Tables of Absorption Coefficients

Throughout we are ignoring the stimulated emission factor.

H Bound – Free

σ is the cross section per particle in level n (cm^2/particle). $\sigma = 2.82 \times 10^{29} Z^4 g_{bf}/(n^5 \nu^3)$, (Rutten formula 2.65) for $\nu > \nu_0$. Z is the nuclear charge and is 1 for H and 2 for He. n is the radial quantum number. Set $g_{bf} \approx 1$.

H Free – Free

κ_{ff} is the absorption coefficient per unit volume (cm^2/cm^3).

$\kappa_{ff} = 3.7 \times 10^8 n_e n_i Z^2 g_{ff}/(\sqrt{T}\nu^3)$

(Rutten formula 2.67) where Z is the nuclear charge, 1 for H, 2 for He. Set $g_{ff} = 1$.

H bound – bound Transitions

These formulae are from Mihalas (equations 4-35 and 4-78). The cross section per particle in level m for a transition from level m (the lower energy level) to level n of higher energy is given by $\sigma = f(\pi e^2/mc)$ (units cm^2 Hz), where the factor in parentheses is the classical cross section, and the factor f (called the oscillator strength) is the effective number of classical oscillators. f is near 1 for very strong lines, but can be much less than 1 in many cases. For hydrogen,

$f = (32/3\pi\sqrt{3})[1/(n^3 m^5)][1/m^2 - 1/n^2]^{-3}$

The f values for H are tabulated in Table 10.1 of Rybicki and Lightman's text "Radiative Processes".

H^- Bound – Free

The formulae for H^- are from "ATLAS: A Computer Program for Calculating Model Atmospheres", by Bob Kurucz (1970), and involve numerical fits to published detailed calculations.

$\alpha_\nu = 6.80 \times 10^{-20} + \lfloor 5.358 \times 10^{-3} + [1.481 \times 10^{13} + (-5.519 \times 10^{27} + 4.808 \times 10^{41}/\nu)/\nu]/\nu \rfloor \nu$ for $\nu \geq 2.111 \times 10^{14}$.

For $1.8259 \times 10^{14} \leq \nu \leq 2.111 \times 10^{14}$, where the first frequency is that of the H^- ionization limit, use $\alpha = 3.695 \times 10^{-16} + (-0.1251 + 1.052 \times 10^{13}/\nu)/\nu$.

Another set of fits for the bound-free H^- absorption coefficient can be found in Gray's book "The Observation and Analysis of Stellar Photospheres". He gives:

$$\alpha_{bf} = a_0 + a_1\lambda + a_2\lambda^2 + a_3\lambda^3 + a_4\lambda^4 + a_5\lambda^5 + a_6\lambda^6$$

where α_{bf} is in units of 10^{-18} cm^2 per H^- ion, and the constants have the values $a_0 = 1.9965$, $a_1 = -1.1827 \times 10^{-5}$, $a_2 = 2.6424 \times 10^{-6}$, $a_3 = -4.405 \times 10^{-10}$, $a_4 = 3.2399 \times 10^{-14}$, $a_5 = -1.396 \times 10^{-18}$, $a_6 = 2.787 \times 10^{-23}$, and λ is in Å.

$\underline{H^-\ Free - Free}$

$\kappa_\nu(free - free) = n(HI, n = 1) n_e F_\nu(T)/\rho$, where
$F_\nu(T) = [1.3727 \times 10^{-25} + (4.3748 \times 10^{-10} - 2.5993 \times 10^{-7}/T)/\nu]/\nu$.