$$

.

4. p189: Section 6.2.4 line 4: delete ‘temperature’; eg., this sentence reads: can estimate the grain size for which fluctuations become important.

5. p191: Section 6.3.2 line 4: The photo-electric ionization rate is then (cf. Eq. (5.63).

6. p192: Line 1: where the yield enhancement factor, $f_y\left(a\right)$, is given by Eq. (5.62).

7. p192: Section 6.3.3 line 2: The electron recombination rates are then calculated following the classical formalism (Eq. (5.51)).

8. p192: Unit of Eq. (6.44) is s^{-1}; eg.,

$$J_e\,(Z=1) \;=\; 4.1\times 10^{-5}\,\phi_{PAH}\,\left(\frac{N_c}{50}\right)^{1/2}\left(\frac{100\ \mathrm{K}}{T}\right)^{1/2}\,n_e \qquad \mathrm{s}^{-1}, \tag{15.7}$$

9. p197: Add to the end of the caption of Figure 6.7: γ is defined as $G_0T^{1/2}/n_{\rm e}$.

10. p202-205: RKM theory should be RRK theory.

15.7 Chapter 7

1. p232: A factor m_H is missing in the right-hand-side of Eq. (7.18) top line. The numerical factor in the bottom line should read 155 instead of 80; e.g.,

$$\begin{aligned} M_{HII} \;&=\; \frac{4}{3}\pi\, n\,\mathcal{R}_s^3\,m_H \;=\; \frac{\mathbb{N}_{Lyc}m_H}{n\,\beta_B} \\ &\simeq\; 155\left(\frac{\mathbb{N}_{Lyc}}{5\times 10^{49}\ \mathrm{photons\ s}^{-1}}\right)\left(\frac{10^3\ \mathrm{cm}^{-3}}{n}\right) \qquad \mathrm{M}_\odot, \end{aligned} \tag{15.8}$$

2. p244: Eq. (7.48) should read:

$$(1\,-\,x)\;\mathcal{R}_s\,n\overline{\alpha}_H\frac{\mathbb{N}_{Lyc}}{4\pi z^2}\;\exp\left[-\tau\right]\,4\pi z^2dz \;=\; 3z^2\mathbb{N}_{Lyc}dz \tag{15.9}$$

3. p244: Eq. (7.49) should read:

$$\left((1\,-\,x)\,n\overline{\alpha}_H\mathcal{R}_s\,+\,\tau_d\right)\,\frac{\mathbb{N}_{Lyc}}{4\pi z^2}\;\exp\left[-\tau\right]\,4\pi z^2dz \;=\; \mathbb{N}_{Lyc}\,\exp\left[-\tau\right]d\tau \tag{15.10}$$

4. p245: Figure 7.6 shows the fraction of EUV photons not absorbed by dust; eg, $1-f_d$ which is equal to z_0^3 (Eq. (7.51); e.g., caption should read: The fraction of EUV photons not absorbed by the dust ($1\,-\,f_d\,=\,z_0^3$) as a function of the dust optical depth in the HII region, τ_o ($=\tau_d\,z_o$).

15.8 Chapter 8

1. p270: Eq. (8.10) misses units:

$$\exp\left[-92\ \mathrm{K}/T\right] \;\simeq\; 10\,\frac{1-x}{x}\left(\frac{G_o}{n}\right) \;\simeq\; 6.4{\times}10^{-5}\left(\frac{100\ \mathrm{K}}{T}\right)^{0.6}\quad, \tag{15.11}$$

2. p270: Eq. (8.11) misses units:

$$\exp\left[-92\text{ K}/T\right] \;=\; 2{\times}10^{-2}\left(\frac{50\text{ cm}^{-3}}{n}\right)\left(\frac{1.4\times10^{-4}}{\mathcal{A}_C}\right)\left(\frac{\zeta_{CR}}{2\times10^{-16}\text{ s}^{-1}}\right) \quad \text{K}, \tag{15.12}$$

3. p270: Eq. (8.12) misses units:

$$\exp\left[-92\text{ K}/T\right] \;=\; 0.3\left(\frac{50\text{ cm}^{-3}}{n}\right)\left(\frac{1.4\times10^{-4}}{\mathcal{A}_C}\right) \quad \text{K}. \tag{15.13}$$

4. p271: Eq. (8.13) misses units:

$$\exp\left[-118,400\text{ K}/T\right] \;\simeq\; 4.5\times10^{-7}\left(\frac{0.1}{x}\right)\left(\frac{0.3\text{ cm}^{-3}}{n}\right)\left(\frac{\epsilon}{10^{-2}}\right) \quad \text{K}, \tag{15.14}$$

5. p271: Section 8.3.1 line 1: The presence of more than one phase in the ISM reflects directly the cooling curve of the interstellar gas (Fig. 2.10)

6. p280: Equation (8.27) should read:

$$T \;\simeq\; 3\times10^{5}\left(\frac{v_s}{100\text{ km s}^{-1}}\right)^2 \quad \text{K}. \tag{15.15}$$

7. p289: Equation (8.43) should read:

$$\frac{4k_{uv}(0)N_o^{3/4}}{k_d n}\left(N(N_{H_2})\right)^{1/4} \;+\; 2N(H_{H_2}) \;=\; N \tag{15.16}$$

8. p291: Equation (8.47) should read:

$$N_{\rm DF} \;\simeq\; 3.7\times10^{22}\left(\frac{G_0}{n}\right)^{4/3} \quad \text{cm}^2 \tag{15.17}$$

Note that this equation adopts $k_d(\text{H}_2) = 3\times10^{-17}$ cm^3 s^{-1}.

