5.2: Absorption

To start with, let us suppose that the predominating mechanism is absorption with no scattering. We can define a *linear absorption coefficient* α as follows. Let the specific intensity at some level in an atmosphere be I. At a level in the atmosphere higher by a distance dx, the specific intensity has dropped, as a result of absorption, to $I+dI$. (Here dI, by the convention of differential calculus, means the increase in I, and it is in this case negative. The quantity $-dx$, which is positive, is the decrease in I.) The linear absorption coefficient α is defined such that the fractional decrease in the specific intensity over a distance dx is given by

$$-\frac{dI}{I}=\alpha dx \tag{5.2.1}$$

The coefficient is of dimension L^{-1} and the SI unit is m^{-1}. In general, α will depend on frequency or wavelength, and, at a particular wavelength, the Equation would be written

$$-\frac{dI_\nu}{I_\nu}=\alpha(\nu)dx \tag{5.2.2}$$

If Equation 5.2.1 is integrated over a finite distance, for a slab of atmosphere, say, between $x=0$, where the specific intensity is I^0, and $x=X$, where the specific intensity is I, it becomes

$$I=I^0\exp\left[-\int_0^X\alpha(x)dx\right] \tag{5.2.3}$$

And if α is uniform and not a function of x, this becomes

$$I=I^0\exp(-\alpha X) \tag{5.2.4}$$

Now let $\alpha_a=\alpha/n$, so that Equation 5.2.1 becomes

$$-dI/I=\alpha_a n dx \tag{5.2.5}$$

and Equation 5.2.4 becomes $I=I^0\exp(-\alpha_a nX)$, where n is the number of atoms per unit volume. Then α_a is the *atomic absorption coefficient*, or *atomic absorption cross-section*. It is of dimension L^2 and the SI unit is m^2.

In a similar manner, we can define $\alpha_m=\alpha/\rho$, where ρ is the mass density, as the *mass absorption coefficient*, with corresponding modifications in all the other equations. It is of dimension $\mathrm{L}^2\mathrm{M}^{-1}$ and the SI unit is $\mathrm{m}^2\mathrm{kg}^{-1}$.

We might also mention here that in laboratory chemistry, one comes across the word *absorbance* of a solution. This is the linear absorption coefficient divided by the concentration of the solute. While this word in not usually encountered in stellar atmosphere theory, it is mentioned here partly because it is very similar in concept to the several concepts discussed in this section, and also because of the similarity of the word to the rather different *absorptance* defined in Chapter 2. In chemical texts, the exponential decrease of intensity with distance is often referred to as the Lambert-Beer Law, or simply as Lambert's Law. This is mentioned here merely to point out that this is not at all related to the *Lambert's Law* discussed in Chapter 1.