1.3: Variation with Frequency or Wavelength

The radiant flux per unit frequency interval can be denoted by Φ_ν W Hz^{-1}, or per unit wavelength interval by Φ_λ W m^{-1}. The relations between them are

$$\Phi_\lambda = \frac{\nu^2}{c}\lambda_\nu; \quad \Phi_\nu = \frac{\lambda^2}{c}\Phi_\lambda \tag{1.3.1}$$

It is useful to use a subscript ν or λ to denote "per unit frequency or wavelength interval", but parentheses, for example $\alpha(\nu)$ or $\alpha(\lambda)$, to denote the value of a quantity at a given frequency or wavelength. In some contexts, where great clarity and precision of meaning are needed, it may not be overkill to use both, the symbol $I_\nu(\nu)$, for example, for the radiant intensity per unit frequency interval at frequency ν.

We shall be defining a number of quantities such as flux, intensity, radiance, etc., and establishing relations between them. In many cases, we shall omit any subscripts, and assume that we are discussing the relevant quantities integrated over all wavelengths. Nevertheless, very often the several relations between the various quantities will be equally valid if the quantities are subscripted with ν or λ.

The same applies to quantities that are weighted according to wavelength-dependent instrumental sensitivities and filters to define a *luminous* flux, which is weighted according to the photopic wavelength sensitivity of a defined standard human eye. The unit of luminous flux is the *lumen*. The number of lumens in a watt of monochromatic radiation depends on the wavelength (it is zero outside the range of sensitivity of the eye!), and for heterochromatic radiation the conversion between lumens and watts requires some careful computation. The number of lumens generated by a lightbulb per watt of power input is called the luminous efficiency of the lightbulb. This may seem at first to be a topic of very remote interest, if any, to astronomers, but those who would observe the faintest and most distant galaxies may well at some time in their careers have occasion to discuss the luminous efficiencies of lighting fixtures in the constant struggle against light pollution of the skies.

The topic of lumens versus watts is a complex and specialist one, and we do not discuss it further here, except for one brief remark. When dealing with visible radiation weighted according to the wavelength sensitivity of the eye, instead of the terms radiant flux, radiant intensity, irradiance and radiance, the corresponding terms that are used become luminous flux (expressed in lumens rather than watts), luminous intensity, illuminance and luminance. Further discussion of these topics can be found in section 1.10 and 1.12.

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