9. p294: Add $= 0$ to the right-hand-side of Eq. (8.60); e.g.,

$$\mu\, k_{pc}\,\theta_p\,(H)\;\theta_c\,(H) \;-\; k_{ev}\,(H_2)\;\theta_p\,(H_2) \;=\; 0 \quad , \tag{15.18}$$

10. p302: paragraph 3 line 3: Other loss channels for OH (e.g., reaction with C^+). eg., this sentence should read: The values for the cosmic ray ionization rate are somewhat uncertain because of dust attenuation – which would decrease the CR ionization rate – and because there are other loss channels for H^+ (eg., recombination) and for OH (eg., reaction with C^+), both of which tend to increase the estimate for the cosmic ray ionization rate.

11. p313: line 11: Replace "However, generally these are at much higher temperatures and are thus very sensitive to the actual temperature" by "However, generally, the levels involved are at much higher energies and hence are much more sensitive to the actual gas temperature."

15.9 Chapter 9

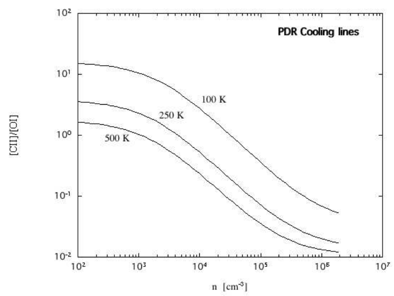

Figure 15.1: *The ratio of the cooling in the [OI] 63μm line to the cooling in the [CII] 158μm line as a function of the density for various temperatures:* $T = 100$ *K red line,* $T = 250$ *K green line,* $T = 500$ *K blue line. These ratios have been calculated in the two-level approximation using the parameters in Table 2.7 and a O/C gas phase abundance ratio of 2.3.*

1. p320: Equation (9.7) should read:

$$A_v = \frac{1}{b} \ln \left[\frac{a G_0 \mathcal{A}_i}{\zeta_{CR}} \right] \quad (15.19)$$

2. The expression for the ionization rate in eh next sentence should read: $k_{\rm ion} = a\, G_0 \exp\left[-bA_v\right]$; e.g.,

3. p321: Replace Figure 9.2 by Figure 15.1.

4. p322: The The first sentence following equation (9.10) should read: and γ the ionization parameter (defined here as $G_0 T^{1/2}/n$ with $n_e = 1.4 \times 10^{-4} n$), which measures the ionization rate over the recombination rate and, hence, the efficiency of the photo electric effect (cf., Chapter 3.3).

5. p335: second paragraph line 4: (cf. Eq. 2.49); eg., this sentence should read: Because these are quadrupole lines with small Einstein A's, optical depth effects are unimportant and the observed intensities can be directly converted into column densities of the upper state (cf., eqn. 2.49).

6. p336: Eq. (9.34) should read:

$$M_H = 3.4 \left(\frac{F_{CII}}{10^{-10}\ \mathrm{erg\ cm^{-2}\ s^{-1}}} \right) \left(\frac{d}{\mathrm{kpc}} \right)^2 \qquad \mathrm{M}_\odot \quad (15.20)$$

7. p343: Table 9.3: Headings should read: NGC 2023 reflection nebula & NGC 7027 planetary nebula
8. p343: Table 9.3: footnote: Observed line intensities are in units of erg cm^{-2} s^{-1} sr^{-1}.

15.10 Chapter 10

1. p352: Second paragraph line 3 should read: $4 \times 10^{-30}\, T^{2.4}$ erg s^{-1} $(H_2)^{-1}$.
2. p370: Eqn. (10.26) should read:

$$k_{\rm ar} = n_{\rm c} \pi a^2 v = 10^2 \left(\frac{a}{1000\ \text{Å}}\right)^2 \left(\frac{X_{\rm c}}{10^{-4}}\right) \left(\frac{n}{10^4\ \text{cm}^{-3}}\right) \qquad \text{year}^{-1} \tag{15.21}$$

3. p375: Second paragraph line 6: units should read cm^{-3}; eg., It is obvious that without the release of stored chemical energy, the gas phase will rapidly accrete out onto grains until the density of condensibles has decreased to $\sim 10^{-1}$ cm^{-3}.
4. p380: The sentence just below Eq, (10.44) should read: At first sight, such a correlation for an optically thick line is curious.
5. p386: just below Eq. (10.51). The abundance of water ice in Taurus does not depend on the H column; eg., Thus, there is a constant abundance of H_2O ice in the Taurus molecular cloud ($X(H_2O) = 1 \times 10^{-4}$ with respect to H-nuclei and assuming standard gas-to-dust values; Chapter 5.3.5).
6. p387: first line: The abundance of carbon monoxide ice in Taurus does not depend on the H column; eg., corresponding to a solid CO abundance deep in the cloud of $X(CO) = 2.1 \times 10^{-6}$ with respect to H-nuclei.
7. p391: line 11: The depletion time scale is: $3 \times 10^5\, (10^4/n\, [\text{cm}^{-3}])$ years; e.g., The depletion timescale for CO on grains is $3 \times 10^5\, (10^4/n\, [\text{cm}^{-3}])$ yr, with n the density of hydrogen nuclei.

15.11 Chapter 11

1. p399: Eq. (11.8) should read:

$$C_{\rm s}^2 = \frac{dP}{d\rho} = \gamma\, \frac{P}{\rho} \tag{15.22}$$

2. p400: The pressure in Eq. (11.10) should have been designated using P rather than p; eg.,

$$F_x = F_{rad} + \sum_i n_i\, v\, I_i + Pv \left(\frac{\gamma}{\gamma - 1} - \frac{5}{2}\right) \tag{15.23}$$

3. p400: Eq. (11.14) should read:

$$\frac{\rho_1}{\rho_0} = \frac{(\gamma+1)\,P_1 \,+\, (\gamma-1)\,P_0}{(\gamma-1)\,P_1 \,+\, (\gamma+1)\,P_0} \tag{15.24}$$

4. p402: line 4 below Eq. (11.25) should read: In that case, the cooling rate, $n^2\Lambda$, scales with n^2, τ_{cool} with $1/n$ and the cooling column is independent of n.

15.12 Chapter 12

1. p420: equation (12.9) should read:

$$v_0 = \mu m_H \frac{\mathcal{N}}{\rho_0} \tag{15.25}$$

.

2. p427: In Eq. (12.29), C_i^2 should read $C^2_{\rm pdr}$.

$$v_{pdr} = \frac{C^2_{\rm pdr}}{2C_{II}} \quad . \tag{15.26}$$

3. p431: Two lines below Eq. (12.46), 'smaller critical dust radius' should read 'smaller critical disk radius'.

4. p438: The comma in the right-hand-side of equation 12.66) isa superfluous; eg.

$$\dot{M} = 2\pi\,\mathcal{R}_s^2\,\mathcal{N}\,m_H = \sqrt{\frac{\pi}{\beta_B}} C m_H \mathcal{R}_s^{1/2} \mathbb{N}_{Lyc}^{1/2} \quad . \tag{15.27}$$

5. p445: line 1: $\overline{P} \sim V^{-\gamma}$.

6. p446: There is a factor v_s missing on the right-hand-side of equation (12.91); eg., this equation should read:

$$\frac{dE}{dt} == 4\pi R_s^2 \left(\frac{1}{2}\rho_0 v_s^3\right) \tag{15.28}$$

7. p453: Equation (12.118) should read:

$$M\,(v\,>\,v_s) \simeq 2.5\times10^3 \left(\frac{E_{sn}}{10^{51}\,\rm erg}\right)^{0.95} \left(\frac{\rm cm^{-3}}{n_0}\right)^{0.1} \left(\frac{100\rm km\ s^{-1}}{v_s}\right)^{9/7} \quad M_\odot \tag{15.29}$$

15.13 index

1. p485: Heading should read: Alphabetic list of molecular species.

2. p485 & 486: Remove page numbers following antanthrene, anthracene, benzo(ghi)perylene, chrysene, circumcoronene, coronene, naphthalene, ovalene, pentacene, pentaphene, perylene, phenanthrene, pyrene, and tetraphene.

3. p489: Add at the end:

Table 15.1: Polyclic Aromatic Hydrocarbons

antanthrene ($C_{22}H_{12}$)	174
anthracene ($C_{14}H_{10}$)	194
benzo(ghi)perylene ($C_{22}H_{12}$)	174
chrysene ($C_{18}H_{12}$)	174
circumcoronene ($C_{54}H_{18}$)	191, 192, 197
coronene ($C_{24}H_{12}$)	191, 192, 203
naphthalene ($C_{10}H_8$)	174, 182, 192
ovalene ($C_{32}H_{14}$)	174, 191, 192, 208
pentacene ($C_{22}H_{14}$)	174
pentaphene ($C_{22}H_{14}$)	174
perylene ($C_{20}H_{12}$)	174
phenanthrene ($C_{14}H_{10}$)	174, 192, 196
pyrene ($C_{16}H_{10}$)	174, 182, 191, 192
tetraphene ($C_{22}H_{14}$)	174